

# Space Program Operations Contract

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## SPACE SHUTTLE ORBITER OPERATIONAL LEVEL C FUNCTIONAL SUBSYSTEM SOFTWARE REQUIREMENTS GUIDANCE, NAVIGATION, AND CONTROL PART A

### GUIDANCE ON-ORBIT/DEORBIT

**Prepared by The Boeing Company  
Space Exploration**

Under Subcontract 6000132079, PDRD P1433q

December 14, 2007

DRD 1.4.3.3-q

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**SPACE SHUTTLE ORBITER OPERATIONAL LEVEL C  
FUNCTIONAL SUBSYSTEM SOFTWARE  
REQUIREMENTS**

**GUIDANCE, NAVIGATION, AND CONTROL PART A**

**GUIDANCE  
ON-ORBIT/DEORBIT**

**Issue Date: December 14, 2007**

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## FOREWORD

The primary avionics software system (PASS) requirements for the computer programs that execute in the Shuttle general-purpose computers (GPC's) are specified in the Computer Program Development Specifications (CPDS's) and the Functional Subsystem Software Requirements (FSSR) documents. The requirements are specified at three levels:

Level A CPDS – System-level constraints and capabilities

Level B CPDS – Functional requirements

Level C FSSR – Detailed-level requirements

The Level A CPDS specifies system-level constraints and capabilities that are not oriented toward any particular program end item. The Level B CPDS specifies system-level requirements for guidance, navigation, and control (GN&C) and detailed requirements for systems management (SM) and vehicle utility (VU). The Level C FSSR's specify the detailed requirements for GN&C and display/controls. The Level C reconfigurable requirements are specified in the systems management and payload documents. The Level A, Level B, and Level C requirements documents are listed in Section 2, Applicable Documents.

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**DOCUMENT CHANGE RECORD**

The following tabulation summarizes the change activity associated with this document.

<b>DOCUMENT CHANGE RECORD</b>			
<b>Issue and Date</b>	<b>Change Summary/Effectivity</b>		
OI-34 Release December 14, 2007	This baseline release for effectivity OI-34 and subs includes:		
	<u>CR</u>	<u>OI</u>	<u>Title</u>
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
	93160B	32	Year End Roll Over (YER) Reset
	93175	32	Expand Effectivity of SCR 93160B
	93177D	32	Clarify LOAD Item Entry
	93182B	34	Make LTVCON More Robust
	93199A	34	LTVCON Task Cleanup

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**CHANGE REQUEST SUMMARY**

The following tabulation lists the paragraphs, tables (T), and figures (F) that have been changed as a result of approved change requests for this release. Changes incorporated prior to this release are listed in Appendix R. Changes from approved change requests (CRs) to this document are indicated by a change bar in the outer margin of the changed page.

<b>CHANGE REQUEST SUMMARY</b>			
<b>Paragraph</b>	<b>CR No.</b>	<b>OI</b>	<b>CR Title</b>
N/A	93175	32	Expand Effectivity of SCR 93160B
1.3-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.1.1-3.(F)	93177D	32	Clarify LOAD Item Entry
4.1.2	93177D	32	Clarify LOAD Item Entry
4.1.3	93177D	32	Clarify LOAD Item Entry
4.1.3-2.(T)	93177D	32	Clarify LOAD Item Entry
4.1.10-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93177D	32	Clarify LOAD Item Entry
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.1.10-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.2.1	93177D	32	Clarify LOAD Item Entry
4.2.7-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.2.7-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.3.24-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.3.24-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.4.1-3.(F)	93177D	32	Clarify LOAD Item Entry
4.4.4	93177D	32	Clarify LOAD Item Entry
4.4.4-2.(T)	93177D	32	Clarify LOAD Item Entry
4.4.5-2.(T)	93177D	32	Clarify LOAD Item Entry
4.4.10-2.(T)	93177D	32	Clarify LOAD Item Entry
4.4.14-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93177D	32	Clarify LOAD Item Entry
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.4.14-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.5.1	93177D	32	Clarify LOAD Item Entry
4.5.6	93182B	33	Make LTVCON More Robust
	93199A	33	LTVCON Task Cleanup
4.5.6-1.(T)	93182B	33	Make LTVCON More Robust
	93199A	33	LTVCON Task Cleanup
4.5.8-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.5.8-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist

<b>CHANGE REQUEST SUMMARY</b>			
<b>Paragraph</b>	<b>CR No.</b>	<b>OI</b>	<b>CR Title</b>
4.5.8-3.(T)	93182B	33	Make LTVCON More Robust
4.6.1-3.(T)	93182B	33	Make LTVCON More Robust
4.6.24-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.6.24-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.6.24-3.(T)	93182B	33	Make LTVCON More Robust
4.7.4-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
A4.1.3.(1)(F)	93177D	32	Clarify LOAD Item Entry
A4.1.3.(2)(F)	93177D	32	Clarify LOAD Item Entry
A4.4.4.(F)	93177D	32	Clarify LOAD Item Entry
A4.5.6.(F)	93182B	33	Make LTVCON More Robust
APPENDIX B	93182B	33	Make LTVCON More Robust

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## 1.0 INTRODUCTION

### 1.1 PURPOSE

This Level C document presents details and formulations of the Guidance Level B functional requirements for the orbiter guidance, navigation, and control software.

### 1.2 SCOPE

This document contains the requirement details and formulations for those functions which are operative during the orbital and deorbital flight phases.

### 1.3 ORGANIZATION

This document is organized into the following sections plus appendixes:

- 1.0 Introduction
- 2.0 Applicable Documents
- 3.0 Overview
- 4.0 Detail Requirements
- 5.0 Supplemental Material

#### Appendixes

- A. Detailed Requirements Flowcharts
- B. Variable Definitions

Section 1.0 is the introduction, and it defines the purpose, scope, and the organization of this document. Applicable documents are listed in Section 2.0. Section 3.0 provides an overview and description of the flight phases, major modes within the flight phases, and principal functions within the major modes. Section 4.0 sets forth the requirements, formulations, and mathematical equations in detail. It also contains applicable tables (Interface Definition Document (IDD) inputs/outputs, I-Loads, K-Loads, and Constants) located at the end of each Principal Function. Section 5.0 provides supplemental material, which includes coordinate systems, acronyms and abbreviations, HAL programming language syntax, and software singularity preventive measures. Appendix A contains flowcharts for each task. Appendix B contains variable definitions.

The automated IDD tables provided herein define signal (parameter) interface requirements either between hardware (LRU) and software elements or between software elements and other software elements. A GN&C software element is either a sequenced principal function (PF), crew generated specialist/display function, or an OPS display function. In the event of a conflict between the IDD tables and other internal text input/output tables, the SASCB data base-controlled IDD tables take precedence.

The following table defines the data elements found in the IDD input/output, I-Load, K-Load, and Constant tables for each principal function.

Table 1.3-1. Parameter Element Description		
Title	Definition	Valid Entries
CAT	Category of the I-Load (**Note)	Three alphanumeric characters: the first character must be alphabetic.
D	Dependency of the I-Load	D = Design M = Mission L = LRU
DESCRIPTION	Parameter description of the K-Load or Constant.	A string of ≤ 64 characters.
DESTINATION	Destination of the output parameter	Abbreviated functional titles. (***) Note)
DT or DATA TYPE	Data Type	* See reference (1) for valid I-Load, K-Load and Constant data types. * See reference (2) for valid IDD data types for parameters with destination TLM. * See reference (3) for valid IDD data types for all other parameters.
ENG UNITS or UNITS	Engineering Units	* See reference (1) for valid I-Load, K-Load and Constant units. * See reference (2) for valid IDD units for parameters with destination TLM. * See reference (3) for valid IDD units for all other parameters.
FSSR NAME	Requirements parameter name	A string (with no embedded blanks) of ≤ 32 characters consisting of alphanumerics, underscores, parenthesis, commas and slashes. Parenthesis are used for array elements. Commas separate the different indices of multidimensional arrays. Slashes are used to separate multiple names used for a single MSID.
LAST CR	The last CR affecting the parameter	5 digit number with an alphabetic revision letter.
MC	Memory Configuration	00=Generic                      05 = SM4 Orbit P/L 01=GN1 Ascent/GN6 RTLS    06 = P/L9 MMU 02=GN2 Orbit                 07 = Not Assigned 03=GN3 Entry                 08 = GN8 On-Orbit C/O 04=SM2 On-Orbit             09 = GN9 Preflight
MSID or M/S ID	Measurement/Stimulus Identification	Maximum of 10 alphanumeric characters. * See reference (3) for specifications
NOMENCLATURE	Parameter description of the IDD parameter.	String of ≤ 34 characters (including underscores and blank spaces).
PR or PREC	Precision	D, DP =Double                 S, SP = Single
SOURCE	Origin of the input parameter	Abbreviated functional titles.

Table 1.3-1. Parameter Element Description		
Title	Definition	Valid Entries
S	Software Utilization	C = Common                      B = BFS Unique P = Primary                      X = BFS Derived A = BFS Converted
PR FCTN	Cross reference of the principal function identifiers that are applicable to this parameter.	See Level B GN&C CPDS SS-P-0002-510
VALUE	The value of the K-Load or Constant	* See reference (1) for valid value formats.
REV	Revision indicator	An Asterisk (*) indicates changes for the current OI version
<p>* References: (1) JSC 19350 I-Load Requirements Document Volume I (2) SS-P-0002-140 Level A SS Downlist/Uplink CPDS (3) JSC 18206 Shuttle Data Integration Plan Volume III MAST II/STAR Deliverable Products.</p> <p>** Note For additional information on any I-Load, contact the I-Load owner defined in CR 98032, JSC, USA, and Boeing I-Load Owner Assignments</p> <p>*** Note IDD output (source) tables which reflect parameters going to input (destination) "TLM" shall not be interpreted as a signal actually being downlisted. The parameter is only available for downlist in COMPOOL and does not appear in a downlist format. Parameters actually on the downlist will be designated with a destination denoting the downlist Format with a Rate Code. The Rate Code legend appears at the end of each FSSR data table. To complete the downlist information, Parent MSIDs (indicated by a 'P' in the 9<sup>th</sup> character of the MSID) are now included in the software function output data tables in which a Child MSID already appears. A Parent MSID will have the same downlist destinations as its Child(ren) MSID(s).</p>		

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## 2.0 APPLICABLE DOCUMENTS

### 2.1 LEVEL A DOCUMENTS

- SS-P-0002-140 Shuttle Downlist/Uplink Software Requirements
- SS-P-0002-150 Shuttle Launch Data Bus Software Interface Requirements
- SS-P-0002-170 Shuttle Systems Level Requirements, Software

### 2.2 LEVEL B DOCUMENTS

- SS-P-0002-510 Shuttle Functional Level Requirements, GN&C
- SS-P-0002-550 Shuttle Functional Level Requirements, Vehicle Utility
- SS-P-0002-580 Shuttle Functional Level Requirements, Systems Management

### 2.3 LEVEL C DOCUMENTS

- STS 83-0001 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Entry Through Landing Guidance
- STS 83-0002 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Guidance Ascent/RTLS
- STS 83-0003 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Guidance On-Orbit/Deorbit
- STS 83-0004 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, Entry Through Landing Navigation
- STS 83-0005 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, Navigation Ascent/RTLS
- STS 83-0006 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, On-Orbit Navigation
- STS 83-0007 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Entry – GRTLS
- STS 83-0008 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Volume 1, Ascent Flight Phase, Volume 2, Ascent
- STS 83-0009 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Orbit DAP
- STS 83-0010 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part D, Redundancy Management

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STS 83-0013	Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Inertial Measurement Unit Subsystem Operating Program
STS 83-0014	Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Volume 1, Navigation Aids Subsystem Operating Program, Volume 2, Star Tracker Subsystem Operating Program
STS 83-0015	Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Subsystem Operating Programs, FC Sensor/Controller
STS 83-0016	Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Subsystem Operating Programs, FC Effector
STS 87-0017	Operational Flight Level C, Functional Subsystem Software Requirements; Remote Manipulator System
STS 83-0020	Operational Flight Level C, Functional Subsystem Software Requirements; Displays and Controls
STS 83-0026	Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Sequencing
JSC-19350	Shuttle Flight Software Initialization Load  Volume I General Requirements  Volume II Mission I-Load Requirements
JSC-19478	Payload Management, Level C Flight Software Requirements
JSC-19590	Systems Management, Level C Flight Software Requirements

**2.4 ICD DOCUMENTS**

ICD-3-1011-02	GPC/DEU ICD
ICD 2-1S001	Orbiter Primary Flight Software System and Backup Flight System Software Interface

In the event of a conflict between the documents referenced herein and the contents of this specification, the precedence shall be determined as defined in paragraph 1.3 of CPDS SS-P-0002-170, Volume 1, System Level Requirements, Software.

### 3.0 OVERVIEW

Shuttle flight phases are categorized by operational sequences. The operational sequences which concern this document are Operational Sequence 2 (OPS 2, Orbit Operation) and Operational Sequence 3 (OPS 3, Entry Operation).

#### 3.1 OPERATIONAL SEQUENCE 2 (ORBIT OPERATION)

OPS 2 is an orbital operational sequence which contains the necessary set of major modes and functions to accomplish on-orbit operations. A brief timeline of OPS 2 is shown in Figure 3-1.

#### 3.2 OPS 2 MAJOR MODE DESCRIPTIONS

MM 201 – Orbit Coast. This major mode contains all functions to monitor and control the vehicle during coast flight and experiment operation.

MM 202 – Maneuver Execute. The detailed formulations of this document are primarily to support the guidance requirements of this major mode. The functions contained in this mode are to accomplish engine selection and guidance target loading, to maneuver the vehicle to burn attitude, and to monitor, guide, and control the vehicle while executing a translation maneuver.

Several major software elements are prominently involved in setting up and performing the guidance-related activities in support of maneuver execute. These principal functions are the following:

1. Orbit Maneuver Display Processing (ORBIT MNVR DIP)
2. On-Orbit Guidance (ON-ORB GUID)
3. Universal Pointing Processor (UNIV POINT PROC)
4. Orbit Targeting Specialist (ORB TGTING SPEC)
5. Relative Navigation Specialist (REL NAV SPEC)
6. On-Orbit Digital Autopilot (ON-ORB DAP)
7. On-Orbit Predictor (ON-ORB PRED)
8. On-Orbit User Parameter Processing (ON-ORB UPP)

The detailed formulations of these five functions, three principal and two specialist, are developed in this document. Brief descriptions of these five functions are as follows:

### **3.2.1 On-Orbit Guidance**

This principal function issues OMS thrust commands to control the vehicle during OMS engine burns required for orbit shaping maneuvers. The propulsion system configurations available for on-orbit maneuvers are two OMS, one OMS, and the +X acceleration RCS.

The primary guidance algorithm is external  $\Delta V$ , a guidance concept which requires a constant inertial direction thrust until a desired velocity-to-go vector is achieved. Additionally, rendezvous maneuvers can use Lambert targeting in which thrust direction is continuously updated to hit a targeted position at some specified time. Lambert maneuvers are initially computed, using the Orbit Targeting Specialist Function, and updated during the maneuver by calls to the Lambert Conic-Velocity-Required Task. The mechanization of the on-orbit guidance algorithm is sufficiently simple that no separate powered explicit guidance (PEG) task is allocated toward its implementation.

### **3.2.2 Orbit Maneuver Display Processing**

This principal function supports the XXXXX Maneuver YYYYYY display. It stores and processes data and serves as interface with MSC, On-Orbit Guidance, and the crew (via the display) during MM 202.

### **3.2.3 Universal Pointing Processor**

This principal function cyclically computes desired attitude rate for On-Orbit DAP. It is available in MM 201 (and active during MM 202) and serves as an interface between keyboard and display, providing the crew the capability to effect orbiter attitude changes.

### **3.2.4 Orbit Targeting Specialist**

The Orbit Targeting Specialist function gives the orbiter crew the capability to generate targets for a sequence of maneuvers that, if executed, would lead to a rendezvous with a target vehicle or payload. The maneuver target outputs of this specialist function will be available for display to the crew and as inputs to the On-Orbit Orbit Maneuver Execute Display Processing principal function.

### **3.2.5 Relative Navigation Specialist**

The Relative Navigation Specialist function will compute data for the relative navigation display that provides the crew with information concerning the relative motion between the orbiter and a target vehicle. Its primary use is during rendezvous and station keeping.

## **3.3 OPERATIONAL SEQUENCE 3 (ENTRY OPERATION)**

OPS 3 is an entry operational sequence which contains a set of major modes and functions required to configure the vehicle for entry and to execute maneuvers to achieve a safe landing. The deorbit flight phase covered by this document consists of the major modes required to prepare the vehicle for entry and to execute the deorbit maneuver to attain the entry trajectory for TAEM interface. These major modes are MM 301, MM 302, and MM 303. A brief time line of OPS 3 is depicted in Figure 3-2.



### 3.4 OPS 3 MAJOR MODE DESCRIPTIONS

1. MM 301–Pre–deorbit Coast. The primary purpose of this major mode is to perform orbital navigation in preparation for executing the deorbit maneuver.
2. MM 302–Deorbit Execute. In this major mode the vehicle is configured for entry and prepared for deorbit maneuvers. Engine select, target loading, deorbit burn attitude, and deorbit maneuvers are executed.
3. MM 303–Pre–Entry Monitor. This major mode contains all functions necessary to guide, monitor, and control the vehicle from completion of deorbit maneuver until achievement of entry interface.

Several principal functions are involved in setting up and performing the guidance–related activities in support of deorbit execute. These principal functions are as follows:

1. Deorbit Maneuver Display Processing (DEORB MNVR DIP)
2. Deorbit Guidance (DEORB GUID)
3. Entry User Parameter Processing (ENTRY UPP)
4. Transition Digital Autopilot (TRANS DAP)
5. Entry Precise Predictor (ENT PREC PRED)

The detail formulations of the first two principal functions are developed in this document. Brief descriptions of DEORB GUID and DEORB MNVR DIP follow.

#### 3.4.1 Deorbit Guidance

This function issues thrust commands to control the vehicle during the OMS/RCS engine burns so as to direct the vehicle through a targeted position while achieving a velocity vector which possesses horizontal and vertical components that satisfy a predetermined linear constraint. The propulsion system configurations for the deorbit maneuver are two OMS, one OMS, and RCS. The primary guidance algorithm to be used is PEG 4 (linear terminal velocity constraint). A secondary contingency guidance algorithm is PEG 7 (external  $\Delta V$ ).

#### 3.4.2 Deorbit Maneuver Display Processing

This function supports the DEORB MNVR EXEC (during MM 302) and DEORB MNVR COAST (during MM's 301 and 303) displays. It stores and processes data, and interfaces with MSC, DEORB GUID, and the crew (via the displays).

### 3.5 MAJOR MODE TRANSITIONS

Transitions from one major mode to another are GN&C events for which event names and event numbers are assigned. Nominal mode transitions for the on-orbit and deorbit maneuver phases of missions are shown in Table 3.5-1. The numeric values in the table designate the event numbers associated with the mode transition events. All these mode transitions are initiated by crew action.

For OPS 2 major mode transitions, it is nominal to go from MM 106 to MM 201 (Event 60), from MM 201 to MM 202 (Event 67), and from MM 202 to MM 201 (Event 73). It is also possible to transition from MM 301 to MM 201 (Event E1). It is also possible to transition from MM 201 to MM 801 (Event 60B), and it is also possible to transition from MM 801 to MM 201 (Event 60A).

For OPS 3 major mode transitions, it is nominal to go from MM 201 to MM 301 (Event 85), from MM 301 to MM 302 (Event E3), and from MM 302 to MM 303 (Event E15). It is also possible to transition from MM 302 and MM 303 to MM 301 (Events E10 and E16B) provided time base is less than -X seconds, and from MM 104, MM 105, and MM 106 directly to MM 301 (Events A16B, A20, and 59). Both of these latter transitions require a crew-initiated OPS 301 PRO action.

Table 3.5-1. Major Mode Transitions and Associated Event Numbers

From	To						
	MM 201	MM 202	MM 301	MM 302	MM 303	MM 304	MM 801
MM 104 OMS 1 Insert			A16B				
MM 105 OMS 2 Insert			A20				
MM 106 Insertion Coast	60		59				
MM 201 Orbit Coast		67	85				60B
MM 202 ORB MNVR EXEC	73						
MM 301 Pre-deorbit Coast	E1			E3			NA
MM 302 Deorb MNVR Execute			E10		E15		
MM 303 Pre-entry Monitor			E16B			E16	
MM 801 FCS Checkout	60A		60H				

### 3.6 GUIDANCE OPTIONS, PROPULSIVE SYSTEM, AND FLIGHT MANEUVERS

The two guidance options for on-orbit maneuvers are external  $\Delta V$  and Lambert. For deorbit maneuver, the options are linear terminal velocity constraint (LTVC) and external  $\Delta V$ . When LTVC is the selected guidance algorithm, the vehicle is guided such that a specified linear relationship between vertical and horizontal velocity components at a desired position is achieved. When external  $\Delta V$  is the selected guidance algorithm, the vehicle is oriented and held in a fixed attitude such that the thrust vector will achieve a specified velocity-to-be gained vector. When Lambert is the selected guidance algorithm, thrust direction is continuously updated to hit a targeted point.

Both external  $\Delta V$  and LTVC guidance options may be performed with two OMS or one OMS, either in manual or automatic maneuver mode. The maneuver modes are transparent to guidance. Guidance issues thrust direction commands to ON-ORBIT DAP (TRANS DAP, if deorbit maneuver), which converts the guidance commands and feedback from vehicle sensors into attitude errors for display on the ADI. If the control mode is manual, the attitude errors are manually removed with the RHC; otherwise, ON-ORBIT DAP (TRANS DAP, if deorbit) automatically removes the attitude discrepancy. Whether manual or automatic control mode, engine ignition and cutoff are automatically performed.

All on-orbit and deorbit maneuvers can be performed with RCS. In this case, only the manual mode is available. For on-orbit maneuver, guidance will assume an RCS configuration which corresponds to +X acceleration control mode (using two jets); for deorbit maneuver, the assumed RCS configuration will correspond to +X acceleration high mode (using four jets). Engine ignition and cutoff are manually controlled by the THC. Otherwise, guidance functions are the same as for manual OMS.

Control over the propellant remaining to minimize the vehicle c.g. problem during reentry is also provided during deorbit maneuver.

### 3.7 IMPLEMENTATION CONSTRAINTS

The guidance subsystem design is capable of recovering from the effects of many transient-type errors. Accordingly, the software design shall not preclude this capability by causing a program halt, permanent discontinuance of guidance processing, or loss of protected data as a result of program check or error interrupts.

Check or error interrupts shall be prevented by software safeguards, or standard fixup and error returns shall be provided that are appropriate in the guidance function as described in Level A CPDS SS-P-0002-170, Section 4.6.4.2.2.

### 3.8 TIMING

Timing in this document is related to error-free processing conditions. See Level A CPDS SS-P-0002-170, paragraph 4.4.2A for timing related to error processing conditions.

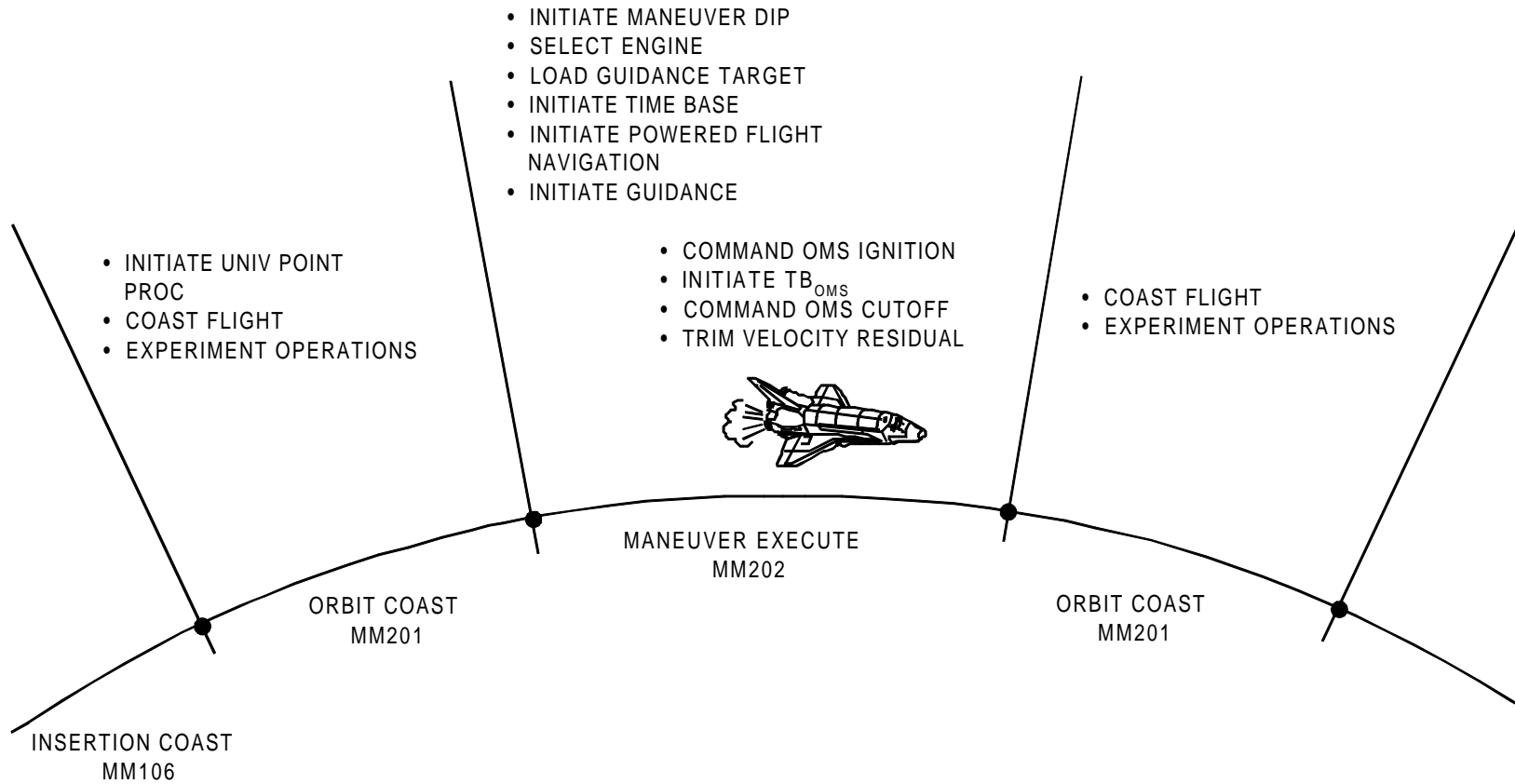


FIGURE 3-1. Typical Timeline for On-Orbit Operational Sequence (OPS 2) Exclusive of Rendezvous Maneuver

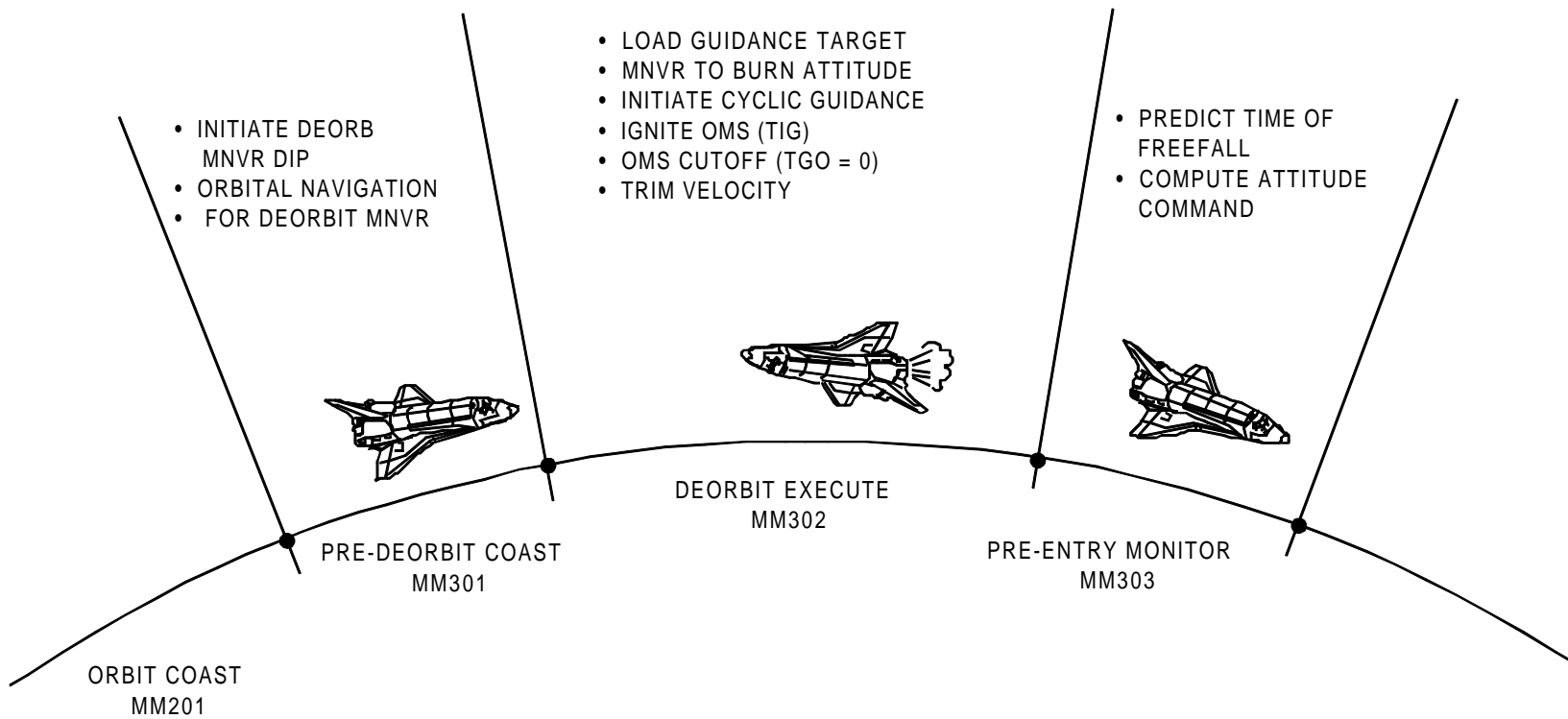


FIGURE 3-2. Typical Timeline for Deorbit Operational Sequence (OPS 3) Before Entry Interface

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## 4.0 GUIDANCE FUNCTIONAL SOFTWARE REQUIREMENTS

This section presents Level C detailed guidance and targeting requirements for the on-orbit (OPS 2) and deorbit (OPS 3) onboard software programs. The software functions are defined at two levels in this document: (1) principal function and (2) task. The principal function level is defined in the Level B CPDS document and is repeated in this document for clarity. The task level is defined so that Level C requirements can be conveniently grouped. The choice of task should not be interpreted as being applicable to the flight program structure or coding block definitions. The two functional levels are defined as follows:

1. Principal function. A grouping of requirements that will satisfy the objectives and constraints for a particular software function. For example, the requirements for the Deorbit Guidance principal function include computing a thrust vector attitude profile and time-to-go until engine cutoff. A complete list of requirements for each principal function is given in the Level B CPDS document.
2. Task. A set of calculations that must be performed once at a particular time or cyclically within a specific time interval before one or more requirements of the principal function can be satisfied. It is important to note that tasks are convenient for grouping logic according to time interval and frequency of calculation. These tasks are not intended in any way to imply a program structure.

Sequencing according to task is shown in each detailed requirements section of this document. Since sequencing is considered to be a necessary part of the document, but not requirements in themselves, this sequencing is not considered a task and is not constraining in terms of where it resides (i.e., MSC or in the principal function).

Each task description contains the detailed, interface, processing, and initialization requirements for that task. Task interface variables (input and output variables) are defined at the end of each task section. Variables that are part of the I-load (premission determined values that are loaded as constants into the on-board software) are included for each principal function. An external interface table defining interfaces between the principal function and other major software elements (principal functions, displays, etc.) is defined for each principal function. A functional flow is presented for each principal function as a visual aid to assist in understanding the sequencing and logic decisions of that principal function. In addition, flowcharts for each task are given in Appendix A. Finally, each principal function includes tables describing IDD, I-loads, K-loads, constants, and name cross-references for externally computed variables.

The on-board software requirements presented in this document are categorized per principal function as On-Orbit Guidance, Orbit Maneuver Display Processing, Deorbit Guidance, Deorbit Maneuver Display Processing, and Universal Pointing Processor. The specialist function on-board software requirements presented in this document are universal pointing, orbit targeting, and relative motion.

The guidance and maneuver display processing principal functions are active during the applicable on-orbit (MM 202) or deorbit (MM 302) maneuver execute major modes. In addition, the Deorbit Maneuver Display Processing principal function is active during the pre-deorbit coast major mode (MM 301) and the pre-entry monitor major mode (MM 303). The Universal Pointing Processing principal function is active in both the on-orbit coast (MM 201) and maneuver execute (MM 202) major modes.

The Universal Pointing principal function provides the crew with the capability to change the orbiter's attitude during coasting flight. These functions compute the parameters to evaluate and perform the desired coasting flight attitude maneuver. The Guidance and Maneuver Execute Display Processing principal functions (on-orbit and deorbit) provide the crew with the capability to set up, evaluate, monitor, and perform a powered flight maneuver. Software from the On-Orbit Orbit Maneuver Execute Display Processing principal function is used to compute the preburn attitude for on-orbit (OPS 2).

The Orbit Targeting Specialist function gives the orbiter crew the capability to generate targets for a sequence of maneuvers that, if executed, would lead to a rendezvous with a target vehicle or payload. The maneuver target outputs of this specialist function will be available for display to the crew and as inputs to the On-Orbit Orbit Maneuver Execute Display Processing principal function.

The Relative Motion Specialist function will compute data for the relative motion display that provide the crew with information concerning the relative motion between the orbiter and a target vehicle. Its primary use is during rendezvous and station keeping.

Overviews for each principal function are presented before the detailed requirements for the function. The Maneuver Display Processing principal functions (on-orbit or deorbit) provide software to set up powered flight maneuvers; therefore, the activities required to execute a maneuver are contained within it and this overview should be read prior to reading the guidance principal functions (on-orbit or deorbit).

Throughout this document, HAL programming language-type equations and symbols will be used for illustrative purposes. The specific tasks, symbols, and equations are not constraining; however, the requirements represented by these symbols and equations are constraining. Certain deviations from the HAL programming language syntax were used to facilitate readability for those not familiar with HAL syntax. Specifically, extra parentheses were added for clarity and the HAL vector cross-product symbol (\*) was changed to the more conventional symbol,  $\times$ . Whenever typographically suitable, the following symbols placed above the variable names were used to denote variable types:  $\vec{\phantom{x}}$  for vectors,  $\mathbf{\phantom{x}}$  for matrices,  $\bullet$  for Booleans, such as flags and discrettes, and  $\mathbf{Q}$  for quaternions that generally have variable names with the leading character "Q". Further information in these symbols can be obtained by referring to the HAL language specification document. Definitions of the HAL syntax used in this document are listed in Section 5.2.

#### **4.0.1 TRACEABILITY OF REQUIREMENTS**

The software baseline document shall provide for identifying like and related requirements so that traceability of these requirements can be established up and down through the different levels of the software documentation hierarchy. Table 4.0-1 shows the traceability of the software paragraphs in this FSSR with respect to the corresponding Principal Functions of the Level B CPDS' SS-P-002-510 documentation. In addition, table 4.0-2 shows the traceability of the PASS GN&C principal functions located in this FSSR with respect to the applicable BFS paragraphs in the Level C PRD specifications. These tables are provided for information only.



Table 4.0-1. Level B to Level C Traceability		
Level B PF No.	Level B PF Name (Acronym)	Level C FSSR Section No.
4.158	Orbit Maneuver Display Processing (ORB MNVR DIP)	4.1
4.7	On-Orbit Guidance (ORB GUID)	4.2
4.213	Universal Pointing Processor (UNIV POINT PROC)	4.3
4.211	Deorbit Maneuver Display Processing (DEORB MNVR DIP)	4.4
4.209	Deorbit Guidance (DEORB GUID)	4.5
5.10	Orbit Targeting (ORB TGT SPEC)	4.6
5.24	Relative Navigation (REL NAV SPEC)	4.7

Table 4.0-2. Onorbit/Deorbit Guidance FSSR/PRD Correlation					
Principal Function	FSSR Paragraph	FSSR Title	BFS PRD	PRD Paragraph	BFS Title
G4.7	4.2	On-Orbit Guidance	N/A	N/A	N/A
G4.158	4.1	Orbit Maneuver Display Processing	N/A	N/A	N/A
G4.209	4.5	Deorbit Guidance	MG038104	3.2.3.1.10.4	OMS Guidance
G4.211	4.4	Deorbit Maneuver Display Processing	MG038104	3.2.3.1.10.11	OMS MNVR DIP
G4.213	4.3	Universal Pointing Processor	N/A	N/A	N/A
G5.10	4.6	Orbit Targeting Specialist Function	N/A	N/A	N/A
G5.24	4.7	Relative Navigation Specialist Function	N/A	N/A	N/A

#### **4.0.2 DOCUMENTED REQUIREMENTS PRECEDENCE**

Requirements precedence in this document shall be as follows:

1. If there is a conflict between the data in the function subtables and the standard principal function tables, the principal function tables shall have precedence.
2. If there is a conflict between the data in the flow diagram and the written requirements, the written requirements shall have precedence.
3. If there is a conflict between the displays and controls data in this document and the displays and controls FSSR, STS 83-0020, the displays and controls FSSR shall have precedence.

#### 4.1 ORBIT MANEUVER DISPLAY PROCESSING PRINCIPAL FUNCTION (ORBIT MNVR DIP)

The Orbit Maneuver Display Processing principal function (referenced in the Level B CPDS, paragraph 4.158) provides software required to support the ORBIT MNVR EXEC display. The ORBIT MNVR EXEC display provides the crew capability to set up maneuvers, adjust target values, monitor maneuvers, and trim burn residuals when required.

Since the ORBIT MNVR DIP provides supporting software for the ORBIT MNVR EXEC display, an understanding of the display is essential to comprehending the details of this section. It is recommended that the Level C FSSR, Displays and Controls, Display Formats, document be reviewed prior to reading this section. The display format is shown for information only in Figure 4.1-1.

##### 4.1.1 Overview

The ORBIT MNVR DIP is active during MM 202 and supports general orbit shaping. Upon entry into MM 202, the maneuver target and setup data obtained from uplink (Items 1 through 5) are used to initialize the display. Data elements included in this category are:

- |    |   |   |
|----|---|---|
| 1. | TIG   | Time of ignition  |
| 2. | $\Delta V_X$ , $\Delta V_Y$ , $\Delta V_Z$      | External delta velocity-to-be-gained components in local vertical, local horizontal coordinates |
| 3. | Both OMS<br>Left OMS<br>Right OMS<br>PLUS_X_RCS | } Propulsion system selected  |
| 4. | TVR_ROLL  | Thrust vector roll angle.   |
| 5. | WT  | Vehicle weight  |

The propulsion-system-selected OMS trim angles, and vehicle weight must be protected and the values kept intact during the transition from OPS 1 to OPS 2.

The desired OMS trim angles are uplinked concurrently with Items 1 through 5. However, these parameters are processed by the ON-ORBIT DAP (OPS 2) or TRANS DAP (OPS 3).

If a deorbit maneuver target and setup data set is uplinked during MM 202, the new data set is placed in a storage that is protected during subsequent OPS transition. Data elements included in this category are of two types. The first type is similar to Items 1 through 5 for an external delta-V guidance target. The second type for a linear terminal velocity constraint guidance mode is as follows:

- |    |       |   |
|----|-------|---|
| 6. | TIG   | Time of ignition  |
| 7. | THETA | Earth central angle from ignition to targeted entry interface |
| 8. | HEI   | Target altitude   |
| 9. | C1    | Intercept of velocity target line                             |

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10. C2		Slope of velocity target line
11. WT		Orbiter weight
12. PROP_DEP		Propellant weight to be expended by maneuver. Direction of out-of-plane waste is specified by $\pm$ sign.
13. BOTH_OMS, LEFT_OMS, RIGHT_OMS, PLUS_X_RCS	}	Propulsion system selection discrettes
14. TVR_ROLL		Thrust vector roll angle
15. VEH_PITCH VEH_YAW VEH_ROLL	}	Post maneuver vehicle attitude

Entry into MM 202 also initiates cyclic computation of current apogee altitude, current perigee altitude, and time-to-next-apsis. Monitoring of the OMS actuator status and setting of the proper flag value to indicate any failure condition are also performed in MM 202.

Upon crew acceptance of this displayed data, a "LOAD" item entry is performed that transfers the currently displayed target and setup data as a group to On-Orbit Guidance and other software principal functions. In addition, the following premaneuver parameters are calculated for the display.

1. Desired ignition attitude (pitch, yaw, and roll angles in ADI inertial coordinate frame); an M50 to commanded body quaternion is also computed as a reference for generation of attitude errors for display on the ADI dedicated display.
2. Velocity-to-go in current body axis coordinates
3. Total delta velocity required
4. Targeted apogee and perigee altitudes
5. Time base time (initiates MSC calculations only; additional crew action is required for this parameter to be displayed).
6. Lambert velocity-to-go in an LVLH coordinate system at TIG

The vehicle may be automatically maneuvered to the desired ignition attitude, which was calculated and displayed when the "LOAD" item entry was made, by input of the "MNVR" item entry. The software requirements to support the actual maneuvering to the desired ignition attitude are not documented in the ORBIT MNVR DIP principal function.

The time to go until the attitude maneuver is complete is then calculated within the ORBIT DAP, sent to the ORB MNVR DIP for further processing, and then to the XXXXX MNVR YYYYYY principal function for display. ORB MNVR DIP sends the preburn maneuver completion time to go (TTG) to the XXXXX MNVR YYYYYY principal function as well as performs checks on MNVR\_CMPL\_TIME\_TGO to alert the crew if the desired attitude will not be achieved in time. If the preburn maneuver will not be completed prior to 30 seconds before the desired ignition time a flag is set to display the TTG field in double overbright. Or, if the preburn maneuver time to go is greater than 59:59 (MM:SS) then the TTG field is set to 59:59 and a flag is set to display it double overbright. Otherwise, it is displayed in normal intensity (unless the DAP is not in AUTO mode, then it is blanked by the XXXXX MNVR YYYYYY principal function).

The crew must perform two actions to enable OMS ignition. The first action is to arm the OMS engines via cockpit hardware switches. This action is independent of the ORBIT MNVR DIP requirements. The second action is crew entering of a software engine ignition proceed to the ORBIT MNVR DIP, which is achieved by depressing the "EXEC" button on the keyboard BURN\_ENABLE\_WINDOW seconds prior to ignition. The ORBIT MNVR DIP recognizes this action as one of two required conditions to allow OMS ignition. The other required condition is that the currently displayed data be consistent with the software recognized data. If these two conditions are satisfied, then an indicator is set to authorize the MSC to allow OMS ignition; i.e., initiate the OMS FIRE SEQ principal function. Maneuvers with the RCS propulsive system assume manual engine ignition and cutoff via the THC, and the above actions and conditions do not apply.

Maneuver parameters monitored on the display that are calculated by the ORBIT MNVR DIP are the velocity-to-go components in current orbiter body axis coordinates, the velocity-to-go magnitude, Lambert velocity-to-go components in LVLH coordinates, current burn attitude in ADI inertial coordinates, the orbiter weight, the current apogee and perigee altitudes, and the time-to-next-apsis. Time-to-go values are calculated by the ONORB GUID principal function, and current values for the OMS gimbal angles are supplied by the OMS TVC FB SOP principal function. These two parameter sets are supplied directly to the ORBIT MNVR display.

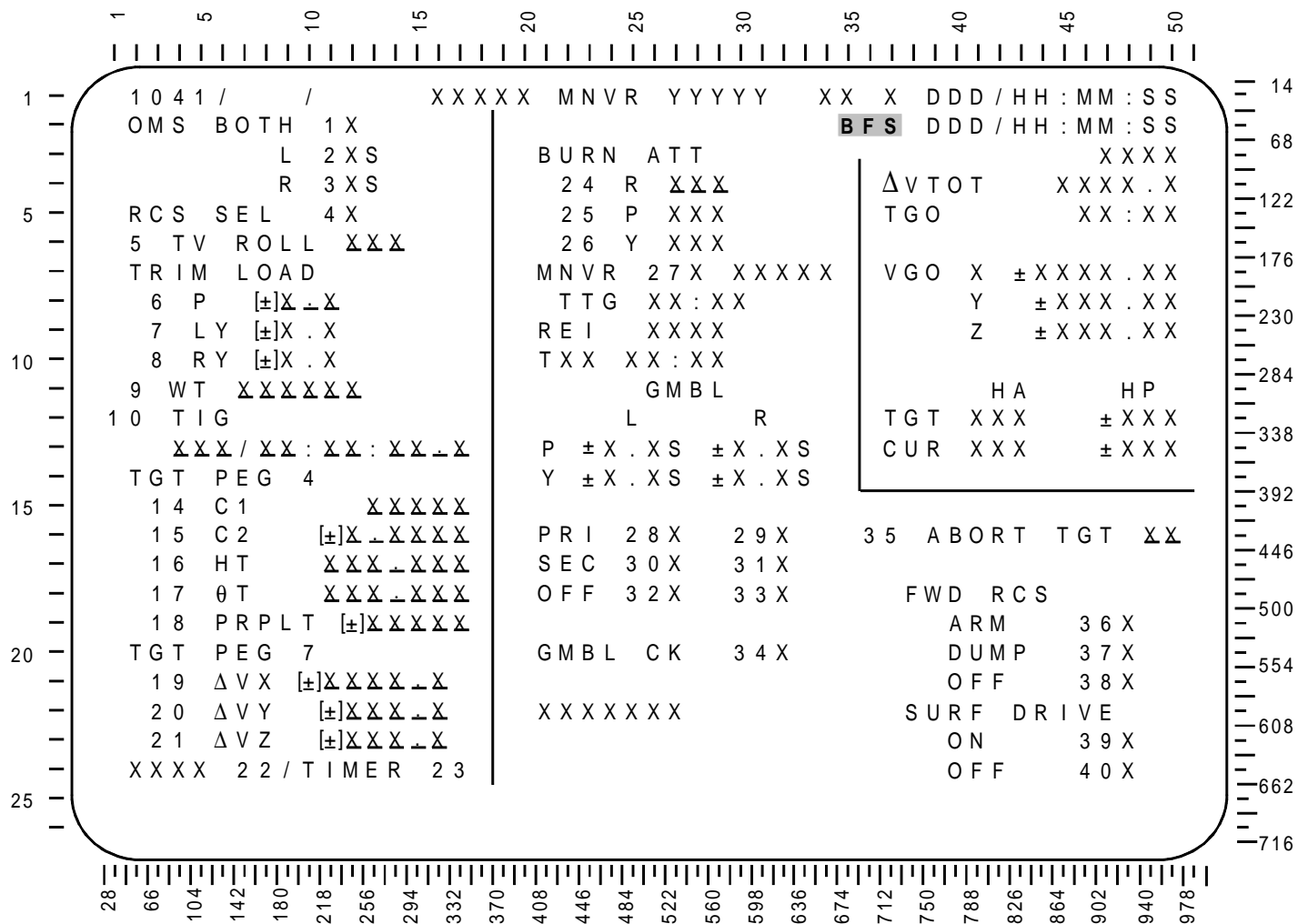
ORBIT MNVR display capabilities that are not supported by the ORBIT MNVR DIP principal function are:

- |   |   |
|---|---|
| 1. Status parameters<br>(Items 2 and 3)       | Driving of status parameter indicators<br>(M, ↓) for OMS engine selection |
| 2. MNVR (Item 27)                             | Automatic maneuver to ignition attitude initiator                         |
| 3. GMBL SEL (Items 28,<br>29, 30, 31, 32, 33) | OMS gimbal drive system selection   |
| 4. GMBL CK (Item 34)                          | OMS gimbal drive check initiator  |
| 5. ABORT TGT (Item 35)                        | AOA/ATO Abort selection/initiator   |
| 6. FWD RCS Dump<br>(Items 36, 37, 38)         | Forward RCS dump  |
| 7. SURF DRIVE<br>(Items 39, 40)               | AEROSURFACE drive function  |

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The functional task organization, logic flow, and data flow for the ORBIT MNVR DIP principal function are shown in Figures 4.1.1-1, 4.1.1-2, and 4.1.1-3.

FOR INFORMATION ONLY\*



\*FOR REQUIREMENT PURPOSES SEE JSC 20379

FIGURE 4.1-1. XXXXX MNVR YYYYYY Generic Display

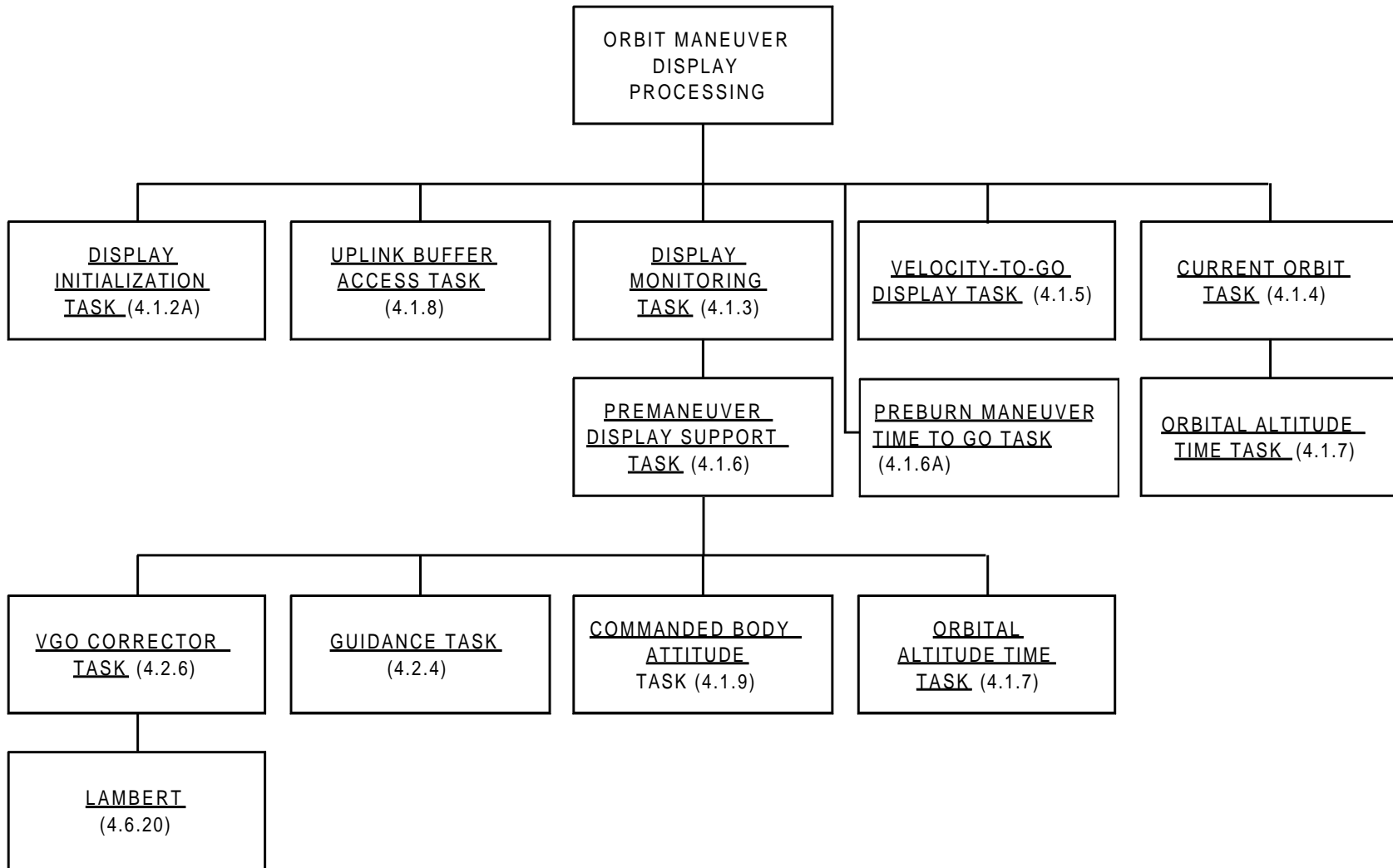


FIGURE 4.1.1-1. Orbit Maneuver Display Processing Principal Function Task Organization



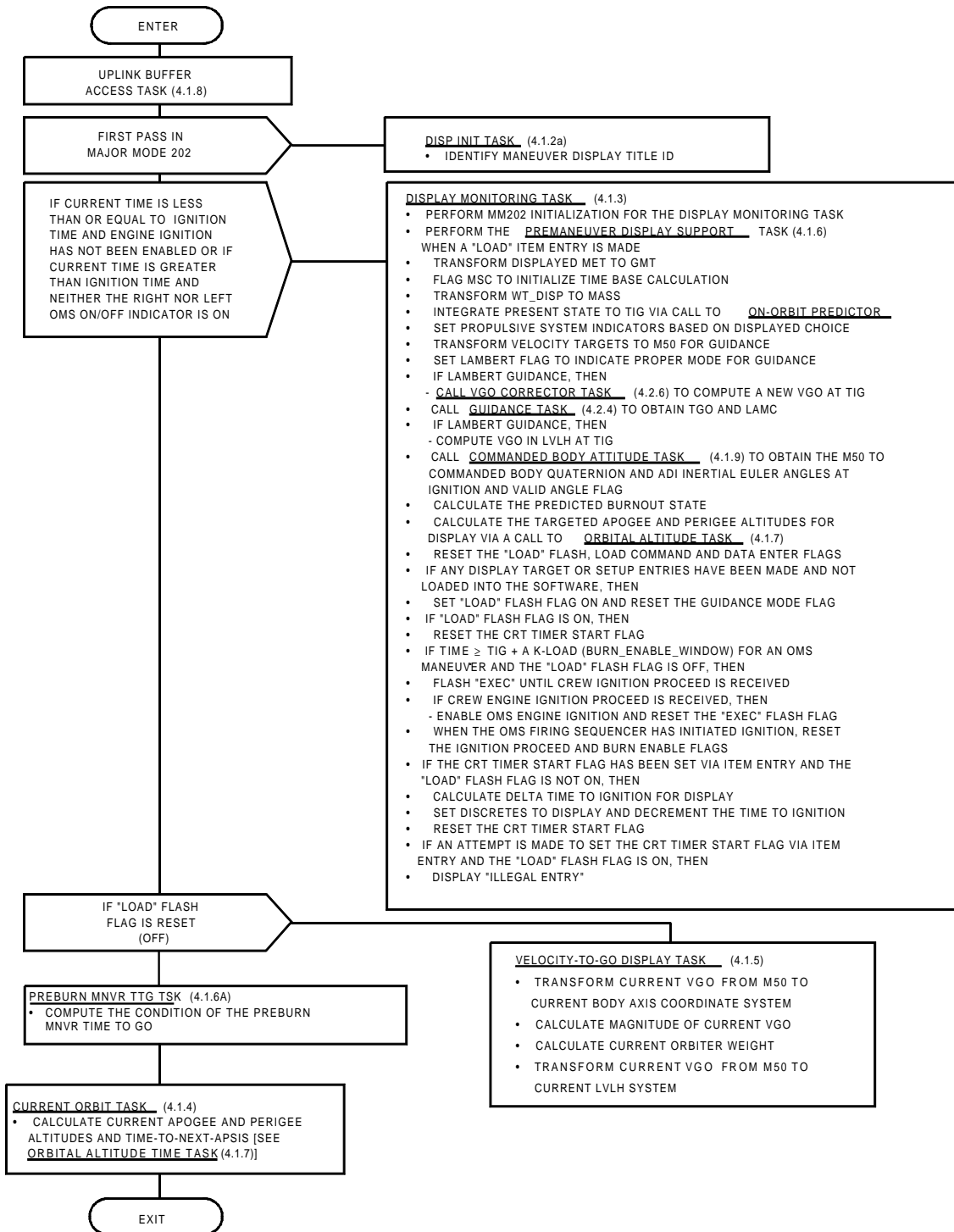
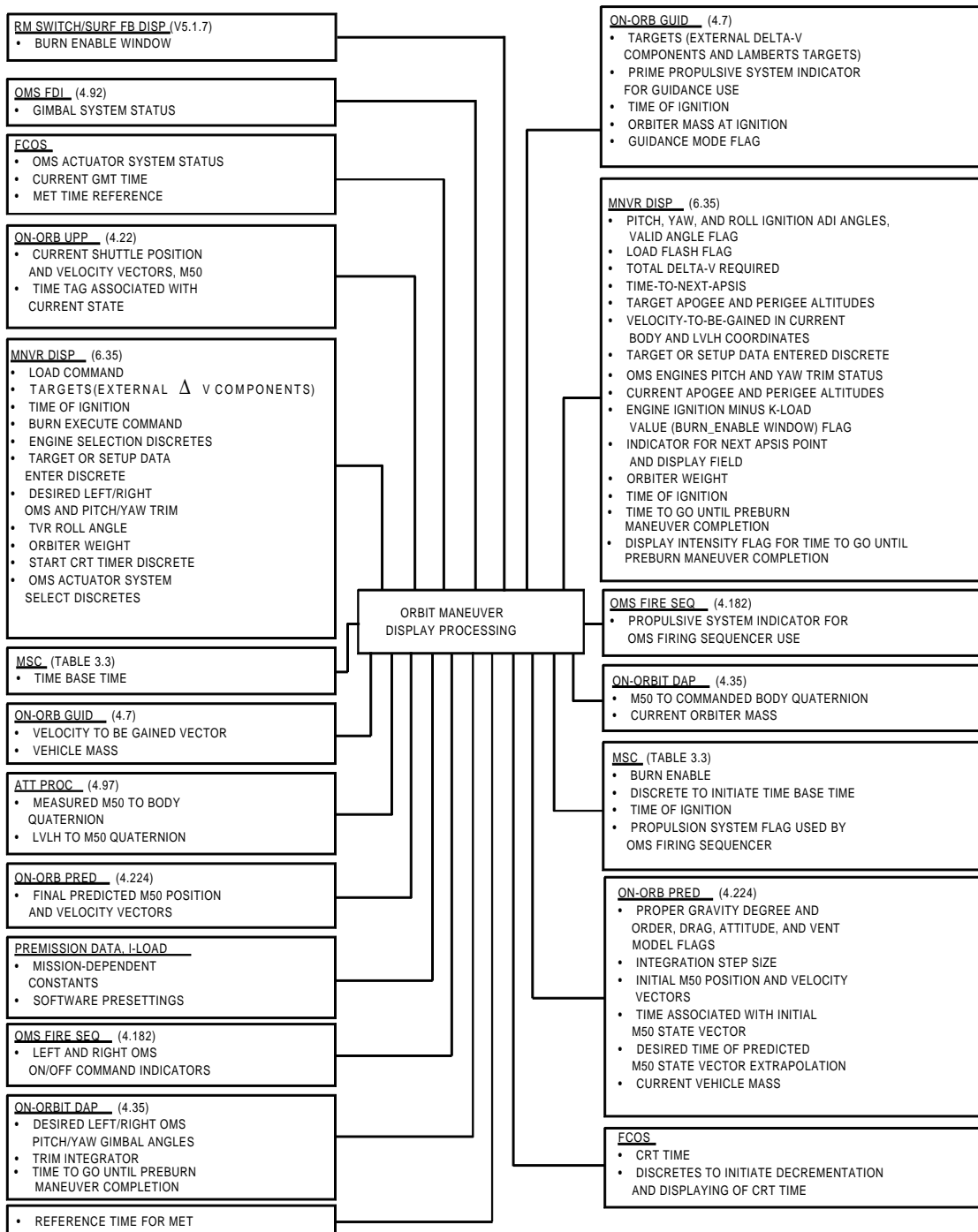


FIGURE 4.1.1-2. Orbit Maneuver Display Processing Principal Function Flow



NOTE: LEVEL B CPDS SS-P-0002-510 AND LEVEL B CPDS SS-P-0002-550 PRINCIPAL FUNCTION NUMBERS ARE SHOWN IN PARENTHESIS.

FIGURE 4.1.1-3. Orbit Maneuver Display Processing Data Flow

#### 4.1.2 Orbit Maneuver Display Processing Sequencing (ORBIT MNVR DIP SEQ)

The correct sequencing of some of the tasks defined in the Orbit Maneuver Display Processing principal function are dependent on the concurrence of specific events. These events are identified in the Level B CPDS SS-P-0002-510.

The tasks to be sequenced are:

1. Display initialization task (DISP INIT TSK)
2. Uplink buffer access task (UL ACCSS TSK)
3. Display monitoring task (DISP MONIT TSK)
4. Velocity-to-go display task (VGO DISP TSK)
5. Preburn maneuver time to go task (PREBRN MNVR TTG TSK)
6. Current orbit task (CUR ORBIT TSK)

Three additional tasks are defined to reflect a large related group of requirements or a group of requirements that is performed more than once within the other tasks. These three additional tasks are:

1. Premaneuver display support task (PRE-MAN DISP SUPT TSK)
2. Commanded body attitude task (CMD BDY ATT TSK)
3. Orbital altitude time task (ORB ALT TIME TSK)

The first group of tasks must be sequenced as follows and are presented in the correct order of solution.

1. The DISP INIT TSK is performed once each time MM 202 (Event 67) is entered.
2. The UL ACCSS TSK is performed repetitively beginning with transition into MM 202 (Event 67) and ending with transition out of MM 202 (Event 73).
3. The DISP MONIT TSK is performed repetitively during MM 202 when current time is less than or equal to engine ignition time (TIG) and OMS engine ignition has not been enabled (BURN\_ENABLE  $\neq$  ON) or when current time is greater than time of ignition and neither the left nor right OMS ON/OFF command indicators (OMS\_L\_CMD\_IND, OMS\_R\_CMD\_IND) is set to ON.
4. The VGO DISP TSK is performed cyclically during MM 202 when LOAD FLASH flag is reset (OFF).
5. The PREBRN MNVR TTG TSK is performed.
6. The CUR ORBIT TSK is performed repetitively at 1.92-second intervals beginning with transition into MM 202 (Event 67) and ending with transition out of MM 202 (Event 73).

The recommended execution rate for Items 2 through 5 is 0.96 seconds.

**4.1.2A Display Initialization Task (DISP INIT TSK)**

This task generates a display title indicator for the variable portion of the display title (“XXXXX” and “YYYYY” of the XXXXX MNVR YYYYY) as follows:

If the Major Mode is 202 (MM 202 = ON; ORBIT execution phase), a display title indicator is generated for the variable portion of the display title. The MNVR\_TITLE\_IND is set equal to 11 to indicate that “ORBIT MNVR EXEC” is to be the display title.

Table 4.1.2A-1. Display Initialization Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90X8646X	MM202	Major Mode 202 indicator	MSC	N/A	D

Table 4.1.2A-2. Display Initialization Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94U4096CA	MNVR_TITLE_IND	Display title indicator	MNVR DISP	N/A	I

**4.1.3 Display Monitoring Task (DISP MONIT TSK)**

This task performs a series of monitoring activities for the MNVR DISP, described as follows:

1. Monitors for a “LOAD” item entry (Item 22 on display) and initiates the required processing upon receipt of this entry.
2. Provides visual cues (display character flash indicators) to the crew if the displayed and software loaded data are inconsistent or if an “EXEC” keyboard entry is required to enable ignition.
3. Sets an OMS engine ignition proceed discrete (BURN\_ENABLE) to ON if the following two conditions are satisfied:
  - a. An “EXEC” keyboard entry has been made subsequent to BURN\_ENABLE\_WINDOW seconds before the time of engine ignition.
  - b. The displayed target and setup data are consistent with the software loaded target and setup data, signified by LOAD\_FLASH = OFF.
4. Monitors for a START CRT TIMER item entry (Item 23 on display) (indicated by ST\_CRT\_TIMER = ON) and initiates the required processing upon receipt of this entry.

A. Detailed Requirements. The display monitoring task performs the following activities each time it is called.

1. To ensure a consistent set of target and setup data and consistency between displayed and software-recognized target and setup data, the "LOAD" becomes a flashing character set (LOAD\_FLASH = ON) according to the following logic. OMS engine ignition is precluded when LOAD\_FLASH is ON.
  - a. The LOAD becomes a dynamic flashing character set (LOAD\_FLASH = ON) if any of the following display item entries are changed either by crew entry or by external delta-V target command load uplink (DATA\_ENTER = ON) and a subsequent "LOAD" item entry is not made:
    - Propulsion system selection (Items 1, 2, 3, and 4)
    - TV roll (Item 5)
    - OMS gimbal trim angles (Items 6, 7, and 8)
    - Weight (Item 9)
    - Time of ignition (Items 10, 11, 12, and 13)
    - PEG 7 Delta velocities (Items 19, 20, and 21)

Additionally, when DATA\_ENTER is set to ON, the guidance mode flag which indicates Lambert or External Delta-V guidance must be set to OFF (GUID\_FLAG = OFF).

  - b. The LOAD also becomes a dynamic flashing character set (LOAD\_FLASH = ON) if an orbit target transfer has occurred (START\_BACKGROUND = ON).
2. If LOAD\_FLASH = ON (indicating LOAD is a dynamic flashing character set) or LOAD\_CMD = ON, then the following activities are performed:
  - a. Reset the discrete for FCOS to display the time to ignition on the CRT:  
CRT\_TIMER\_START = OFF
  - b. Reset the discrete to enable MSC to maintain time base calculations:  
TB\_ENABLE = OFF
  - c. Reset the discrete to cause EXEC to flash on the maneuver display:  
TIG\_MINUS5\_FLAG = OFF
3. If the LOAD\_CMD = ON, then the following activities are performed once:
  - a. The premaneuver display support task (PRE-MAN DISP SUPT TSK, Section 4.1.6) is performed:  
CALL PRE-MAN DISP SUPT TSK
  - b. The LOAD\_FLASH discrete is set to OFF.
  - c. The LOAD\_CMD discrete is set to OFF to preclude the above activities from being performed, except as required upon keyboard entry.
  - d. The DATA\_ENTER discrete is set to OFF.

4. For an OMS maneuver ( $PLUS\_X\_RCS = OFF$ ), positive crew action (pushing the “EXEC” [ $EXEC\_CMD = ON$ ] keyboard button subsequent to planned OMS ignition time minus  $BURN\_ENABLE\_WINDOW$  seconds) is required to enable OMS engine ignition ( $BURN\_ENABLE = ON$ ). Until the EXEC button is pushed, the “EXEC” character set is flashing ( $TIG\_MINUS5\_FLAG = ON$ ). An additional requirement for enabling engine ignition is  $LOAD\_FLASH = OFF$ . These requirements are depicted in the following logic:
  - a. If  $T\_GMT - TIG \geq BURN\_ENABLE\_WINDOW$  and the  $LOAD\_FLASH$  flag is OFF (indicating a consistent target and setup data group), then proceed to Step b. Otherwise, the  $EXEC\_CMD$  and  $TIG\_MINUS5\_FLAG$  must be set to OFF values to null any previous crew action for enabling OMS ignition and stop the “EXEC” dynamic characters from flashing, respectively, and proceed to Item 5.
  - b. If the  $EXEC\_CMD$  flag is ON (indicating crew authorization of OMS ignition), then set the  $BURN\_ENABLE$  flag to ON (necessary condition for the MSC to allow OMS ignition) and set the  $TIG\_MINUS5\_FLAG$  to OFF (stop the “EXEC” dynamic characters from flashing). Otherwise, the  $TIG\_MINUS5\_FLAG$  must be set to ON (initiate the “EXEC” dynamic characters flash).
  - c. The flags  $EXEC\_CMD$  and  $BURN\_ENABLE$  should be reset to off any time the OMS FIRING SEQUENCE is called to initiate OMS ignition. This will allow the DISP MONIT TSK to be properly sequenced if OMS ignition does not occur as planned.
5. If the  $ST\_CRT\_TIMER = ON$  and  $LOAD\_FLASH = OFF$ , then the following activities are performed once:
  - a. The delta time to ignition is calculated in seconds to establish a display time base:
$$CRT\_SEC = TIG - T\_GMT$$
  - b. Set the discretes for system software (FCOS) to display and decrement the time to ignition:
$$CRT\_TIMER\_START = ON$$
$$COUNTDOWN = ON$$
  - c. Reset the start CRT timer discrete to allow reinitiation of this activity:
$$ST\_CRT\_TIMER = OFF$$
6. If  $LOAD\_FLASH$  is ON and a  $ST\_CRT\_TIMER$  entry is made, then illegal entry must be displayed.

B. Interface Requirements. The input and output parameters for the display monitoring task are given in Tables 4.1.3-1 and 4.1.3-2. A flow diagram of DISP MONIT TSK functional requirements is given in Appendix A.

C. Processing Requirements. The display monitoring task is performed repetitively during MM 202 when current time is less than or equal to engine ignition time (TIG) and OMS engine ignition has not been enabled ( $BURN\_ENABLE \neq ON$ ) or when current time is greater than time of ignition and neither the left nor the right OMS ON/OFF command indicators are set to ON.

D. Initialization Requirements. The following parameters must be set or initialized as follows:

1. LOAD\_FLASH = ON  
Discrete to indicate that the “LOAD” character set is to be flashed to indicate an inconsistency between displayed setup data and software recognized target; data LOAD\_FLASH is initially set to a flash condition.
2. DATA\_ENTER = OFF  
Discrete to indicate crew entry of target or setup data. It is initially set to indicate no crew entry.
3. EXEC\_CMD = OFF  
Discrete to indicate that the “EXEC” button has been set to indicate a “not pushed” state.
4. BURN\_ENABLE = OFF  
Discrete to allow OMS engine ignition is initially set to disallow OMS engine ignition.
5. TIG\_MINUS5\_FLAG = OFF  
Discrete to indicate that “EXEC” character set is to be flashed to prompt crew for an engine ignition proceed. It is initially set to a nonflash condition.
6. TB\_ENABLE = OFF  
Discrete to initiate establishment and maintenance of ignition time base. It is initially set to not initiate this action.
7. ST\_CRT\_TIMER = OFF  
Discrete to indicate that time to ignition is to be displayed. It is initially set to a nondisplay condition.
8. CRT\_TIMER\_START = OFF  
COUNTDOWN = OFF  
Discretizes to initiate decrementation of time-to-ignition are initially set to not perform decrementation.
9. WT\_DISP = M G\_TO\_FPS2  
Calculate the initial value of orbiter weight for display.

Table 4.1.3-1. Display Monitoring Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V93X6973X	DATA_ENTER	Discrete indicating target or setup data entries have been made	MNVR DISP, UL ACCSS TSK	N/A	D
V93X6956X	LOAD_CMD	Load command	MNVR DISP	N/A	D
V91W5000C	T_GMT	Current GMT computer time	FCOS	DP	s
V93X6553X	ST_CRT_TIMER	Start CRT timer flag	MNVR DISP, UL ACCSS TSK	N/A	D
V94W3790CD	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V93X1050XA	EXEC_CMD	Burn execute command	MNVR DISP	N/A	D
V90U1961CD	M	Current orbiter mass	GUID INP TSK	SP	slugs
V97U4393C	G_TO_FPS2	Earth's gravitational acceleration	CONSTANT	SP	ft/s <sup>2</sup>
V94X3814XB	LOAD_FLASH	Load flash flag	UL ACCSS TSK	N/A	D
V97U5181C	BURN_ENABLE_WINDOW	Burn enable window	K-LOAD, RM SWITCH/ SURF FB DISP	DP	s
V95X7328X	START_BACKGROUND	Begin targeting calculations flag	ORB TGT	N/A	D

Table 4.1.3-2. Display Monitoring Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94X3814XB	LOAD_FLASH	Load flash flag	MNVR DISP	N/A	D
V94W4053CD	CRT_SEC	Seconds to ignition	FCOS	DP	s
V94X4063XD	CRT_TIMER_START	CRT timer start flag	FCOS	N/A	D
V94X4064XD	COUNTDOWN	CRT timer flag to indicate countdown mode is desired	FCOS	N/A	D
V94X3813XB	TIG_MINUS5_FLAG	Engine ignition minus K-Load value (BURN_ENABLE WINDOW) flag	MNVR DISP	N/A	D
V94X3815XB	BURN_ENABLE	Burn enable	MSC	N/A	D
V93G6940CC	WT_DISP	Vehicle weight	MNVR DISP	SP	lb
V94X4029X	GUID_FLAG	Guidance option flag	PRE MNVR DISP SUPT TASK, VGO DISP TSK	N/A	D
V94X3826XB	TB_ENABLE	Discrete to initiate time base calculations	MSC	N/A	D



#### 4.1.4 Current Orbit Task (CUR ORBIT TSK)

This task cyclically computes the current orbit apogee and perigee altitudes and the time-to-next-apsis (apogee or perigee).

A. Detailed Requirements. The values of current apogee and perigee altitude and time-to-next-apsis (measured from current time) are calculated by calling the orbital altitude time task (ORB ALT TIME TSK, Subsection 4.1.7). Inputs to this task are the current navigation state ( $\overline{RNAV}$  and  $\overline{VNAV}$ ), which must be assigned to  $\overline{R}$  and  $\overline{V}$ , respectively:

CALL ORB ALT TIME TSK

Inputs:  $\overline{R}$ ,  $\overline{V}$

Outputs: HA, HP, TT\_X, TXX\_FLAG

The outputs are the apogee altitude (HA), perigee altitude (HP), the time to-next-apsis (TT\_X), and an indicator for next apsis point and label field (TXX\_FLAG). The outputs of HA, HP, and TXX\_FLAG must be assigned to CUR\_HA, CUR\_HP, and TXX\_FLAG\_DISP, respectively. A flow diagram of CUR ORBIT TSK functional requirements is given in Appendix A.

The MNVR DISP background field corresponding to the TXX\_FLAG\_DISP value is defined below.

<u>TXX Flag Disp</u>	<u>Label Field Displayed</u>	<u>Next Apsis</u>
1	TTA	Apogee
2	TTP	Perigee
3	TTC	Near circular

B. Interface Requirements. The input and output parameters for the current orbit task are given in Tables 4.1.4-1 and 4.1.4-2.

C. Processing Requirements. The current orbit task is performed repetitively at 1.92-second intervals during MM 202.

D. Initialization Requirements. None.

Table 4.1.4-1. Current Orbit Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V95H0185CF thru V95U0187CF V95L0190CF thru V95L0192CF	HA	Apogee altitude	ORB ALT TIME TSK	SP	nmi
	HP	Perigee altitude	ORB ALT TIME TSK	SP	nmi
	TXX_FLAG	Indicator for next apsis point and label field [= 1, TTA (apogee); = 2, TTP (perigee); = 3, TTC (circular)]	ORB ALT TIME TSK	N/A	I
	TT_X	Time to next apsis (apogee or perigee)	ORB ALT TIME TSK	SP	s
	$\bar{R}_{NAV}$	Current Shuttle position vector	ON-ORB UPP	DP	ft
	$\bar{V}_{NAV}$	Current Shuttle velocity vector	ON-ORB UPP	SP	ft/s

Table 4.1.4-2. Current Orbit Task Output Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V94H3810CB V94H3811CB V94X3961X V94W3796CB	$\bar{R}$	Position vector	ORB ALT TIME TSK	DP	ft
	$\bar{V}$	Velocity vector	ORB ALT TIME TSK	SP	ft/s
	CUR_HA	Current apogee altitude	MNVR DISP	SP	nmi
	CUR_HP	Current perigee altitude	MNVR DISP	SP	nmi
	TXX_FLAG_DISP	Indicator for next apsis point and label field [= 1, TTA (apogee); = 2, TTP (perigee); = 3, TTC (circular)]	MNVR DISP	N/A	I
	TT_X	Time to next apsis (apogee or perigee)	MNVR DISP	SP	s

#### 4.1.5 Velocity-To-Go Display Task (VGO DISP TSK)

This task transforms the velocity-to-go vector from M50 coordinates into current orbiter body axis coordinates (refer to Section 5, Figures 5.1-1 and 5.1-2) and computes the magnitude of the current velocity-to-go (DV\_TOT) and orbiter weight (WT\_DISP). For Lambert guidance only, velocity-to-go in M50 coordinates is converted to current LVLH coordinates.

##### A. Detailed Requirements.

1. The guidance computed velocity-to-go in M50 coordinates ( $\overline{VGO}$ ) is transformed to velocity-to-go in current body axis coordinates ( $\overline{VGO\_DISP}$ ) for display. This transformation is made by the use of a quaternion transformation module (QUAT\_XFORM), which is defined in the Flight Control Level C FSSR document and repeated (for information only) in Part E of Section 4.1.6.

CALL QUAT\_XFORM

Inputs:             $Q\_B\_I\_S$ ,  $Q\_B\_I\_V$ ,  $\overline{VGO}$

Outputs:            $\overline{VGO\_DISP}$

The variables  $Q\_B\_I\_S$  and  $Q\_B\_I\_V$  are the scalar and vector quaternion elements defining the transformation from M50 coordinates to current body axis coordinates, as computed by the ATT PROC principal function.

2. Lambert guidance computed velocity-to-go in mean-of-1950 coordinates ( $\overline{VGO}$ ) is transformed to current LVLH coordinates ( $\overline{VGO\_LVLH}$ ) for cyclic display. This transformation is accomplished by the use of a quaternion transformation module (QUAT\_XFORM). The LVLH to mean of 1950 quaternion from the ATT PROC principal function is conjugated prior to calling QUAT\_XFORM. The velocity-to-go in LVLH ( $\overline{VGO\_LVLH}$ ) is displayed in the PEG 7 target section of the Maneuver Execute Display. For a Lambert load,  $\overline{VGO\_LVLH}$  is computed by the Premaneuver Display Support Task with respect to an LVLH coordinate system at the planned time-of-ignition. After the planned time-of-ignition (TIG),  $\overline{VGO\_LVLH}$  is computed for display with respect to the current LVLH coordinate system.

If the guidance mode is not Lambert ( $\dot{G}UID\_FLAG = OFF$ ) or current time ( $T\_GMT$ ) is less than TIG, skip the following step:

CALL QUAT\_XFORM

Inputs:             $-Q\_M50\_LVLH\_S$ ,  $Q\_M50\_LVLH\_V$ ,  $\overline{VGO}$

Output:             $\overline{VGO\_LVLH}$

3. The current magnitude of velocity-to-go is calculated:

$$DV\_TOT = ABVAL(\overline{VGO})$$

4. The current orbiter estimated mass is converted to weight for display:

$$WT\_DISP = M G\_TO\_FPS2$$

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B. Interface Requirements. The input and output parameters for the velocity-to-go display task are given in Tables 4.1.5-1 and 4.1.5-2. A flow diagram of VGO DISP TSK functional requirements is given in Appendix A.

C. Processing Requirements. During MM 202 when LOAD\_FLASH\_FLAG is reset (OFF),  $\overline{VGO\_DISP}$  is calculated at 1.04 Hz, and DV\_TOT and WT\_DISP are calculated at 1.92 seconds or 0.52 Hz.

D. Initialization Requirements. None.

Table 4.1.5-1. Velocity-To-Go Display Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90U2240CB thru V90U2243CB	Q_B_I_S, Q_B_I_V	Quaternion to transfer from M50 coordinates to current vehicle body axis coordinates	ATT PROC	SP	none
V90L2118C thru V90L2120C	$\overline{VGO}$	Velocity-to-be gained vector in M50 coordinates	GUID INP TSK	SP	ft/s
V90U1961CJ	M	Current vehicle mass	GUID INP TSK	SP	slugs
V90U2641CA thru V90U2644CA	Q_M50_LVLH_S, Q_M50_LVLH_V	Quaternion to transform from LVLH to M50 coordinates	ATT PROC	SP	ND
V94X4029X	GUID_FLAG	Guidance mode flag	DISP MONIT TSK	N/A	D
V94W3790CC	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V91W5000C	T_GMT	Current GMT computer time	FCOS	DP	s
V97U4393C	G_TO_FPS2	Earth's gravitational acceleration	CONSTANT	SP	ft/s <sup>2</sup>

Table 4.1.5-2. Velocity-To-Go Display Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94U3800CC	VGO_DISP	Maneuver velocity-to-be gained in current body axis coordinates	MNVR DISP	SP	ft/s
V94L3348C	DV_TOT	Total delta-V required for maneuver	MNVR DISP	SP	ft/s
V93G6940CA	WT_DISP	Orbiter weight	MNVR DISP	SP	lb
V94L3945CC thru V94L3947CC	VGO_LVLH	Lambert velocity-to-go in LVLH coordinates	MNVR DISP	SP	ft/s

#### 4.1.6 Premaneuver Display Support Task (PRE-MAN DISP SUPT TSK)

This task provides software that computes parameters required for premaneuver evaluation of the maneuver setup and target information. In addition, the current display values for the target and setup data are transferred to on-orbit guidance and other software functions by this task.

A. Detailed Requirements. The premaneuver display support task performs the following activities each time it is called:

1. The current displayed MET value of time of ignition in days, hours, minutes, and seconds must be transformed to a GMT time. A GMT value of time of ignition (TIG) in seconds is calculated

$$TIG = TIG\_SEC + TIG\_MIN \ 60 + TIG\_HR \ 3600 + TIG\_DAY \ 86400 + T\_MET\_REF$$

The evaluation of OMS burns should be limited to 12 hours in the future and five minutes in the past.

If  $-300 > (TIG - T\_GMT)$ , or  $(TIG - T\_GMT) > 43200$ , then display "illegal entry" and return control to the display monitoring task.

Also, the evaluation of Lambert guided burns should be limited to before TIG. This is due to the difficulty of accurately initializing a conic orbiter vector for Lambert guidance after TIG.

If  $\dot{G}UID\_FLAG = ON$  and  $T\_GMT \geq TIG$ , then display "illegal entry" and return control to the display monitoring task.

2. A switch (TB\_ENABLE) is set indicating to the MSC that a new time base should be established consistent with the current value of TIG and maintained:

$$TB\_ENABLE = ON$$

3. The current orbiter weight (WT\_DISP) is transformed to mass:

$$M = WT\_DISP / G\_TO\_FPS2$$

4. Before the display parameters required to evaluate a maneuver can be computed, a state vector at ignition must be obtained. This is done by utilizing a Navigation Precision State Predictor principal function (ON-ORB PRED) that propagates the current state ( $R_{NAV}$ ,  $V_{NAV}$ ,  $T_{NAV}$ ) to the time of ignition and outputs the propagated ignition state ( $R_{GD}$ ,  $V_{GD}$ ).

$$R\_PRED\_INIT = R_{NAV}$$

$$V\_PRED\_INIT = V_{NAV}$$

$$T\_PRED\_INIT = T_{NAV}$$

$$T\_PRED\_FINAL = TIG$$

Also, copy the current accumulated IMU sensed delta velocity for use by Lambert Guidance.

$$V_{SP} = V_{S}$$

Other inputs required by the ON-ORB PRED principal function are the maximum time interval step size (DTMIN), and integers (GMD\_PRED, GMO\_PRED) that determine the gravity degree and order models to be assumed. These integers must both be set to 4 to indicate precise gravity modeling. Additionally, the drag and vent (DMP, VMP) models and attitude mode (ATM) must be set to 1 to activate the models.

```
GMD_PRED = 4
GMO_PRED = 4
PRED_STEP = DTMIN
DMP = 1
VMP = 1
ATM = 1
```

Additionally, the orbiter area, mass, and drag coefficient must be specified for use by the predictor, i.e.,

```
PRED_ORB_CD = REF_ORB_CD
PRED_ORB_AREA = REF_ORB_AREA
PRED_ORB_MASS = M
```

```
CALL ON-ORB PRED
```

```
Inputs:      R_PRED_INIT, V_PRED_INIT, T_PRED_INIT,
              T_PRED_FINAL, PRED_ORB_MASS, PRED_ORB_AREA,
              PRED_ORB_CD, PRED_STEP, GMD_PRED, GMO_PRED,
              DMP, VMP, ATM
```

```
Outputs:     R_PRED_FINAL, V_PRED_FINAL
```

5. On completion of the predictor, the results must be set equal to local variables. Set  $\overline{RGD}$ ,  $\overline{VGD}$  equal to the predictor outputs and create the timetag TGD, i.e.,

```
 $\overline{RGD} = R\_PRED\_FINAL$ 
```

```
 $\overline{VGD} = V\_PRED\_FINAL$ 
```

```
TGD = TIG
```

6. The on-orbit guidance principal function requires an input of a propulsive system flag (PROP\_FLAG\_GUID) and an estimated acceleration (ATR) to compute time to go (TGO). In addition, the MSC and OMS FIRE SEQ require a prime propulsion system indicator (PROP\_FLAG\_OFS). Based on the discrete settings input from the MNVR DISP, these quantities are set as follows:

- a. If BOTH $\dot{O}MS = ON$ , then PROP\_FLAG\_GUID = 1 and PROP\_FLAG\_OFS = 1.
- b. If LEFT $\dot{O}MS = ON$ , then PROP\_FLAG\_GUID = 2 and PROP\_FLAG\_OFS = 2.
- c. If RIGHT $\dot{O}MS = ON$ , then PROP\_FLAG\_GUID = 2 and PROP\_FLAG\_OFS = 3.

- d. If  $\dot{X}_{RCS} = ON$ , then  $PROP\_FLAG\_GUID = 3$  and  $PROP\_FLAG\_OFS = 4$ .

The estimated acceleration is computed:

$$ATR = FT_{PROP\_FLAG\_GUID}/M$$

For each of the above conditions, the previous value for the prime propulsion system must be set equal to zero

$$PROP\_FLAG\_OFS\_P = 0$$

7. The velocity targets are transformed to M50 inertial coordinates from the ignition state local vertical, local horizontal (LVLH) coordinates for input to on-orbit guidance. Software modules documented in the Control Level C FSSR are used to perform this transformation. The RV\_TO\_QLVLH module accepts an input state (ignition position and velocity in this case) and outputs the scalar and vector components of the quaternion to transfer from the ignition state local vertical, local horizontal coordinate system to the M50 coordinate system (Q\_I\_LVLH\_S and Q\_I\_LVLH\_V). This quaternion is an input to the QUAT\_XFORM module, which transforms the input EXT\_DV\_LVLH vector to the VGO vector required for on-orbit guidance. Descriptions of the RV\_TO\_QLVLH and QUAT\_XFORM modules are presented, for information only, in Part E of this task.

CALL RV\_TO\_QLVLH

Inputs:  $\overline{RGD}$ ,  $\overline{VGD}$

Outputs: Q\_I\_LVLH\_S, Q\_I\_LVLH\_V

CALL QUAT\_XFORM

Inputs: Q\_I\_LVLH\_S, Q\_I\_LVLH\_V,  $\overline{EXT\_DV\_LVLH}$

Outputs:  $\overline{VGO}$

8. A maneuver targeted by the Orbit Targeting Specialist function can be either external delta-V or Lambert guidance. Maneuvers entered through the maneuver execute display (either keyboard or uplink) are external delta-V guidance. To ensure that the proper guidance algorithm is performed by on-orbit guidance, the flags GUID\_FLAG and LAMBERT\_FLAG are used. GUID\_FLAG is set by the Orbit Targeting Specialist function to indicate the desired guidance mode to maneuver display processing. LAMBERT\_FLAG is set by maneuver display processing to indicate the desired guidance mode to on-orbit guidance.

If  $\dot{GUID\_FLAG} = ON$ , then  $LAMBERT\_FLAG = 1$

else  $LAMBERT\_FLAG = 0$

Since external delta-V and Lambert maneuvers look alike on the orbit maneuver execute display, the following item should be noted:

After targets for a Lambert maneuver are transferred from orbit targeting to the maneuver execute display and the maneuver display processing, then maneuver display processing recognizes the maneuver as a Lambert maneuver at the execution of the LOAD item entry as long as none of the target and setup data defined in the Display Monitoring Task (4.13) have been changed since target transfer.

If any display entries (target and setup) are made either before or after the initial LOAD is executed, then another target transfer from the orbit targeting display to the maneuver execute display must be made before the Lambert maneuver can be performed.

9. If Lambert guidance is desired (LAMBERT\_FLAG = 1), the velocity to go ( $\overline{VGO}$ ) is computed by calling the velocity-to-go corrector task. That task sets up target parameters, calls the Lambert task, and computes a new velocity to go ( $\overline{VGO\_NEW}$ ).

Call VGO CORR TSK

Inputs:

- a. Time of Lambert target position vector (T\_OFFSET\_GUID)
- b. Estimated vehicle acceleration (ATR)
- c. Projection flag for near 180° transfers (S\_ROTATE\_GUID)
- d. Lambert target position vector ( $\overline{R\_OFFSET\_GUID}$ )
- e. Guidance time at ignition (TGD)
- f. Position vector at ignition ( $\overline{RGD}$ )
- g. Velocity vector at ignition ( $\overline{VGD}$ )
- h. Initial estimate of velocity to go ( $\overline{VGO}$ )
- i. Time of ignition (TIG)
- j. Accumulated IMU sensed delta velocity (VSP)

Outputs:

- a. New velocity to go ( $\overline{VGO\_NEW}$ )

The velocity to go is updated

$$\overline{VGO} = \overline{VGO\_NEW}$$



10. The current guidance target values are evaluated by calculating for display the velocity-to-go ( $\overline{VGO}$ ) and time-to-go (TGO), resulting from these target values. The guidance task (GUID TSK, Subsection 4.2.4) is called:

CALL GUID TSK

Inputs to the guidance task from the ORBIT MNVR DIP principal function are:

- a. External delta velocity to go ( $\overline{VGO}$ )
- b. Orbiter ignition mass (M)
- c. Propulsion system flag (PROP\_FLAG = PROP\_FLAG\_GUID)
- d. Steering enable flag (SSTEER = ON)

Outputs from the guidance task to be used by the ORBIT MNVR DIP principal function are:

- a. Time-to-go (TGO)
- b. Commanded reference thrust orientation parameter ( $\overline{LAMC}$ )

11. For Lambert guidance (LAMBERT\_FLAG = 1), compute velocity-to-go in LVLH coordinates at TIG using the guidance state at TIG determined in Step 5.

CALL RV\_TO\_QLVLH

Input:  $\overline{RGD}$ ,  $\overline{VGD}$

Output:  $Q_{M50\_LVLH\_S}$ ,  $Q_{M50\_LVLH\_V}$

CALL QUAT\_XFORM

Input:  $-Q_{M50\_LVLH\_S}$ ,  $Q_{M50\_LVLH\_V}$ ,  $\overline{VGO}$

Output:  $\overline{VGO\_LVLH}$

12. The desired vehicle attitude at ignition (pitch, yaw, and roll Euler angles based upon the current ADI inertial attitude reference) is calculated for display as follows:

CALL CMD BDY ATT TSK

Inputs to the CMD BDY ATT TSK from the ORBIT MNVR DIP principal function are:

- a. Time of ignition (TIG)
- b. Predicted position vector at TIG ( $\overline{RGD}$ )
- c. Predicted velocity vector at TIG ( $\overline{VGD}$ )
- d. Prime propulsive system flag (PROP\_FLAG\_OFS)
- e. Time tag of  $\overline{RGD}$  and  $\overline{VGD}$  (TGD)

- f. Previous value of prime propulsive system flag (PROP\_FLAG\_OFS\_P)
- g. Unit desired thrust direction vector in M50 coordinates ( $\overline{LAMC}$ ), source GUID TSK.

Outputs from the CMD BDY ATT TSK

- a. M50-to-commanded body quaternion (Q\_CB\_M50, destination ORBIT DAP)
  - b. ADI inertial Euler angles (VEH\_PITCH, VEH\_YAW, and VEH\_ROLL, destination MNVR DISP)
  - c. Valid angle comp flag (X\_FLAG, destination MNVR DISP)
  - d. Body thrust vector (THRUST\_BODY, destination OMS TSK)
13. The calculation of target apogee and perigee altitudes (Item 11) requires a predicted burnout state. The desired guidance cutoff trajectory defined by the vectors ( $\overline{RD}$ ,  $\overline{VD}$ ) is computed by calculating a state vector that approximates the powered flight burnout trajectory as:

$$\overline{VD} = \overline{VGD} + \overline{VGO}$$

$$\overline{RD} = \overline{RGD} - 0.5 \text{ TGO } \overline{VGO}$$

where:

$\overline{RGD}$  is the predicted position vector at TIG

$\overline{VGD}$  is the predicted velocity vector at TIG

$\overline{VGO}$  is the external delta velocity guidance target vector

TGO is the time-to-go until thrust cutoff

14. The target apogee (TGT\_HA) and perigee (TGT\_HP) altitudes are next computed for display using the Orbital Altitude Time Task (Subsection 4.1.7).

The orbital altitude time task is called with the state ( $\overline{VD}$ ,  $\overline{RD}$ ) input as  $\overline{V}$  and  $\overline{R}$ , respectively. The resulting outputs are apogee altitude (HA) and perigee altitude (HP), which are then assigned to the target apogee (TGT\_HA) and target perigee (TGT\_HP) altitude.

CALL ORB ALT TIME TSK

Inputs:  $\overline{RD}$ ,  $\overline{VD}$

Outputs: TGT\_HA, TGT\_HP

B. Interface Requirements. The input and output parameters for the premaneuver display support task are given in Tables 4.1.6-1 and 4.1.6-2. A flow diagram of PRE-MAN DISP SUPT TSK functional requirements is given in Appendix A.

C. Processing Requirements. The premaneuver display support task is performed once when the LOAD\_CMD is set to ON by keyboard input.

D. Initialization Requirements. None.

E. Supplemental Information. The (1) QUAT\_XFORM and (2) RV\_TO\_QLVLH modules referenced in this task and formally documented in the Flight Control Level C FSSR are presented here for information only.

1. QUAT\_XFORM

$$QTMP_S = -Q_{B_I_V} \cdot VGO$$

$$QTMP_V = Q_{B_I_S} VGO + Q_{B_I_V} \times VGO$$

$$VGO_{DISP} = -QTMP_S Q_{B_I_V} + Q_{B_I_S} QTMP_V - QTMP_V \times Q_{B_I_V}$$

2. RV\_TO\_QLVLH

$$\bar{XZ} = \text{UNIT}(-RGD)$$

$$\bar{XY} = \text{UNIT}(VGD \times RGD)$$

$$\bar{XX} = \text{UNIT}(XY \times \bar{XZ})$$

$$\dot{X}M = (\text{MATRIX}(\bar{XX}, \bar{XY}, \bar{XZ}))^T$$

The output quaternion is formed from  $\dot{X}M$  by invoking MAT\_TO\_QUAT module.

Table 4.1.6-1. Premaneuver Display Support Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V93W6944CA thru V93W6947CA	TIG_SEC, TIG_MIN, TIG_HR, TIG_DAY	Time of ignition	MNVR DISP	SP	s,min, hr,days
V95H0185CF thru V950187CF	$\bar{R}$ NAV	Current Shuttle position vector in M50 coordinates	ON-ORB UPP	DP	ft
V95L0190CF thru V95L0192CF	$\bar{V}$ NAV	Current Shuttle velocity vector in M50 coordinates	ON-ORB UPP	SP	ft/s
V95W0200CF	TNAV	Time associated with current Shuttle state	ON-ORB UPP	SP	s
V93L6950CA thru V93L6952CA	EXT_D $\bar{V}$ _LVLH	External delta-V to be gained vector in LVLH coordinates	MNVR DISP	SP	ft/s
V93G6940CA	WT_DISP	Orbiter weight	MNVR DISP	SP	lb
V93X6925XA	LEFT_OMS	Left OMS engine select discrete	MNVR DISP	N/A	D
V93X6926XA	RIGHT_OMS	Right OMS engine select discrete	MNVR DISP	N/A	D
V93X6922XA	BOTH_OMS	Both OMS engine select discrete	MNVR DISP	N/A	D
V93X6929XA	PLUS_X_RCS	RCS engine select discrete	MNVR DISP	N/A	D
V95H0811C thru V95H0813C	R_PRED_FINAL	Predicted position vector at time of ignition in M50 coordinates	ON-ORB PRED	DP	ft
V95L0814C thru V95L0816C	V_PRED_FINAL	Predicted velocity vector at time of ignition in M50 coordinates	ON-ORB PRED	SP	ft/s
	HA	Apogee altitude	ORB ALT TIME TSK	SP	nmi
	HP	Perigee altitude	ORB ALT TIME TSK	SP	nmi
V90W1941C	TGO	Time-to-go to thrust cutoff	GUID TSK	SP	s
V91W5000C	T_GMT	Current GMT computer time	SYS S/W	DP	s
V97U4393C	G_TO_FPS2	Earth's gravitational acceleration	CONSTANT	SP	ft/s <sup>2</sup>
V97U4370C	DTMIN	Time interval step size to be used by ON-ORB PREC PRED func-tion to predict current state to ignition	K-LOAD	SP	s
V97U0383C	RAD_PER_DEG	Degrees to radians conversion factor	CONSTANT	SP	rad/deg

Table 4.1.6-1. Premaneuver Display Support Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V97U5034C	FT <sub>1</sub>	Nominal vacuum thrust for maneuver with 2 OMS engines	K-LOAD	SP	lb
V97U5035C	FT <sub>2</sub>	Nominal vacuum thrust for maneuver with 1 OMS engine	K-LOAD	SP	lb
V97U5036C	FT <sub>3</sub>	Nominal vacuum thrust for maneuver with +X RCS engines	K-LOAD	SP	lb
V91W1996C	T_MET_REF	MET start time in GMT	FCOS	DP	s
V94X4029X	GUID_FLAG	Flag to indicate Lambert maneuver	ORB TGTING SPEC, DISP MONIT TSK	N/A	D
V94W4015CA	T_OFFSET_GUID	Time of Lambert target position vector	ORB TGTING SPEC	DP	s
V94J4025CA	S_ROTATE_GUID	Projection flag for near 180° maneuvers	ORB TGTING SPEC	SP	I
V94H4016CA thru V94H4018CA	R_OFFSET_GUID	Lambert target offset position vector	ORB TGTING SPEC	DP	ft
V96U9161C	VGO_NEW	New velocity to go	VGO CORR TASK	SP	ft/s
V96U9160C	REF_ORB_CD	Drag coefficient for orbiter	K-LOAD	SP	none
V95L0210CD thru V95L0212CD	REF_ORB_AREA	Orbiter reference area	I-LOAD	SP	ft <sup>2</sup>
	V $\bar{S}$	Total accumulated IMU velocity vector in M50 coordinates	ON-ORB UPP	DP	ft/s

Table 4.1.6-2. Premaneuver Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94W3790CC	TIG	Time of ignition	MSC, ON-ORB PRED, VGO CORR TSK, DISP MONIT TSK, GUID INP TSK, CMD BDY ATT TSK, VGO DISP TSK, PREBRN MNVR TTG TSK	DP	s
V94X3826XC	TB_ENABLE	Discrete to initiate time base calculations	MSC	N/A	D

Table 4.1.6-2. Premaneuver Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94H3930C thru V94H3932C	$\overline{RGD}$	Predicted position vector at time of ignition	CMD BDY ATT TSK, VGO CORR TASK	DP	ft
V94H3935C thru V94H3937C	$\overline{VGD}$	Predicted velocity vector at time of ignition	CMD BDY ATT TSK, VGO CORR TASK	SP	ft/s
V90U1961CJ	M	Current orbiter mass	GUID INP TSK, GUID TSK, ON-ORB DAP	SP	slugs
V94J3791CB	PROP_FLAG_OFS	Prime propulsive system flag	OMS FIRE SEQ, MSC, CMD BDY ATT TSK	N/A	I
V94X3962XB	PROP_FLAG_GUID	Prime propulsive system flag for guidance use	GUID INP TSK	N/A	D
V94H3798CB	TGT_HA	Target apogee altitude	MNVR DISP	SP	nmi
V94H3799CB	TGT_HP	Target perigee altitude	MNVR DISP	SP	nmi
V94H4026C thru V94H4028C	$\overline{VGO}$	Initial velocity to go	GUID TSK, GUID INP TSK	SP	ft/s
	$\overline{RD}$	Position vector at predicted burnout	ORB ALT TIME TSK	DP	ft
	$\overline{VD}$	Velocity vector at predicted burnout	ORB ALT TIME TSK	SP	ft/s
V95W8512CP	TGD	Timetag of $\overline{RGD}$ , $\overline{VGD}$	CMD BDY ATT TASK, VGO CORR TASK	DP	s
V94J3975CA	GMO_PRED	Gravity model order flag	ON-ORB PRED	N/A	I
V94J3963CA	GMD_PRED	Gravity model degree flag	ON-ORB PRED	N/A	I
V94X3771XA	VMP	Vent model flag	ON-ORB PRED	N/A	D
V94X3969XA	DMP	Drag model flag	ON-ORB PRED	N/A	D
V94J3999CA	ATM	Altitude mode flag	ON-ORB PRED	N/A	I
V90W3964C	PRED_STEP	Maximum integration step interval	ON-ORB PRED	SP	s
V94H4002C thru V94H4004C	$R_{\overline{PRED\_INIT}}$	Current Shuttle position vector	ON-ORB PRED	DP	ft
V94L4006C thru V94L4008C	$V_{\overline{PRED\_INIT}}$	Current Shuttle velocity vector	ON-ORB PRED	SP	ft/s
V94W3970C	T_PRED_INIT	Time associated with current Shuttle state	ON-ORB PRED	DP	s

Table 4.1.6-2. Premaneuver Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90U1954CE thru V90U1956CE	PROP_FLAG_OFS_P	Previous value of prime propulsive system flag	CMD BDY ATT TSK	N/A	I
	$\overline{L}AMC$	Unit desired thrust direction vector in M50 coordinates	CMD BDY ATT TSK	SP	none
	PROP_FLAG	Propulsive system indicator	GUID TSK	N/A	I
	ATR	Estimated vehicle acceleration	VGO CORR TSK	SP	ft/s <sup>2</sup>
V94W3979C	T_PRED_FINAL	Final prediction time	ON-ORB PRED	DP	s
V93U6955C	PRED_ORB_AREA	Orbiter ref area	ON-ORB PRED	SP	ft <sup>2</sup>
V93U6954C	PRED_ORB_CD	Orbiter drag coeff	ON-ORB PRED	SP	
V93U6953CC	PRED_ORB_MASS	Orbiter mass	ON-ORB PRED	SP	slugs
V94W4015CA	T_OFFSET_GUID	Time of Lambert position vector	VGO CORR TSK, ON-ORB GUID	DP	s
V94J4025CA	S_ROTATE_GUID	Projection flag for near 180° maneuvers	VGO CORR TSK, ON-ORB GUID	SP	I
V94H4016CA thru V94H4018CA	$\overline{R}$ _OFFSET_GUID	Lambert target offset position vector	VGO CORR TSK, ON-ORB GUID	DP	ft
V94X4024X	LAMBERT_FLAG	Lambert guidance mode flag (1 = yes, 0 = no)	ON-ORB GUID, GUID INP TSK	N/A	D
V94L3945CC thru V94L3947CC	$\overline{V}GO\_LVLH$	Velocity to go in LVLH coordinates	MNVR DISP	SP	ft/s
	SS $\dot{T}$ EER	Steering enable flag	GUID TSK	N/A	D
V93U6909CD	VEH_PITCH	Desired burn attitude in pitch	MNVR DISP, TLM	SP	deg
V93U6910CD	VEH_ROLL	Desired burn attitude in roll	MNVR DISP, TLM	SP	deg
V93U6911CD	VEH_YAW	Desired burn attitude in yaw	MNVR DISP, TLM	SP	deg
V90X0414XC	$\overline{X}$ _FLAG	Valid angle comp flag	MNVR DISP	N/A	D
V95L3878C thru V95L3880C	$\overline{V}SP$	Total accumulated IMU velocity vector in M50 coordinates	VGO CORR TSK	DP	ft/s

#### 4.1.6A Preburn Maneuver Time To Go Task (PREBRN MNVR TTG TSK)

This task computes the condition when the nominal preburn maneuver completion time to go, MNVR\_CMPL\_TIME\_TGO, is displayed as double overbright versus normal intensity on the XXXXX MNVR YYYYYY display.

- A. Detailed Requirements. The condition of MNVR\_CMPL\_TIME\_TGO is calculated for the current preburn maneuver and displayed as either normal intensity or double overbright in MM:SS format on the XXXXX MNVR YYYYYY display when a “MNVR” (ITEM 27) has been initiated and the DAP is “AUTO”.

While MNVR\_CMPL\_TIME\_TGO is being computed via the ON-ORBIT DAP (PREBURN\_MNVR\_IN\_PROGRESS = ON), the following logic applies:

1. Initialize variables.

TTG = MNVR\_CMPL\_TIME\_TGO

TTG\_FLAG = OFF

2. Check to determine if the preburn maneuver time to go exceeds the 59:59 (MM:SS) limit (TTG > 3599.0).

If the preburn maneuver time to go is greater than 59:59, then set TTG to the time limit, set the flag to display TTG in double overbright, and skip step #3.

TTG = 3599.0

TTG\_FLAG = ON

3. Check to determine if the preburn maneuver will be completed at least 30 seconds prior to burn ignition.

If the preburn maneuver will not be completed 30 seconds prior to burn ignition, then set the flag to display TTG in double overbright.

If:  $TTG + T\_GMT > TIG - 30 \text{ seconds}$

Then:  $TTG\_FLAG = ON$

The preburn maneuver display flag is set equal to the preburn maneuver in progress flag for display processing:

$PREBURN\_MNVR\_DISP = PREBURN\_MNVR\_IN\_PROGRESS$

- B. Interface Requirements. The input and output parameters for the time to go task are given in Tables 4.1.6A-1 and 4.1.6A-2.
- C. Processing Requirements. This task is processed every 0.96 seconds.
- D. Initialization Requirements. PREBURN\_MNVR\_DISP is set to zero upon entry into MM201.



E. Supplemental Requirements. None.

Table 4.1.6A-1. Preburn Maneuver Time to Go Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V91W5000C	T_GMT	Current time (GMT)	FCOS	DP	S
V90X1589XB	PREBURN_MNVR_IN_· PROGRESS	Preburn maneuver in progress flag	ON-ORB DAP	N/A	D
V94W3790CC	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	S
V95W7240CB	MNVR_CMPL_TIME_TGO	Preburn mnvr time to go	ON-ORB DAP	SP	S

Table 4.1.6A-2. Preburn Maneuver Time to Go Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90W2638CB	TTG	Preburn mnvr time to go	MNVR DISP	SP	S
V90X2639XB	TTG_·FLAG	TTG display intensity flag	MNVR DISP	N/A	D
V85X9529XB	PREBURN_·MNVR_DISP	Preburn maneuver display flag	MNVR DISP	N/A	D

#### 4.1.7 Orbital Altitude Time Task (ORB ALT TIME TSK)

This task provides software to compute apogee and perigee altitude above a spherical earth and the time-to-next-apsis based on an input state ( $\bar{R}$ ,  $\bar{V}$ ). This procedure may be done in single precision.

##### A. Detailed Requirements.

1. Calculate the magnitude of the radius vector (RMAG), the vertical velocity magnitude (RDOT), and the unit radius vector ( $\bar{R\_UNIT}$ ):

$$RMAG = ABVAL(\bar{R})$$

$$\bar{R\_UNIT} = \bar{R}/RMAG$$

$$RDOT = \bar{V} \cdot \bar{R\_UNIT}$$

2. Calculate the two Keplerian elements, the semimajor axis (AM) and the semilatus rectum (P):

$$AM = EARTH\_MU \cdot RMAG / (2 \cdot EARTH\_MU - RMAG(\bar{V} \cdot \bar{V}))$$

$$P = RMAG [2 - (RMAG/AM) - RMAG \cdot RDOT^2/EARTH\_MU]$$

The variable EARTH\_MU is the earth's gravitational constant.

3. Compute a term to be used repeatedly in subsequent calculations

$$K = J2\_GRAV \cdot RE^2 / (4 \cdot P)$$

where J2\_GRAV is the second gravitational zonal harmonic ( $J_2$ ) for the earth and RE is the reference radius of the earth.

4. Compute three quantities to be used in later computations – the product of the sine of the inclination and the sine of the argument of latitude (MM), the product of the sine of the inclination and the cosine of the argument of latitude (NN), and the square of the sine of the inclination (S\_INC):

$$MM = EARTH\_POLE \cdot \bar{R\_UNIT}$$

$$NN = UNIT(\bar{V} - RDOT \cdot \bar{R\_UNIT}) \cdot EARTH\_POLE$$

$$S\_INC = MM^2 + NN^2$$

where EARTH\_POLE is the current M50 unit angular momentum vector of the earth.

5. Compute the mean semimajor axis (AM) and the inverse of the mean orbital rate (NU):

$$AM = AM - (J2\_GRAV \cdot RE^2 \cdot AM^2 / RMAG^3) (1 - 3 \cdot MM^2)$$

$$NU = AM \cdot SQRT(AM/EARTH\_MU)$$

6. Compute the adjusted elements: radius (RMAG), vertical velocity (RDOT), and semimajor axis (AM):

$$RMAG = RMAG + K (MM^2 - NN^2)$$

$$RDOT = RDOT + 4 K MM NN/NU$$

$$AM = AM - K (2 - 3 S\_INC)$$

7. Compute two quantities to be used in later computations – the product of the eccentricity and the sine of the eccentric anomaly (M), and the product of the eccentricity and the cosine of the eccentric anomaly (N):

$$M = RMAG RDOT/SQRT(EARTH\_MU AM)$$

$$N = 1 - RMAG/AM$$

8. Compute the eccentricity (E):

$$E = SQRT(M^2 + N^2)$$

9. Compute a term (DELTA) to be applied to correct the apogee and perigee altitudes:

$$DELTA = K (NN^2 - MM^2)$$

10. Check the difference in apogee and perigee radii (2 AM E) to determine if the orbit is near circular:

$$\text{If } 2 AM E NMI\_PER\_FT < DELT\_H\_CIRC$$

then set the flag (TXX\_FLAG) to indicate a circular orbit and the time-to-next-apsis (TT\_X) to zero:

$$TXX\_FLAG = 3$$

$$TT\_X = 0$$

Proceed to Step 16.

Else (2 AM E NMI\_PER\_FT ≥ DELT\_H\_CIRC), go to Step 11.

11. For an elliptical orbit (2 AM E NMI\_PER\_FT ≥ DELT\_H\_CIRC), compute the time-to-next-apsis (TT\_X), and compute the sine of the true anomaly (M) and the cosine of the true anomaly (N):

$$TT\_X = ((1 + SIGN(RDOT)) PI/2 + M - ARCTAN2(M, N)) NU$$

$$M = SQRT(1-E^2) M/(E (1-N))$$

$$N = (N-E^2)/(E (1-N))$$

12. Test the sign of RDOT to determine if the next apsis is to be apogee (TXX\_FLAG=1) or perigee (TXX\_FLAG=2), and set the TXX\_FLAG to the proper value:

$$\text{If } (\text{RDOT} \geq 0) \text{ then TXX\_FLAG} = 1$$

$$\text{Else TXX\_FLAG} = 2$$

13. Recompute the correction to apogee and perigee (DELTA) to include a true anomaly factor:

$$\text{DELTA} = \text{DELTA} (\text{N}^2 - \text{M}^2) + 4 \text{ M MM N NN K}$$

14. Compute a term (KK) to correct the time-to-next-apsis (TT\_X):

$$\text{KK} = (\text{AM}^2 \text{E}) / (4 \text{P})$$

15. To prevent numerical problems in applying this correction term (KK), a check is performed to ensure that it is in the allowable range (if  $\text{KK} > \text{K S\_INC}$ ):

If it is not in this range ( $\text{KK} \leq \text{K S\_INC}$ ), proceed to Step 16. For an allowable value, compute  $\text{K S\_INC}$  multiplied by the sine of twice the argument of perigee (DELTB) and check to ensure that it has a nonzero value:

$$\text{DELTB} = 2 \text{K} [\text{M N} (\text{MM}^2 - \text{NN}^2) - \text{MM NN} (\text{M}^2 - \text{N}^2)]$$

For a nonzero value of DELTB, compute the time correction term (KK) and the time-to-next-apsis (TT\_X):

$$\text{KK} = -[\text{SIGN}(\text{RDOT}) \text{KK} + \text{DELTA}] / \text{DELTB}$$

$$\text{TT\_X} = \text{TT\_X} + [1 + 2 \text{SIGN}(\text{RDOT}) \text{E}] \text{NU} / [\text{KK} + \text{SIGN}(\text{KK}) \text{SQRT}(\text{KK}^2 + 2)]$$

If the time-to-next-apsis (TT\_X) is negative add half the period to this time and update the TXX\_FLAG:

$$\text{TT\_X} = \text{TT\_X} + \text{PI NU}$$

$$\text{TXX\_FLAG} = 1 + \text{MOD}(\text{TXX\_FLAG}, 2)$$

16. Compute the altitudes of apogee (HA) and perigee (HP) above a spherical earth.

$$\text{HA} = (\text{AM} (1+\text{E}) + \text{DELTA} - \text{RE}) \text{NMI\_PER\_FT}$$

$$\text{HP} = (\text{AM} (1-\text{E}) + \text{DELTA} - \text{RE}) \text{NMI\_PER\_FT}$$

The variable NMI\_PER\_FT is the conversion factor from feet to nautical miles.

B. Interface Requirements. The input and output parameters for the orbital altitude time task are given in Tables 4.1.7-1 and 4.1.7-2. A flow diagram of ORB ALT TIME TSK functional requirements is given in Appendix A.

C. Processing Requirements. This task is performed once when called.

D. Initialization Requirements. None.

Table 4.1.7-1. Orbital Altitude Time Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
	$\bar{R}$	Position vector	CUR ORBIT TSK, PRE-MAN DISP SUPT TSK	DP	ft
	$\bar{V}$	Velocity vector	CUR ORBIT TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
V97U4378C	EARTH_MU	Earth's gravitational constant	CONSTANT	DP	ft <sup>3</sup> /s <sup>2</sup>
V97U4416C	J2_GRAV	The second gravitational zonal harmonic (J <sub>2</sub> ) for the earth	CONSTANT	SP	none
V97U5324C	RE	Reference earth's radius	CONSTANT	DP	ft
V90U0190C thru V90U0192C	EARTH_POLE	M50 unit vector normal to equator pointing north	RNP MAT COMP	DP	none
V97U4832C	DELT_H_CIRC	Maximum difference between apogee and perigee for orbit to be considered circular	K-LOAD	SP	nmi
V97U5423C	NMI_PER_FT	Feet to nautical mile conversion factor	CONSTANT	SP	nmi/ft
V98U8725C	PI	Ratio of circumference of a circle to its diameter	CONSTANT	DP	none

Table 4.1.7-2. Orbital Altitude Time Task Output Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
	HA	Apogee altitude	CUR ORBIT TSK, PRE-MAN DISP TSK	SP	nmi
	HP	Perigee altitude	CUR ORBIT TSK, PRE-MAN DISP TSK	SP	nmi
V94W3796CB	TT_X	Time to next apsis	CUR ORBIT TSK	SP	s
V94X3961X	TXX_FLAG	Indicator for next apsis and label field [= 1, TTA (apogee) = 2, TTP (perigee) = 3, TTC (circular)]	CUR ORBIT TSK	N/A	I

#### 4.1.8 Uplink Buffer Access Task (UL ACCSS TSK)

Upon recognition that a guidance target and setup data set has been uplinked, this task retrieves the data from the uplink module, then it either resets the required parameters for reinitialization of the display or places the uplinked data into protective storage for use during OPS 3.

A. Detailed Requirements. UL ACCSS TSK performs the following activities each time it is called.

1. Interrogate the OP code to determine whether a guidance target set has been updated via uplink. If so, set the guidance mode discrete if required and branch as indicated. Otherwise, exit this task.

If OP\_CODE = 0010000, then proceed to Step 6.

If OP\_CODE = 0010001, then set PEG\_MODE4 = OFF and proceed to Step 2.

If OP\_CODE = 0010100, then set PEG\_MODE4 = ON and proceed to Step 2.

If OP\_CODE is equal to none of the above, then exit task.

2. The uplinked data that are common to external delta-V and LTVC guidance are placed in protective storage.

TVR\_ROLL\_STO = TVR\_ROLL\_UL

WT\_DISP\_STO = WT\_UL

BOTH\_OMS\_STO = BOTH\_OMS\_UL

LEFT\_OMS\_STO = LEFT\_OMS\_UL

RIGHT\_OMS\_STO = RIGHT\_OMS\_UL

PLUS\_X\_RCS\_STO = PLUS\_X\_RCS\_UL

VEH\_PITCH\_STO = VEH\_PITCH\_UL

VEH\_YAW\_STO = VEH\_YAW\_UL

VEH\_ROLL\_STO = VEH\_ROLL\_UL

3. If  $PEG\_MODE\_4 = OFF$ , the uplinked external delta-V target vector is

$$EXT\_D\bar{V}\_LVLH\_STO = EXT\_D\bar{V}\_LVLH\_UL$$

If  $PEG\_MODE\_4 = ON$ , the uplinked LTVC target parameters are placed in protective storage.

$$C1\_DISP\_STO = C1\_UL$$

$$C2\_DISP\_STO = C2\_UL$$

$$HEI\_DISP\_STO = HEI\_UL$$

$$THETA\_DISP\_STO = THETA\_UL$$

$$PROP\_DEP\_STO = PROP\_DEP\_UL$$

4. The uplinked time of ignition must be converted to the applicable time reference.

$$TIG = TIG\_UL - T\_MET\_REF$$

The applicable display time units are computed and placed in protective storage.

$$TIG\_SEC\_STO = TRUNCATE(MOD (TIG, 60))$$

$$TIG\_MIN\_STO = TRUNCATE((MOD (TIG, 3600))/60)$$

$$TIG\_HR\_STO = TRUNCATE((MOD (TIG, 86400))/3600)$$

$$TIG\_DAY\_STO = TRUNCATE(TIG/86400)$$

5. The OP code is set to zero to preclude reprocessing the uplinked data on the next call to this task.

$$OP\_CODE = 0$$

This task is then exited.

6. The uplinked time of ignition must be converted to the applicable time reference.

$$TIG = TIG\_UL - T\_MET\_REF$$

The appropriate display time units are computed.

$$TIG\_SEC = TRUNCATE(MOD (TIG, 60))$$

$$TIG\_MIN = TRUNCATE((MOD (TIG, 3600))/60)$$

$$TIG\_HR = TRUNCATE((MOD (TIG, 86400))/3600)$$

$$TIG\_DAY = TRUNCATE(TIG/86400)$$

7. The remaining guidance target and setup data are set to their corresponding uplinked values.

$EXT\_D\bar{V}\_LVLH = EXT\_D\bar{V}\_LVLH\_UL$

$TVR\_ROLL = TVR\_ROLL\_UL$

$WT\_DISP = WT\_UL$

$BOTH\_OMS = BOTH\_OMS\_UL$

$LEFT\_OMS = LEFT\_OMS\_UL$

$RIGHT\_OMS = RIGHT\_OMS\_UL$

$PLUS\_X\_RCS = PLUS\_X\_RCS\_UL$

8. Three discretes ( $DATA\_ENTER$ ,  $LOAD\_FLASH$ , and  $ST\_CRT\_TIMER$ ) are reset in order to (re)initialize the display.

$DATA\_ENTER = OFF$

$LOAD\_FLASH = ON$

$ST\_CRT\_TIMER = OFF$

9. Repeat Step 5 here.

B. Interface Requirements. The input and output parameters for the UL ACCSS TSK are presented in Tables 4.1.8–1 and 4.1.8–2. A flow diagram of the UL ACCSS TSK functional requirements is given in Appendix A.

C. Processing Requirements. The UL ACCSS TSK is performed from entry into MM 202 until MM 202 is exited.

D. Initialization Requirements. None.



Table 4.1.8-1.Uplink Access Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V91W1996C	T_MET_REF	MET start time in GMT time base	FCOS	DP	s
V96J3524C	OP_CODE	Data type OP code	UPLINK	NA	7-bit
V94W3790CD	TIG_UL	Time of ignition	UPLINK	DP	s
V93L6950CF thru V93L6952CF	EXT_DV_LVLH_UL	Ext ΔV in LVLH coord	UPLINK	SP	ft/s
V93H6936CD	TVR_ROLL_UL	Thrust vector roll angle	UPLINK	SP	deg
V93G6940CD	WT_UL	Orbiter weight	UPLINK	SP	lb
V93X6922XB	BOTH_OMS_UL	Prop sys both	UPLINK	NA	D
V93X6925XB	LEFT_OMS_UL	Prop sys left	UPLINK	NA	D
V93X6926XB	RIGHT_OMS_UL	Prop sys right	UPLINK	NA	D
V93X6929XB	PLUS_X_RCS_UL	Prop sys plus X RCS	UPLINK	NA	D
V93U6909CE	VEH_PITCH_UL	Pitch angle post mnvr	UPLINK	SP	deg
V93U6911CE	VEH_YAW_UL	Yaw angle post mnvr	UPLINK	SP	deg
V93U6910CE	VEH_ROLL_UL	Roll angle post mnvr	UPLINK	SP	deg
V93U6966CD	C1_UL	Target line intercept	UPLINK	SP	ft/s
V93U6967CD	C2_UL	Target line slope	UPLINK	SP	none
V93U6968CD	HEI_UL	Altitude at entry intf	UPLINK	SP	ft
V93U6969CD	THETA_UL	Travel angle ign to EI	UPLINK	SP	deg
V93U6970CB	PROP_DEP_UL	Fuel wt mnvr and waste	UPLINK	SP	lb

Table 4.1.8-2.Uplink Buffer Access Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V93X6976XD	PEG_MODE_4	Guidance mode indicator	STORAGE	NA	D
V94X3814XB	LOAD_FLASH	Load flash flag	DISP MONIT TSK	NA	D
	DATA_ENTER	Discrete indicating target or setup data entry	DISP MONIT TSK	NA	D
V94X4063XD	ST_CRT_TIMER	Start CRT timer flag	DISP MONIT TSK	NA	D
V93W6947CE V93W6944CE V93W6945CE V93W6946CE	TIG_DAY, TIG_HR, TIG_MIN, TIG_SEC	Time of ignition in display format	MNVR DISP	SP	d:h:m:s
V93L6950CE thru V93L6952CE	EXT_DV_LVLH	External ΔV target vector	MNVR DISP	SP	ft/s
V93H6936CC	TVR_ROLL	Thrust vector roll angle	MNVR DISP	SP	deg

Table 4.1.8-2. Uplink Buffer Access Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
V93G6940CE	WT_DISP	Vehicle weight	MNVR DISP	SP	lb
V93X6922XC	BOTH_OMS	Both engine select discrete	MNVR DISP	NA	D
V93X6925XC	LEFT_OMS	Left engine select discrete	MNVR DISP	NA	D
V93X6926XC	RIGHT_OMS	Right engine select discrete	MNVR DISP	NA	D
V93X6929XC	PLUS_X_RCS	Plus X RCS select discrete	MNVR DISP	NA	D
	TIG_DAY_STO, TIG_HR_STO, TIG_MIN_STO, TIG_SEC_STO	Time of ignition in display units	STORAGE	SP	d:h:m:s
	EXT_DV_LVLH _STO	External $\Delta V$ target vector- storage	STORAGE	SP	ft/s
	TVR_ROLL_STO	Thrust vector roll – storage	STORAGE	SP	deg
	WT_DISP_STO	Vehicle weight – storage	STORAGE	SP	lb
	BOTH_OMS_STO	Both engine select – storage	STORAGE	NA	D
	LEFT_OMS_STO	Left engine select – storage	STORAGE	NA	D
	RIGHT_OMS_STO	Right engine select – storage	STORAGE	NA	D
	PLUS_X_RCS_STO	Plus X RCS select – storage	STORAGE	NA	D
	VEH_PITCH_STO	Pitch angle desired – ADI – storage	STORAGE	SP	deg
	VEH_YAW_STO	Yaw angle desired – ADI – storage	STORAGE	SP	deg
	VEH_ROLL_STO	Roll angle desired – ADI – storage	STORAGE	SP	deg
	C1_DISP_STO	Velocity target line – xcpt – storage	STORAGE	SP	ft/s
	C2_DISP_STO	Velocity target line – slope – storage	STORAGE	SP	none
	HEI_DISP_STO	Altitude at entry interface – storage	STORAGE	SP	ft
	THETA_DISP_STO	Earth central angle from ignition to entry interface	STORAGE	SP	deg
	PROP_DEP_STO	Propellant weight for maneuver and waste (out-of-plane direction indicated by +/-)	STORAGE	SP	lb

#### 4.1.9 Commanded Body Attitude Task (CMD BDY ATT TSK)

The commanded body attitude task computes a quaternion relating body axes to the M50 coordinate system initially for use in computing a preburn attitude alignment and cyclically for use in computing attitude errors for the ADI. This task also computes the desired vehicle attitude cyclically during the burn.

A. Detailed Requirements. An M50 inertial to commanded body quaternion is computed based upon a unit thrust vector in the body axis coordinate system ( $\overline{\text{THRUST\_BODY}}$ ), the desired thrust orientation vector ( $\overline{\text{LAMC}}$ ), the roll reference vector ( $\overline{\text{ROLL\_REF}}$ ), and the desired thrust vector roll angle ( $\text{TVR\_ROLL}$ ).

The body fixed thrust direction is assumed to remain fixed throughout a maneuver if an engine reconfiguration does not occur. Therefore, a new body fixed thrust direction must be computed if any of the following conditions occurs:

- A new target set is evaluated.
- An engine fails during the maneuver.
- Nominal cutoff of an OMS burn occurs.

These conditions are satisfied each time the current propulsion system flag is set or reset.

1. If ( $\text{PROP\_FLAG\_OFS} \neq \text{PROP\_FLAG\_OFS\_P}$ ), then the body fixed thrust direction is computed as follows:
  - a. If an OMS engine configuration is to be used ( $\text{PROP\_FLAG\_OFS} < 4$ ), the  $\overline{\text{THRUST\_BODY}}$  unit vector is calculated as a function of OMS trim angles referenced to the body axis coordinate system. These OMS trim angles are related to the desired OMS trim angles through constant bias terms. These bias terms transform the desired OMS trim angles from an electrical null reference to a body axis reference.

- (1) Compute the OMS yaw and pitch trim angles for premaneuver calculations ( $\text{PROP\_FLAG\_OFS\_P} = 0$ ). The trim angles are input from the ON-ORBIT DAP principal function. If an engine fails during the maneuver, the trim angles are updated with K-loads for one engine.

- (a) If ( $\text{PROP\_FLAG\_OFS\_P} = 0$ ), then:

$$\text{YAW\_TRIM}_1 = \text{OMS\_YAW\_TRIM}_1$$

$$\text{YAW\_TRIM}_2 = \text{OMS\_YAW\_TRIM}_2$$

$$\text{PITCH\_TRIM} = \text{OMS\_PITCH\_TRIM}$$

- (b) If ( $\text{PROP\_FLAG\_OFS\_P} \neq 0$ ), then:

$$\text{YAW\_TRIM}_1 = \text{ONE\_ENG\_OMS\_YAW\_TRIM}_1$$

$$\text{YAW\_TRIM}_2 = \text{ONE\_ENG\_OMS\_YAW\_TRIM}_2$$

$$\text{PITCH\_TRIM} = \text{ONE\_ENG\_OMS\_PITCH\_TRIM}$$

- (2) Next compute the OMS yaw body angle. The subscript (1) denotes left OMS and (2) denotes right OMS.

$$\text{OMS\_YAW\_BODY}_1 = \text{YAW\_TRIM}_1 \text{ RAD\_PER\_DEG} + \text{YAW\_BIAS}$$

$$\text{OMS\_YAW\_BODY}_2 = \text{YAW\_TRIM}_2 \text{ RAD\_PER\_DEG} - \text{YAW\_BIAS}$$

- (3) Set the subscript limits (J1, J2) for the appropriate OMS system selected:

$$\text{Set } J1 = 1, J2 = 2$$

$$\text{If PROP\_FLAG\_OFS} = 2 \text{ then } J2 = 1 \text{ (left OMS)}$$

$$\text{If PROP\_FLAG\_OFS} = 3 \text{ then } J1 = 2 \text{ (right OMS)}$$

- (4) Convert the pitch trim values to a body reference and compute the OMS thrust body vector for each OMS.

$$\text{OMS\_PITCH\_BODY} = \text{PITCH\_BIAS} - \text{PITCH\_TRIM RAD\_PER\_DEG}$$

Do for J = J1 TO J2

$$C\_YAW = \text{COS}(\text{OMS\_YAW\_BODY}_J)$$

$$\text{THRUST\_BODY\_OMS}_J = \text{VECTOR}(\text{COS}(\text{OMS\_PITCH\_BODY}) C\_YAW, \\ \text{SIN}(\text{OMS\_YAW\_BODY}_J), \\ \text{SIN}(\text{OMS\_PITCH\_BODY}) C\_YAW)$$

The resultant OMS thrust body vectors are summed and unitized:

$$\text{THRUST\_BODY} = \text{UNIT}((J2 - J1) \text{THRUST\_BODY\_OMS}_1 \\ + (J1 - J2) \text{THRUST\_BODY\_OMS}_2)$$

- b. If the +X RCS is to be the engine configuration (PROP\_FLAG\_OFS = 4), the resultant body unit thrust vector is set equal to a K-load quantity (THRUST\_BODY\_RCS\_X):

$$\text{THRUST\_BODY} = \text{THRUST\_BODY\_RCS\_X}$$

- c. After computing the body fixed thrust direction for either OMS or RCS, PROP\_FLAG\_OFS\_P must be set equal to PROP\_FLAG\_OFS.

$$\text{PROP\_FLAG\_OFS\_P} = \text{PROP\_FLAG\_OFS}$$

2. Next, the M50-to-commanded-body quaternion is computed. If the current time is less than or equal to the time of ignition (TGD ≤ TIG), then perform the following calculations:

- a. The roll reference vector required for the preburn attitude calculations is calculated as:

$$\text{ROLL\_REF} = \text{UNIT}(\text{RGD})$$

- b. If the desired thrust vector is within a K-loaded tolerance (CBETA\_EPS) of the radial direction (e.g., thrust up or down), then a different roll reference vector must be used to avoid an attitude singularity.

If  $ABS(ROLL\_REF \cdot LAMC) > CBETA\_EPS$ , then:

$$ROLL\_REF = -VGD \text{ for } (ROLL\_REF \cdot LAMC) > 0$$

$$ROLL\_REF = VGD \text{ for } (ROLL\_REF \cdot LAMC) \leq 0$$

where  $RGD$  and  $VGD$  are the guidance state quantities computed in Item 4 of PRE-MAN DISP SUPT TSK (4.1.6), or in the Guidance Input Task (4.2.3).

- c. The desired thrust vector roll (TVR\_ROLL) angle is obtained from the ORBIT MNVR EXEC display, and the desired thrust orientation vector ( $LAMC$ ) has been calculated previously. The calculations necessary to complete the definition of the desired vehicle attitude at ignition are as follows:

The attitude matrix from the mean-of-50 to the body is computed.

$$\bar{Y}_N = UNIT(THRUST\_BODY_3, 0, -THRUST\_BODY_i)$$

$$\bar{Y}_T = UNIT(LAMC \times ROLL\_REF) SIN(TVR\_ROLL \text{ RAD\_PER\_DEG})$$

$$- LAMC \times UNIT(LAMC \times ROLL\_REF) COS(TVR\_ROLL \text{ RAD\_PER\_DEG})$$

$$MTP^* = MATRIX(THRUST\_BODY, THRUST\_BODY \times \bar{Y}_N, -\bar{Y}_N)$$

$$MTP^* = MTP^{*T} MATRIX(LAMC, LAMC \times \bar{Y}_T, -\bar{Y}_T)$$

- d. The M50-to-commanded-body quaternion ( $Q\_CB\_M50\_S$ ,  $Q\_CB\_M50\_V$ ) is computed by calling the MAT\_TO\_QUAT utility routine:

CALL MAT\_TO\_QUAT

Input:  $MTP^*$

Outputs:  $Q\_CB\_M50\_S$ ,  $Q\_CB\_M50\_V$

3. If the current time is greater than time of ignition ( $TGD > TIG$ ), the M50-to-commanded-body quaternion is computed as follows:

- a. The commanded unit thrust vector is transformed into current body coordinates by calling the QUAT\_XFORM utility routine:

CALL QUAT\_XFORM

Inputs:  $Q\_B\_I\_S$ ,  $Q\_B\_I\_V$ ,  $LAMC$

Outputs:  $\bar{UFB}$

- b. Obtain the difference of  $\overline{\text{THRUST\_BODY}}$  and  $\overline{\text{UFB}}$ :

$$\overline{\text{YN}} = \overline{\text{UFB}} - \overline{\text{THRUST\_BODY}}$$

- c. If the magnitude of  $\overline{\text{YN}}$  is less than 0.001, then no attitude change is required; hence set the body-to-commanded-body quaternion to identity:

$$\text{If } \text{ABVAL}(\overline{\text{YN}}) < 0.001, \text{ then } \text{Q\_CB\_B\_S} = 1, \overline{\text{Q\_CB\_B\_V}} = 0$$

- d. If  $\text{ABVAL}(\overline{\text{YN}}) > 0.001$ , then:

- (1) Construct the single rotation axis:

$$\overline{\text{SRA}} = \text{UNIT}(0, \text{YN}_3, -\text{YN}_2)$$

$$\text{If } \overline{\text{SRA}} \cdot \overline{\text{UFB}} < 0, \text{ then } \overline{\text{SRA}} = -\overline{\text{SRA}}$$

- (2) Compute the body-to-commanded-body quaternion:

$$\overline{\text{ATB}} = (\overline{\text{SRA}} \times \overline{\text{THRUST\_BODY}}) \times \overline{\text{SRA}}$$

$$\overline{\text{B}} = \text{UNIT}(\overline{\text{ATB}} + 0.5 \overline{\text{YN}})$$

$$\overline{\text{ATB}} = \text{UNIT}(\overline{\text{ATB}})$$

$$\text{Q\_CB\_B\_S} = \overline{\text{B}} \cdot \overline{\text{ATB}}$$

$$\overline{\text{Q\_CB\_B\_V}} = ((\overline{\text{B}} \times \overline{\text{ATB}}) \cdot \overline{\text{SRA}}) \overline{\text{SRA}}$$

- e. Compute the M50-to-commanded-body quaternion by calling the QUAT\_MULT utility routine:

CALL QUAT\_MULT

Inputs:  $\text{Q\_CB\_B\_S}, \overline{\text{Q\_CB\_B\_V}}, \text{Q\_B\_I\_S}, \overline{\text{Q\_B\_I\_V}}$

Outputs:  $\text{Q\_CB\_M50\_S}, \overline{\text{Q\_CB\_M50\_V}}$

4. After obtaining the M50-to-commanded-body quaternion ( $\text{Q\_CB\_M50\_S}, \overline{\text{Q\_CB\_M50\_V}}$ ), the ADI inertial to commanded body quaternion ( $\text{Q\_CB\_ADI\_S}, \overline{\text{Q\_CB\_ADI\_V}}$ ) is obtained by multiplying the M50-to-commanded-body quaternion with the ADI to M50 quaternion as follows:

CALL QUAT\_MULT

Inputs:  $\text{Q\_CB\_M50\_S}, \overline{\text{Q\_CB\_M50\_V}}, \text{Q\_M50\_INRTL\_ORB\_S}, \overline{\text{Q\_M50\_INRTL\_ORB\_V}}$

Outputs:  $\text{Q\_CB\_ADI\_S}, \overline{\text{Q\_CB\_ADI\_V}}$

5. The resulting quaternion ( $Q\_CB\_ADI\_S$ ,  $\overline{Q\_CB\_ADI\_V}$ ) is used in deriving the sines and cosines of the Euler angles by the QUAT\_TO\_ADI\_ANG module, as documented in the Flight Control Level C FSSR:

CALL QUAT\_TO\_ADI\_ANG

Inputs:  $Q\_CB\_ADI\_S$ ,  $Q\_CB\_ADI\_V$

Outputs: PTCHSINE, PTCHCOS, YAWSINE, YAWCOS, ROLLSINE, ROLLCOS,  $X\_FLAG$

6. If  $X\_FLAG$  is ON, compute the burn attitude.

$$VEH\_PITCH = \text{ARCTAN2}(-PTCHSINE, -PTCHCOS)/RAD\_PER\_DEG + 180$$

$$VEH\_YAW = \text{ARCTAN2}(-YAWSINE, -YAWCOS)/RAD\_PER\_DEG + 180$$

$$VEH\_ROLL = \text{ARCTAN2}(-ROLLSINE, -ROLLCOS)/RAD\_PER\_DEG + 180$$

If  $X\_FLAG$  is OFF, an attitude singularity exists and only the yaw burn attitude is computed.

If  $YAWSINE \geq 0$ , then  $VEH\_YAW = 90$

If  $YAWSINE < 0$ , then  $VEH\_YAW = 270$

B. Interface Requirements. The input and output parameters for the commanded body attitude task are given in Tables 4.1.9-1 and 4.1.9-2. A flow diagram of CMD BDY ATT TSK functional requirements is given in Appendix A.

C. Processing Requirements. The commanded body attitude task is performed once each time the premaneuver display support task (4.1.7) is called and cyclically when current time ( $T\_GMT$ ) exceeds time of ignition (TIG) minus BURN\_ENABLE\_WINDOW seconds until MM 202 is exited.

D. Initialization Requirements. None.

Table 4.1.9-1. Commanded Body Attitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V93H6915CB	OMS_PITCH_TRIM	OMS pitch angle	ON-ORB DAP	SP	deg
V93H6916CB	OMS_YAW_TRIM <sub>1</sub>	Left OMS yaw angle	ON-ORB DAP	SP	deg
V93H6918CB	OMS_YAW_TRIM <sub>2</sub>	Right OMS yaw angle	ON-ORB DAP	SP	deg
	PROP_FLAG_OFS	Prime propulsion system indicator	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
V94W3938C	TGD	GMT of guidance state vector	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	s
V97U4812C thru V97U4814C	THRUST_BOD $\bar{Y}$ _RCS_X	Unit body thrust vector for the +X RCS propulsive system in body coordinates	K-LOAD	SP	none
V90U1954CE thru V90U1956CE	LAMC	Unit desired thrust direction vector in M50 coordinates	GUID TSK PRE-MAN DISP SUP TSK	SP	none
	PROP_FLAG_OFS_P	Previous prime propulsion system indicator	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
V94H3930C thru V94H3932C	RGD	Vehicle position vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	ft
V90U1202C thru V90U1204C	VGD	Vehicle velocity vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
V93H6936C	TVR_ROLL	Thrust vector roll angle	I-LOAD, MNVR DISP	SP	deg
V97U4485C	PITCH_BIAS	Constant bias term to convert OMS engine electrical null pitch trim angles to the body axis reference	K-LOAD	SP	rad
V97U4829C	YAW_BIAS	Constant bias term to convert OMS engine electrical null yaw trim angles to the body axis reference	K-LOAD	SP	rad
V97U0383C	RAD_PER_DEG	Degree-to-radian conversion factor	CONSTANT	SP	rad/deg
V91W5000C	T_GMT	Current computer GMT time	FCOS	DP	s
V97U5127C	CBETA_EPS	Tolerance for roll reference vector orientation	K-LOAD	SP	none
V90U2240C thru V90U2243C	Q_B_I_S, Q $\bar{B}$ _I_V	M50 to body quaternion	ORB ATT PROC	SP	none
V94W3790C	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s



Table 4.1.9-1. Commanded Body Attitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V97U2368C	ONE_ENG_OMS_ YAW_TRIM <sub>1</sub>	Left OMS yaw trim for single engine*	K-LOAD	SP	deg
V97U2369C	ONE_ENG_OMS_ YAW_TRIM <sub>2</sub>	Right OMS yaw trim for single engine*	K-LOAD	SP	deg
V97U2367C	ONE_ENG_OMS_ PITCH_TRIM	Pitch trim for single engine*	K-LOAD	SP	deg
V97U2214CC thru V97U2217CC	Q_M50_INRTL_ ORB_S Q_M50_INRTL_ ORB_V	ADI to M50 Quaternion	K-LOAD	SP	none
*Note: This K-load is shared with ON-ORB DAP (4.35).					

Table 4.1.9-2. Commanded Body Attitude Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94U3980CA thru V94U3983CA	Q_CB_M50_S  Q_CB_M50_V	M50-to-commanded-body quaternion	PRE-MAN DISP SUPT TSK, ON-ORB DAP	SP	none
V93U6909CH thru V93U6911CH	VEH_PITCH VEH_ROLL VEH_YAW	ADI inertial Euler angle	MNVR DISP, TLM	SP	deg
	THRUST_BODY	Unit engine thrust direction in body coordinates	OMS TSK	SP	none
V90X0414XB	X_FLAG	Valid angle comp flag	MNVR DISP	D	none

**4.1.10 Parameter Tables for Orbit MNVR DIP (G4.158)**

The IDD inputs and outputs are listed in Tables 4.1.10–1 and 4.1.10–2 respectively. Values for the I–loads are contained in the I–load requirements document (JSC–19350); however, I–load definitions applicable to this principal function are listed in Table 4.1.10–3. K–loads are listed in Table 4.1.10–4. Constants are listed in Table 4.1.10–5. The cross–reference listing is presented in the table listed below.

Orbit MNVR DIP (G4.158) Cross Reference Listing		
Local Name	Source Name	MSID
$\dot{O}MS\_L\_CMD\_IND$	OMS_L_ON_CMD_IND	V90X8271X
$\dot{O}MS\_R\_CMD\_IND$	OMS_R_ON_CMD_IND	V90X8272X
$Q\_B\_I$	Q_BOD_M50(1)	V90U2240CB
	Q_BOD_M50(2)	V90U2241CB
	Q_BOD_M50(3)	V90U2242CB
	Q_BOD_M50(4)	V90U2243CB
$\overline{RNAV}$	R_AVGG(1)	V95H0185CF
	R_AVGG(2)	V95H0186CF
	R_AVGG(3)	V95H0187CF
T_GMT	CLOCK	V91W5000C
TNAV	T_STATE	V95W0200CF
$\overline{VNAV}$	V_AVGG(1)	V95L0190CF
	V_AVGG(2)	V95L0191CF
	V_AVGG(3)	V95L0192CF
$\overline{VS}$	V_IMU_OLD(1)	V95L0210CD
	V_IMU_OLD(2)	V95L0211CD
	V_IMU_OLD(3)	V95L0212CD

TABLE 4.1.10-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
BOTH_OMS	V93X6922XA	BOTH OMS ENG SEL	XXXXX MNVR DISP					
BOTH_OMS	V93X6922XB	BOTH OMS ENG SEL	UL					
BURN_ENABLE_WINDOW	V97U5181C	BURN ENABLE WINDOW	RM SWITCH/SURF FB DISP	S	DPL		93023D	
C1_DISP	V93U6966CD	INTERCEPT OF TARGET LINE	UL	FT/S				
C2_DISP	V93U6967CD	SLOPE OF TARGET LINE	UL					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER (GMT)	FCOS	S			93160B	*
DATA_ENTER	V93X6973X	TGT/SETUP DATA ENTERED FLAG	XXXXX MNVR DISP					
EARTH_POLE(1)	V90U0190C	X-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(2)	V90U0191C	Y-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(3)	V90U0192C	Z-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EXEC_CMD	V93X1050XA	BURN EXECUTE CMD	XXXXX MNVR DISP					
EXT_DV_LVLH(1)	V93L6950CA	EXT DELTA V X-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(1)	V93L6950CF	EXT DELTA V X-COMP	UL	FT/S				
EXT_DV_LVLH(2)	V93L6951CA	EXT DELTA V Y-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(2)	V93L6951CF	EXT DELTA V Y-COMP	UL	FT/S				
EXT_DV_LVLH(3)	V93L6952CA	EXT DELTA V Z-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CF	EXT DELTA V Z-COMP	UL	FT/S				
GUID_FLAG	V94X4029X	GUIDANCE OPTION FLAG	ORB TGT SPEC		BD		93017G	*
HTGT_DISP	V93U6968CD	TGT ALTITUDE MAGNITUDE	UL	NM				
LEFT_OMS	V93X6925XA	L OMS ENG SEL	XXXXX MNVR DISP					
LEFT_OMS	V93X6925XB	L OMS ENG SEL	UL					
LOAD_CMD	V93X6956X	LOAD COMMAND	XXXXX MNVR DISP		BD		93177D	*
M	V90U1961CD	CURRENT VEHICLE MASS	ORB GUID	SLUGS			89648A	
MNVR_CMPL_TIME_TGO	V95W7240CB	PREBURN MNVR TIME TO GO	ORB DAP	S	SPL		92510E	
OMS_L_ON_CMD_IND	V90X8271X	OMS-L ON CMD IND	OMS FIRE SEQ				90120B	
OMS_PITCH_TRIM	V93H6915CB	OMS PITCH TRIM	ORB DAP	DEG	SPL		89645A	
OMS_PITCH_TRIM	V93H6915CD	OMS PITCH TRIM	UL	DEG	SPL		89645A	
OMS_R_ON_CMD_IND	V90X8272X	OMS-R ON CMD IND	OMS FIRE SEQ				90120B	
OMS_YAW_TRIM(1)	V93H6916CB	OMS L YAW TRIM	ORB DAP	DEG	SPL		89645A	
OMS_YAW_TRIM(1)	V93H6916CD	OMS L YAW TRIM	UL	DEG	SPL		89645A	
OMS_YAW_TRIM(2)	V93H6918CB	OMS R YAW TRIM	ORB DAP	DEG	SPL		89645A	
OMS_YAW_TRIM(2)	V93H6918CD	OMS R YAW TRIM	UL	DEG	SPL		89645A	
OP_CODE	V96J3524C	OP CODE TO DEFINE CMD LOAD	UL				89590B	
PEG_MODE_4	V93X6976XD	PEG4/PEG 7 TGT DATA ENTERED	UL					
PLUS_X_RCS	V93X6929XA	RCS ENG SEL CMD	XXXXX MNVR DISP					
PLUS_X_RCS	V93X6929XB	RCS ENG SEL CMD	UL					
PREBURN_MNVR_IN_PROGRESS	V90X1589XB	PRE-BURN MNVR-IN-PROGRESS FLAG	ORB DAP				92510E	
PROP_DEP	V93U6970CD	OUT OF PLANE PRPLT WASTE	UL					
Q_M50_LVLH(1)	V90U2641CA	M50 WRT_LVLH QUAT 1	ORB ATT PROC				93017G	*
Q_M50_LVLH(2)	V90U2642CA	M50 WRT_LVLH QUAT 2	ORB ATT PROC				93017G	*
Q_M50_LVLH(3)	V90U2643CA	M50 WRT_LVLH QUAT 3	ORB ATT PROC				93017G	*
Q_M50_LVLH(4)	V90U2644CA	M50 WRT_LVLH QUAT 4	ORB ATT PROC				93017G	*
RIGHT_OMS	V93X6926XA	R OMS ENG SEL	XXXXX MNVR DISP					
RIGHT_OMS	V93X6926XB	R OMS ENG SEL	UL					
R_AVGG(1)	V95H0185CF	X-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*

TABLE 4.1.10-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
R_AVGG(2)	V95H0186CF	Y-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CF	Z-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_OFFSET_GUID(1)	V94H4016CA	LAMBERT TGT OFFSET VECTOR X-COMP	ORB TGT SPEC	FT			93017G	*
R_OFFSET_GUID(2)	V94H4017CA	LAMBERT TGT OFFSET VECTOR Y-COMP	ORB TGT SPEC	FT			93017G	*
R_OFFSET_GUID(3)	V94H4018CA	LAMBERT TGT OFFSET VECTOR Z-COMP	ORB TGT SPEC	FT			93017G	*
R_PRED_FINAL(1)	V95H0811C	X-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
R_PRED_FINAL(2)	V95H0812C	Y-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
R_PRED_FINAL(3)	V95H0813C	Z-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
START_BACKGROUND	V95X7328X	BEGIN TARGETING CALCULATION FLAG	ORB TGT SPEC					
ST_CRT_TIMER	V93X6553X	START CRT TIMER CMD	XXXXX MNVR DISP		BD		89461	
S_ROTATE_GUID	V94J4025CA	NEAR 180 DEG MNVR PROJ FLAG	ORB TGT SPEC				93017G	*
TB_TIME	V90W8625C	ENGINE IGNITION TIME BASE TIME	MSC	S			89599C	
THETA_DISP	V93U6969CD	TGT INPLN DNRNG ANG FROM LANH	UL	RAD				
TIG	V94W3790CD	TIME OF IGNITION	UL	S				
TIG_DAY	V93W6947CA	TIG(DAYS)	XXXXX MNVR DISP	DAYS				
TIG_HR	V93W6944CA	TIG(HOURS)	XXXXX MNVR DISP	HRS				
TIG_MIN	V93W6945CA	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_SEC	V93W6946CA	TIG(SEC)	XXXXX MNVR DISP	S				
TVR_ROLL	V93H6936CA	ROLL ANGLE	XXXXX MNVR DISP	DEG				
TVR_ROLL	V93H6936CD	ROLL ANGLE	UL	DEG				
T_GMT_MET	V91X1013X	GMT/MET SELECT IND	FCOS		BD			
T_MET_REF	V91M1996P	MET REFERENCE	SYS S/W	S			93017G	*
T_OFFSET_GUID	V94W4015CA	TIME OF LAMB TGT POSN VECTOR	ORB TGT SPEC	S			93017G	*
T_STATE	V95W0200CF	TIME TAG ASSOC WITH CURRENT STATE	ORB UPP	S			93017G	*
VEH_PITCH	V93U6909CE	PITCH ANGLE IN ADI INERTIAL COORD	UL	DEG				
VEH_ROLL	V93U6910CE	ROLL ANGLE IN ADI INERTIAL COORD	UL	DEG				
VEH_YAW	V93U6911CE	YAW ANGLE IN ADI INERTIAL COORD	UL	DEG				
VGO-X	V90L2118C	X VEL TO BE GAINED VECTOR IN M50	ORB GUID	FT/S				
VGO-Y	V90L2119C	Y VEL TO BE GAINED VECTOR IN M50	ORB GUID	FT/S				
VGO-Z	V90L2120C	Z VEL TO BE GAINED VECTOR IN M50	ORB GUID	FT/S				
V_AVGG(1)	V95L0190CF	X-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CF	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CF	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_IMU_OLD(1)	V95L0210CD	X-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	
V_IMU_OLD(2)	V95L0211CD	Y-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	
V_IMU_OLD(3)	V95L0212CD	Z-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	
V_PRED_FINAL(1)	V95L0814C	X-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
V_PRED_FINAL(2)	V95L0815C	Y-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
V_PRED_FINAL(3)	V95L0816C	Z-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
WT_DISP	V93G6940CA	VEHICLE WEIGHT	XXXXX MNVR DISP	LB				
WT_DISP	V93G6940CD	VEHICLE WEIGHT	UL	LBS				

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.1.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ATM	V94J3999CA	ATTITUDE MODE FLAG	DL FMT 22/1 DL FMT 32/1 ORB PRED				93017G	*
BOTH_OMS	V93X6922XD	BOTH OMS ENG SEL	XXXXX MNVR DISP					
BURN_ENABLE	V94X3815XB	BURN ENABLE	MSC				92876B	
CRT_COUNTDOWN	V94X4064XD	CRT TIMER COUNTDOWN FLAG	FCOS					
CRT_SEC	V94W4053CD	SECONDS TO IGNITION	FCOS	S				
CRT_TIMER_START	V94X4063XD	CRT TIMER START FLAG	FCOS					
CUR_HA	V94H3810CB	CURRENT APOGEE ALTITUDE	DL FMT 22/1 XXXXX MNVR DISP	NM			93017G	*
CUR_HP	V94H3811CB	CURRENT PERIGEE ALTITUDE	DL FMT 22/1 XXXXX MNVR DISP	NM			93017G	*
DMP	V94X3969XA	PROPER DRAG MODEL FLAG	ORB PRED					
DV_TOT	V94L3795CB	TOTAL DELTA V REQD FOR MANEUVER	DL FMT 22/1 XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(1)	V93L6950CE	EXT DELTA V X-COMP	DL FMT 22/A ORB GUID XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(2)	V93L6951CE	EXT DELTA V Y-COMP	DL FMT 22/A ORB GUID XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CE	EXT DELTA V Z-COMP	DL FMT 22/A ORB GUID XXXXX MNVR DISP	FT/S			93017G	*
GMD_PRED	V94J3975CA	GRAVITY MODEL DEGREE FLAG	ORB PRED					
GMO_PRED	V94J3963CA	GRAVITY MODEL ORDER FLAG	ORB PRED					
IN_VGO(1)	V94H4026C	INITIAL VEL TO GO VECTOR X-COMP	ORB GUID					
IN_VGO(2)	V94H4027C	INITIAL VEL TO GO VECTOR Y-COMP	ORB GUID				92739D	
IN_VGO(3)	V94H4028C	INITIAL VEL TO GO VECTOR Z-COMP	ORB GUID				92739D	
LAMBERT_FLAG	V94X4024X	LAMBERT GUIDANCE MODE FLAG	ORB GUID					
LEFT_OMS	V93X6925XD	L OMS ENG SEL	XXXXX MNVR DISP					
LOAD_FLASH	V94X3814XB	LOAD FLASH FLAG	DL FMT 22/A ORB TGT SPEC XXXXX MNVR DISP				93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CJ	CURRENT VEHICLE MASS	ORB DAP ORB GUID TLM	SLUGS			89250B	
MNVR_TITLE_IND	V94U4096CC	DISPLAY TITLE IND	XXXXX MNVR DISP				91072D	
OMSL_ACT_SEL	V93J6904CC	L P/S/OFF GMBL ACTR SEL	OMS RM					
OMSR_ACT_SEL	V93J6906CC	R P/S/OFF GMBL ACTR SEL	OMS RM					
PLUS_X_RCS	V93X6929XD	RCS ENG SEL CMD	XXXXX MNVR DISP					
PREBURN_MNVR_DISP	V85X9529XB	PREBURN MANEUVER DISPLAY FLAG	XXXXX MNVR DISP		BD		92859C	
PRED_ORB_AREA	V93U6955CC	ORBITER REF AREA USED IN PRED	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT2			93017G	*

TABLE 4.1.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
PRED_ORB_CD	V93U6954CC	ORBITER DRAG COEFF USED IN PRED	DL FMT 22/1 DL FMT 32/1 ORB PRED				93017G	*
PRED_ORB_MASS	V93U6953CC	ORBITER MASS USED IN PREDICTION	DL FMT 22/1 DL FMT 32/1 ORB PRED	SLUGS			93017G	*
PRED_STEP	V90W3964CA	INTEGRATION STEP SIZE	DL FMT 22/1 DL FMT 32/1 ORB PRED	S			93017G	*
PROP_FLAG_GUID	V94X3962XA	PRIME PROP SYS FLAG FOR GUID	ORB GUID					
PROP_FLAG_OFS	V94J3791CB	PRIME PROP SYS INDICATOR FLAG	DL FMT 22/A MSC OMS FIRE SEQ				93017G	*
Q_CB_M50_S	V94U3980CA	M50 TO BODY QUAT ELEM 1	ORB DAP					
Q_CB_M50_V(1)	V94U3981CA	M50 TO BODY QUAT ELEM 2	ORB DAP					
Q_CB_M50_V(2)	V94U3982CA	M50 TO BODY QUAT ELEM 3	ORB DAP					
Q_CB_M50_V(3)	V94U3983CA	M50 TO BODY QUAT ELEM 4	ORB DAP					
RIGHT_OMS	V93X6926XD	R OMS ENG SEL	XXXXX MNVR DISP					
R_OFFSET_GUID(1)	V94H4016CB	LAMBERT TGT OFFSET VECTOR X-COMP	ORB GUID					
R_OFFSET_GUID(2)	V94H4017CB	LAMBERT TGT OFFSET VECTOR Y-COMP	ORB GUID					
R_OFFSET_GUID(3)	V94H4018CB	LAMBERT TGT OFFSET VECTOR Z-COMP	ORB GUID					
R_PRED_INIT(1)	V94H4002CA	X-COMP POS VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT			93017G	*
R_PRED_INIT(2)	V94H4003CA	Y-COMP POS VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT			93017G	*
R_PRED_INIT(3)	V94H4004CA	Z-COMP POS VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT			93017G	*
S_ROTATE_GUID	V94J4025CB	NEAR 180 DEG MNVR PROJ FLAG	ORB GUID					
TB_ENABLE	V94X3826XC	TIME BASE TIME INITIATOR FLAG	MSC TLM				92739D	
TGT_HA	V94H3798CB	TARGET APOGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
TGT_HP	V94H3799CB	TARGET PERIGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
TIG	V94W3790CC	TIME OF IGNITION	DL FMT 22/A MSC ORB GUID	S			93017G	*
TIG_DAY	V93W6947CE	TIG(DAYS)	XXXXX MNVR DISP	DAYS				
TIG_HR	V93W6944CE	TIG(HOURS)	XXXXX MNVR DISP	HR				
TIG_MIN	V93W6945CE	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_MINUS5_FLAG	V94X3813XB	ENGINE IGNITION MINUS 5 SEC FLAG	XXXXX MNVR DISP					
TIG_SEC	V93W6946CE	TIG(SEC)	XXXXX MNVR DISP	S				
TTG	V90W2638CB	DISPLAY PREBURN MNVR TIME TO GO	XXXXX MNVR DISP	S	SPL		92510E	
TTG_FLAG	V90X2639XB	TTG DISPLAY INTENSITY FLAG	XXXXX MNVR DISP		BD		92510E	

TABLE 4.1.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
TT_X	V94W3796CB	TIME TO NEXT APSIS/FREE FALL	DL FMT 22/1 XXXXX MNVR DISP	S			93017G	*
TVR_ROLL	V93H6936CC	ROLL ANGLE	DL FMT 22/1 XXXXX MNVR DISP	DEG			93017G	*
TXX_FLAG_DISP	V94X3961X	APSIS INDICATOR (A.P.C)	XXXXX MNVR DISP		BD			
T_OFFSET_GUID	V94W4015CB	TIME OF LAMB TGT POSN VECTOR	ORB GUID					
T_PRED_FINAL	V94W3979CA	TIME AT WHICH STATE IS DESIRED	DL FMT 22/1 DL FMT 32/1 ORB PRED	S			93017G	*
T_PRED_INIT	V94W3970CA	TIME AT BEGINNING OF PRED	DL FMT 22/1 DL FMT 32/1 ORB PRED	S			93017G	*
VEH_PITCH	V93U6909CD	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 22/A XXXXX MNVR DISP	DEG			93017G	*
VEH_ROLL	V93U6910CD	ROLL ANGLE IN ADI INERTIAL COORD	DL FMT 22/A XXXXX MNVR DISP	DEG			93017G	*
VEH_YAW	V93U6911CD	YAW ANGLE IN ADI INERTIAL COORD	DL FMT 22/A XXXXX MNVR DISP	DEG			93017G	*
VGO(X)	V94L3804CB	X-EXTERNAL DEL V TARGET VECTOR	ORB GUID	FT/S				
VGO(Y)	V94L3805CB	Y-EXTERNAL DEL V TARGET VECTOR	ORB GUID	FT/S				
VGO(Z)	V94L3806CB	Z-EXTERNAL DEL V TARGET VECTOR	ORB GUID	FT/S				
VGO_DISP(X)	V94U3800CB	X-COMP OF VGO OF MNVR-BODY COORD	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_DISP(Y)	V94U3801CB	Y-COMP OF VGO OF MNVR-BODY COORD	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_DISP(Z)	V94U3802CB	Z-COMP OF VGO OF MNVR-BODY COORD	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_LVLH(X)	V94L3945CC	PEG 4 LVLH X-COMP OF VGO	TLM XXXXX MNVR DISP	FT/S				
VGO_LVLH(Y)	V94L3946CC	PEG 4 LVLH Y-COMP OF VGO	TLM XXXXX MNVR DISP	FT/S				
VGO_LVLH(Z)	V94L3947CC	PEG 4 LVLH Z-COMP OF VGO	TLM XXXXX MNVR DISP	FT/S				
VMP	V94X3971XA	PROPER VENT MODEL FLAG	ORB PRED					
VSP(1)	V95L3878C	X-COMP OF CURRENT ACCUM IMU VEL	ORB GUID	FT/S	DPL		92843B	
VSP(2)	V95L3879C	Y-COMP OF CURRENT ACCUM IMU VEL	ORB GUID	FT/S	DPL		92843B	
VSP(3)	V95L3880C	Z-COMP OF CURRENT ACCUM IMU VEL	ORB GUID	FT/S	DPL		92843B	
V_PRED_INIT(1)	V94L4006CA	X-COMP VEL VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT/S			93017G	*
V_PRED_INIT(2)	V94L4007CA	Y-COMP VEL VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT/S			93017G	*
V_PRED_INIT(3)	V94L4008CA	Z-COMP VEL VEC AT INITIAL TIME	DL FMT 22/1 DL FMT 32/1 ORB PRED	FT/S			93017G	*

TABLE 4.1.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT MANEUVER DISPLAY PROCESSING (G4.158)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
WT_DISP	V93G6940CC	VEHICLE WEIGHT	XXXXX MNVR DISP	LB				
X_FLAG	V90X0414XC	VALID ANGLE COMP FLAG	XXXXX MNVR DISP		BD		90763E	
	V94M3042PB	CGZB_MNVR_DISP_FLAG1	DL FMT 22/A				93017G	*

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

**Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
(HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec**



TABLE 4.1.10-3. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
M	V97U4429C	SLUGS	F	S	M	X	G4.1 G4.158 G4.211	01 02 03 08 09	AMC ZF2 AMC ZF2 AMC	DC2248	
REF_ORB_AREA	V96U9160C	FT**2	F	S	D	P	G4.126 G4.148 G4.158	00	ZFB	89622A	
TVR_ROLL	V93H6936C	DEG	F	S	D	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	00	ZF2	91019A	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.1.10-4. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
BURN_ENABLE_WINDOW BURN ENABLE WINDOW	V97U5181C	00	-1.5	E+01 SEC	F	D	X	G3.3 G4.158 G4.210 G4.211	92751B	
CBETA_EPS	V97U5127C	00	+9.998480	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89542A	
DELT_H_CIRC	V97U4832C	00	+5.0	E+00 NMI	F	S	A	G4.158 G4.210 G4.211	39534	
DTMIN	V97U4370C	01 02 03	+2.0 +3.00 +2.0	E+00 SEC E+02 E+00	F	S	C	G4.13 G4.158 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	29975A	
FT1 VACUUM THRUST OF TWO OMS ENGINES	V97U5034C	00	+1.2174000	E+04 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT2 VACUUM THRUST OF ONE OMS ENGINES	V97U5035C	00	+6.0870000	E+03 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT3 VACUUM THRUST OF PRIMARY RCS JETS	V97U5036C	02 03	+1.780 +3.509	E+03 LBS E+03	F	S	P	G4.158 G4.209 G4.211 G4.7	90329C	
ONE_ENG_OMS_PITCH_TRIM OMS ENG PITCH TRIM ANG THRUST -CG	V97U2367C	01 02 03	+4.0 -1.0 -3.1	E-01 DEG E-01 E-01	F	S	X	G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	

TABLE 4.1.10-4. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
ONE_ENG_OMS_YAW_TRIM(1) OMS ENG YAW TRIM ANG THRUST - CG	V97U2368C	01	+5.2100000	E+00	DEG	F	S	C G4.158	90353G	
		02	+5.2100000	E+00				G4.201		
		03	+5.2100000	E+00				G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.35		
								G4.7		
ONE_ENG_OMS_YAW_TRIM(2) OMS ENG YAW TRIM ANG THRUST - CG	V97U2369C	01	-5.2100000	E+00	DEG	F	S	C G4.158	90353G	
		02	-5.2100000	E+00				G4.201		
		03	-5.2100000	E+00				G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.35		
								G4.7		
PITCH_BIAS CONST OMS ENG ELEC PITCH TRIM ANG	V97U4485C	00	+2.7605300	E-01	RAD	F	S	C G4.158	59955	
								G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.7		
Q_M50_INRTL_ORB(1) M50 WRT INERT QUAT ELEM 1	V97U2214CC	00	+1.0	E+00	ND	F	S	P G4.158	89590B	
								G4.213		
								G4.7		
								G4.97		
Q_M50_INRTL_ORB(2) M50 WRT INERT QUAT ELEM 2	V97U2215CC	00	+0.0	E+00	ND	F	S	P G4.158	89590B	
								G4.213		
								G4.7		
								G4.97		
Q_M50_INRTL_ORB(3) M50 WRT INERT QUAT ELEM 3	V97U2216CC	00	+0.0	E+00	ND	F	S	P G4.158	89590B	
								G4.213		
								G4.7		
								G4.97		
Q_M50_INRTL_ORB(4) M50 WRT INERT QUAT ELEM 4	V97U2217CC	00	+0.0	E+00	ND	F	S	P G4.158	89590B	
								G4.213		
								G4.7		
								G4.97		
REF_ORB_CD	V96U9161C	00	+2.0	E+00	ND	F	S	P G4.126	89542A	
								G4.148		
								G4.158		
THRUST_BODY_RCS_X(1) X-COMPONENT OF RCS THRUST DIRECTION	V97U4812C	00	+9.8480780	E-01	ND	F	S	C G4.158	90329C	
								G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.7		

TABLE 4.1.10-4. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
THRUST_BODY_RCS_X(2) Y-COMPONENT OF RCS THRUST DIRECTION	V97U4813C	00	+0.0	E+00 ND	F		S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(3) Z-COMPONENT OF RCS THRUST DIRECTION	V97U4814C	00	+1.7364820	E-01 ND	F		S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
VEX1 TWO OMS EXHAUST VELOCITY	V97U5114C	00	+1.0136800	E+04 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90924B	
VEX2 ONE OMS EXHAUST VELOCITY	V97U5115C	00	+1.0136800	E+04 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90924B	
VEX3 RCS EXHAUST VELOCITY	V97U5116C	00	+8.2327000	E+03 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90329C	
YAW_BIAS CNST OMS ENG ELEC YAW TRIM ANGLE	V97U4829C	00	+1.134460	E-01 RAD	F		S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89541	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.1.10-5. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_MU EARTH GRAVITATIONAL CONSTANT	V97U4378C	00	+1.40764487566E+16	FT**3/SEC**2	F		D C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.2 G4.205 G4.209 G4.210 G4.211 G4.224 G4.236 G4.3 G4.4 G5.10 G5.24 G5.26 G5.27	93090E	
EARTH_RADIUS_EQUATOR EARTH EQUATORIAL RADIUS	V97U5324C	00	+2.09257414698E+07	FT	F		D C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.19 G4.20 G4.205 G4.210 G4.211 G4.213 G4.23 G4.236 G4.238 G4.24 G4.25 G5.26 G5.27 V5.1.8	93090E	

TABLE 4.1.10-5. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
G_2_FPS2 MASS-TO-WEIGHT CONVERSION	V97U4393C	00	+3.2174049	E+01	LB/SLUG	F	S	P A6.9 G4.13 G4.148 G4.158 G4.210 G4.211 G4.5	90374C	
J2_GRAV J2 GRAVITY HARMONIC	V97U4416C	00	+1.0826271	E-03	LB/SLUG	F	S	P A6.9 G4.158 G4.210 G4.211	90374C	
NAUTMI_PER_FT FEET TO NAUTICAL MILES CONVERSION FACTOR	V97U5423C	00	+1.6457884	E-04	NMI/FT	F	S	C A6.9 G4.127 G4.144 G4.158 G4.19 G4.20 G4.205 G4.21 G4.210 G4.211 G4.220 G4.23 G4.237 G4.24 G4.25 G4.8 G5.27	93090E	

TABLE 4.1.10-5. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PI RATIO OF CIRCUMFERENCE TO DIAMETER	V98U8725C	00	+3.14159265358E+00	ND	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.144 G4.15 G4.158 G4.16 G4.19 G4.2 G4.20 G4.205 G4.209 G4.210 G4.213 G4.220 G4.236 G4.237 G4.3 G4.4 G4.5 G4.97 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.1.10-5. ORBIT MANEUVER DISPLAY PROCESSING (G4.158) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RAD_PER_DEG DEGREE TO RADIAN CONVERSION FACTOR	V97U0383C	00	+1.7453293	E-02	RAD/DEG	F	S	C A6.9 G4.1 G4.126 G4.127 G4.128 G4.144 G4.15 G4.158 G4.175 G4.20 G4.201 G4.204 G4.205 G4.209 G4.210 G4.211 G4.213 G4.220 G4.223 G4.226 G4.227 G4.236 G4.237 G4.3 G4.35 G4.36 G4.7 G4.72 G4.9 G4.97 G5.27	93090E	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**



## 4.2 ON-ORBIT GUIDANCE PRINCIPAL FUNCTION (ON-ORB GUID)

The On-orbit Guidance principal function (referenced in the Level B CPDS, paragraph 4.7) provides guidance requirements for the on-orbit maneuver execute major mode (MM 202). Since the requirements of this section are interrelated with the requirements for the On-Orbit Maneuver Execute Display Processing principal function (ORBIT MNVR DIP), it is recommended that Section 4.1 be read prior to this section.

### 4.2.1 Overview

ON-ORB GUID is active during the on-orbit maneuver execute major mode, beginning a K-load value (BURN\_ENABLE\_WINDOW) seconds prior to the planned ignition time and ending at the transition out of the maneuver execute major mode (Event 73) or the crew enters new target data or a LOAD item is made on the maneuver display (Event 69B).

The primary requirement of this principal function is to perform an externally targeted maneuver in support of on-orbit operations, specifically orbit shaping and rendezvous maneuvers. The powered flight guidance algorithms used for on-orbit maneuvers are external delta velocity, in which the thrust is directed along the velocity-to-be-gained vector until the specified velocity change has been achieved, and Lambert, in which velocity-to-be-gained is continuously updated to achieve position targets.

The externally computed targets are input to ON-ORB GUID from the ORBIT MNVR DIP along with the prime propulsive system flag. Engine ON command indicators from the OMS FIRE SEQ are monitored internal to guidance and the initial propulsive system flag is updated to allow transition across an engine failure so that if an OMS fails during a two-OMS burn, guidance will allow completion of the maneuver with the remaining OMS. If both OMS fail during the maneuver or nominal OMS cutoff occurs, guidance downmodes to the +X RCS configuration, allowing the maneuver to be manually completed, if desired, using the RCS. In any case, the velocity-to-be-gained vector and TGO are computed and output to the ORBIT MNVR DIP for display. For an OMS maneuver, the time of engine cutoff is computed by guidance and output to the MSC to cue engine cutoff.

A typical timeline of guidance-related events for the on-orbit maneuver execute major mode is as follows:

1. Guidance calculations are initiated.
2. Engine ignition occurs and attitude errors are removed by the ON-ORBIT DAP using guidance commands.
3. If an engine failure occurs, guidance updates propulsive system parameters.
4. Time of engine cutoff is computed for the OMS/RCS maneuver.
5. Engine cutoff occurs.
6. Velocity residuals are trimmed.
7. The maneuver execute major mode is exited by crew action.

Figures 4.2.1-1, 4.2.1-2, and 4.2.1-3 illustrate the on-orbit guidance task organization, functional flow, and data flow.

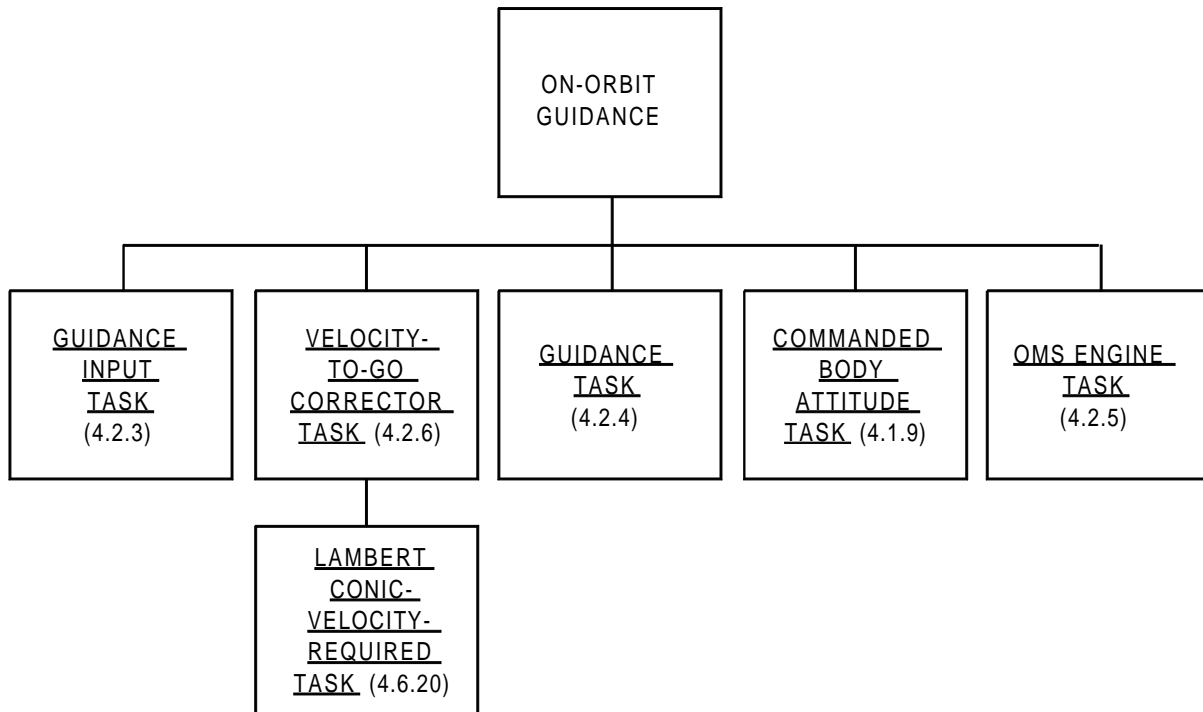


FIGURE 4.2.1-1. On-Orbit Guidance Principal Function Task Organization

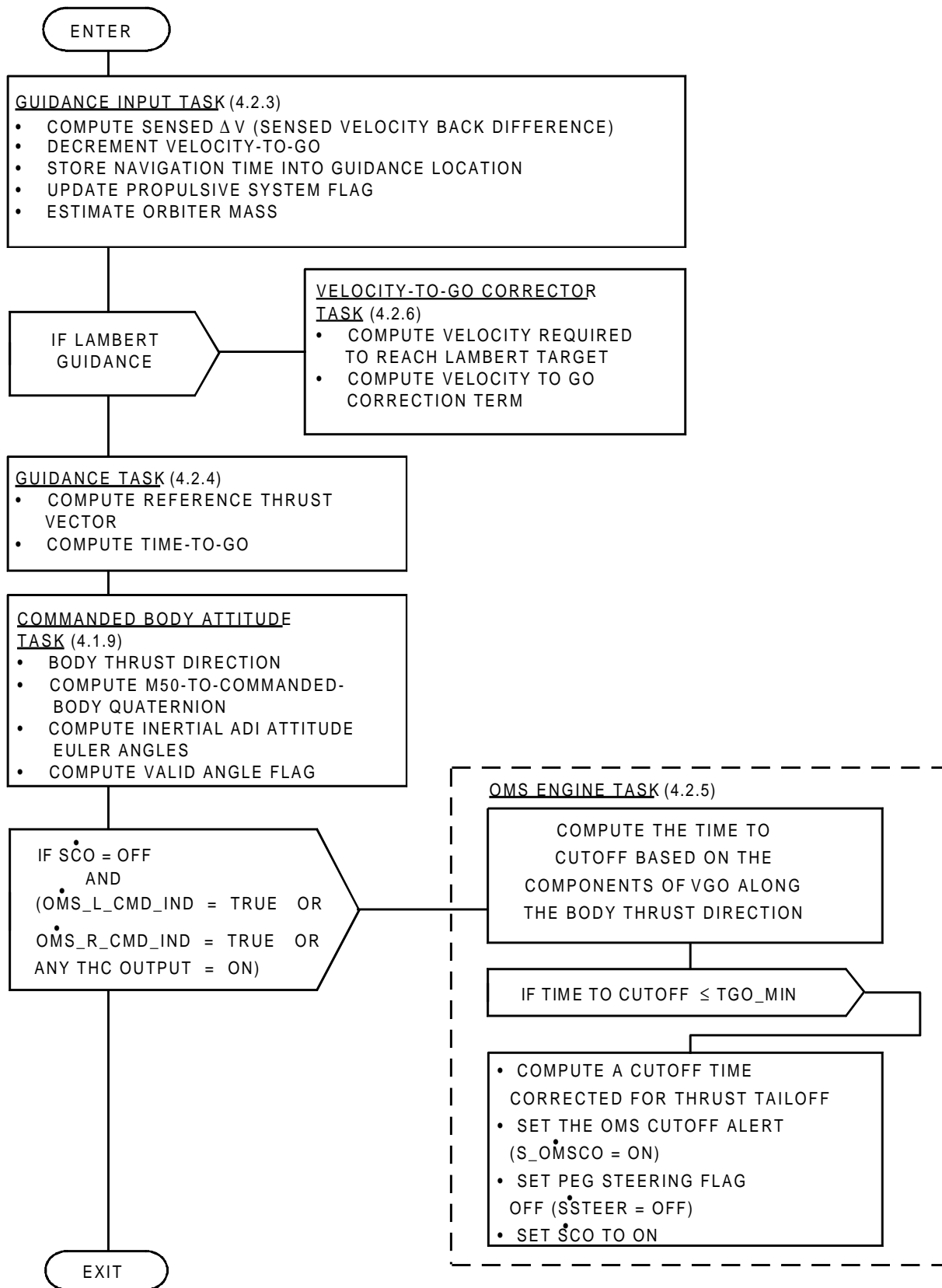
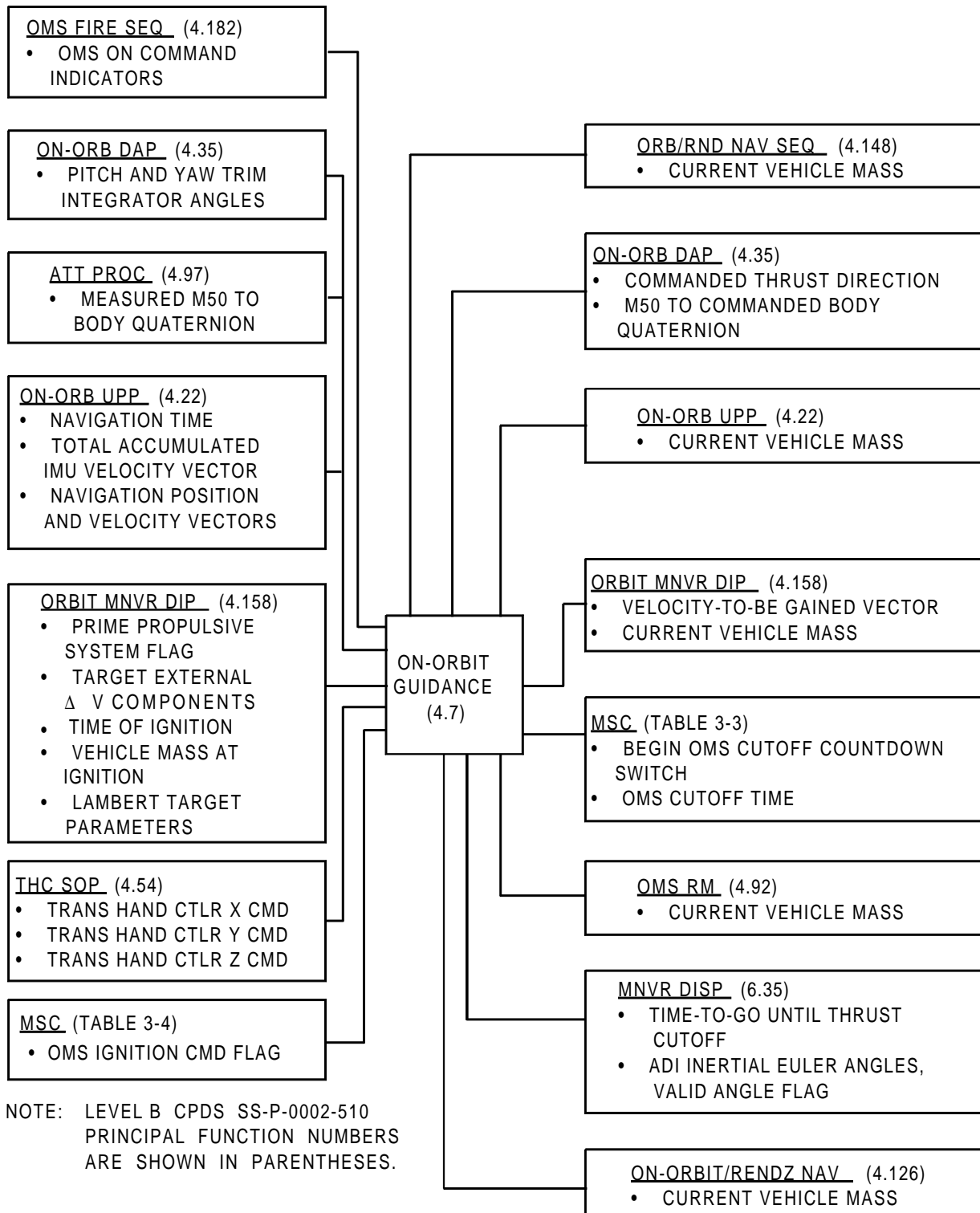


FIGURE 4.2.1-2. On-Orbit Guidance Principal Function Functional Flow



NOTE: LEVEL B CPDS SS-P-0002-510  
 PRINCIPAL FUNCTION NUMBERS  
 ARE SHOWN IN PARENTHESES.

FIGURE 4.2.1-3. On-Orbit Guidance Data Flow

#### 4.2.2 On-Orbit Guidance Sequencing (ON-ORB GUID SEQ)

The correct sequencing of some of the tasks defined in the On-Orbit Guidance principal function are dependent on the occurrence of specific events. These events are identified in the Level B CPDS SS-P-0002-510.

On-orbit Guidance is composed of the following tasks:

1. Guidance Input Task (4.2.3)
2. Guidance Task (4.2.4)
3. OMS Engine Task (4.2.5)
4. Commanded Body Attitude Task (4.1.9)
5. Velocity-to-Go Corrector Task (4.2.6)

The guidance input task is performed in every guidance pass, followed by the guidance task and the OMS engine task.

Detailed sequencing requirements are:

1. The guidance input task is initiated when On-Orbit Guidance is initiated and is terminated when On-Orbit Guidance is terminated. It is performed every 0.96 second.
2. The velocity-to-go corrector task is performed only when Lambert guidance is desired (LAMBERT\_FLAG = 1). It is initiated when On-Orbit Guidance is initiated and is terminated when On-Orbit Guidance is terminated. It is performed every 3.84 seconds.
3. The guidance task is initiated when On-Orbit Guidance is initiated and is terminated when On-Orbit Guidance is terminated. It is performed every 0.96 second after the guidance input task.
4. The commanded body attitude task is initiated when On-Orbit Guidance is initiated and is terminated when On-Orbit Guidance is terminated. It is performed every 0.96 second after the guidance task.
5. The OMS engine task is initiated at ignition (OMS L or R CMD IND = TRUE or any THC output is ON) and is terminated after the cutoff flag is set (SCO = ON). It is performed every 0.96 second after the commanded body attitude task.

### 4.2.3 Guidance Input Task (GUID INP TSK)

This task decrements the velocity-to-go by the accumulated IMU-sensed velocity change since the previous pass, estimates vehicle mass, and monitors the OMS ON command indicators and updates the propulsive system flag when an engine is shut down, and stores the current navigation time.

A. Detailed Requirements. The velocity-to-go is decremented by the accumulated IMU-sensed velocity change since the previous pass. To do this, the following three steps are performed:

1. The saved past value of the accumulated IMU-sensed velocity ( $\overline{VSP}$ ) is subtracted from the current value ( $\overline{VS}$ ) to obtain the change since the last guidance pass ( $\overline{DVS}$ ):

$$\overline{DVS} = \overline{VS} - \overline{VSP}$$

2. Velocity-to-go ( $\overline{VGO}$ ) is decremented by the IMU-sensed velocity ( $\overline{DVS}$ ) and the VGO correction term ( $\overline{DVGO}$ )

$$\overline{VGO} = \overline{VGO} - \overline{DVS} + \overline{DVGO}$$

$$\overline{DVGO} = 0$$

After engine cutoff,  $\overline{VGO}$  becomes the velocity residual to be manually trimmed.

3. The current value is saved for the next pass:

$$\overline{VSP} = \overline{VS}$$

4. The navigated state and timetag are saved for use by the commanded body attitude task and the vgo corrector task.

$$\overline{RGD} = \overline{RNAV}; \overline{VGD} = \overline{VNAV}; \overline{TGD} = \overline{TNAV}$$

5. If OMS ignition has been commanded, the OMS engine ON command indicators are monitored and the current propulsive system flag (PROP\_FLAG) is updated when an engine is shut down. A flag indicating the active propulsion system (left, right, or both OMS, or +X RCS) (PROP\_FLAG\_OFS) must also be set for use in calculating the commanded body attitude:

If  $\text{OMS\_IGNITION\_CMD} = \text{ON}$ , then

If  $\text{OMS\_L\_ON\_CMD\_IND} = \text{ON}$  and  $\text{OMS\_R\_ON\_CMD\_IND} = \text{OFF}$ , then

$$\text{PROP\_FLAG} = 2 \text{ and } \text{PROP\_FLAG\_OFS} = 2$$

If  $\text{OMS\_L\_ON\_CMD\_IND} = \text{OFF}$  and  $\text{OMS\_R\_ON\_CMD\_IND} = \text{ON}$ , then

$$\text{PROP\_FLAG} = 2 \text{ and } \text{PROP\_FLAG\_OFS} = 3$$

If  $\text{OMS\_L\_ON\_CMD\_IND} = \text{OFF}$  and  $\text{OMS\_R\_ON\_CMD\_IND} = \text{OFF}$ , then

$$\text{PROP\_FLAG} = 3 \text{ and } \text{PROP\_FLAG\_OFS} = 4$$

where  $\text{OMS\_L\_ON\_CMD\_IND}$  and  $\text{OMS\_R\_ON\_CMD\_IND}$  are discretely set to ON in the OMS FIRE SEQ principal function when the left or right OMS engines, respectively, are

commanded to fire. Propulsive system flag values and the corresponding propulsive system configuration assumed are:

$$\text{PROP\_FLAG} = 1 \quad 2 \text{ OMS}$$

$$\text{PROP\_FLAG} = 2 \quad 1 \text{ OMS}$$

$$\text{PROP\_FLAG} = 3 \quad +X \text{ RCS}$$

Beginning at the time of ignition (TIG) and terminating when time-to-go (TGO) becomes zero, current orbiter mass is estimated based on the exhaust velocity of the current propulsive system ( $\text{VEX}_{\text{PROP\_FLAG}}$ ), indicated by PROP\_FLAG, and the change in sensed velocity as:

$$M = M \text{ EXP } (-\text{ABVAL}(\overline{DVS})/\text{VEX}_{\text{PROP\_FLAG}})$$

where the initial mass value is obtained from the ORBIT MVNR DIP principal function.

B. Interface Requirements. The input and output parameters for the guidance input task are given in Tables 4.2.3-1 and 4.2.3-2. A flow diagram of GUID INP TSK functional requirements is given in Appendix A.

C. Processing Requirements. The guidance input task is performed prior to any other guidance task at 1.0 Hz from the time On-Orbit Guidance is initiated until On-Orbit Guidance is terminated.

D. Initialization Requirements. The following value must be initialized.

$$\text{VSP} = \text{VS}$$

The time of cutoff (T\_CUTOFF) must be initialized to zero, the cutoff flag set to off,  $\overline{DVGO}$  set to zero and the current propulsive system flag (PROP\_FLAG) set to the initial propulsive system flag (PROP\_FLAG\_GUID) the first time this task is executed following a load.

$$\text{T\_CUTOFF} = 0$$

$$\dot{\text{SCO}} = \text{OFF}$$

$$\overline{DVGO} = 0$$

$$\text{PROP\_FLAG} = \text{PROP\_FLAG\_GUID}$$

$$\dot{\text{OMS\_IGNITION\_CMD}} = \text{OFF}$$

Table 4.2.3-1. Guidance Input Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V94H4026C thru V94H4028C	$\bar{V}GO$	Velocity vector of external delta-V guidance target in M50 coordinates	PRE-MAN DISP SUPT TSK	SP	ft/s
V95L0210CD thru V95L0212CD	$\bar{V}S$	Total accumulated IMU velocity vector in M50 coordinates	ON-ORB UPP	DP	ft/s
V95W0200CD	TNAV	Time associated with total accumulated IMU velocity vector in M50 coordinates	ON-ORB UPP	DP	s
	$\bar{D}VGO$	VGO correction term	VGO CORR TSK	SP	ft/s
V90U1961CJ	M	Current vehicle mass	PRE-MAN DISP SUPT TSK	SP	slugs
V94X3962XA	PROP_FLAG_GUID	Prime propulsive system indicator	PRE-MAN DISP SUPT TSK	N/A	I
V97U5114C	$VEX_1$	Nominal effective exhaust velocity for maneuver with 2 OMS engines	K-LOAD	SP	ft/s
V97U5115C	$VEX_2$	Nominal effective exhaust velocity for maneuver with 1 OMS engine	K-LOAD	SP	ft/s
V97U5116C	$VEX_3$	Nominal effective exhaust velocity for maneuver with +X RCS engines	K-LOAD	SP	ft/s
V94W3790CC	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V95H0185CF thru V95H0187CF	$\bar{R}NAV$	Current nav position vector	ON-ORB UPP	DP	ft
V95L0190CF thru V95L0192CF	$\bar{V}NAV$	Current nav velocity vector	ON-ORB UPP	SP	ft/s
V94X4024X	LAMBERT_FLAG	Lambert flag	PRE-MAN DISP SUPT TSK	N/A	I
V90W1941CD	TGO	Time to go to thrust termination	GUID TSK	SP	sec
V90X8271X	OMS_L_ON_ CMD_IND	Left OMS ON command indicator	OMS FIRE SEQ	N/A	D
V90X8272X	OMS_R_ON_ CMD_IND	Right OMS ON command indicator	OMS FIRE SEQ	N/A	D
V90X8190X	OMS_IGNITION_ CMD	OMS ignition command flag	MSC	N/A	D



Table 4.2.3-2. Guidance Input Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90L2118C thru V90L2120C	$\overline{VGO}$	Velocity to be gained vector in M50 coordinate system	GUID TSK, VGO DISP TSK, VGO CORR TSK	SP	ft/s
	PROP_FLAG	Propulsive system indicator	GUID TSK CMD BODY ATT TSK	N/A	I
V90U1961CK	M	Current orbiter mass	OMS RM, ON-ORB NAV, RENDZ NAV, ORB RENDZ NAV SEQ, ON-ORB PRED, ORB UPP SEQ, DISP MONIT TSK, VGO DISP TSK	SP	slugs
V95W8512CP	TGD	Current guidance time	OMS TSK, VGO CORR TSK	DP	s
V90H8508CG thru V90H8510CG	$\overline{RGD}$	Current guidance position vector	CMD BDY ATT TSK, VGO CORR TSK	DP	ft
V90L8513CG thru V90L8515CG	$\overline{VGD}$	Current guidance velocity vector	VGO CORR TSK, CMD BDY ATT TSK	SP	ft/s
V94J3791CB	PROP_FLAG_OFS	Prime propulsive system flag	CMD BDY ATT TSK	N/A	I
V90W2034C	T_CUTOFF	OMS/RCS cutoff time	OMS TSK	DP	sec
	$\dot{SCO}$	Cutoff	OMS TSK	D	N/A
V95L3878C thru V95L3880C	$\overline{VSP}$	Total accumulated IMU velocity vector in M50 coordinates	VGO CORR TSK	DP	ft/s

#### 4.2.4 Guidance Task (GUID TSK)

This task computes time-to-go until thrust cutoff and commanded thrust direction.

A. Detailed Requirements. The time-to-go until thrust cutoff is computed as a function of the velocity-to-go magnitude and nominal acceleration. The velocity-to-go magnitude (VGOMAG) is the magnitude of the velocity-to-go until thrust cutoff ( $\overline{VGO}$ ):

$$VGOMAG = ABVAL(\overline{VGO})$$

The value of VGOMAG is tested for a very small number. If VGOMAG is less than a very small number, then this task is exited.

The nominal acceleration (ATR) is a function of the nominal thrust of the current propulsive system ( $FT_{PROP\_FLAG}$ ), indicated by PROP\_FLAG and current orbiter mass. It is computed by:

$$ATR = FT_{PROP\_FLAG}/M$$

Time-to-go (TGO) is then a function of VGOMAG, ATR, and the nominal exhaust velocity of the current propulsive system ( $VEX_{PROP\_FLAG}$ ), indicated by PROP\_FLAG:

$$VRATIO = VGOMAG/(6 VEX_{PROP\_FLAG})$$

$$TGO = VGOMAG/(ATR(1 + 3 VRATIO + 3 VRATIO^2))$$

The commanded reference thrust direction ( $L\overline{AMC}$ ) is set equal to the unit vector of  $\overline{VGO}$  if the steering enable flag is on:

$$\text{IF } S\overline{STEER} = \text{ON, then } L\overline{AMC} = \overline{VGO}/VGOMAG$$

B. Interface Requirements. The input and output parameters for the guidance task are given in Tables 4.2.4-1 and 4.2.4-2. A flow diagram of GUID TSK functional requirements is given in Appendix A.

C. Processing Requirements. The guidance task is nominally performed immediately after the guidance input task every 0.96 second, from the time On-Orbit Guidance is initiated until On-Orbit Guidance is terminated.

D. Initialization Requirements. None.

E. Supplemental Information. Very small number = 0.0001.

Table 4.2.4-1. Guidance Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V90L2118B thru V90L2120B V90L1961CJ	VGO	Velocity-to-be-gained vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
	M	Current orbiter mass	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	slugs
	PROP_FLAG	Propulsive system indicator	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
V97U5034C	FT <sub>1</sub>	Nominal vacuum thrust for maneuver with 2 OMS engines	K-LOAD	SP	lb
V97U5035C	FT <sub>2</sub>	Nominal vacuum thrust for maneuver with 1 OMS engine	K-LOAD	SP	lb
V97U5036C	FT <sub>3</sub>	Nominal vacuum thrust for maneuver with +X RCS engines	K-LOAD	SP	lb
V97U5114C	VEX <sub>1</sub>	Nominal effective exhaust velocity for maneuver with 2 OMS engines	K-LOAD	SP	ft/s
V97U5115C	VEX <sub>2</sub>	Nominal effective exhaust velocity for maneuver with 1 OMS engine (same value as VEX <sub>1</sub> )	K-LOAD	SP	ft/s
V97U5116C	VEX <sub>3</sub>	Nominal effective exhaust velocity for maneuver with +X RCS engines	K-LOAD	SP	ft/s
	SSTEER	Steering enable flag	PRE-MAN DISP SUPT TSK, OMS TSK	D	N/A

Table 4.2.4-2. Guidance Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90W1941CD	TGO	Time-to-go until thrust cutoff	OMS TSK, PRE-MAN DISP SUPT TSK, MNVR DISP	SP	s
V90U1954CE thru V90U1956CE	LAMC	Commanded reference thrust direction in M50 coordinates	ON-ORB DAP, PRE-MAN DISP SUPT TSK, CMD BDY ATT TSK	SP	none
	ATR	Estimated vehicle acceleration	VGO CORR TSK	SP	fps <sup>2</sup>

#### 4.2.5 OMS Engine Task (OMS TSK)

This task performs the following activity:

1. Computes the OMS engine cutoff time and sets the switch to initiate the engine cutoff sequence.
2. Determines the status of the steering outputs and the commanded body attitude quaternion.

##### A. Detailed Requirements.

1. Compute the time to cutoff ( $TGO\_CUTOFF$ ) by first transforming the thrust body vector computed in the Commanded Body Attitude task from body to M50 coordinates using the  $Q\_B\_I$  quaternion.  $TGO\_CUTOFF$  is then computed using the component of  $\bar{V}GO$  along this M50 thrust direction,  $TGO$ , and the magnitude of  $\bar{V}GO$ .

CALL QUAT\_XFORM

Inputs:  $-Q\_B\_I\_S, Q\_B\_I\_V, \bar{T}HRUST\_BODY$

Outputs:  $\bar{T}HRUST\_M50$

$$TGO\_CUTOFF = TGO (\bar{T}HRUST\_M50 \cdot \bar{V}GO) / ABVAL(\bar{V}GO)$$

2. If time to cutoff ( $TGO\_CUTOFF$ ) is less than or equal to  $TGO\_MIN$ , then a cutoff time corrected for thrust tailoff is computed, the OMS cutoff alert is set, the PEG steering flag is turned off, and the cutoff flag is set.

IF  $TGO\_CUTOFF \leq TGO\_MIN$ ,

$$T\_CUTOFF = TGD + TGO\_CUTOFF - TCO\_BIAS$$

$$S\_O\dot{M}SCO = ON$$

$$S\dot{S}TEER = OFF$$

$$S\dot{C}O = ON$$

B. Interface Requirements. The input and output parameters for the OMS engine task are given in Tables 4.2.5-1 and 4.2.5-2. A flow diagram of the OMS TSK functional requirements is given in Appendix A.

C. Processing Requirements. The OMS engine task is performed every 0.96 second after the commanded body attitude task at ignition (OMS L or R CMD IND = TRUE or any THC output is ON) and is terminated after the cutoff flag is set ( $S\dot{C}O = ON$ ).

D. Initialization Requirements. The following values must be initialized each time cyclic guidance is initiated:

$$S\_O\dot{M}SCO = OFF$$

$$S\dot{S}TEER = ON$$

$$S\dot{C}O = OFF$$

Table 4.2.5-1.OMS Engine Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V95W8512CD	TGD	Current guidance time	GUID INP TSK	DP	s
V90W1941CD	TGO	Time-to-go until thrust termination	GUID TSK	SP	s
V97U4665C	TGO_MIN	Value of TGO_CUTOFF when steering outputs are inhibited	K-LOAD	SP	s
V97U4662C	TCO_BIAS	Bias for OMS thrust tailoff	K-LOAD	SP	s
V90U2240C thru V90U2243C	Q_B_I_S, Q_B_I_V	M50-to-measured-body quaternion	ORB ATT PROC	SP	none
	$\bar{T}$ THRUST_ BODY	Unit engine thrust direction in body coordinates	CMD BDY ATT TSK	SP	none
V90L2118C thru V90L2120C	$\bar{V}$ GO	M50 velocity-to-be-gained vector	GUID INP TSK	SP	ft/s
	S $\dot{C}$ O	Cutoff flag	GUID INP TSK	N/A	D

Table 4.2.5-2.OMS Engine Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90X2035XC	S_OM $\dot{S}$ CO	Switch indicator countdown to engine cutoff should begin	MSC	N/A	D
V90W2034CC	T_CUTOFF	OMS cutoff time	MSC	DP	s
	SSTEER	Steering enable flag	GUID TSK	N/A	D

#### 4.2.6 Velocity-To-Go Corrector Task (VGO CORR TSK)

This task computes a velocity-to-go correction term for Lambert guidance. This term periodically updates the velocity-to-go that is concurrently being decremented by sensed velocity in the guidance input task (4.2.3).

A. Detailed Requirements. Since Lambert targets are offset to compensate for noncentral body gravity effects over the powered and coasting flight trajectory arcs, a conic state vector must be maintained.

1. IMU velocity measurements will be incorporated into the conic vector propagation. Snap the current cumulative IMU sensed velocity resolved about the orbiter center of gravity ( $\overline{VSP}$ ) and its time tag (TGD). This will be used to compute the delta velocity sensed by the IMUs between guidance cycles ( $\overline{DV\_IN}$ ). T\_COUNT will be used as the conic orbiter vector time tag and must be consistent with the time of the IMU sensed delta velocity.

$$\begin{aligned} \overline{V\_COUNT} &= \overline{VSP} \\ T\_COUNT &= TGD \end{aligned}$$

2. This step initializes the SUPER G GPS input parameters to maintain consistency between the orbiter state vector and the Lambert targets for use in Lambert guidance: During vgo corrector task execution prior to and at the time of ignition (TIG), including the call from the premaneuver display support task, the latest guidance copy of the UPP Orbiter vector (RGD, VGD and TGD) shall be copied and predicted to TIG using "real world" acceleration models. After TIG, the latest guidance states shall be propagated conically (central body gravity) to the current time (TGD). The IMU sensed delta velocity shall only be incorporated into propagation after TIG.

- a. If  $T\_COUNT \leq TIG$ , then;

The current time tag is before or at TIG. Hence, predict RGD, VGD, and TGD to TIG using "real world" acceleration models.

Note that when the vgo corrector task is called by the premaneuver display support task, TGD is set equal to TIG. Therefore the above test will be true.

Initialize the conic guidance vectors ( $\overline{RGD\_C}$  and  $\overline{VGD\_C}$ ) to the guidance copy of the UPP orbiter vector (RGD and VGD).

$$\begin{aligned} \overline{RGD\_C} &= \overline{RGD} \\ \overline{VGD\_C} &= \overline{VGD} \end{aligned}$$

Set the propagation interval to be from TGD to TIG.

$$\begin{aligned} T\_COUNT &= TIG \\ T\_COUNT\_OLD &= TGD \end{aligned}$$

Set the old value of the accumulated IMU sensed delta velocity ( $\overline{V\_COUNT\_OLD}$ ) equal to the latest accumulated sensed delta velocity ( $\overline{V\_COUNT}$ ). This shall cause the change in accumulated IMU sensed velocity ( $\overline{DV\_IN}$ ) to be zero.

$$V\_C\_COUNT\_OLD = V\_C\_COUNT$$

Set the gravity model flags to degree (GDM) and order (GDO) of 4 x 4 for use by ACCEL\_ONORBIT, which is called internal to SUPER G GPS. Also, set the drag model flag ( $\dot{D}$ ) to ON and the vent ( $\dot{V}$ ) model flag to OFF.

$$\begin{aligned} GDM &= 4 \\ GDO &= 4 \\ \dot{D} &= \text{ON} \\ \dot{V} &= \text{OFF} \end{aligned}$$

Else, if  $T\_COUNT > TIG$ , then;

The current time tag is past TIG. Hence, the latest conic guidance vector shall be propagated conically to the current time.

Set the gravity model flags to degree (GDM) and order (GDO) of 0 x 0 (central body gravity) for use by ACCEL\_ONORBIT called internal to SUPER G GPS. Also, set the drag and vent model flags ( $\dot{D}$  and  $\dot{V}$ ) to OFF.

$$\begin{aligned} GDM &= 0 \\ GDO &= 0 \\ \dot{D} &= \text{OFF} \\ \dot{V} &= \text{OFF} \end{aligned}$$

- b. Compute the delta guidance time (DTP) and IMU sensed delta velocity ( $D\bar{V}\_IN$ ) since the last execution of the VGO CORR TSK for propagation.

$$\begin{aligned} DTP &= T\_COUNT - T\_COUNT\_OLD \\ D\bar{V}\_IN &= V\_C\_COUNT - V\_C\_COUNT\_OLD \end{aligned}$$

- c. Call the SUPER G GPS function (defined as a subfunction in the ENTRY THROUGHT LANDING NAVIGATION FSSR: STS83-0004, section 4.2.1.4.1) to propagate the latest guidance vector ( $R\bar{G}D\_C$ ,  $V\bar{G}D\_C$  at  $T\_COUNT\_OLD$ ) to the current time or TIG as appropriate ( $T\_C\_COUNT$ ).

CALL SUPER G GPS

Inputs:  $R\bar{G}D\_C$ ,  $V\bar{G}D\_C$ ,  $D\bar{V}\_IN$ , DTP,  $T\_COUNT\_OLD$ , GDM, GDO,  $\dot{D}$ ,  $\dot{V}$

Outputs:  $R\bar{G}D\_C$ ,  $V\bar{G}D\_C$ , DUMMY

3. Set the previous Guidance time ( $T\_COUNT\_OLD$ ) and sensed velocity ( $V\_C\_COUNT\_OLD$ ) equal to the current guidance time ( $T\_COUNT$ ) and sensed velocity ( $V\_C\_COUNT$ ) for the next guidance propagation interval.

$$\begin{aligned} T\_COUNT\_OLD &= T\_COUNT \\ V\_C\_COUNT\_OLD &= V\_C\_COUNT \end{aligned}$$

- The transfer time (DT) is computed as the difference between current guidance time and the target time.

$$DT = T\_OFFSET\_GUID - T\_COUNT$$

- Finite burn biasing is accomplished by using an initial position offset position vector

$$\overline{RS\_IPO} = \overline{RGD\_C} - \frac{0.5 (ABVAL(\overline{VGO})) \overline{VGO}}{ATR}$$

- If the transfer angle is near 180 degrees ( $S\_ROTATE\_GUID = 0$ ), then the target plane is defined by a unit vector normal to the Shuttle orbital plane.

$$\text{If } S\_ROTATE\_GUID = 0, \text{ then } \overline{UN} = \text{UNIT}(\overline{RS\_IPO} \times (\overline{VGD\_C} + \overline{VGO}))$$

- If the transfer is not near 180 degrees ( $S\_ROTATE\_GUID = \pm 1$ ), then the unit normal is defined as follows:

If  $S\_ROTATE\_GUID \neq 0$ , then

$$\overline{UN} = S\_ROTATE\_GUID \text{ UNIT} (\overline{RS\_IPO} \times \overline{R\_OFFSET\_GUID})$$

- The Lambert conic required velocity task (LAMBERT) is called to compute the velocity required at the current position to intercept the target position at the targeted time. Prior to calling the LAMBERT task, the stop computations, flag  $\dot{ALARM\_KILL}$  is set to zero (OFF).

CALL LAMBERT

Input:  $\overline{RS\_IPO}$ ,  $\overline{R\_OFFSET\_GUID}$ ,  $\overline{UN}$ , DT,  $\dot{ALARM\_KILL}$

Output:  $\overline{VS\_REQUIRED}$ ,  $\dot{ALARM\_KILL}$

- If the LAMBERT task successfully computed the current required velocity ( $\dot{ALARM\_KILL} = \text{OFF}$ ), then compute a new velocity-to-go ( $\overline{VGO\_NEW}$ ) as the difference between the current required velocity and the current guidance velocity, and compute the velocity-to-go correction term ( $\overline{DVGO}$ ) as the difference between the new and current velocity-to-go.

If  $\dot{ALARM\_KILL} = \text{OFF}$ , then

$$\overline{VGO\_NEW} = \overline{VS\_REQUIRED} - \overline{VGD\_C}$$

$$\overline{DVGO} = \overline{VGO\_NEW} - \overline{VGO}$$

If the LAMBERT task did not successfully compute the current required velocity ( $\dot{ALARM\_KILL} = \text{ON}$ ), then set both the new velocity-to-go ( $\overline{VGO\_NEW}$ ) and the velocity-to-go correction term ( $\overline{DVGO}$ ) to zero.

If  $\dot{ALARM\_KILL} = \text{ON}$ , then

$$\overline{VGO\_NEW} = 0$$



$$\overline{DVGO} = 0$$

B. Interface Requirements. The input and output parameters for the velocity-to-go corrector task are shown in Tables 4.2.6-1 and 4.2.6-2. A flow diagram of VGO CORR TSK functional requirements is given in Appendix A.

C. Processing Requirements. This task is processed once every 3.84 seconds from the time On-Orbit Guidance is initiated until On-Orbit Guidance is terminated. The task is not executed at all for external delta-V guidance.

D. Initialization Requirements. ALARM\_A should be set to zero (OFF) before cyclic processing of this task is initiated.

E. Supplemental Information. This task is set up such that a velocity-to-go correction term ( $\overline{DVGO}$ ) can be computed in the low frequency executive based on a closed loop Lambert's solution to the guidance problem. The correction term may then be passed to the mid frequency executive and applied to the velocity-to-go. If a closed-loop LAMBERT's solution to the guidance problem was not found, then the correction term will be set to zero so that it will have no effect on the velocity-to-go.

The document, JSC-49830: "Space Shuttle Lambert Guidance Improvement, SCR 92843", provides more information regarding the conic guidance vector initialization and propagation scheme.

Table 4.2.6-1. Velocity-to-Go Corrector Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V95W8512CP	TGD	State vector time tag	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	s
V90H8508CG thru V90H8510CG	$\overline{RGD}$	Position vector	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	ft
V90L8513CG thru V90L8515CG	$\overline{VGD}$	Velocity vector	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
	ATR	Estimated vehicle acceleration	GUID TSK, PRE-MAN DISP SUPT TSK	SP	ft/s <sup>2</sup>
V94H4016CA thru V94H4018CA	$\overline{R\_OFFSET\_GUID}$	Offset target position vector	PRE-MAN DISP SUPT TSK	DP	ft
V94J4025CA	S_ROTATE_GUID	180-degree flag	PRE-MAN DISP SUPT TSK	SP	I
	$\overline{VS\_REQUIRED}$	Velocity required to intercept Lambert target	LAMBERT TASK	DP	ft/s
V94W3790CC	TIG	Time of ignition	ORB MNVR DIP, PRE-MAN DISP SUPT TSK	DP	s
V94W4015CA	T_OFFSET_GUID	Target time	PRE-MAN DISP SUPT TSK	DP	s

Table 4.2.6-1. Velocity-to-Go Corrector Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90L2118B thru V90L2120B	$\bar{V}GO$	Velocity to go	GUID INP TSK	SP	ft/s
V94H4026C thru V94H4028C	$\bar{V}GO$	Initial velocity to go	PRE-MAN DISP SUPT TSK	SP	ft/s
	ALARM_KILL	Stop computations flag	LAMBERT TSK	D	-
V95L3878C thru V95L3880C	$\bar{V}SP$	Total Accumulated IMU velocity vector in M50 coordinates	GUID INP TSK PRE-MAN DISP SUPT TSK	DP	ft/s

Table 4.2.6-2. Velocity-to-Go Corrector Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94H4034C thru V94H4036C	$\bar{R}S\_IPO$	Initial position offset vector	LAMBERT TSK	DP	ft
V94H4016CA thru V94H4018CA	$\bar{R}\_OFFSET\_GUID$	Offset target position vector	LAMBERT TSK	DP	ft
	$\bar{U}N$	Normal to target plane	LAMBERT TSK	DP	none
	DT	Delta time to target	LAMBERT TSK	SP	s
	$D\bar{V}GO$	Velocity-to-go correction time	GUID INP TSK	SP	ft/s
	$\bar{V}GO\_NEW$	New velocity-to-go	PRE-MAN DISP SUPT TSK	SP	ft/s
	ALARM_KILL	Stop computations flag	LAMBERT TSK	D	-

#### 4.2.7 Parameter Tables for On-Orbit Guidance (G4.7)

The IDD inputs and outputs are listed in Tables 4.2.7-1 and 4.2.7-2 respectively. Values for the I-loads are contained in the I-load requirements document (JSC-19350); however, I-load definitions applicable to this principal function are listed in Table 4.2.7-3. K-loads are listed in Table 4.2.7-4. Constants are listed in Table 4.2.7-5. The cross-reference listing is given in the table listed below.

On-Orbit Guidance (G4.7) Cross-Reference Listing		
Local Name	Source Name	MSID
OMS_L_CMD_IND	OMS_L_ON_CMD_IND	V90X8271X
OMS_R_CMD_IND	OMS_R_ON_CMD_IND	V90X8272X
Q_B_I_S	Q_BOD_M50 (1)	V90U2240CB
Q_B_I_V	Q_BOD_M50(2) Q_BOD_M50(3) Q_BOD_M50(4)	V90U2241CB V90U2242CB V90U2243CB
R $\bar$ NAV	R_AVGG(1) R_AVGG(2) R_AVGG(3)	V95H0185CF V95H0186CF V95H0187CF
TNAV	T_STATE	V95W0200CF
V $\bar$ NAV	V_AVGG(1) V_AVGG(2) V_AVGG(3)	V95L0190CF V95L0191CF V95L0192CF
V $\bar$ S	V_IMU_OLD(1) V_IMU_OLD(2) V_IMU_OLD(3)	V95L0210CD V95L0211CD V95L0212CD

TABLE 4.2.7-1. INPUT FUNCTIONAL PARAMETERS FOR ONORBIT GUIDANCE (G4.7)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
EXT_DV_LVLH(1)	V93L6950CE	EXT DELTA V X-COMP	ORB MNVR DIP	FT/S			93017G	*
EXT_DV_LVLH(2)	V93L6951CE	EXT DELTA V Y-COMP	ORB MNVR DIP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CE	EXT DELTA V Z-COMP	ORB MNVR DIP	FT/S			93017G	*
IN_VGO(1)	V94H4026C	INITIAL VEL TO GO VECTOR X-COMP	ORB MNVR DIP					
IN_VGO(2)	V94H4027C	INITIAL VEL TO GO VECTOR Y-COMP	ORB MNVR DIP				92739D	
IN_VGO(3)	V94H4028C	INITIAL VEL TO GO VECTOR Z-COMP	ORB MNVR DIP				92739D	
LAMBERT_FLAG	V94X4024X	LAMBERT GUIDANCE MODE FLAG	ORB MNVR DIP					
M/CURR_ORB_MASS/WEIGHT	V90U1961CJ	CURRENT VEHICLE MASS	ORB MNVR DIP	SLUGS			89250B	
M/CURR_ORB_MASS/WEIGHT	V90U1961CK	CURRENT VEHICLE MASS	ORB/RND NAV SEQ	SLUGS				
OMS_IGNITION_CMD	V90X8190XA	OMS IGNITION COMMAND FLAG	MSC		BD		90007G	
OMS_L_ON_CMD_IND	V90X8271X	OMS-L ON CMD IND	OMS FIRE SEQ				90120B	
OMS_PITCH_TRIM	V93H6915CB	OMS PITCH TRIM	ORB DAP	DEG	SPL		89645A	
OMS_R_ON_CMD_IND	V90X8272X	OMS-R ON CMD IND	OMS FIRE SEQ				90120B	
OMS_YAW_TRIM(1)	V93H6916CB	OMS L YAW TRIM	ORB DAP	DEG	SPL		89645A	
OMS_YAW_TRIM(2)	V93H6918CB	OMS R YAW TRIM	ORB DAP	DEG	SPL		89645A	
PROP_FLAG_GUID	V94X3962XA	PRIME PROP SYS FLAG FOR GUID	ORB MNVR DIP					
Q_BOD_M50(1)/Q_B_M50(1)	V90U2240CB	M50 TO BODY QUAT MEASURED ELEM 1	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(2)/Q_B_M50(2)	V90U2241CB	M50 TO BODY QUAT MEASURED ELEM 2	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(3)/Q_B_M50(3)	V90U2242CB	M50 TO BODY QUAT MEASURED ELEM 3	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(4)/Q_B_M50(4)	V90U2243CB	M50 TO BODY QUAT MEASURED ELEM 4	ORB ATT PROC		SPL		93017G	*
R_AVGG(1)	V95H0185CF	X-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CF	Y-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CF	Z-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_OFFSET_GUID(1)	V94H4016CB	LAMBERT TGT OFFSET VECTOR X-COMP	ORB MNVR DIP					
R_OFFSET_GUID(2)	V94H4017CB	LAMBERT TGT OFFSET VECTOR Y-COMP	ORB MNVR DIP					
R_OFFSET_GUID(3)	V94H4018CB	LAMBERT TGT OFFSET VECTOR Z-COMP	ORB MNVR DIP					
S_ROTATE_GUID	V94J4025CB	NEAR 180 DEG MNVR PROJ FLAG	ORB MNVR DIP					
THC(1)	V96J0401C	TRANS HAND CTRL X CMD	THC SOP					
THC(2)	V96J0402C	TRANS HAND CTRL Y CMD	THC SOP					
THC(3)	V96J0403C	TRANS HAND CTRL Z CMD	THC SOP					
TIG	V94W3790CC	TIME OF IGNITION	ORB MNVR DIP	S			93017G	*
T_OFFSET_GUID	V94W4015CB	TIME OF LAMB TGT POSN VECTOR	ORB MNVR DIP					
T_STATE	V95W0200CF	TIME TAG ASSOC WITH CURRENT STATE	ORB UPP	S			93017G	*
VGO(X)	V94L3804CB	X-EXTERNAL DEL V TARGET VECTOR	ORB MNVR DIP	FT/S				
VGO(Y)	V94L3805CB	Y-EXTERNAL DEL V TARGET VECTOR	ORB MNVR DIP	FT/S				
VGO(Z)	V94L3806CB	Z-EXTERNAL DEL V TARGET VECTOR	ORB MNVR DIP	FT/S				
VSP(1)	V95L3878C	X-COMP OF CURRENT ACCUM IMU VEL	ORB MNVR DIP	FT/S	DPL		92843B	
VSP(2)	V95L3879C	Y-COMP OF CURRENT ACCUM IMU VEL	ORB MNVR DIP	FT/S	DPL		92843B	
VSP(3)	V95L3880C	Z-COMP OF CURRENT ACCUM IMU VEL	ORB MNVR DIP	FT/S	DPL		92843B	
V_AVGG(1)	V95L0190CF	X-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CF	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CF	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_IMU_OLD(1)	V95L0210CD	X-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	
V_IMU_OLD(2)	V95L0211CD	Y-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	
V_IMU_OLD(3)	V95L0212CD	Z-COMP OF CURRENT ACCUM IMU VEL	ORB UPP	FT/S	DPL		92843B	

TABLE 4.2.7-1. INPUT FUNCTIONAL PARAMETERS FOR ONORBIT GUIDANCE (G4.7)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
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**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

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TABLE 4.2.7-2. OUTPUT FUNCTIONAL PARAMETERS FROM ONORBIT GUIDANCE (G4.7)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALARM_A	V95X7330XA	ALARM(A) REQUESTING "TGT ITER"	ORB TGT SPEC					
LAMC(X)	V90U1954CE	X-COMP OF M50 REF THR VECTOR	DL FMT 22/1				93017G	*
			ORB DAP					
LAMC(Y)	V90U1955CE	Y-COMP OF M50 REF THR VECTOR	DL FMT 22/1				93017G	*
			ORB DAP					
LAMC(Z)	V90U1956CE	Z-COMP OF M50 REF THR VECTOR	DL FMT 22/1				93017G	*
			ORB DAP					
M	V90U1961CD	CURRENT VEHICLE MASS	OMS RM	SLUGS			89648A	
			ORB MNVR DIP					
			ORB TGT SPEC					
			ORB/RND NAV					
			ORB/RND NAV SEQ					
			TLM					
Q_CB_M50_S	V94U3980CD	M50 TO BODY QUAT ELEM 1	ORB DAP					
Q_CB_M50_V(1)	V94U3981CD	M50 TO BODY QUAT ELEM 2	ORB DAP					
Q_CB_M50_V(2)	V94U3982CD	M50 TO BODY QUAT ELEM 3	ORB DAP					
Q_CB_M50_V(3)	V94U3983CD	M50 TO BODY QUAT ELEM 4	ORB DAP					
S_OMSCO	V90X2035XC	OMS CUTOFF ALERT DISCRETE	DL FMT 22/1				93017G	*
			MSC					
T_CUTOFF	V90W2034CC	DESIRED CUTOFF TIME	MSC	S				
VEH_PITCH	V93U6909CH	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 22/A	DEG			93017G	*
			XXXXX MNVR DISP					
VEH_ROLL	V93U6910CH	ROLL ANGLE IN ADI INERTIAL COORD	DL FMT 22/A	DEG			93017G	*
			XXXXX MNVR DISP					
VEH_YAW	V93U6911CH	YAW ANGLE IN ADI INERTIAL COORD	DL FMT 22/A	DEG			93017G	*
			XXXXX MNVR DISP					
VGO-X	V90L2118C	X VEL TO BE GAINED VECTOR IN M50	ORB MNVR DIP	FT/S				
VGO-Y	V90L2119C	Y VEL TO BE GAINED VECTOR IN M50	ORB MNVR DIP	FT/S				
VGO-Z	V90L2120C	Z VEL TO BE GAINED VECTOR IN M50	ORB MNVR DIP	FT/S				
X_FLAG	V90X0414XB	VALID ANGLE COMP FLAG	XXXXX MNVR DISP		BD		90763E	
	V90M2926PC	CGEB_FLT_LG1_FLAG2_MFE	DL FMT 22/1				93017G	*

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
 (HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec

TABLE 4.2.7-3. ONORBIT GUIDANCE (G4.7) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TVR_ROLL	V93H6936C	DEG	F	S	D	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	00	ZF2	91019A	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**



TABLE 4.2.7-4. ONORBIT GUIDANCE (G4.7) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
CBETA_EPS	V97U5127C	00	+9.998480	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89542A	
FT1 VACUUM THRUST OF TWO OMS ENGINES	V97U5034C	00	+1.2174000	E+04 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT2 VACUUM THRUST OF ONE OMS ENGINES	V97U5035C	00	+6.0870000	E+03 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT3 VACUUM THRUST OF PRIMARY RCS JETS	V97U5036C	02 03	+1.780 +3.509	E+03 LBS E+03	F	S	P	G4.158 G4.209 G4.211 G4.7	90329C	
ONE_ENG_OMS_PITCH_TRIM OMS ENG PITCH TRIM ANG THRUST -CG	V97U2367C	01 02 03	+4.0 -1.0 -3.1	E-01 DEG E-01 E-01	F	S	X	G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(1) OMS ENG YAW TRIM ANG THRUST - CG	V97U2368C	01 02 03	+5.2100000 +5.2100000 +5.2100000	E+00 DEG E+00 E+00	F	S	C	G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(2) OMS ENG YAW TRIM ANG THRUST - CG	V97U2369C	01 02 03	-5.2100000 -5.2100000 -5.2100000	E+00 DEG E+00 E+00	F	S	C	G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	

TABLE 4.2.7-4. ONORBIT GUIDANCE (G4.7) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PITCH_BIAS CONST OMS ENG ELEC PITCH TRIM ANG	V97U4485C	00	+2.7605300	E-01	RAD	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	59955	
Q_M50_INRTL_ORB(1) M50 WRT INERT QUAT ELEM 1	V97U2214CC	00	+1.0	E+00	ND	F	S	P G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(2) M50 WRT INERT QUAT ELEM 2	V97U2215CC	00	+0.0	E+00	ND	F	S	P G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(3) M50 WRT INERT QUAT ELEM 3	V97U2216CC	00	+0.0	E+00	ND	F	S	P G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(4) M50 WRT INERT QUAT ELEM 4	V97U2217CC	00	+0.0	E+00	ND	F	S	P G4.158 G4.213 G4.7 G4.97	89590B	
TCO_BIAS OMS CUTOFF TIME BIAS	V97U4662C	00	+3.98	E-01	SEC	F	S	C G4.209 G4.3 G4.7	90329C	
TGO_MIN MIN TIME-TO-GO THRUST TERMINATE	V97U4665C	00	+6.0000000	E+00	SEC	F	S	C G4.209 G4.3 G4.7	89542A	
THRUST_BODY_RCS_X(1) X-COMPONENT OF RCS THRUST DIRECTION	V97U4812C	00	+9.8480780	E-01	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(2) Y-COMPONENT OF RCS THRUST DIRECTION	V97U4813C	00	+0.0	E+00	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(3) Z-COMPONENT OF RCS THRUST DIRECTION	V97U4814C	00	+1.7364820	E-01	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	

TABLE 4.2.7-4. ONORBIT GUIDANCE (G4.7) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
VEX1 TWO OMS EXHAUST VELOCITY	V97U5114C	00	+1.0136800	E+04 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90924B	
VEX2 ONE OMS EXHAUST VELOCITY	V97U5115C	00	+1.0136800	E+04 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90924B	
VEX3 RCS EXHAUST VELOCITY	V97U5116C	00	+8.2327000	E+03 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90329C	
YAW_BIAS CNST OMS ENG ELEC YAW TRIM ANGLE	V97U4829C	00	+1.134460	E-01 RAD	F		S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89541	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

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TABLE 4.2.7-5. ONORBIT GUIDANCE (G4.7) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RAD_PER_DEG DEGREE TO RADIAN CONVERSION FACTOR	V97U0383C	00	+1.7453293	E-02	RAD/DEG	F	S	C A6.9 G4.1 G4.126 G4.127 G4.128 G4.144 G4.15 G4.158 G4.175 G4.20 G4.201 G4.204 G4.205 G4.209 G4.210 G4.211 G4.213 G4.220 G4.223 G4.226 G4.227 G4.236 G4.237 G4.3 G4.35 G4.36 G4.7 G4.72 G4.9 G4.97 G5.27	93090E	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

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### 4.3 UNIVERSAL POINTING PROCESSOR PRINCIPAL FUNCTION (UNIV POINT PROC)

The Universal Pointing Processor principal function (referenced in the Level B CPDS, principal function 4.213) provides the software that determines Shuttle on-orbit orientations and attitude rates which satisfy specified attitude and pointing requirements and provides for activation/de-activation of a reboost. The attitude and pointing and reboost requirements are input to the processor via crew interactive computer keyboard execute commands to the universal pointing display function (referenced in the Level B CPDS, principal function 6.27).

The capability to change the attitude of the orbiter is provided by the universal pointing processor through the selection of one of three mutually exclusive auto attitude options:

1. Maneuver (MNVR)
2. Tracking (TRK)
3. Rotation (ROT)

The MNVR option places the orbiter in a specified inertial attitude. The TRK option maneuvers the orbiter to an initial tracking attitude and then maintains a specified body-fixed vector locked-on to a given target line-of-sight. The ROT option maneuvers the orbiter at a constant attitude rate about a specified body-fixed vector. All options are terminated by a cancel command (CNCL).

The UNIV POINT PROC also provides the capability to define and start a reboost. Entries of burn duration, start time, reboost request, and cancel from the UNIV PTG display are processed and a reboost is executed or terminated accordingly. The reboost burn time remaining is reflected in the duration field of the display when a reboost burn is in progress.

Another capability provided by the UNIV POINT PROC is the software that generates the required local vertical local horizontal (LVLH) attitude rate for proximity operations (PROX OPS). LVLH is a manual attitude hold/rate command mode relative to LVLH coordinates. The LVLH attitude mode inhibits the cyclic computations of universal pointing current and future attitude options until the LVLH mode is deselected.

Therefore, the universal pointing processor provides the software that interfaces the universal pointing display (UNIV PTG) function with the on-orbit digital autopilot (ON-ORBIT DAP), referenced in Level B, CPDS, principal function 4.35; it also provides the software for attitude and line-of-sight related parameters for other on-board software functions. In particular, it provides the software that determines the rendezvous target line-of-sight for Ku-band antenna pointing.

In addition to serving as an interface between the UNIV PTG display and the ON-ORBIT DAP, the UNIV POINT PROC function provides support software to drive parameters on the UNIV PTG display; e.g., parameters dependent on inputs from onboard software external to universal pointing. Hence, an understanding of the UNIV PTG display is required to better comprehend the details of this section. The Level C FSSR, Displays and Controls, Display Formats, presents the detailed display requirements. The UNIV PTG display is shown in Figure 4.3-1.

On the display, a specific integer is assigned to each unique display item. The items are addressed via the computer keyboard. Items 1 through 17, 22 and 27 through 29 require data entries. All other items are executable items only, requiring no data.

All crew inputs to the UNIV POINT PROC function originate at the computer keyboard and are transmitted to the UNIV POINT PROC function immediately upon execution of an item number.

#### **4.3.1 Overview**

The UNIV POINT PROC principal function is activated on entering OPS 2; it remains active and is not affected by transitions between OPS 2 and OPS 8 or by transitions between MM's 201 and 202 in OPS 2. The function is terminated when transitions to other major modes occur and must be reinitialized on returning to OPS 2.

The UNIV PTG display function is available only during MM201. Initialization of the display occurs when OPS 2 is entered from modes other than OPS 8. The initialization data are accessed by the display function from a protected storage area common to both the UNIV PTG display and the UNIV POINT PROC. OPS 2 recalls have no effect on the UNIV POINT PROC or UNIV PTG display.

Data required to initialize the display are:

- |                |   |
|----------------|---|
| 1. IDAY        | Day to start attitude option            |
| 2. I HOUR      | Hour to start attitude option           |
| 3. IMIN        | Minute to start attitude option         |
| 4. ISEC        | Second to start attitude option         |
| 5. ROLLI       | Input inertial roll angle               |
| 6. PITCHI      | Input inertial pitch angle              |
| 7. YAWI        | Input inertial yaw angle                |
| 8. TGT_ID      | Target or tracking vector identifier    |
| 9. TGT_RA      | Celestial target vector right ascension |
| 10. TGT_DEC    | Celestial target vector declination     |
| 11. TGT_LAT    | Earth-fixed target latitude             |
| 12. TGT_LON    | Earth-fixed target longitude            |
| 13. TGT_ALT    | Earth-fixed target altitude             |
| 14. BODV_ID    | Body vector identifier                  |
| 15. BODV_PITCH | Pitch coordinate of body vector         |
| 16. BODV_YAW   | Yaw coordinate of body vector           |



17. OMICRON	Constraint angle about body vector
18. THREE_°AXIS	Three-axis tracking flag
19. OPT_CUR	Current attitude option indicator
20. OPT_FUT	Future attitude option indicator
21. MON_AXIS	Monitor axis indicator
22. ERR_°SEL	Total/DAP attitude error discrete

These items represent most of the protected data that must remain constant for transitions between OPS 2 and OPS 8, and for major mode transitions in OPS 2. The remaining protected data items common to the UNIV POINT PROC and UNIV PTG display are:

23. OPT_SEL	Selected attitude option
24. OPT_°CNCL	Cancel maneuver termination option discrete
25. TRK_°DCD	Tracking option data change discrete
26. ROT_°DCD	Rotation option data change discrete
27. MNV_°DCD	Maneuver option data change discrete
28. FUT_°DCD	Future option data change discrete
29. MNVR_CMPL_TIME	Maneuver completion time (MET)
30. MNVR_TRACK_°OPTION	Maneuver/tracking option discrete

There are 13 dynamic display variables computed by the UNIV POINT PROC that are available for crew monitor during auto and manual attitude maneuvers. They are:

1. ROLLC	Current inertial roll angle
2. PITCHC	Current inertial pitch angle
3. YAWC	Current inertial yaw angle
4. ROLLR	Required inertial roll angle
5. PITCHR	Required inertial pitch angle
6. YAWR	Required inertial yaw angle
7. ATT_ERR_X	X-component of attitude error
8. ATT_ERR_Y	Y-component of attitude error
9. ATT_ERR_Z	Z-component of attitude error

- |                    |                              |
|--------------------|------------------------------|
| 10. ATT_RATE_X     | X-component of attitude rate |
| 11. ATT_RATE_Y     | Y-component of attitude rate |
| 12. ATT_RATE_Z     | Z-component of attitude rate |
| 13. MNVR_CMPL_TIME | Maneuver completion time     |

The following paragraphs describe the UNIV PTG display quantities that initialize the UNIV POINT PROC attitude options.

1. Start Time (Items 1, 2, 3, and 4). This set of variables is days, hours, minutes, and seconds mission elapsed time (MET) to start processing of a selected attitude option. It “comes-up” initialized to all zeroes and maintains the values of the last entries after that time. Executing a MNVR, TRK, or ROT attitude option on the initialization MET, current MET, or any past MET initiates cyclic processing of the selected attitude option. Executing a future MET followed by the execution of an attitude option schedules that attitude option to begin at that future time.
2. R, P, and Y MNVR Angles (Items 5, 6, and 7). These attitude angles are required to specify the orientation of the Shuttle relative to the inertial attitude director indicator (ADI) for the MNVR option. The angles are specified in the order of roll (R), pitch (P), and yaw (Y); but the internal software assumes the pitch, yaw, and roll Euler sequence and +X axis control sense for computation of the required attitude orientation.

The angles are initialized to zero and maintain the loaded value from that point on. Executing a MNVR option initiates the software execution that reads the angles from the UNIV PTG display and computes the required attitude reference.

Entering data outside of the allowable range (0 to 359.99 degrees for roll and pitch, 0 to 90 or 270 to 359.99 for yaw) will trigger an “ILLEGAL ENTRY” message.

3. TGT\_ID (Item 8). This parameter is required for the TRK attitude option, and it specifies the desired type of target. There are six target types. They are associated with the following identifiers:

TGT_ID	Target Type
2	Center of earth
1	Orbital object (rendezvous)
3	Earth surface
4	Center of sun
5	Celestial – manual data entry
11–110	Navigation stars

Executing any TGT\_ID’s not listed above will result in an “ILLEGAL ENTRY” message on the UNIV PTG display.

This parameter is initialized to a value of 2, and it maintains the last loaded value after initialization.

4. RA and DEC (Items 9 and 10). This set of variables is the right ascension (RA) and declination (DEC) of either the sun (TGT\_ID = 4), the celestial/manual data entry target (TGT\_ID = 5), or the selected navigation star ( $11 \leq \text{TGT\_ID} \leq 110$ ).

Executing a TGT\_ID of 5 initiates the flashing of the prior loaded values of the RA and DEC. Each value will “go steady” or stop flashing when it is overwritten by a new RA/DEC data load, when the TGT\_ID is changed, or when an attitude option is executed.

Both the RA and DEC are initialized to zero and maintain the last loaded values after initialization. Entering data outside of the allowable range (0 to 359.99 degrees for RA and  $\pm 90$  degrees for DEC) for a TGT\_ID of 5 will trigger an “ILLEGAL ENTRY” message.

Executing a TGT\_ID of 4 or 11 to 110 will display the RA and DEC of either the sun or the corresponding navigation star.

When either the sun or a navigation star is selected as a target, attempting to load a RA and DEC will trigger an “ILLEGAL ENTRY” message.

5. LAT, LON, and ALT (Items 11, 12, and 13). This set of variables is used to compute an earth-fixed target position vector required for earth surface target tracking. Executing a TGT\_ID of 3 initiates the flashing of the latitude (LAT), longitude (LON), and altitude (ALT) values. Each value will “go steady” when it is overwritten by a new LAT, LON, or ALT entry, when the TGT\_ID is changed, or when attitude option is executed.

Each of these variables is initialized to zero and maintains the last loaded value after initialization.

Attempting to load data into these items for an identifier other than 3 will trigger an “ILLEGAL ENTRY” message. Or entering data out of the allowable range ( $\pm 90$  degrees for LAT,  $\pm 180$  degrees for LON, and  $-3444./+20000$ . nautical miles for ALT) will trigger an “ILLEGAL ENTRY” message.

6. BODY VECT (Item 14). This parameter is required for the TRK or ROT attitude options, and it specifies the body fixed pointing vector. There are five distinct body vectors:

BODY VECT Identifier	Pointing Vector
1	+X body axis
2	-X body axis
3	-Z body axis
4	-Y ST
5	Universal/manual pitch and yaw data entries

Executing any BODY VECT not listed in the above table will result in an “ILLEGAL ENTRY” message.

This parameter is initialized to 1.

7. P and Y Body Vector Angles (Items 15 and 16). These two angles are the pitch (P) and yaw (Y) components of the pointing vector direction in body coordinates.

Executing a BODY VECT identifier initiates the display of the corresponding body vector pitch and yaw components. If an identifier of 5 is executed, the values of P and Y begin flashing the prior loaded values. Each value will “go steady” when it is overwritten by a new data entry, when the body vector identifier is changed, or when an attitude option is executed.

The body vector angles are initialized to zero.

Attempting to load data into these items for identifiers other than 5 will trigger an “ILLEGAL ENTRY” message. Similarly, attempting to load data outside of the allowable range (0 to 359.99 for P and 270 to 359.99 or 0 to 90 for Y) will trigger an “ILLEGAL ENTRY” message when the identifier is 5.

8. OM Angle (Item 17). This angle, omicron (OM), is associated with the TRK attitude option only. It is an input attitude constraint that specifies the orbiter attitude orientation about the pointing line-of-sight.

Omicron is the angle between two planes. The normal to one plane is defined by the cross product of the target line-of-sight and the negative angular momentum vectors. The normal to the other plane is defined by the cross product of the body vector and the Y body axis.

Executing a TGT\_ID of any defined value resets a three-axis tracking flag and causes the value of OM to blank on the display. If the TRK option is subsequently executed, OM remains blank. This indicates that two-axis tracking is selected. On the other hand, if omicron is executed, the loaded value is displayed; and if the TRK option is subsequently executed, OM retains the executed value. This indicates that three-axis tracking is selected.

The three-axis tracking flag is defined as follows:

THREE\_AXIS = 1 perform three-axis tracking (set)

THREE\_AXIS = 0 perform two-axis tracking (reset)

Attempting to load data outside of the allowable range (0 to 359.99 degrees) will trigger an “ILLEGAL ENTRY” message.

If omicron is not blank, executing a body vector identifier initiates the flashing of the value of omicron. Flashing is terminated when a value of omicron is executed or when an attitude option is executed.

Omicron is initialized to zero, and the three-axis tracking flag is initialized to a value of 1 such that a steady value of 0 appears next to OM at the initialization.

9. Selected Attitude Option (Items 18, 19, and 20). These items select the MNVR (Item 18), TRK (Item 19), or ROT (Item 20) attitude option. Executing a MNVR, TRK, or ROT item number on the initialization time, current time, or any past time initiates immediate processing of the

selected attitude option. In that case, an asterisk will appear in the CUR column adjacent to the selected option.

The current options are mutually exclusive, and executing another current option will terminate the previously selected option and begin the new option immediately. However, if a future time is loaded prior to selection of an option, the current option will not be affected by the future loaded option until the specified start time. At the specified start time, the future option becomes current and replaces the present active option. In that case, an asterisk will appear momentarily in the FUT column of the selected option and move to the CUR column of the selected option.

The CUR and FUT attitude options are not mutually exclusive. For example, both a CUR and FUT MNVR option or a CUR MNVR and FUT TRK attitude option can be set up.

If a future start time is selected, an attitude option is executed, and the auto flight control mode is not selected, a message, SEL AUTO, begins flashing on the message line 30 seconds before the attitude option is scheduled to start. The indicator that initiates that message will be reset when auto is selected, when the cancel option is executed, or when the future attitude option becomes current.

An integer parameter, OPT\_SEL, specifies the selected attitude option. This parameter is defined as follows:

OPT_SEL = 0	No option selected (reset)
OPT_SEL = 1	MNVR option selected
OPT_SEL = 2	TRK option selected
OPT_SEL = 3	ROT option selected

The OPT\_SEL parameter is reset after the current or future option indicator is set. OPT\_SEL is initialized to 0.

10. Current Attitude Option Indicator (CUR). This parameter is required to control where the asterisk for the current attitude option appears on the UNIV PTG display. The indicator is an integer parameter having only one of four possible values:

OPT_CUR = 0	No current attitude option (reset)
OPT_CUR = 1	Current MNVR option
OPT_CUR = 2	Current TRK option
OPT_CUR = 3	Current ROT option

The OPT\_CUR parameter is initialized to zero and assumes one of the above values when an attitude option is executed on a past or current start time, or when a future attitude option becomes current.

11. Future Attitude Option Indicator (FUT). This parameter is required to control where the asterisk for the future attitude option appears on the UNIV PTG display. The indicator is an integer parameter having only one of four possible values:

OPT_FUT = 0	No future attitude option (reset)
OPT_FUT = 1	Future MNVR option
OPT_FUT = 2	Future TRK option
OPT_FUT = 3	Future ROT option

The OPT\_FUT parameter is initialized to zero and assumes one of the above values when an attitude option is executed on a future start time.

12. Cancel Option (Item 21). This item selects the cancel (CNCL) option. Executing the CNCL item number deselects both current and future attitude options and initiates inertial attitude hold about the current attitude. When the CNCL option is executed, a discrete is set. This discrete is defined as follows:

OPT_CNCL = 1	CNCL selected (set)
OPT_CNCL = 0	(reset)

The discrete is reset when CNCL option processing is complete.

13. MON Axis (Item 22). This parameter selects the coordinate system of the displayed attitude angles, errors, and rates. The parameter has two values:

MON_AXIS = 1	+X sense
MON_AXIS = 2	-X sense

Executing a value of 1 for the monitor axis will initiate the display of a 1 +X adjacent to Item 22. In that case, the attitude monitor quantities will be displayed relative to the standard Orbiter body axis coordinate system. However, executing a value of 2 for the monitor axis will initiate the display of a 2 -X adjacent to Item 22 of the display. In that case, the attitude monitor quantities will be displayed relative to a coordinate system that is rotated 180 degrees about the Z axis with respect to the standard body coordinate system. The MON\_AXIS is initialized to 1.

14. Attitude Errors (Items 23 and 24). These items are mutually exclusive and control the type of attitude errors on the ADI error needles and the UNIV PTG display. The ADI error needles in OPS 201 or 801 are controlled by the selected attitude errors on the universal pointing display and reflect the attitude option being processed in either OPS 201 or OPS 801 (for total attitude errors). The DAP mode has no control over selection of these errors. All errors are displayed in a "fly-to" sense, such that the sign of the true body rate components is the same as the sign of the corresponding attitude error components when the orbiter is maneuvering to the desired attitude.

Executing Item 23 selects total attitude errors. Total (TOT) attitude errors are defined as the negative of the product of the eigen axis and eigen angle extracted from the current to required body quaternion.

Executing Item 24 selects DAP attitude errors. DAP attitude errors are defined as the negative of the phase plane attitude errors.

The display is initialized with TOT attitude errors selected.

15. Current and Required Attitude Angles. These display variables are the current (CUR) and required (REQD) pitch–yaw–roll Euler angles of the orbiter relative to the inertial ADI coordinate system. However, the angles are displayed in the order of roll–pitch–yaw.

The current attitude angles must be computed each cycle and represent the present inertial attitude in the selected control axis sense.

The required attitude angles are computed from the required body quaternion and represent the desired attitude (in the selected control axis sense) that satisfies the requirements of the selected attitude option. If a future MNVR or TRK option is selected and there is no current option selected, the required attitude and attitude errors for the selected future option will be displayed.

16. Attitude Rate. The variables displayed for this quantity are the estimated body rates from the ORBIT DAP. The sense of the displayed rates is specified by the MON\_AXIS selected.
17. CUR MNVR COMPL. This set of variables is the MET of the completion of a current inertial maneuver, a maneuver to an initial tracking attitude, or the execution time of a rotation option. This time is expressed as hours, minutes, and seconds of maneuver completion, so the crew is obliged to determine the day of maneuver completion.

This time is cyclically updated only during a MNVR or TRK attitude option and will “freeze” when current attitude errors are within a given tolerance of the DAP attitude deadband. It is initially set to zero and is also set to zero whenever the cancel option is active.

18. Data Change Discrettes. Data change discrettes are required from the display to determine when certain data items are executed. The discrettes trigger certain computations and can deselect future attitude options. For example, if a future MNVR option is scheduled and new R, P, or Y angle inputs are executed, the future MNVR option is deselected. However, if any other data are loaded, such as rotation option or tracking option data, the future MNVR option will not be deselected, since those data are not related to the future MNVR option.

Similarly, if a future TRK or ROT option is scheduled, R, P, and Y angles may be loaded without deselecting the TRK or ROT option.

Therefore, loading data only associated with an attitude option that is scheduled for the future deselects the future attitude option. Since the Start Time is associated with a MNVR, TRK, and ROT attitude option, Start Time inputs will deselect any future attitude option. Start Time inputs, with no current attitude option selected, will set the required attitude equal to the current attitude, causing the attitude errors to zero. The data change discrettes are initialized to zero.

19. Reboost enable request (Item 25) When a reboost request is executed, the UNIV PTG PROC will consult the reboost duration time and will enable a reboost if the duration is non-zero and

the current time is either equal to or greater than the start time of Items 1-4. If the start time is in the future the reboost enable will be delayed until the current time reaches the start time. The FUT status will indicate a reboost is pending. When the current time is equal to or greater than the start time, the FUT status will blank and CUR status will be driven to show that a reboost is in progress.

20. Reboost cancel (Item 26) The reboost cancel item allows cancellation of the reboost at any time either prior to or during a reboost event. Execution of item 26 will zero the duration time and if a reboost is in progress will initiate a cancellation request to the Orbit DAP. The Orbit DAP will terminate the reboost by resetting the reboost enable after transitioning out of translation to rotation with the required delay. If the reboost is not enabled or when the reboost enable is reset by the DAP the CUR and FUT statuses will be cleared reflecting the successful termination of the reboost.
21. Reboost duration (Items 27 through 29) Items 27 through 29 allow entry of the reboost duration in hours, minutes, and seconds. If a reboost is in progress, the duration field will reflect the time remaining in the reboost. The duration field will be zeroed anytime a reboost is canceled, whether it be by item entry or software processing.

The following timeline of on-orbit events is presented to clarify the operation of the UNIV POINT PROC.

1. The UNIV PTG display appears on the specified CRT when the crew reconfigures the onboard software for OPS 2 (GNC, OPS 201 PRO).
2. The crew changes the displayed data through keyboard item execute commands, and the corresponding data items in the protected data area are then overwritten by the new values resulting from the commands.
3. The crew evaluates the displayed data, updates any of the displayed input parameters, and executes the desired attitude option once the displayed data are verified. At that moment, initialization parameters are computed to cue the selected attitude option.
4. The UNIV POINT PROC cyclically computes parameters necessary to maneuver the orbiter to the required attitude. The maneuver begins at the specified start time or immediately, if the specified start time is prior to the current time.
5. At the option of the crew, the UNIV PTG display is reviewed for attitude option select status and monitored for current attitude, required attitude, attitude errors, body rates, and maneuver completion time until steady-state attitude requirements are achieved.
6. If a reboost is desired, the crew enters a duration for the reboost, sets the start time for a current or future start, and initiates a reboost request. Progress of the reboost is monitored through observation of the status indicators and time remaining via the duration field.
7. While an attitude option is active, an additional attitude option may be executed at any time for the future and the option will begin at the specified start time.
8. The processor remains active after transitioning to MM 202 or OPS 8 and back to MM 201 or OPS 2. However, the display is not available in MM 202 or OPS 8.



9. Performing a prethrust attitude alignment in MM 202 inhibits UNIV POINT PROC cyclic outputs to the ORBIT DAP so long as the prethrust attitude alignment flag is set by the ORBIT DAP. When the PREBURN\_MNVR\_IN\_PROGRESS flag is reset, cyclic processing resumes, however, DAP does not use this data until MM 201 is reentered. The cyclic processing required to support the DAP LVLH attitude mode resumes when LVLH is selected in MM 202.
10. When OPS 201 is recalled, the item select status that existed prior to recall is shown on the UNIV PTG display.
11. All attitude options are terminated and deselected by crew execution of the option cancel command.
12. If the flight control system is in AUTO, the option cancel command initiates inertial attitude hold about the current attitude at the time of command execution. In addition, whenever the cancel option is either executed or reexecuted, the required attitude is set equal to the current attitude.
13. Selecting the LVLH attitude mode inhibits the cyclic processing of the selected universal pointing attitude option until the LVLH mode is deselected.

The functional task organization and logic flow for the UNIV POINT PROC principal function are shown in Figures 4.3.1-1 and 4.3.1-2. The logic flow is included for information only and is not intended to specify programming requirements.

Traceability to Level B software requirements is illustrated in Figure 4.3.1-3, which presents the interfaces between the UNIV POINT PROC and other software elements. The number in the upper right-hand corner of each block of the figure references the paragraph number in the Level B, GN&C, CPDS in which the function is discussed. Inputs to the UNIV POINT PROC from other software elements are located in the blocks on the left side of the figure. Outputs from the processor to other software elements are located in the blocks on the right side of the figure.

The Universal Pointing principal function input and output parameters, as well as I-load/K-load PTC axis parameters, are given in Section 4.3.24.

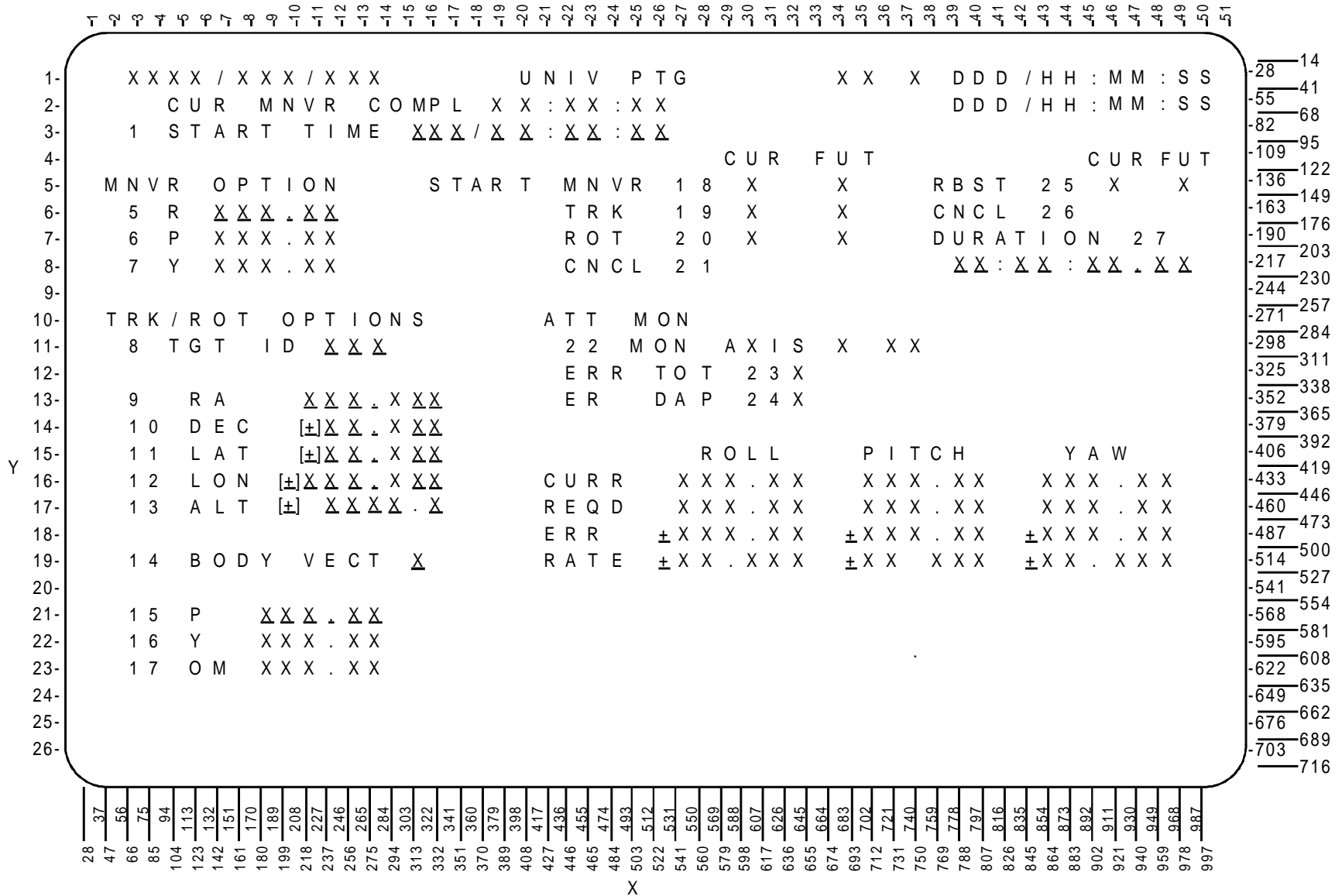


FIGURE 4.3-1. Universal Pointing Display

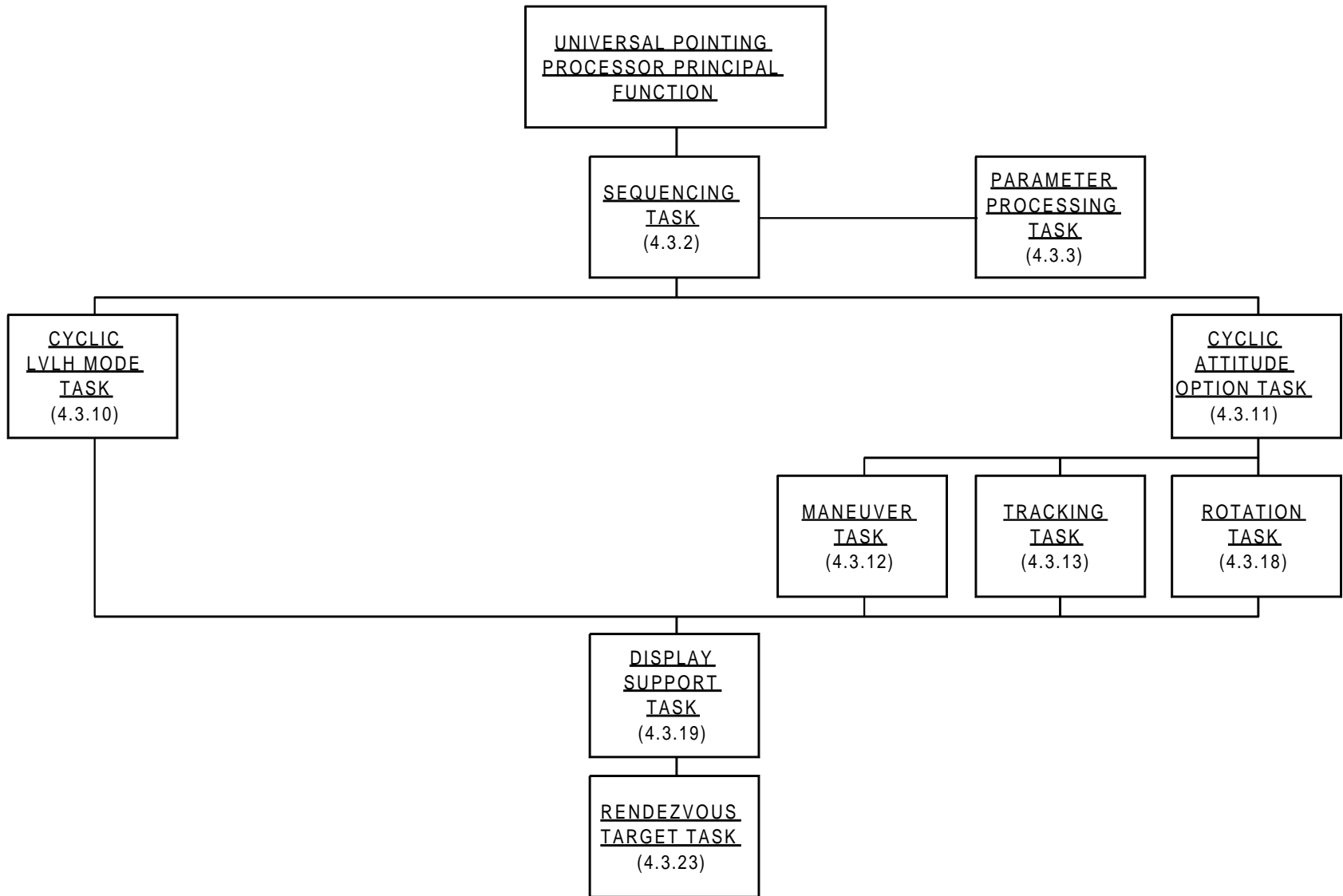


FIGURE 4.3.1-1. Universal Pointing Processor Principal Function Task Organization

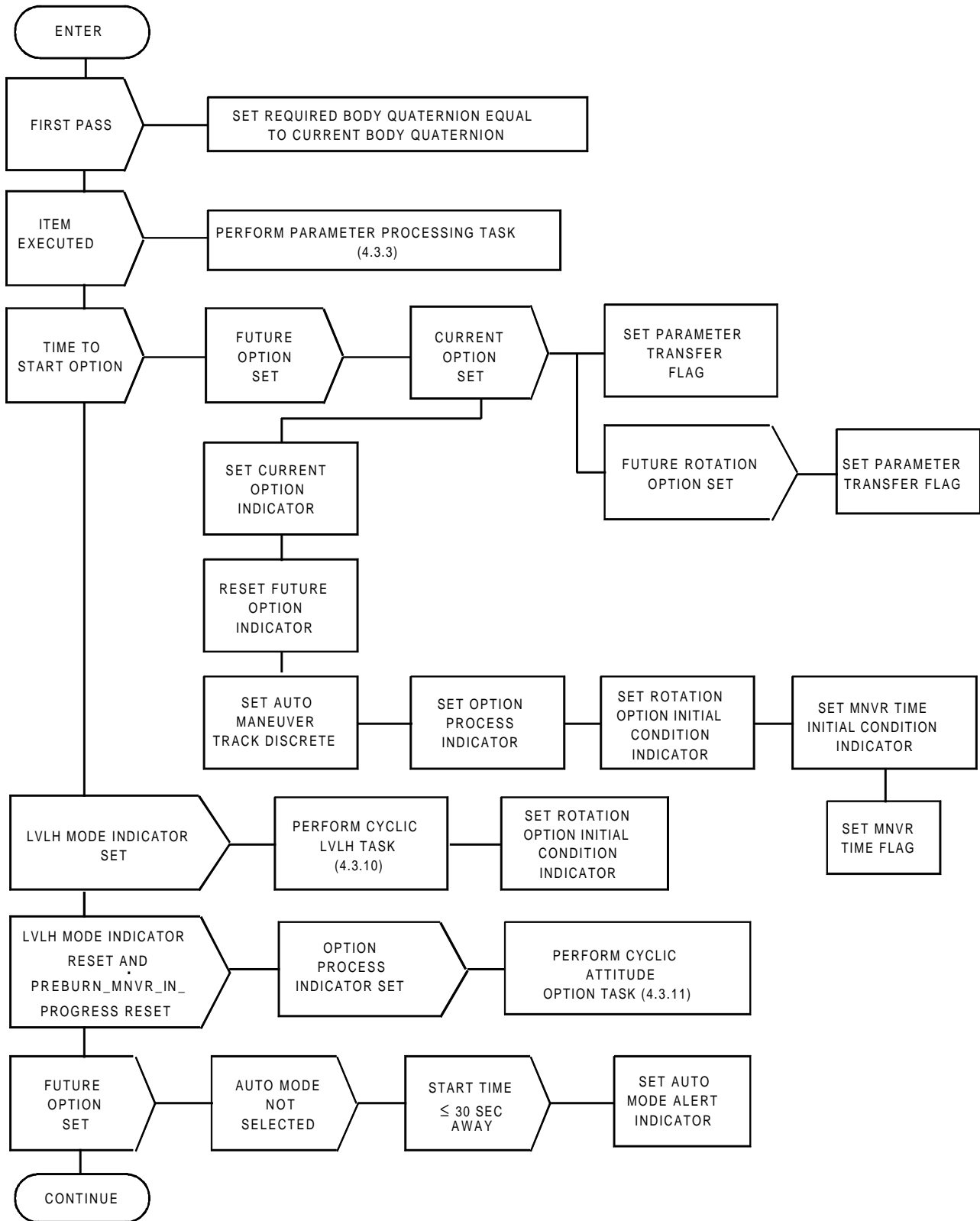


FIGURE 4.3.1-2.(1) Universal Pointing Processor Functional Flow (Sheet 1 of 3)

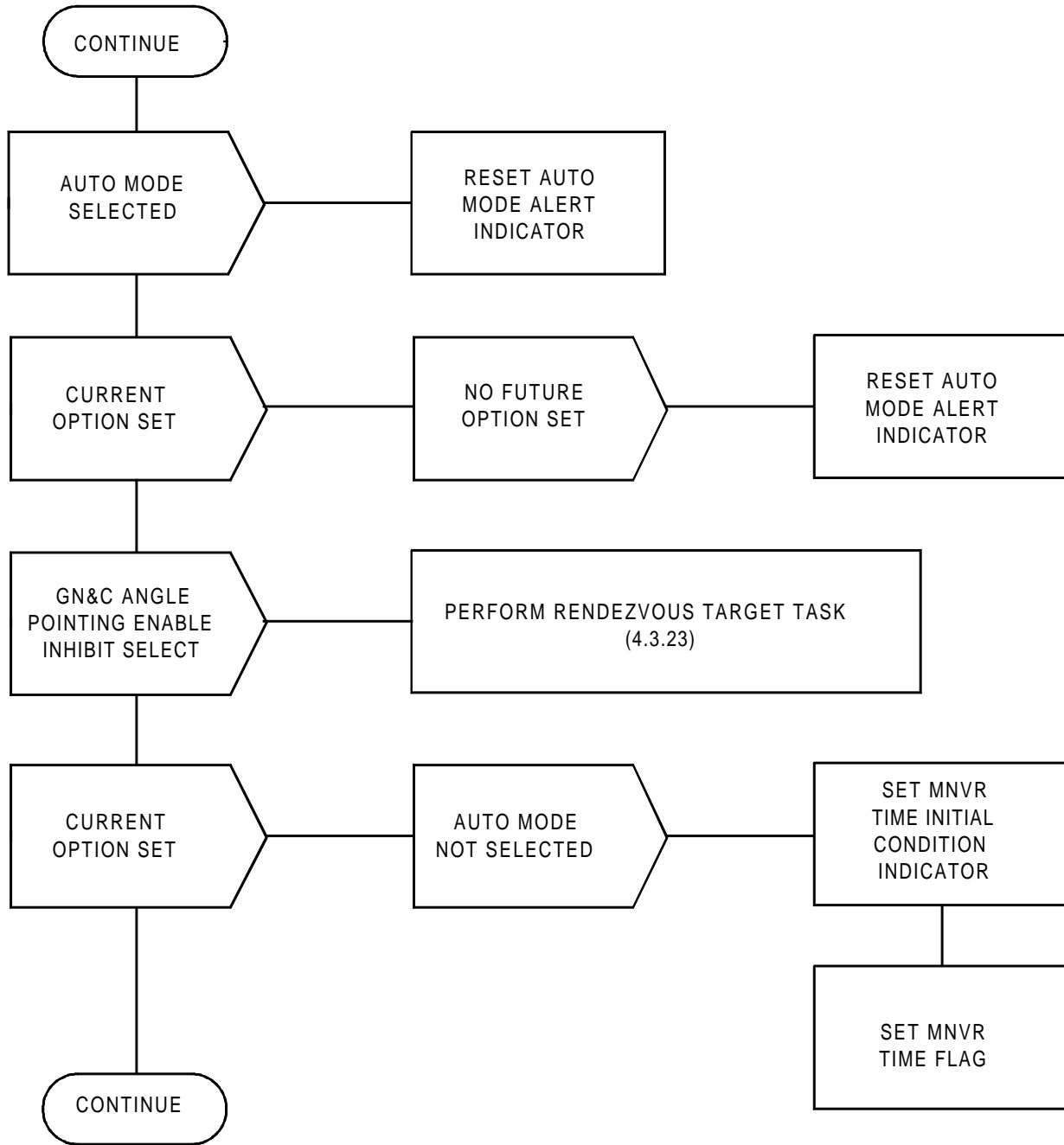


FIGURE 4.3.1-2.(2) Universal Pointing Processor Functional Flow (Sheet 2 of 3)

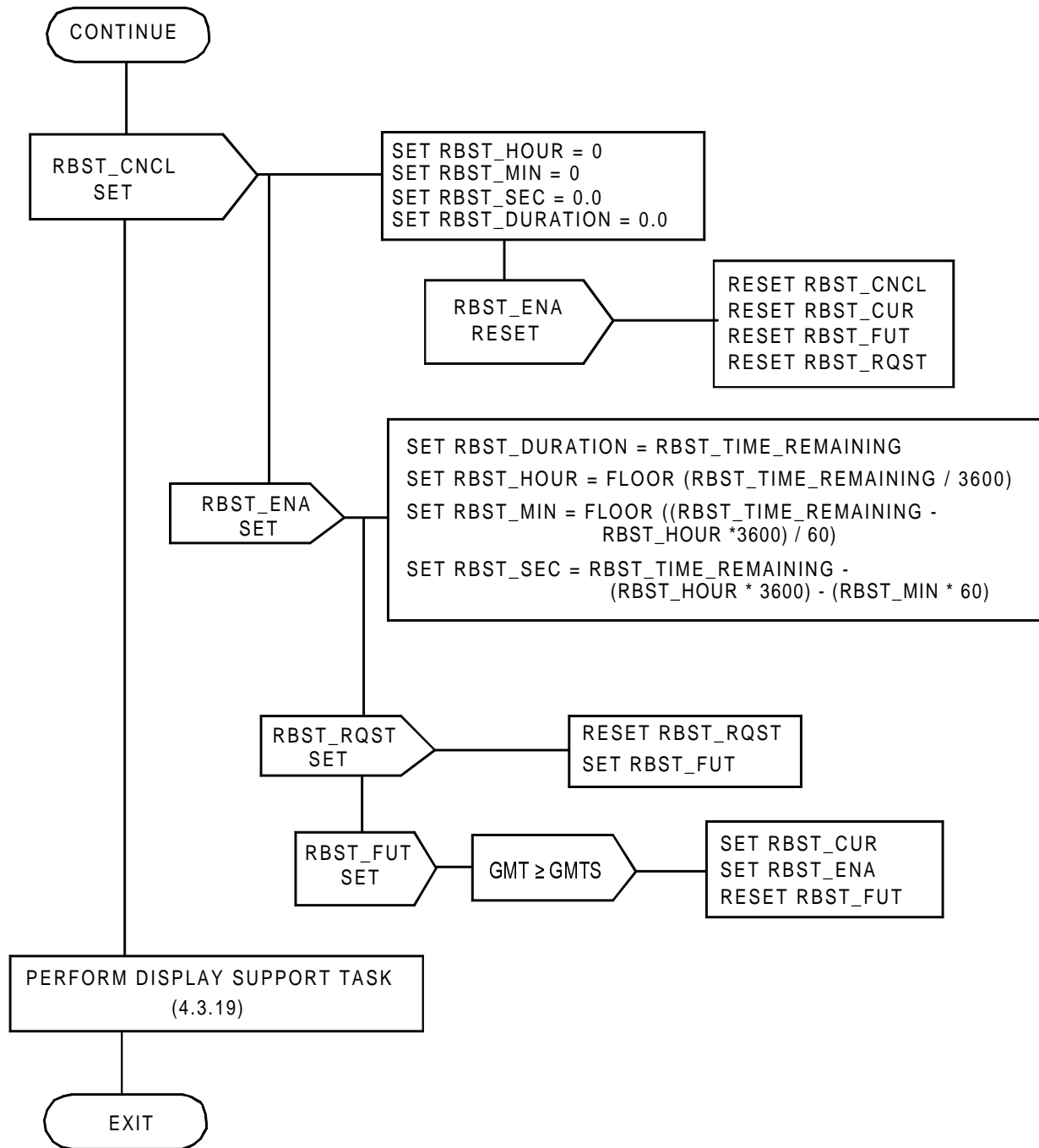


FIGURE 4.3.1-2.(3) Universal Pointing Processor Functional Flow (Sheet 3 of 3)

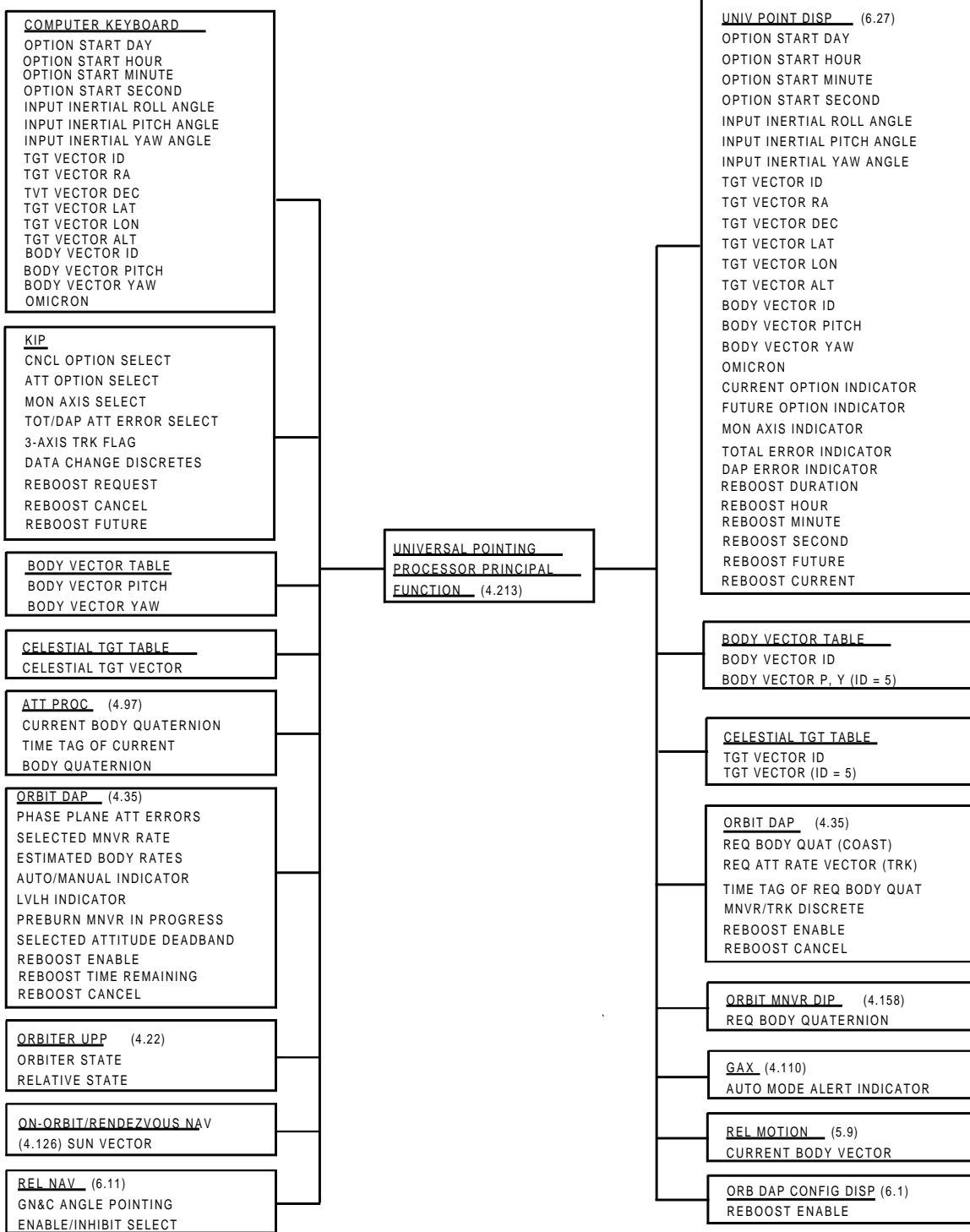


FIGURE 4.3.1-3. Universal Pointing Processor Data Flow

#### 4.3.2 Universal Pointing Processing Sequencing Task (UNIV SEQ)

This task provides the sequencing logic for all major tasks of the universal pointing processor principal function. The major tasks are:

1. Parameter Processing Task (PARAM PROC)
2. Cyclic LVLH Mode Task (CYC LVLH)
3. Cyclic Attitude Option Task (CYC OPT)
4. Rendezvous Target Task (RNDZTGT)
5. Display Support Task (DISP SUP)

The UNIV SEQ task is performed once every 1.92 seconds. It accepts input parameters from the UNIV PTG display and from GN&C functions external to universal pointing in order to cue the appropriate attitude computations. (Please refer to Figure 4.3.1–2 for the following discussion.)

A. Detailed Requirements. The first computation performed by the UNIV SEQ task is the initialization of the required body quaternion. The initialization consists of setting the required body quaternion, Q\_RBOD\_M50, equal to the current body quaternion, Q\_BOD\_M50, as follows:

$$Q\_RBOD\_M50\_S = Q\_BOD\_M50\_S$$

$$Q\_RBOD\_M50\_V = Q\_BOD\_M50\_V$$

That initialization is performed only once on entering OPS 2 from other legal OPS transitions, excluding OPS 8.

The PARAM PROC task is performed next each time a reboost request or an attitude option related item on the universal pointing display is executed. Therefore, each time a data change discrete is set, an attitude option is selected, a reboost request is executed or the maneuver cancel option is selected, the parameter processing task is executed.

Outputs of the parameter processing task that are required by this task consist of the starting GMT (GMTS) and three indicators: the current attitude option indicator (OPT\_CUR), the future attitude option indicator (OPT\_FUT), and the option process indicator (OPT\_PROC).

The starting GMT is then tested relative to the current GMT to determine when to initiate the selected attitude option. If  $GMT \geq GMTS$  and  $OPT\_FUT \neq 0$ , the following equations are executed:

$$OPT\_CUR = OPT\_FUT$$

$$OPT\_FUT = 0$$

$$MNVR\_TRACK\_OPTION = 1$$

$$OPT\_PROC = OPT\_CUR$$

$$ROT\_IC = 1$$



$MNVR\_TIME\_IC = 1$  (Set)

$MNVR\_TIME\_FLAG = 1$  (Set)

In addition, if  $OPT\_CUR \neq 0$  prior to executing the above equations, the parameter transfer flag is set

$PARAM\_XFR = 1$

Or if  $OPT\_CUR = 0$  prior to executing the above equations and  $OPT\_FUT = 3$ , the parameter transfer flag is also set. The parameter transfer flag initiates the transfer of future attitude parameters to the current state for active processing.

Next, the LVLH\_MODE indicator,  $LVLH\_MODE$ , is tested to determine if the cyclic universal pointing attitude options should be inhibited and the cyclic LVLH attitude mode task performed. If  $LVLH\_MODE = 1$ , the rotation option initial condition indicator is set, and the LVLH mode task is performed each pass through the UNIV SEQ task. But, if both  $LVLH\_MODE = 0$  and  $PREBURN\_MNR\_IN\_PROGRESS = 0$  and if  $OPT\_PROC \neq 0$ , the cyclic attitude option task is performed. Therefore, CYC LVLH and CYC OPT are mutually exclusive tasks.

If a future attitude option is scheduled ( $OPT\_FUT \neq 0$ ) and the auto attitude mode is not selected ( $AUTO = 0$ ) and the future attitude option start time (GMTS) is 30 seconds prior to the current time (GMT), an auto mode alert indicator is set ( $AUTO\_ALERT=1$ ) to initiate the message "SELECT AUTO" on the message line. This indicator is reset when the future option becomes current or when the auto mode is selected ( $AUTO=1$ ).

If the GN&C angle pointing enable/inhibit line-of-sight discrete,  $KU\_SEL$ , is enabled, the rendezvous target line-of-sight (RNDZTGT) task is performed.

On each cycle during which a current option is active ( $OPT\_CUR \neq 0$ ) and the auto mode is not selected ( $AUTO = 0$ ), the maneuver completion time calculation is reinitialized:

$MNVR\_TIME\_IC = 1$

$MNVR\_TIME\_FLAG = 1$

If a reboost cancellation is required ( $RBST\_CNCL = 1$ ), the reboost hours, mins, seconds and duration will all be zeroed.

$RBST\_HOUR = 0$

$RBST\_MIN = 0$

$RBST\_SEC = 0$

$RBST\_DURATION = 0.0$

Also, if or when the reboost becomes disabled ( $RBST\_ENA = 0$ ) the reboost cancel, the reboost current and future status indicators, and the reboost request will be reset.

$RBST\_CNCL = 0$  (Reset)

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RBST\_CUR = 0 (Reset)

RBST\_FUT = 0 (Reset)

RBST\_RQST = 0 (Reset)

Else if the reboost is enabled (RBST\_ENA = 1) the reboost duration will be set to the reboost time remaining and the reboost hours, minutes, seconds will be computed to reflect the reboost time remaining.

RBST\_DURATION = RBST\_TIME\_REMAINING

RBST\_HOUR = FLOOR(RBST\_TIME\_REMAINING / 3600)

RBST\_MIN = FLOOR((RBST\_TIME\_REMAINING - RBST\_HOUR \* 3600)/60)

RBST\_SEC = RBST\_TIME\_REMAINING - RBST\_HOUR \* 3600 - RBST\_MIN \* 60

Else if the reboost is not in progress (RBST\_ENA = 0), a check is made to see if a reboost is being requested (RBST\_RQST = 1). If so, the reboost future status indicator will be set. The reboost request will be reset after its use.

RBST\_FUT = 1 (Set)

RBST\_RQST = 0 (Reset)

Also if the reboost is not in progress (RBST\_ENA = 0), if a future reboost is pending (RBST\_FUT = 1), the start time is consulted to determine if the reboost is to be executed immediately or in the future. If the start time is in the past, GMT greater than or equal to GMTS, the reboost will be enabled, the current status indicator will be set, and the reboost future status indicator will be reset.

RBST\_CUR = 1 (Set)

RBST\_ENA = 1 (Set)

RBST\_FUT = 0 (Reset)

Finally, the display support task is performed prior to exiting the universal pointing processor principal function.

The tasks identified in this section will be described in detail in the following sections.

B. Interface Requirements. The input and output parameters for the universal pointing processor sequencing task are presented in Tables 4.3.2-1 and 4.3.2-2. This task calls the PARAM PROC, CYC LVLH, CYC OPT, RNDZTGT, and DISP SUP tasks.

C. Processing Requirements. This task is processed once every 1.92 seconds. Processing begins when OPS 2 is entered and continues for major mode transitions in OPS 2. Processing also continues after transitioning to OPS 8 from OPS 2. Processing is terminated when a transition from OPS 2 to a sequence other than OPS 8 is performed. When processing is terminated, this task must be reinitialized. OPS 2 recalls do not interrupt the cyclic processing. The cyclic attitude option task does not require processing in MM 202 after a prethrust attitude alignment is initiated. In that case, the UNIV POINT PROC computations will be inhibited or bypassed until MM 201 is reselected.

D. Initialization Requirements. In addition to the initialization described in paragraph A above, the universal pointing processor is initialized with no option active.

The initial values of the maneuver track discrete, parameter transfer flag, and the rotation option initial condition indicator are as follows:

$$\text{MNVR\_TRACK\_OPTION} = 0$$

$$\text{PARAM\_XFR} = 0$$

$$\text{ROT\_IC} = 0$$

E. Supplemental Information. All quaternions described in this document are resolved into scalar and vector components such that the vector component is proportional to the negative of the eigenaxis of rotation extracted from the quaternion when its scalar component is positive. For example, the required body quaternion Q\_RBOD\_M50 is defined as follows:

$$Q\_RBOD\_M50 = \begin{bmatrix} Q\_RBOD\_M50\_S \\ Q\_RBOD\_M50\_V \end{bmatrix} = \begin{bmatrix} S \\ -\bar{V} \end{bmatrix}$$

where UNIT ( $\bar{V}$ ) is the eigenaxis of rotation to the RBOD coordinate system from the M50 coordinate system when  $S > 0$ .

Table 4.3.2-1. Universal Pointing Processor Sequencing Task Input Parameters						
MSID No.	Name	Definition	Source	Precision	Type	Units
	GMTS	Attitude option start time	PARAM PROC	DP		s
V95J7483C	OPT_FUT	Future attitude option indicator	PARAM PROC	N/A	I	none
V90X2174X	LVLH_MODE	LVLH mode indicator	ORBIT DAP	N/A	D	none
V97U5061C	OPT_PROC	Option process indicator	PARAM PROC	N/A	I	none
V72X2850XA	AUTO	Auto mode discrete	ORBIT DAP	N/A	D	none
V93X6859XA	KU_SEL	GN&C angle pointing enable/ inhibit discrettes	REL NAV	N/A	D	none
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT PROC	SP		none
V95J7482C	OPT_CUR	Current option indicator	PARAM PROC	N/A	I	none
V91W5006C	GMT	Current time	FCOS	DP		s
V90X1587X	PREBURN_MNVR_IN_PROGRESS	Preburn maneuver in progress flag	ORBIT DAP	N/A	D	none
V93J6829C	OPT_SEL	Selected attitude option indicator	UNIV PTG DISP	N/A	I	none
V93X6871X	OPT_CNCL	Cancel option discrete	UNIV PTG DISP	N/A	D	none
V93X6882X	TRK_DCD	Tracking data change discrete	UNIV PTG DISP	N/A	D	none
V93X6883X	ROT_DCD	Rotation data change discrete	UNIV PTG DISP	N/A	D	none
V93X6884X	MNV_DCD	Maneuver data change discrete	UNIV PTG DISP	N/A	D	none
V93X6885X	FUT_DCD	Future option data change discrete	UNIV PTG DISP	N/A	D	none
V94X0215X	RBST_FUT	Reboost future status indicator	UNIV PTG DISP	N/A	B	none
V94X0217X	RBST_CNCL	Reboost cancel	UNIV PTG DISP, ORBIT DAP	N/A	B	none
V90W0443C	RBST_TIME_REMAINING	Reboost time remaining	ORBIT DAP	SP	F	s
V94X0214X	RBST_RQST	Reboost Request	UNIV PTG DISP	N/A	B	none
V90X0442X	RBST_ENA	Reboost Enable	ORBIT DAP	N/A	B	none

Table 4.3.2-2. Universal Pointing Processor Sequencing Task Output Parameters						
MSID No.	Name	Definition	Destination	Precision	Type	Units
V95U2209C thru V95U2212C V95J7482C	Q_RBOD_M50	Required body quaternion	ORBIT DAP, CYC OPT, DISP SUP	SP		none
V97J7483C	OPT_CUR	Current attitude option indicator	UNIV PTG, DISP SUP, CYC OPT, PARAM PROC	N/A	I	none
V94X4692X	AUTO_ALERT	Auto mode alert indicator	GAX	N/A	D	none
V97U5061C	OPT_PROC	Option process indicator	CYC OPT	N/A	I	none
	PARAM_XFR	Parameter transfer flag	CYC OPT	N/A	D	none
V95X2222X	MNVR_TRACK_OPTION	Maneuver/tracking option discrete	ORBIT DAP	N/A	D	none
V96U9754C	ROT_IC	Rotation option initial condition indicator	ROTR, CYC OPT	N/A	D	none
	MNVR_TIME_IC	Maneuver time initial condition indicator	CMPLT TIME	N/A	D	none
	MNVR_TIME_FLAG	Maneuver time flag	CMPLT TIME	N/A	D	none
V94X0215X	RBST_FUT	Reboost future status indicator	UNIV PTG DISP, TLM	N/A	B	none
V94X0216X	RBST_CUR	Reboost current status indicator	UNIV PTG DISP, TLM	N/A	B	none
V94X0217X	RBST_CNCL	Reboost cancel	ORBIT DAP	N/A	B	none
V94W0213C	RBST_DURATION	Reboost duration	UNIV PTG DISP, TLM	SP	F	s
V94W0210C	RBST_HOUR	Reboost duration hours	UNIV PTG DISP	SP	I	hr
V94W0211C	RBST_MIN	Reboost duration minutes	UNIV PTG DISP	SP	I	min
V94W0212C	RBST_SEC	Reboost duration seconds	UNIV PTG DISP	SP	F	s
V90X0442X	RBST_ENA	Reboost enable	ORBIT DAP, ORB DAP CONFIG DISP, TLM	N/A	B	none

### 4.3.3 Parameter Processing Task (PARAM PROC)

This task computes initialization parameters for the cyclic attitude option computations task (CYC OPT). The parameters cue a selected attitude option and control or terminate certain computations in CYC OPT. The parameters are computed in association with the execution of certain data items of UNIV PTG and are transferred to CYC OPT as a consistent data set when an attitude option is executed.

A. Detailed Requirements. Associated with the execution of each attitude option is a set of parameters that remain constant. It is that set of parameters which is computed by this task. The computed parameters consist of a body vector, an earth-fixed target position vector, a celestial target vector, a maneuver option quaternion, an attitude option start time, and several integer and discrete parameters associated with the initiation and termination of a selected attitude option. (Please refer to Figure 4.3.3-1 for the following discussion.)

1. Attitude Option Selection. If an attitude option is selected,  $OPT\_SEL \neq 0$ , the future attitude option indicator is set and the selected attitude option indicator is reset.

$$OPT\_FUT = OPT\_SEL$$

$$OPT\_SEL = 0$$

2. Maneuver Option Quaternion. If a future maneuver option is selected,  $OPT\_FUT = 1$ , the maneuver option quaternion subtask is called to calculate the maneuver option quaternion.

CALL MNVR QUAT

Inputs: ROLLI, PITCHI, YAWI

Q\_M50\_INRTL\_ORB\_S,

Q\_M50\_INRTL\_ORB\_V

Outputs: Q\_MNVR\_S, Q\_MNVR\_V

3. Body Vector. If a future tracking or rotation option is selected,  $OPT\_FUT = 2$  or  $3$ , the body vector subtask is called to calculate the body vector:

CALL BODY VEC

Inputs: BODV\_PITCH, BODV\_YAW

Outputs: PLOS

4. Earth-Fixed Target Position Vector. If a future tracking option is selected,  $OPT\_FUT = 2$ , and  $TGT\_ID = 3$ , the earth-fixed target position vector subtask is called:

CALL ETGT POS

Inputs: TGT\_LAT, TGT\_LON, TGT\_ALT

Outputs: TGPOS

5. Attitude Option Cueing. If no current option is set ( $OPT\_CUR = 0$ ), then perform the following:

- a. If no future rotation option is set ( $OPT\_FUT \neq 3$ ), then set the option process indicator and the parameter transfer indicator:

$$OPT\_PROC = OPT\_FUT$$

$$PARAM\_XFR = 1$$

- b. Otherwise, if a future rotation option is set ( $OPT\_FUT = 3$ ), then reset the option process indicator:

$$OPT\_PROC = 0$$

6. Attitude Option Start Time. The attitude option start time is computed in seconds of Greenwich mean time (GMT). First, the start time is computed in seconds, mission elapsed time (MET):

$$METS = (86,400) IDAY + (3,600) IHOURL + (60) IMIN + ISEC$$

Second, METS is converted to GMT by adding the MET/GMT reference time to METS:

$$GMTS = METS + BASE\_MET$$

7. Maneuver Option Data Change Discrete. If the maneuver option data change discrete is set,  $MNV\_DCD = 1$ , and a future maneuver option is selected,  $OPT\_FUT = 1$ , then set the future option data change discrete:

$$FUT\_DCD = 1$$

8. Tracking Option Data Change Discrete. If the tracking option data change discrete is set,  $TRK\_DCD = 1$ , several parameters are tested and set.

First, if a future tracking option is selected, then set the future option data change discrete:

$$FUT\_DCD = 1$$

Second, if  $TGT\_ID = 5$  or  $11 \leq TGT\_ID \leq 110$ , and if no target RA or DEC has been executed, the celestial target RA/DEC subtask is called:

CALL RA DEC

Inputs: TGT\_ID

Outputs: TGT\_RA, TGT\_DEC

Third, if  $TGT\_ID = 4$ , the celestial target RA/DEC subtask is called:

$$\overline{TGT\_VEC} = \overline{UR\_SUN}$$

CALL RA DEC

Inputs:  $\overline{\text{TGT\_VEC}}$ , TGT\_ID

Outputs: TGT\_RA, TGT\_DEC

Fourth, if TGT\_ID = 5, the celestial target vector subtask is called:

CALL STAR

Inputs: TGT\_RA, TGT\_DEC

Outputs:  $\overline{\text{TGT\_VEC}}$

9. Tracking or Rotation Option Data Change Discrete. If the tracking  $\text{TRK\_DCD} = 1$ , or rotation option data change discrete is set,  $\text{ROT\_DCD} = 1$ , several parameters are computed.

First, if no body vector pitch or yaw has been executed, the body vector pitch/yaw subtask is called:

CALL PY

Inputs: BODV\_ID

Outputs: BODV\_PITCH, BODV\_YAW

Then, if BODV\_ID = 5, the body vector pitch and yaw components are stored in the body vector table:

$$\text{BODV\_SCL}(5, 1) = \text{BODV\_PITCH}$$

$$\text{BODV\_SCL}(5, 2) = \text{BODV\_YAW}$$

where BODV\_SCL is a two-dimensional array in K-load.

10. Rotation Option Data Change Discrete. If the rotation option data change discrete is set,  $\text{ROT\_DCD} = 1$ , and a future rotation option is selected,  $\text{OPT\_FUT} = 3$ , then set the future option data change discrete:

$$\text{FUT\_DCD} = 1$$

11. Future Option Data Change Discrete. If the future option data change discrete is set,  $\text{FUT\_DCD} = 1$ , then perform the following:

- a. Reset the future attitude option indicator:

$$\text{OPT\_FUT} = 0$$

- b. If no current option is set ( $\text{OPT\_CUR} = 0$ ), the following equations are executed:

$$\text{OPT\_PROC} = 0$$



$$\text{AUTO\_ALERT} = 0$$

$$Q\_RBOD\_M50\_S = Q\_BOD\_M50\_S$$

$$Q\_RBOD\_M50\_V = Q\_BOD\_M50\_V$$

12. Data Change Discretes. Data change discretes are required by the PARAM PROC task so that it may determine when the execution of specific items occurs. There are four data change discretes: one for the execution of items associated with the tracking option (TRK\_DCD), one for the execution of items associated with the rotation option (ROT\_DCD), one for the execution of items associated with the maneuver option (MNV\_DCD), and one for the execution of start time items (FUT\_DCD). The values of the discretes are defined as follows:

TRK_DCD = 0	No tracking option data executed
TRK_DCD = 1	Tracking option data executed
ROT_DCD = 0	No rotation option data executed
ROT_DCD = 1	Rotation option data executed
MNV_DCD = 0	No maneuver option data executed
MNV_DCD = 1	Maneuver option data executed
FUT_DCD = 0	No Start Time data executed
FUT_DCD = 1	Start Time data executed

All data change discretes are reset before exiting the PARAM PROC task.

13. Cancel Option Selection. If OPT\_CNCL is equal to one, the cancel option has been selected. The following equations are then executed:

$$Q\_RBOD\_M50\_S = Q\_BOD\_M50\_S$$

$$Q\_RBOD\_M50\_V = Q\_BOD\_M50\_V$$

$$\text{OPT\_CNCL} = 0$$

$$\text{OPT\_CUR} = 0$$

$$\text{OPT\_FUT} = 0$$

$$\text{MNVR\_TRACK\_OPTION} = 0$$

$$\text{OPT\_PROC} = 0$$

$$\text{AUTO\_ALERT} = 0$$

$$\text{MNVR\_CMPL\_TIME} = 0$$

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- B. Interface Requirements. Input and output parameters for the parameter processing task are given in Tables 4.3.3-1 and 4.3.3-2.
- C. Processing Requirements. Each component of this task is executed when the associated data item is executed. This task is also executed when an attitude option is selected.
- D. Initialization Requirements. All initialization parameters for this task are obtained from the keyboard.
- E. Supplemental Information. Attitude option cueing is performed for MNVR and TRK attitude options, but not the ROT option.

Table 4.3.3-1. Parameter Processing Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Type	Units
V93W6801C	IDAY	Attitude option start day	UNIV PTG DISP	N/A	I	day
V93W6802C	IHOURL	Attitude option start hour	UNIV PTG DISP	N/A	I	hr
V93W6803C	IMIN	Attitude option start minute	UNIV PTG DISP	N/A	I	min
V93W6804C	ISEC	Attitude option start second	UNIV PTG DISP	N/A	I	s
V93U6805C	BODV_ID	Body vector identifier	UNIV PTG DISP	N/A	I	none
V93U6806CB	BODV_PITCH	Body vector pitch coordinate	UNIV PTG DISP, PY	SP	F	rad
V93U6807CB	BODV_YAW	Body vector yaw coordinate	UNIV PTG DISP, PY	SP	F	rad
V93U6810C	TGT_ID	Target vector identifier	UNIV PTG DISP	N/A	I	none
V93H6813CB	TGT_RA	Target vector right ascension	UNIV PTG DISP	SP	F	rad
V93H6815CB	TGT_DEC	Target vector declination	UNIV PTG DISP	SP	F	rad
V93H6820C	TGT_LAT	Earth-fixed target latitude	UNIV PTG DISP	SP	F	rad
V93H6821C	TGT_LON	Earth-fixed target longitude	UNIV PTG DISP	SP	F	rad
V93H6822C	TGT_ALT	Earth-fixed target altitude	UNIV PTG DISP	SP	F	nmi
V93J6829C	OPT_SEL	Selected attitude option indicator	UNIV PTG DISP	N/A	I	none
V93H6837C	ROLLI	Input inertial roll angle (YZX Euler)	UNIV PTG DISP	SP	F	rad
V93H6838C	PITCHI	Input inertial pitch angle (YZX Euler)	UNIV PTG DISP	SP	F	rad
V93H6839C	YAWI	Input inertial yaw angle (YZX Euler)	UNIV PTG DISP	SP	F	rad
V91W1996C	BASE_MET	GMT/MET reference time	FCOS	DP		s
V93X6871X	OPT_CNCL	Cancel option discrete	UNIV PTG DISP	N/A	D	none
V93X6882X	TRK_DCD	Tracking data change discrete	UNIV PTG DISP	N/A	D	none

Table 4.3.3-1. Parameter Processing Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Type	Units
V97U2214CC thru V97U2217CC	Q_M50_ INRTL_ORB	Inertial to M50 quaternion	K-LOAD	SP		none
V93X6883X	ROT_·DCD	Rotation data change discrete	UNIV PTG DISP	N/A	D	none
V93X6884X	MNV_·DCD	Maneuver data change discrete	UNIV PTG DISP	N/A	D	none
V90U4972C thru V90U4974C	UR_·SUN	Sun unit vector in M50 coordinates	ORB/RND NAV	SP	F	none
V90U2240X thru V90U2243X	Q_BOD_M50	Current body quaternion	ATT PROC	SP		none
V95J7482C	OPT_CUR	Current option indicator	UNIV SEQ	N/A	I	none
V93X6885X	FUT_·DCD	Future option data change discrete	UNIV PTG DISP	N/A	D	none

Table 4.3.3-2. Parameter Processing Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Type	Units
	GMTS	Attitude option start time	UNIV SEQ	DP		s
	$\overline{PLOS}$	Body unit vector	CYC OPT	SP		none
	$\overline{TGPOS}$	Earth-fixed target position vector	CYC OPT	SP		ft
V95J7483C	Q_MNVR	Maneuver option quaternion	CYC OPT	SP		none
	OPT_FUT	Future attitude option indicator	UNIV SEQ, UNIV PTG DISP, TLM	N/A	I	none
V93H6813CA	$\overline{TGT\_VEC}$	Celestial target vector	I_STAR_SEL	SP		none
	TGT_RA	Celestial target right ascension	UNIV PTG DISP	SP	F	rad
V93H6815CA	TGT_DEC	Celestial target declination	UNIV PTG DISP	SP	F	rad
V93U6806CA	BODV_PITCH	Body vector pitch coordinate	UNIV PTG DISP	SP	F	rad
V93U6807CA	BODV_YAW	Body vector yaw coordinate	UNIV PTG DISP	SP	F	rad
V97U5061C	OPT_PROC	Option process indicator	UNIV SEQ, CYC OPT	N/A	I	none
V95U2209C thru V95U2212C	PARAM_XFR	Parameter transfer flag	CYC OPT	N/A	D	none
	Q_RBOD_M50	Required body quaternion	CYC OPT	SP		none
V95J7482C	OPT_CUR	Current attitude option indicator	UNIV SEQ, UNIV PTG DISP, TLM	N/A	I	none
V95X2222X	MNVR_TRACK_OPTION	Maneuver/tracking option discrete	ORBIT DAP	N/A	D	none
V94X4692X	AUTO_ALERT	Auto mode alert discrete	GAX	N/A	D	none
V95W7472C	MNVR_CMPL_TIME	Current maneuver completion time	UNIV PTG DISP	DP		s

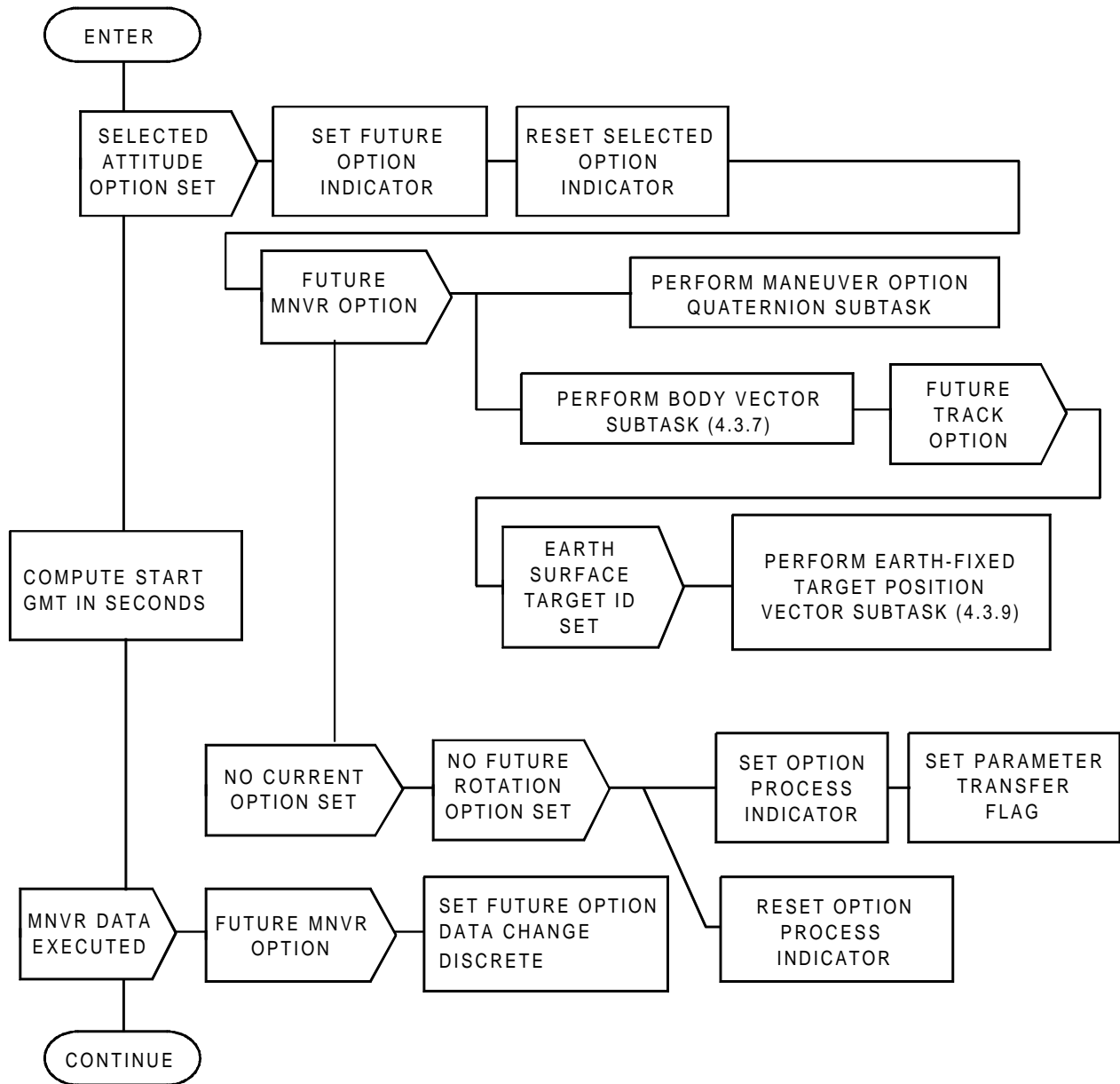


FIGURE 4.3.3-1.(1) Parameter Processing Task Functional Flow (Sheet 1 of 3)

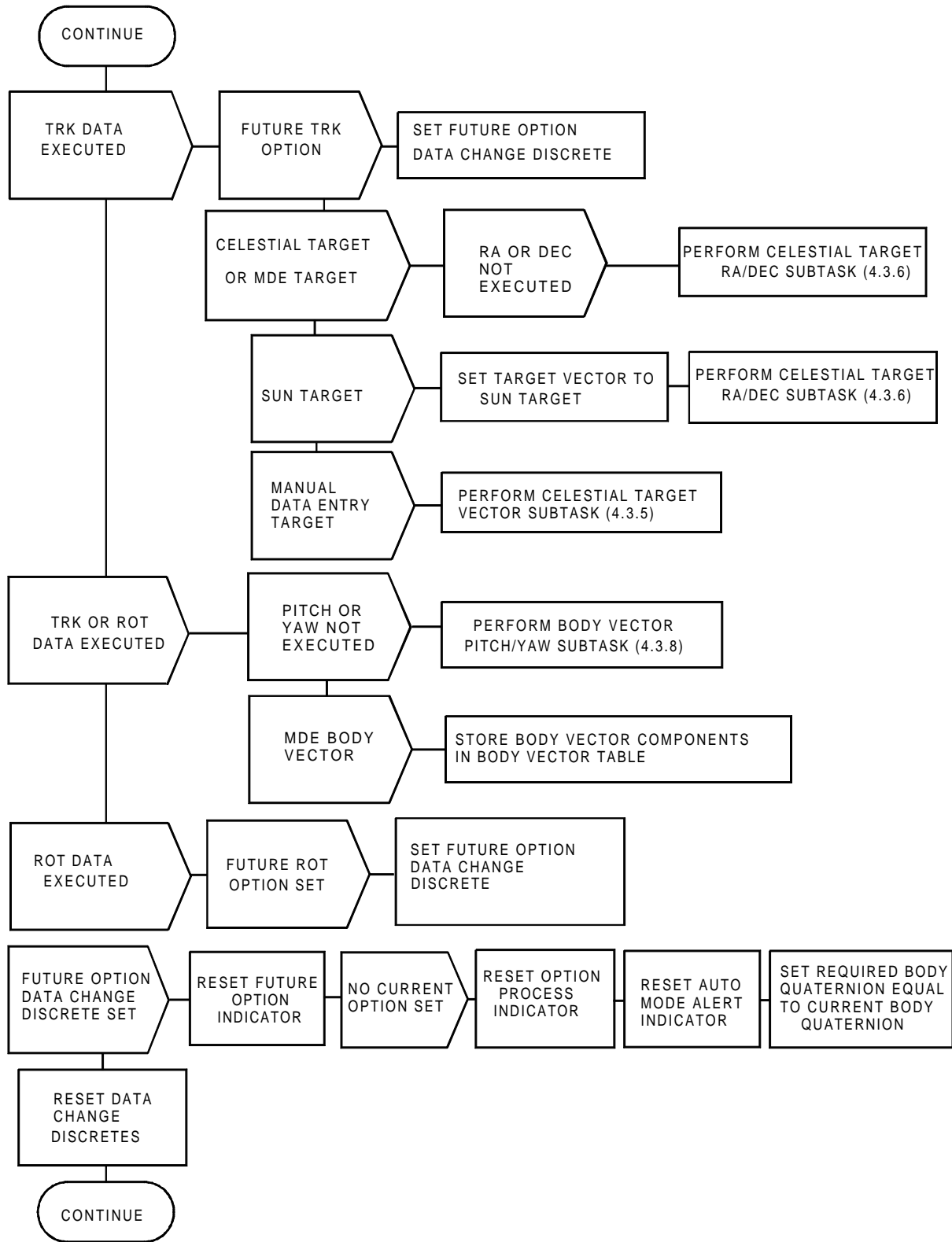


FIGURE 4.3.3-1.(2) Parameter Processing Task Functional Flow (Sheet 2 of 3)

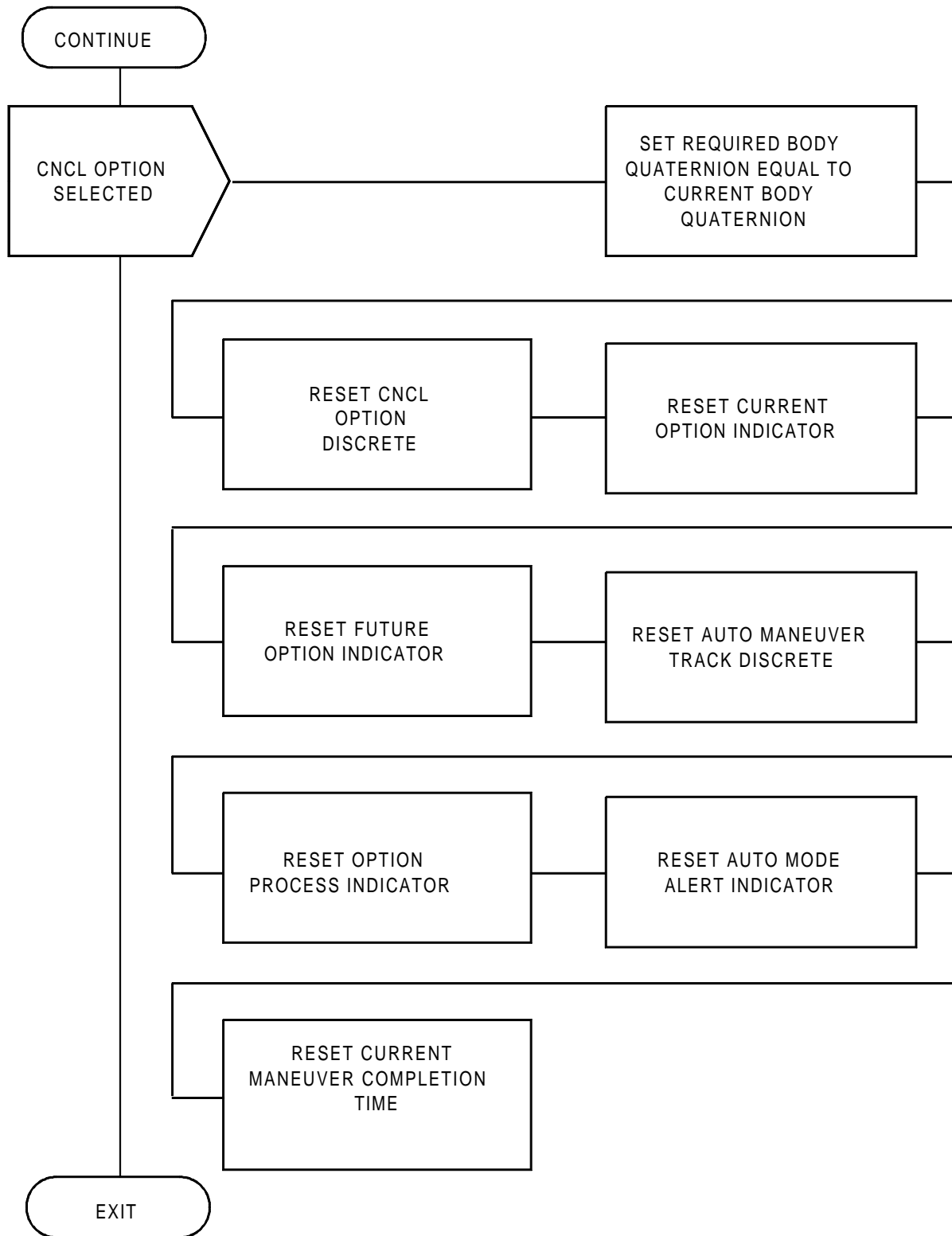


FIGURE 4.3.3-1.(3) Parameter Processing Task Functional Flow (Sheet 3 of 3)



#### 4.3.4 Maneuver Option Quaternion Subtask (MNVR QUAT)

This subtask calculates the inertial body quaternion, Q\_MNVR, required by the MNVR attitude option. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. Q\_MNVR represents a required body attitude relative to the M50 coordinate system and is computed from a set of roll, pitch, and yaw input angles input to the UNIV PTG display. The input roll (ROLLI), pitch (PITCHI), and yaw (YAWI) angles specify the required orientation of the body axes relative to the inertial attitude direction indicator (ADI) reference in a Y, Z, X Euler sequence. The quaternion to the required body axes from the ADI is computed from the input angles as follows:

$$Q\_RBOD\_ADI\_S = CR CP CY - SR SP SY$$

$$Q\_RBOD\_ADI\_V = VECTOR(-SR CP CY - CR SP SY, -CR SP CY - SR CP SY, -CR CP SY + SR SP CY)$$

where R = ROLLI/2, P = PITCHI/2, Y = YAWI/2, and S and C are the sine and cosine functions, respectively.

A quaternion multiplication is then performed to compute the required body quaternion relative to the M50 reference.

CALL QUAT\_MULT

Inputs:            Q\_RBOD\_ADI\_S, Q\_RBOD\_ADI\_V  
                      Q\_M50\_INRTL\_ORB\_S, -Q\_M50\_INRTL\_ORB\_V

Outputs:            Q\_MNVR\_S, Q\_MNVR\_V

B. Interface Requirements. The input and output parameters for the maneuver option quaternion subtask are given in Tables 4.3.4-1 and 4.3.4-2.

C. Processing Requirements. This subtask is processed once each time the maneuver option is executed.

D. Initialization Requirements. The quaternion Q\_M50\_INRTL\_ORB is obtained from the on-orbit attitude processor and is equal to the inertial M50 quaternion for the inertial reference frame.

E. Supplemental Information. The QUAT\_MULT module referenced in this task and documented in the flight control Level C, GN&C, FSSR is presented here for information only. For the operation Q3 = Q1 Q2, where:

$$Q1 = \begin{bmatrix} Q1S \\ Q1V \end{bmatrix} \text{ and } Q2 = \begin{bmatrix} Q2S \\ Q2V \end{bmatrix}$$

the product of the two quaternions Q1 and Q2 is given as:

$$Q3 = \begin{bmatrix} Q1S \\ Q1V \end{bmatrix} \begin{bmatrix} Q2S \\ Q2V \end{bmatrix} = \begin{bmatrix} Q1S Q2S - Q1V \cdot Q2V \\ Q1S Q2V + Q2S Q1V + Q1V \times Q2V \end{bmatrix}$$

where

$$Q_{3S} = Q_{1S} Q_{2S} - \overline{Q_{1V}} \cdot \overline{Q_{2V}}$$

and

$$\overline{Q_{3V}} = Q_{1S} \overline{Q_{2V}} + Q_{2S} \overline{Q_{1V}} \times \overline{Q_{2V}}$$

Table 4.3.4-1. Maneuver Option Quaternion Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93H6837C	ROLLI	Input inertial roll angle (YZX Euler)	UNIV PTG DISP	SP	rad
V93H6838C	PITCHI	Input inertial pitch angle (YZX Euler)	UNIV PTG DISP	SP	rad
V93H6839C	YAWI	Input inertial yaw angle (YZX Euler)	UNIV PTG DISP	SP	rad
V97U2214CC thru V97U2217CC	Q_M50_ INRTL_ORB	Inertial to M50 quaternion	K-LOAD	SP	none

Table 4.3.4-2. Maneuver Option Quaternion Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	Q_MNVR	Maneuver option quaternion	CYC OPT	SP	none

#### 4.3.5 Celestial Target Vector Subtask (STAR)

This subtask computes the inertially referenced unit vector,  $\overline{\text{TGT\_VEC}}$ , required for celestial target pointing. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The inertial celestial target vector is computed in the following equation:

$$\text{RA} = \text{TGT\_RA}$$

$$\text{DEC} = \text{TGT\_DEC}$$

$$\overline{\text{TGT\_VEC}} = \text{VECTOR} [\text{COS}(\text{RA}) \text{COS}(\text{DEC}), \text{SIN}(\text{RA}) \text{COS}(\text{DEC}), \text{SIN}(\text{DEC})]$$

where  $\overline{\text{TGT\_VEC}}$  is the unit celestial target or TGT vector expressed in the M50 coordinate system. This computation is performed each time the TGT\_RA or TGT\_DEC is executed when the TGT\_ID is 5. After each computation, the vector is stored in the celestial target table (star table) in I-load.

$$\text{I\_STAR\_SEL}(5) = \overline{\text{TGT\_VEC}}$$

B. Interface Requirements. The input and output parameters for the celestial target vector subtask are given in Tables 4.3.5-1 and 4.3.5-2.

C. Processing Requirements. This subtask is processed once when the TGT\_ID = 5 and the TRK\_DCD is set, TRK\_DCD = 1.

D. Initialization Requirements. None.

E. Supplemental Information. I\_STAR\_SEL is a navigation star table look-up function called by the star tracker SOP. The celestial target vector computed by this subtask is stored in the I-load location accessed by this function for TGT\_ID = 5.

Table 4.3.5-1. Celestial Target Vector Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93H6813CB	TGT_RA	Target right ascension	UNIV PTG DISP	SP	rad
V93H6815CB	TGT_DEC	Target declination	UNIV PTG DISP	SP	rad

Table 4.3.5-2. Celestial Target Vector Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V96U9725C thru V96U9727C	I_STAR_SEL	Celestial target vector	STAR CATALOG TABLE	SP	none

#### 4.3.6 Celestial Target RA/DEC Subtask (RA DEC)

This subtask calculates the right ascension (TGT\_RA) and declination (TGT\_DEC) of celestial targets for the universal pointing display. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The TGT\_RA and TGT\_DEC are computed from the celestial target unit vector for the sun or a star target. If TGT\_ID = 4, the sun target vector,  $\overline{TGT\_VEC}$ , is provided by the calling task. If the target ID = 5 or  $11 \leq TGT\_ID \leq 110$ , then the vector is obtained from the celestial target table:

$$\overline{TGT\_VEC} = I\_STAR\_SEL(TGT\_ID)$$

Then, since the vector is a unit vector, the right ascension and declination are computed as follows:

$$TGT\_RA = ARCTAN2(TGT\_VEC\_Y, TGT\_VEC\_X)$$

$$TGT\_DEC = ARCSINE(TGT\_VEC\_Z)$$

where TGT\_VEC\_X, TGT\_VEC\_Y, and TGT\_VEC\_Z are the components of the selected celestial target unit vector,  $\overline{TGT\_VEC}$ .

B. Interface Requirements. The input and output parameters of the celestial target right ascension and declination subtask are given in Tables 4.3.6-1 and 4.3.6-2.

C. Processing Requirements. This subtask is processed when called.

D. Initialization Requirements. None.

E. Supplemental Information. I\_STAR\_SEL is a table look-up function called by the star tracker SOP. The input argument is the identification of the navigation star, and the output is the unit vector to the star in Aries mean of 1950 coordinates.

Table 4.3.6-1. Celestial Target Right Ascension and Declination Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V96U9725C thru V96U9727C	I_STAR_SEL	Celestial target unit vector	STAR CATALOG TABLE	SP	none
V93U6810C	TGT_ID	Target vector identifier	UNIV PTG DISP	SP	none
	$\overline{TGT\_VEC}$	Target vector	PARAM PROC	SP	none

Table 4.3.6-2. Celestial Target Right Ascension and Declination Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V93H6813CA	TGT_RA	Celestial target right ascension	UNIV PTG DISP	SP	rad
V93H6815CA	TGT_DEC	Celestial target declination	UNIV PTG DISP	SP	rad

#### 4.3.7 Body Vector Subtask (BODY VEC)

This subtask computes the body referenced unit vector,  $\overline{PLOS}$ , required by the tracking and rotation attitude options. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The body vector is a constant and is specified by its pitch and yaw components. The Cartesian components of the body vector ( $\overline{PLOS}$ ) are computed from the pitch–yaw spherical coordinates as follows:

$$PITCH = BODV\_PITCH$$

$$YAW = BODV\_YAW$$

$$\overline{PLOS} = VECTOR[COS(PITCH) COS(YAW), SIN(YAW), - SIN(PITCH) COS(YAW)]$$

B. Interface Requirements. The input and output parameters for the body vector subtask are given in Tables 4.3.7–1 and 4.3.7–2.

C. Processing Requirements. This subtask is processed when called.

D. Initialization Requirements. None.

E. Supplemental Information. None.

Table 4.3.7-1. Body Vector Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93U6806CB	BODV_PITCH	Body vector pitch coordinate	UNIV PTG DISP	SP	rad
V93U6807CB	BODV_YAW	Body vector yaw coordinate	UNIV PTG DISP	SP	rad

Table 4.3.7-2. Body Vector Subtask Output Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	$\overline{PLOS}$	Body unit vector	CYC OPT, PARAM PROC	SP	none

**4.3.8 Body Vector PITCH/YAW Subtask (PY)**

This subtask obtains the pitch (BODV\_PITCH) and yaw (BODV\_YAW) coordinates of the selected body vector required by the universal pointing display. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The BODV\_PITCH and BODV\_YAW are obtained from the body vector table by:

$$\text{BODV\_PITCH} = \text{BODV\_SCL}(\text{BODV\_ID}, 1)$$

$$\text{BODV\_YAW} = \text{BODV\_SCL}(\text{BODV\_ID}, 2)$$

where BODV\_SCL is a two-dimensional array in K-load.

B. Interface Requirements. The input and output parameters for the body vector pitch and yaw coordinates subtask are given in Tables 4.3.8-1 and 4.3.8-2.

C. Processing Requirements. This subtask is processed once each time it is called.

D. Initialization Requirements. None.

Table 4.3.8-1. Body Vector Pitch and Yaw Coordinates Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93U6805C	BODV_ID	Body vector identifier	UNIV PTG DISP	SP	none
V96U9715C thru V96U9722C	BODV_SCL	Body vector array	K-LOAD	SP	rad

Table 4.3.8-2. Body Vector Pitch and Yaw Coordinates Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V93U6806CA	BODV_PITCH	Body vector pitch coordinate	UNIV PTG DISP, PARAM PROC	SP	rad
V93U6807CA	BODV_YAW	Body vector yaw coordinate	UNIV PTG DISP, PARAM PROC	SP	rad

#### 4.3.9 Earth-Fixed Target Position Vector Subtask (ETGT POS)

This subtask computes the earth-fixed or Greenwich true-of-date position vector,  $\overline{\text{TGPOS}}$ , required for earth surface pointing. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The earth-fixed (Greenwich true-of-date) position vector is computed in the following equations:

$$\text{ALT} = \text{TGT\_ALT} \text{ FT\_PER\_NMI}$$

$$\text{TEMP\_1} = (1 - \text{ELLIPT})^2$$

$$\text{TEMP\_2} = \text{EARTH\_RADIUS\_EQUATOR} / \text{SQRT}[\text{COS}^2(\text{TGT\_LAT}) + \text{TEMP\_1} \text{ SIN}^2(\text{TGT\_LAT})]$$

$$\text{TEMP\_3} = (\text{TEMP\_2} + \text{ALT}) \text{ COS}(\text{TGT\_LAT})$$

$$\overline{\text{TGPOS}} = \text{VECTOR}[\text{TEMP\_3} \text{ COS}(\text{TGT\_LON}), \text{TEMP\_3} \text{ SIN}(\text{TGT\_LON}), (\text{TEMP\_1} \text{ TEMP\_2} + \text{ALT}) \text{ SIN}(\text{TGT\_LAT})]$$

where ELLIPT and EARTH\_RADIUS\_EQUATOR are the flattening and earth equatorial radius of the 1960 Fischer ellipsoid, respectively; and  $\overline{\text{TGPOS}}$  is the earth-fixed target position vector. TEMP\_1, TEMP\_2, and TEMP\_3 are temporary variables.

B. Interface Requirements. The input and output parameters for the earthfixed target position vector subtask are given in Tables 4.3.9-1 and 4.3.9-2.

C. Processing Requirements. This subtask is processed once at the moment the tracking option is executed with a TGT\_ID of 3 specified.

D. Initialization Requirements. None.

E. Supplemental Information. The values of the constants required by this subtask are:

$$\text{ELLIPT} = 3.352329869 \text{ E-3}$$

$$\text{EARTH\_RADIUS\_EQUATOR} = 2.092574147 \text{ E+07 ft}$$

$$\text{FT\_PER\_NMI} = 6076.115486 \text{ ft/nmi}$$

Table 4.3.9-1. Earth-Fixed Target Position Vector Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93H6820C	TGT_LAT	Earth-fixed target latitude	UNIV PTG DISP	SP	rad
V93H6821C	TGT_LON	Earth-fixed target longitude	UNIV PTG DISP	SP	rad
V93H6822C	TGT_ALT	Earth-fixed target altitude	UNIV PTG DISP	SP	nmi
V97U6791C	FT_PER_NMI	Nautical miles to feet	CONSTANT	SP	ft/nmi
V97U5324C	EARTH_RADIUS_EQUATOR	Earth's equatorial radius	CONSTANT	DP	ft
V97U5332C	ELLIPT	Flattening of 1960 Fischer ellipsoid	CONSTANT	DP	none

Table 4.3.9-2. Earth-Fixed Target Position Vector Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	TGPOS	Earth-fixed target position vector	CYC OPT	SP	ft



#### 4.3.10 Cyclic LVLH Mode Task (CYC LVLH)

This task provides the local vertical, local horizontal body attitude rate vectors required for proximity operations. The outputs of this task support the DAP manual LVLH attitude mode. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. For each computation cycle, the following computations are performed. The target line-of-sight vector is computed for LVLH attitude reference as follows. First, the current target vector identifier is stored temporarily.

TEMP\_ID = TGT\_ID\_C

TGT\_ID\_C = 2

CALL LOS VEC

Inputs: TGT\_ID\_C

Outputs:  $\overline{TLOS}$

Then, the tracking rate subtask is called to obtain the body rate vector:

CALL TRK RATE

Inputs: TGT\_ID\_C,  $\overline{TLOS}$

Outputs:  $\overline{REQD\_BRATE}$

Finally, the target vector identifier is reset to its current value

TGT\_ID\_C = TEMP\_ID

B. Interface Requirements. The input and output parameters for this task are presented in Tables 4.3.10-1 and 4.3.10-2. The target line-of-sight vector subtask and tracking rate vector subtask are required.

C. Processing Requirements. This task is processed once every 1.92 seconds only when  $LVLH\_MODE = 1$ .

D. Initialization Requirements. None.

E. Supplemental Information. A bilevel discrete,  $LVLH\_MODE$ , is set by the flight control software when the LVLH mode is selected. The two states are defined as follows:

$LVLH\_MODE = 0$  Inhibit LVLH cyclic processing (reset)

$LVLH\_MODE = 1$  Enable LVLH cyclic processing (set)

When  $LVLH\_MODE = 1$ , cyclic processing of all universal pointing attitude options is inhibited, and this task assumes priority. This indicator is tested in the UNIV SEQ task and reset by the flight control software.

Table 4.3.10-1. Cyclic LVLH Mode Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	TGT_ID_C	Current target vector identifier	CYC OPT	N/A	none

Table 4.3.10-2. Cyclic LVLH Mode Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95R2216C thru V95R2218C	REQD_BRATE	Required body rate vector	ORBIT DAP	SP	deg/s
	TGT_ID_C	Current target vector identifier	LOS VEC	N/A	none

#### 4.3.11 Cyclic Attitude Option Computations Task (CYC OPT)

This task interprets the inputs from the PARAM PROC task, provides the logic that chooses the attitude task corresponding to a given attitude option, and executes the task. (Please refer to Figure 4.3.11-1 for the following discussion.)

A. Detailed Requirements. A number of parameters are required by CYC OPT to initialize each attitude option selected via the UNIV PTG display. The parameters are transferred to this task from the UNIV PTG display, UNIV SEQ, and PARAM PROC tasks whenever an attitude option is executed. These parameters are:

- |    |                    |                                       |
|----|--------------------|---------------------------------------|
| 1. | $\overline{PLOS}$  | Body vector                           |
| 2. | TGT_ID             | Target vector identifier              |
| 3. | $\overline{TGPOS}$ | Earth-fixed target position vector    |
| 4. | OMICRON            | Attitude constraint about body vector |
| 5. | THREE_AXIS         | Three-axis tracking flag              |
| 6. | OPT_PROC           | Option process indicator              |
| 7. | Q_MNVR             | Maneuver option quaternion            |

1. Parameter transfer flag. The parameter transfer flag is a discrete that controls the initialization of the chosen attitude option. If  $PARAM\_XFR = 1$ , then the parameters from UNIV PTG and the PARAM PROC task are transferred to a set of locations allocated for current processing; the following equalities are, therefore, executed:

$$\overline{PLOS\_C} = \overline{PLOS}$$

$$TGT\_ID\_C = TGT\_ID$$

$$\overline{TGPOS\_C} = \overline{TGPOS}$$

$$OMICRON\_C = OMICRON$$

$$THREE\_AXIS\_C = THREE\_AXIS$$

$$Q\_MNVRC\_S = Q\_MNVR\_S$$

$$Q\_MNVRC\_V = Q\_MNVR\_V$$

Then the parameter transfer flag is reset.

$$PARAM\_XFR = 0$$

The current processing parameters are used directly by the three attitude tasks supporting the three attitude options: maneuver, tracking, and rotation.

2. Attitude option processing. Processing of an attitude option is required for either a current option or a future tracking or maneuver attitude option when there is no current option. Cyclic processing for the future option is required to support the computation of total attitude errors. A single parameter, OPT\_PROC, indicates which option is currently being processed.

If OPT\_PROC = 1, the maneuver task is processed at a frequency of 0.5 Hz.

CALL MNVR

Inputs: Q\_MNVRC\_S, Q\_MNVRC\_V

Outputs: Q\_RBOD\_M50\_S, Q\_RBOD\_M50\_V

If OPT\_PROC = 2, the tracking task is processed at a frequency of 0.5 Hz. If THREE\_AXIS\_C = 1, the three-axis tracking subtask is called by the tracking task. If THREE\_AXIS\_C = 0, the two-axis tracking subtask is called by the tracking task.

CALL TRACK

Inputs: TGT\_ID\_C, PLOS\_C, OMICRON\_C, THREE\_AXIS\_C

Outputs: Q\_RBOD\_M50\_S, Q\_RBOD\_M50\_V

If OPT\_PROC = 3 and the auto mode is selected (AUTO = 1), then the rotation task is processed at a frequency of 0.5 Hz. If the auto mode is not selected, AUTO = 0, then the rotation option initial condition discrete is set:

ROT\_IC = 1

- B. Interface Requirements. The input and output parameters for the cyclic attitude option task are presented in Tables 4.3.11-1 and 4.3.11-2.
- C. Processing Requirements. This task is processed when requested by the sequencing task.
- D. Initialization Requirements. All parameters requiring initialization are contained in the UNIV POINT PROC I-load.
- E. Supplemental Information. Note that the value of the OPT\_PROC indicator may be different from the value of the OPT\_CUR indicator. For example, if there is no current option but a future maneuver option is selected, the values of the indicators are:

OPT\_CUR = 0                      No current option

OPT\_FUT = 1                      Future maneuver option

OPT\_PROC = 1                      Maneuver option processing required

When PREBURN\_MNVR\_IN\_PROGRESS or LVLH\_MODE flag is set, the UNIV POINT PROC cyclic outputs to the DAP shall be inhibited and when the flag is reset cyclic processing resumes.

Table 4.3.11-1. Cyclic Attitude Option Computations Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93U6810C	PLOS	Body unit vector	PARAM PROC	SP	none
	TGT_ID	Target vector identifier	UNIV PTG DISP	N/A	none
V93H6825C	TGPOS	Earth-fixed target position vector	PARAM PROC	SP	ft
	OMICRON	Constraint angle about body vector	UNIV PTG DISP	SP	rad
V93X6881X	THREE_AXIS	Three-axis tracking flag	UNIV PTG DISP	N/A	none
	OPT_PROC	Option process indicator	PARAM PROC, UNIV SEQ	N/A	none
V96U9754C	Q_MNVR	Maneuver option quaternion	PARAM PROC	SP	none
	PARAM_XFR	Parameter transfer flag	PARAM PROC, UNIV SEQ	N/A	none
V96U9754C	ROT_IC	Rotation option initial condition indicator	UNIV SEQ	N/A	none
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	MNVR,TRACK, ROTR	SP	none
V72X2850XA	AUTO	Auto mode discrete	ORBIT DAP	N/A	none

Table 4.3.11-2. Cyclic Attitude Option Computations Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95U2225C thru V95U2227C	PLOS_C	Current option body vector	TRACK, ROTR	SP	none
	TGT_ID_C	Current target vector identifier	TRACK, CYC LVLH	N/A	none
V95U2227C	TGPOS_C	Current earth-fixed target vector	LOS VEC	SP	ft
	OMICRON_C	Current constraint angle about body vector	TRACK	SP	rad
V95U2209C thru V95U2212C	THREE_AXIS_C	Current three-axis tracking flag	TRACK	N/A	none
	Q_MNVRC	Current maneuver option quaternion	MNVR	SP	none
V95U2209C thru V95U2212C	OPT_PROC	Option process indicator	UNIV SEQ	N/A	none
	Q_RBOD_M50	Required body quaternion	DISP SUP, ORBIT DAP	SP	none
V95U2212C	ROT_IC	Rotation option initial condition indicator	ROTR	N/A	none

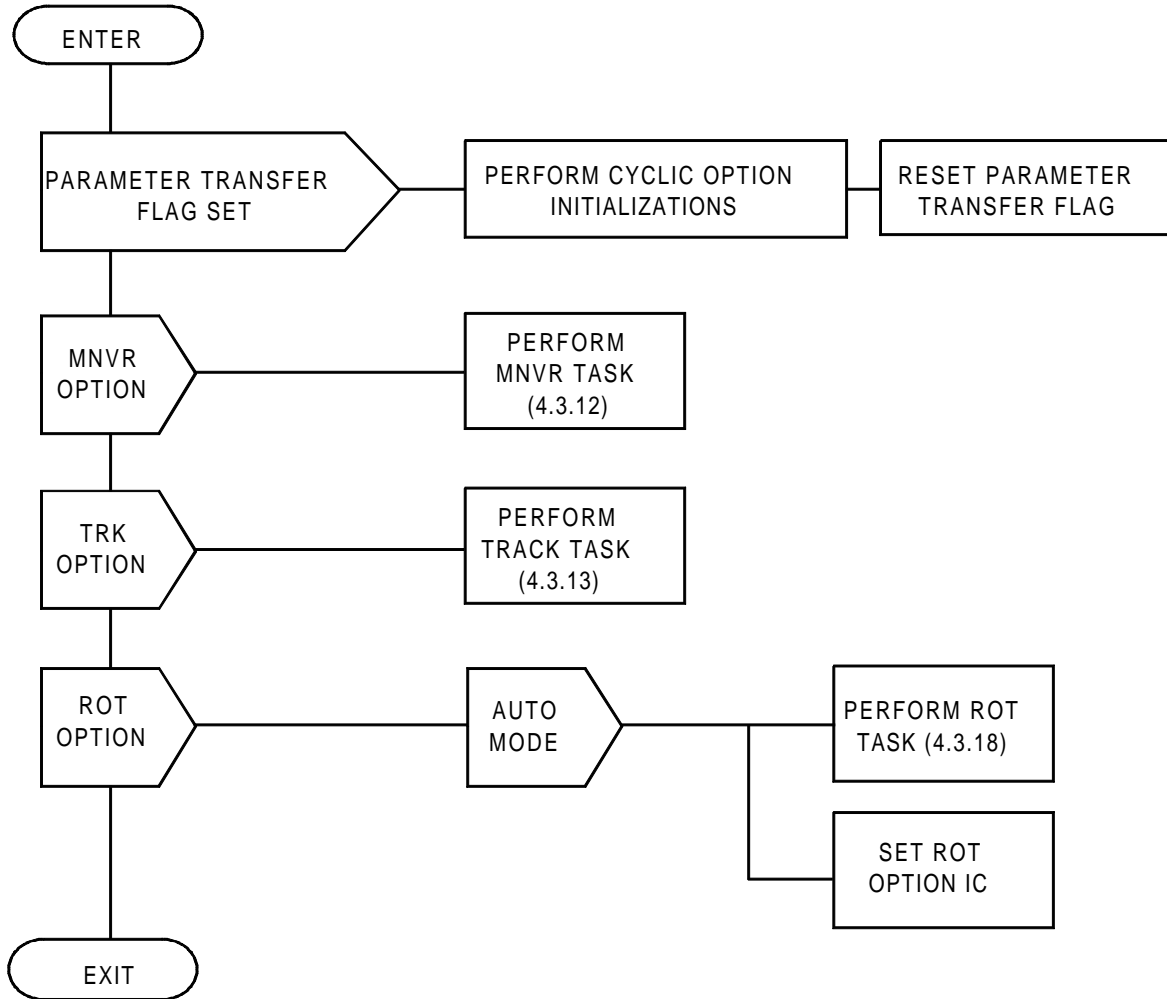


FIGURE 4.3.11-1. Cyclic Attitude Option Task Functional Flow

#### 4.3.12 Universal Pointing Maneuver Task (MNVR)

This task provides the required attitude to attain a specified set of pitch–yaw–roll Euler angles input through the UNIV PTG display function. The angles are referenced to the inertial ADI coordinate system. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The required body quaternion is set equal to the maneuver option quaternion and the required body rate vector is set to zero.

$$Q\_RBOD\_M50\_S = Q\_MNVRC\_S$$

$$Q\_RBOD\_M50\_V = Q\_MNVRC\_V$$

$$REQD\_BRATE = 0$$

No attitude rate computation is required for this attitude task, since the DAP maneuver rate will be used.

B. Interface Requirements. The input and output parameters for the universal pointing maneuver task are given in Tables 4.3.12–1 and 4.3.12–2.

C. Processing Requirements. Attitude processing to output the required body quaternion is performed by this task every 1.92 seconds.

D. Initialization Requirements. None.

Table 4.3.12-1. Universal Pointing Maneuver Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	Q_MNVRC	Current maneuver option quaternion	CYC OPT	SP	none

Table 4.3.12-2. Universal Pointing Maneuver Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	CYC OPT	SP	none
V95R2216C thru V95R2218C	REQD_BRATE	Required body attitude rate vector	ORBIT DAP	SP	deg/s

#### 4.3.13 Universal Pointing Processor Tracking Task (TRACK)

This task provides the body attitude and body attitude rate vector required to align the orbiter body vector with a target vector. Two attitude alignment modes are available: 2AXIS and 3AXIS. The 2AXIS mode provides a minimum attitude change in which the maneuver eigenangle is minimized. The 3AXIS mode provides for an attitude constraint by specifying a fixed angle of rotation about the required pointing line-of-sight. Please refer to Figure 4.3.13–1 for the following discussion.

A. Detailed Requirements. Two unit vectors are required by this task, a target vector ( $\overline{TLOS}$ ) and a current body vector ( $\overline{PLOS\_C}$ ). The body vector is provided by the CYC OPT task.

1. Target vector. The target vector is either computed or obtained as a function of the target or TGT vector identifier (TGT\_ID\_C) from I-load locations common to both the Star Tracker SOP and this function.

The target line-of-sight vector subtask is used to produce  $\overline{TLOS}$ :

CALL LOS VEC

Inputs: TGT\_ID\_C

Outputs:  $\overline{TLOS}$

This vector is used to calculate the required body quaternion using the 2AXIS or 3AXIS tracking subtask.

2. Minimum attitude change/2AXIS tracking. If  $\text{THREE\_AXIS\_C} = 0$ , then the 2AXIS tracking mode is selected. This tracking mode computes the minimum eigenangle required to align  $\overline{PLOS\_C}$  with  $\overline{TLOS}$ . The 2AXIS tracking subtask is called to obtain the required body quaternion.

CALL 2AXIS

Inputs:  $\overline{PLOS\_C}$ ,  $\overline{TLOS}$ , Q\_BOD\_M50\_S, Q\_BOD\_M50\_V

Outputs: Q\_RBOD\_M50\_S, Q\_RBOD\_M50\_V

3. Constrained attitude change/3AXIS tracking. If the angle OMICRON\_C is specified ( $\text{THREE\_AXIS\_C} = 1$ ), then the 3AXIS tracking mode is selected. This tracking mode computes parameters required to implicitly select an eigenaxis and eigenangle of rotation that will satisfy the pointing requirement and at the same time satisfy an attitude constraint. The attitude constraint is specified by an angle, omicron, about the required line-of-sight vector. Omicron is the angle between the plane defined by  $\overline{PLOS\_C}$  and the Y-body axis ( $\overline{Y}$ ) and the plane defined by  $\overline{TLOS}$  and the negative of the orbital angular momentum vector ( $-\overline{H}$ ) when  $\overline{PLOS\_C}$  is aligned with (and in the same direction as)  $\overline{TLOS}$ . Hence, the body roll reference vector is nominally the Y-body axis.

$\overline{RR\_BOD} = \text{VECTOR}(0, 1, 0)$



and the inertial roll reference vector is the negative of the angular momentum vector

$$\overline{RR\_M50} = -\text{UNIT}(\overline{RORB} \times \overline{VORB})$$

There are two cases in which OMICRON is undefined; one case occurs when the body vector is parallel or antiparallel to the Y-body axis; the other case occurs when the TGT vector is parallel or antiparallel to the angular momentum vector. In these two cases, OMICRON is redefined through the specification of alternate roll reference vectors.

The alternate body roll reference vector is the negative Z-body axis.

$$\overline{RRA\_BOD} = \text{VECTOR}(0, 0, -1)$$

Therefore, if  $\text{ABS}(\overline{PLOS\_C} \cdot \overline{RR\_BOD}) > \overline{PLOS\_TOL}$ , then  $\overline{RR\_BOD} = \overline{RRA\_BOD}$ .

The alternate inertial roll reference is defined as follows:

$$\overline{RRA\_M50} = \text{VECTOR}(0, 0, 1) \times \overline{RR\_M50}$$

The roll constraint angle is defined by

$$\text{ROLL} = \text{OMICRON\_C} + \text{PI}/2.0$$

and the three-axis tracking subtask is invoked to compute the required body quaternion:

CALL 3AXIS

Inputs:  $\overline{PLOS\_C}$ ,  $\overline{TLOS}$ , ROLL,  $\overline{RR\_BOD}$ ,  $\overline{RR\_M50}$ ,  $\overline{RRA\_M50}$

Outputs:  $\overline{Q\_RBOD\_M50\_S}$ ,  $\overline{Q\_RBOD\_M50\_V}$ ,  $\overline{RR\_M50}$

4. Tracking rate vector. A body attitude rate vector is required by the DAP AUTO\_MNVR\_TRACK function for target tracking. The computation of this rate vector is based on the type of target selected. This vector is computed by the tracking rate vector subtask and expressed in body axes.

CALL TRK RATE

Inputs: TGT\_ID\_C

Outputs:  $\overline{REQD\_BRATE}$

5. Time tag of required body attitude and rate. The DAP requires a time tag associated with the required body quaternion and attitude rate vector in order to remove phase plane bias errors during target tracking. The time tag will be the time of the attitude input to the UNIV POINT PROC from the attitude processor.

$$\text{GMTR} = \text{GMTC}$$

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B. Interface Requirements. The input and output parameters for the universal pointing processor tracking task are given in Tables 4.3.13-1 and 4.3.13-2. The quaternion vector transformation module is required, and several navigation functions must be accessed: earth-fixed-to-M50 coordinate transformation, and the star vector table look-up function.

C. Processing Requirements. Processing is performed by this task once every 1.92 seconds when  $OPT\_PROC = 2$ .

D. Initialization Requirements. This task is initialized by the CYC OPT task.

E. Supplemental Information. For three-axis tracking a tolerance parameter,  $PLOS\_TOL$ , is required to determine when the alternate body roll reference vector is required. The Y-body axis alternate roll reference vector (-Z body axis) is used when  $PLOS\_C$  is within 1 degree of the Y-body axis; therefore,  $PLOS\_TOL = 0.999848 \cong \cos 1^\circ$ . A similar check is made for the alternate inertial roll reference vector inside the three-axis tracking task.

Table 4.3.13-1. Universal Pointing Tracking Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V90W2310C	TGT_ID_C	Current target vector identifier	CYC OPT	N/A	none
	GMTC/T_NOW	Time tag of current body quaternion	ATT PROC	DP	s
V95U2225C thru V95U2227C	$\overline{PLOS\_C}$	Current body unit vector	CYC OPT	SP	none
V90U2240CB thru V90U2243CB	$Q_{\dot{BOD\_M50}}$	Current body quaternion	ATT PROC	SP	none
V95H0185C thru V95H0187C	$\overline{RORB}$	Orbiter position vector	ORBIT UPP	SP	ft
V95L0190C thru V95L0192C	$\overline{VORB}$	Orbiter velocity vector	ORBIT UPP	SP	ft/s
V96U9712C	PLOS_TOL	Alternate body vector tolerance	K-LOAD	SP	none
	OMICRON_C	Constraint angle about body vector	CYC OPT	SP	rad
	THREE_AXIS_C	Current three-axis tracking flag	CYC OPT	N/A	none
V98U8725C	PI	Ratio of circumference to diameter	CONSTANT	DP	none

Table 4.3.13-2. Universal Pointing Tracking Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95U2209C thru V95U2212C	$Q_{\dot{R}BOD\_M50}$	Required body quaternion	CYC OPT	SP	none
V95R2216C thru V95R2218C	REQD_BRATE	Required body attitude rate vector	ORBIT DAP	SP	deg/s
V95W2201C	GMTR	GMT of required body quaternion	ORBIT DAP	DP	s

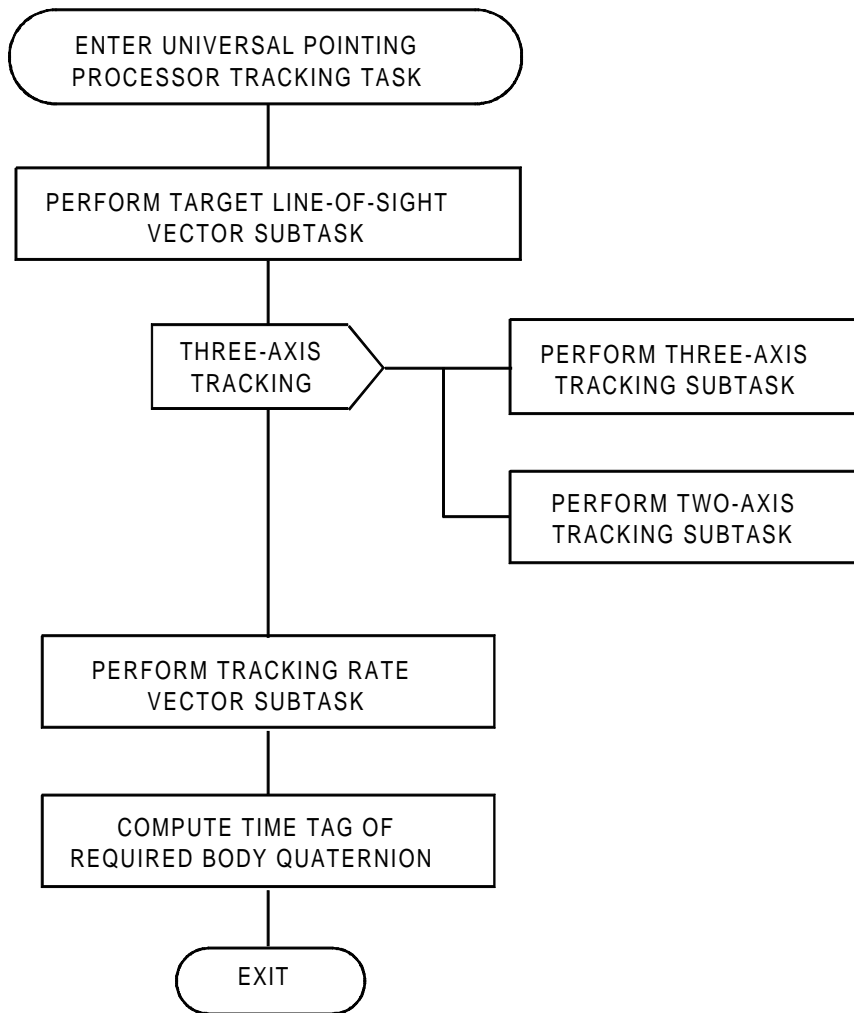


FIGURE 4.3.13-1. Universal Pointing Processor Tracking Task Functional Flow

#### 4.3.14 Target Line-of-Sight Vector Subtask (LOS VEC)

This subtask computes the target line-of-sight vector,  $\overline{TLOS}$ , required by the tracking task. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. Certain special computations are required to obtain the required target line of sight or TGT vector. The TGT or target vector is defined to be a unit vector from the orbiter's center of mass to the selected target. The method of calculation is determined by the TGT\_ID\_C.

1. Rendezvous. If TGT\_ID\_C = 1, the TGT vector ( $\overline{TLOS}$ ) is the unit relative position vector.

$$\overline{TLOS} = \text{UNIT}(\overline{RREL})$$

2. Center of earth. If TGT\_ID\_C = 2, the TGT vector is opposite in direction to the orbiter's position vector:

$$\overline{TLOS} = \text{UNIT}(-\overline{RORB})$$

3. Earth site. If TGT\_ID\_C = 3, the TGT vector is computed from the earth referenced target position vector ( $\overline{TGPOS\_C}$ ) and the orbiter's position vector. First, the earth-fixed-to-M50 transformation matrix is computed for the current time:

CALL EARTH\_FIXED\_TO\_M50\_COORD

Input: GMTC

Output:  $\overline{EF\_TO\_M50}$

and the earth pole vector is stored for use by TRK RATE

$$\overline{EARTH\_POLE} = \text{VECTOR}[\overline{EF\_TO\_M50}(1,3), \overline{EF\_TO\_M50}(2,3), \overline{EF\_TO\_M50}(3,3)]$$

Second, the earth-fixed position vector is expressed in M50 coordinates:

$$\overline{TPOS} = (\overline{EF\_TO\_M50}) \overline{TGPOS\_C}$$

Then, the TGT vector is computed:

$$\overline{TLOS} = \text{UNIT}(\overline{TPOS} - \overline{RORB})$$

4. Center of the sun. If TGT\_ID\_C = 4, then the TGT vector is obtained directly from the on-orbit rendezvous navigation function.

$$\overline{TLOS} = \overline{UR\_SUN}$$

The vector  $\overline{TLOS}$  is then sent to the tracking task.

5. Celestial target. If TGT\_ID\_C = 5 or  $11 \leq \text{TGT\_ID\_C} \leq 110$ , then the TGT vector is obtained directly from the celestial target table (star table).

$$\overline{TLOS} = \overline{I\_STAR\_SEL}(\text{TGT\_ID\_C})$$

The vector  $\overline{TLOS}$  is then sent to the tracking task.

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- B. Interface Requirements. The input and output parameters for the target line-of-sight vector subtask are given in Tables 4.3.14-1. and 4.3.14-2.
- C. Processing Requirements. This subtask is processed once when called.
- D. Initialization Requirements. None.
- E. Supplemental Information. The earth pole vector is the last column of the earth-fixed to mean of 1950 transformation matrix. It is used by the tracking rate vector subtask to calculate the inertial rate vector for an earth site target.

The unit position vector of the sun is calculated by the on-orbit rendezvous navigation function.

Table 4.3.14-1. Target Line-of-Sight Vector Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	TGT_ID_C	Current target vector identifier	CYC OPT, CYC LVLH	N/A	none
V95H0185C thru V95H0187C V90W2310C	$\overline{RORB}$	Orbiter position vector	ORBIT UPP	SP	ft
	GMTC/T_NOW	Time tag of current body quaternion	ATT PROC	DP	s
	$\overline{TGPOS}_C$	Current earth-fixed target position vector	CYC OPT	SP	ft
V90U4972C thru V90U4974C	$\overline{UR}_SUN$	Sun unit vector in M50 coord	ORB/RND NAV	SP	none
V96U9725C thru V96U9727C	$\overline{I\_STAR\_SEL}$	Celestial target unit vector	CELESTIAL TARGET TABLE	SP	none
	$\overline{EF\_TO\_M50}^*$	Earth-fixed to M50 transformation matrix	NAV FUNCT	SP	none
V95H0855C thru V95H0857C	$\overline{RREL}$	Orbiter/target relative position vector	ORBIT UPP	SP	ft

Table 4.3.14-2. Target Line-of-Sight Vector Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	$\overline{TLOS}$	Target line-of-sight vector	2AXIS, 3AXIS, TRK RATE, CYC LVLH	SP	none
	$\overline{TPOS}$	Earth-fixed target position vector expressed in M50 coordinates	TRK RATE	SP	ft
	$\overline{EARTH\_POLE}$	Earth's unit angular momentum vector in M50 coordinates	TRK RATE	SP	none

#### 4.3.15 Two-Axis Tracking Subtask (2AXIS)

This subtask computes the required body quaternion that will align a given body referenced vector,  $\bar{P}$ , with a given inertial referenced vector,  $\bar{T}$ , through a minimum attitude maneuver. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. Since the vector  $\bar{T}$  is expressed in the M50 coordinate system, it must be transformed into the body coordinate system. The transformation is accomplished through the QUAT\_XFORM module.

CALL QUAT\_XFORM

Inputs:  $\bar{T}$ , Q\_BOD\_M50\_S, Q\_BOD\_M50\_V

Outputs:  $\bar{TB}$

where  $\bar{TB}$  is the target vector expressed in the body coordinate system.

If  $\bar{P}$  and  $\bar{TB}$  are nearly 180° apart, a rotation axis is chosen as near as possible to the body X-axis:

$$\text{DOT} = \bar{P} \cdot \bar{TB}$$

If  $\text{DOT} < -.9999996$  then execute ITEM 1; else execute ITEM 2.

1. Q\_RBOD\_BOD\_S = 0

$$\text{MAG} = 1 - P_1^2$$

If  $\text{MAG} < .0000008$ , then Q\_RBOD\_BOD\_V = VECTOR (0,-1,0); else

$$\text{MAG} = \text{SQRT}(\text{MAG})$$

$$\text{Q\_RBOD\_BOD\_V} = \text{VECTOR} \left( -\text{MAG}, \frac{P_1 P_2}{\text{MAG}}, \frac{P_1 P_3}{\text{MAG}} \right)$$

2.  $\bar{LAMBDA} = (\bar{P} + \bar{TB})/\text{SQRT}(2 + 2 \text{DOT})$

$$\text{Q\_RBOD\_BOD\_S} = \bar{LAMBDA} \cdot \bar{P}$$

$$\text{Q\_RBOD\_BOD\_V} = \bar{LAMBDA} \times \bar{P}$$

3. This body-to-required-body quaternion is used to produce the required body quaternion:

CALL QUAT\_MULT

Inputs: Q\_RBOD\_BOD\_S, Q\_RBOD\_BOD\_V, Q\_BOD\_M50\_S,  
Q\_BOD\_M50\_V

Outputs: Q\_RBOD\_M50\_S, Q\_RBOD\_M50\_V



B. Interface Requirements. The input and output parameters for the two-axis tracking subtask are given in Tables 4.3.15-1 and 4.3.15-2. The QUAT\_MULT module is required.

C. Processing Requirements. This subtask is processed when invoked by the tracking task.

D. Initialization Requirements. None.

E. Supplemental Information. The quaternion transformation module referenced in this task, QUAT\_XFORM is documented in the Level C, GN&C, FSSR Part C: Flight Control. The functional operation of this module is presented here for information only. The quaternion transformation is written symbolically as  $\overline{WB} = Q \overline{WI} Q^*$ , where “Q” is a quaternion transformation from the “I” system to the “B” system, and “Q” and “Q\*” are interpreted as:

$$Q = \begin{bmatrix} S \\ \overline{V} \end{bmatrix} \text{ and } Q^* = \begin{bmatrix} S \\ -\overline{V} \end{bmatrix},$$

where  $S$  is the scalar component of “Q” and  $\overline{V}$  is the vector component of “Q.” In the product  $Q \overline{WI} Q^*$ , the  $\overline{WI}$  vector may be regarded as a quaternion with a zero scalar component when applying the multiplication algorithm described in Subsection 4.3.4, Part E. The result of this product is:

$$\begin{bmatrix} 0 \\ \overline{WB} \end{bmatrix} = \begin{bmatrix} 0 \\ \overline{WI} + 2 S (\overline{V} \times \overline{WI}) + 2 \overline{V} \times (\overline{V} \times \overline{WI}) \end{bmatrix}$$

where  $\overline{WB}$  is the vector transformed from the “I” system by the transformation quaternion “Q.”

Table 4.3.15-1. Two-Axis Tracking Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V90U2240CB thru V90U2243CB	$\overline{P}$	Pointing vector in body coordinates	TRACK	SP	none
	$\overline{T}$	Target vector in M50 coordinates	TRACK	SP	none
	Q_BOD_M50	Current body quaternion	ATT PROC	SP	none

Table 4.3.15-2. Two-Axis Tracking Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	TRACK	SP	none

#### 4.3.16 Three-Axis Tracking Subtask (3AXIS)

This subtask computes a quaternion that will align a given body referenced vector,  $\overline{VEC\_BOD}$ , with a given inertial vector,  $\overline{VEC\_M50}$ , such that a specified attitude constraint is satisfied. The attitude constraint is specified by a roll angle,  $ROLL$ , and two roll reference vectors: a body roll reference vector,  $\overline{RR\_BOD}$ , and an inertial roll reference vector,  $\overline{RR\_M50}$ . An alternate inertial roll reference vector,  $\overline{RRA\_M50}$ , must be specified to avoid inherent software singularities when  $\overline{VEC\_M50}$  is within a given tolerance of  $\overline{RR\_M50}$ . The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. Initially, a test is performed to determine if the alternate inertial roll reference vector is to be used in computing the quaternion. First, the dot product of the inertial vector and the inertial roll reference vector is taken:

$$DOT = \overline{VEC\_M50} \cdot \overline{RR\_M50}$$

If  $ABS(DOT) > TLOS\_TOL$  then

$$\overline{RR\_M50} = SIGN(DOT) \overline{RRA\_M50}$$

The direction cosine matrix transformation from the M50 system to the required body system is computed as follows:

$$\overline{YN} = UNIT(\overline{VEC\_BOD} \times \overline{RR\_BOD})$$

$$\overline{YT} = UNIT(\overline{VEC\_M50} \times \overline{RR\_M50}) \sin(ROLL) \\ - (\overline{VEC\_M50} \times UNIT(\overline{VEC\_M50} \times \overline{RR\_M50}) \cos(ROLL))$$

$$\overline{MTP} = TRANSPOSE (MATRIX(\overline{VEC\_BOD}, \overline{VEC\_BOD} \times \overline{YN}, -\overline{YN})) \\ MATRIX (\overline{VEC\_M50}, \overline{VEC\_M50} \times \overline{YT}, -\overline{YT})$$

The required quaternion is computed from the  $\overline{MTP}$  matrix by calling the  $MAT\_TO\_QUAT$  utility function:

CALL  $MAT\_TO\_QUAT$

Input:  $\overline{MTP}$

Outputs:  $Q\_ATT\_M50\_S, Q\_ATT\_M50\_V$

B. Interface Requirements. The input and output parameters for the three-axis tracking subtask are given in Tables 4.3.16-1 and 4.3.16-2. The MAT\_TO\_QUAT, matrix multiplication, and matrix transpose modules are required.

C. Processing Requirements. This subtask is processed when called.

D. Initialization Requirements. None.

E. Supplemental Information. Prior to calling this subtask, the calling task must provide a body roll reference vector that avoids the software singularity which may occur when the body roll reference vector is close to the given body referenced vector.

A tolerance parameter TLOS\_TOL, is required to determine when the alternate inertial roll reference vector is required. The alternate roll reference vector is used when  $\overline{TLOS}$  is within  $1^\circ$  of the angular momentum vector; therefore,  $TLOS\_TOL = 0.999848 = \cos 1^\circ$ .

Table 4.3.16-1. Three-Axis Tracking Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V96U9713C	VEC_BOD	Pointing vector in body coordinates	TRACK	SP	none
	VEC_M50	Target vector in M50 coordinates	TRACK	SP	none
	ROLL	Roll angle	TRACK	SP	rad
	RR_BOD	Body roll reference vector	TRACK	SP	none
	RR_M50	Inertial roll reference vector	TRACK	SP	none
	RRA_M50	Alternate inertial roll reference vector	TRACK	SP	none
	TLOS_TOL	Alternate target vector tolerance	K-LOAD	SP	none

Table 4.3.16-2. Three-Axis Tracking Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	Q_ATT_M50	Required body quaternion	TRACK	SP	none
	RR_M50	Inertial roll reference vector	TRK RATE	SP	none

#### 4.3.17 Tracking Rate Vector Subtask (TRK RATE)

This subtask calculates the tracking rate vector,  $\overline{REQD\_BRATE}$ , required by the DAP AUTO\_MNVR\_TRACK function for target tracking. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. If  $TGT\_ID\_C \geq 4$ , set  $\overline{REQD\_BRATE} = 0$ . For all other targets, first, the inertial rate vector,  $\overline{WBI}$ , is calculated as a function of the target selected.

1. Rendezvous. If  $TGT\_ID\_C = 1$ , 
$$\overline{WBI} = \frac{\overline{TLOS} \times \overline{VREL}}{\text{MAX}(\text{ABVAL}(\overline{RREL}), \text{RNG\_TOL\_UPTG})}$$

where  $\overline{TLOS}$  is computed by LOS VEC.

2. Center of earth. If  $TGT\_ID\_C = 2$ , 
$$\overline{WBI} = \frac{\overline{VORB} \times \overline{TLOS}}{\text{ABVAL}(\overline{RORB})}$$

where  $\overline{TLOS}$  is computed by LOS VEC.

3. Earth site. If  $TGT\_ID\_C = 3$ , first the inertial target velocity is computed as

$$\overline{VPOS} = \text{EARTH\_RATE}(\overline{\text{EARTH\_POLE}}) \times \overline{TPOS}$$

Second, the inertial rate vector is computed as

$$\overline{WBI} = \frac{\overline{TLOS} \times (\overline{VPOS} - \overline{VORB})}{\text{MAX}(\text{ABVAL}(\overline{TPOS} - \overline{RORB}), \text{RNG\_TOL\_UPTG})}$$

where  $\overline{TLOS}$ ,  $\overline{TPOS}$ , and  $\overline{\text{EARTH\_POLE}}$  are computed by LOS VEC.

If the three-axis tracking mode is selected ( $\text{THREE\_AXIS\_C} = 1$ ) and the LVLH mode is not selected ( $\text{LVLH\_MODE} = 0$ ), a correction term must be added to the inertial rate vector to satisfy the roll constraint.

$$\text{DOT} = \overline{TLOS} \cdot \overline{RR\_M50}$$

$$\overline{WBI} = \overline{WBI} + \overline{TLOS} (\overline{WBI} \cdot \overline{RR\_M50}) \text{DOT} / (1 - \text{DOT}^2)$$

The required body attitude rate vector is then computed.

CALL QUAT\_XFORM

Inputs:  $\overline{WBI}$ ,  $Q\_BOD\_M50\_S$ ,  $Q\_BOD\_M50\_V$

Output:  $\overline{REQD\_BRATE}$

Finally, the required body attitude rate vector is scaled to units of degrees per second.

$$\overline{REQD\_BRATE} = \overline{REQD\_BRATE} \text{ DEG\_PER\_RAD}$$

If the magnitude of the required body attitude rate vector,  $ABVAL(\overline{REQD\_BRATE})$ , is greater than  $RTE\_LIM$ , then each component of the rate vector is scaled down such that the resulting magnitude is equal to  $RTE\_LIM$ .

$$\overline{REQD\_BRATE} = \frac{\overline{REQD\_BRATE} RTE\_LIM}{ABVAL(\overline{REQD\_BRATE})}$$

B. Interface Requirements. The input and output parameters for the tracking rate subtask are given in Tables 4.3.17-1 and 4.3.17-2.

C. Processing Requirements. This subtask is processed once when called.

D. Initialization Requirements. None.

E. Supplemental Information. A tolerance parameter is required to protect from division by zero in the calculation of the inertial rate vector for the rendezvous and earth site targets. The specific value of this parameter is  $RNG\_TOL\_UPTG = 100.0$  (ft).

The values of the constants used by this subtask are:

$$EARTH\_RATE = 7.29211514646 \text{ E-05 rad/sec}$$

$$DEG\_PER\_RAD = 5.72957795131 \text{ E+01 deg/rad}$$

Table 4.3.17-1. Tracking Rate Vector Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	TGT_ID_C	Current target vector identifier	CYC OPT, CYC LVLH	SP	none
	$\overline{TLOS}$	Target line-of-sight vector	LOS VEC, CYC LVLH	SP	none
V95H0185C thru V95H0187C	$\overline{RORB}$	Orbiter position vector	ORBIT UPP	SP	ft
V95L0190C thru V95L0192C	$\overline{VORB}$	Orbiter velocity vector	ORBIT UPP	SP	ft/s
V95H0855C thru V95H0857C	$\overline{RREL}$	Orbiter/target relative position vector	ORBIT UPP	SP	ft
V95L0858C thru V95L0860C	$\overline{VREL}$	Orbiter/target relative velocity vector	ORBIT UPP	SP	ft/s
	EARTH_POLE	Earth's unit angular momentum vector in M50 coordinates	LOS VEC	SP	none
V97U4379C	EARTH_RATE	Earth's rotation rate	CONSTANT	DP	rad/s
V96U8560C	RTE_LIM	Limiting value of tracking rate vector	K-LOAD	SP	deg/s
V97U0112C	DEG_PER_RAD	Degrees per radian	CONSTANT	SP	deg/ rad
V96U9714C	RNG_TOL_UPTG	Inertial rate range tolerance	K-LOAD	SP	ft
	$\overline{TPOS}$	Earth-fixed target position vector expressed in M50 coordinates	LOS VEC	SP	ft
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT PROC	SP	none
	THREE_AXIS_C	Current three-axis tracking flag	CYC OPT	N/A	none
	$\overline{RR}_{M50}$	Inertial roll reference vector	3AXIS	SP	none
V90X2174X	$\overline{LVLH}_{MODE}$	LVLH mode indicator	ORBIT DAP	N/A	none

Table 4.3.17-2. Tracking Rate Vector Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95R2216C thru V95R2218C	REQD_BRATE	Required body attitude rate	TRACK, ORBIT DAP	SP	deg/s

#### 4.3.18 Universal Pointing Rotation Task (ROTR)

This task provides the body attitude and body attitude rate required to maintain a predictable and continual attitude change about a selected axis of rotation. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. To initialize, the ROTR task stores four parameters if the rotation option initial condition indicator,  $\text{ROT\_IC}$ , is set or if the current rotation rate,  $\text{ROTR\_RATE\_C}$ , is not equal to the selected DAP maneuver rate,  $\text{DAP\_RATE}$ .

The first parameter stored is the selected DAP rate:

$$\text{ROTR\_RATE\_C} = \text{DAP\_RATE}$$

The second parameter stored is the starting attitude quaternion.

$$\text{Q\_BODC\_M50\_S} = \text{Q\_BOD\_M50\_S}$$

$$\text{Q\_BODC\_M50\_V} = \text{Q\_BOD\_M50\_V}$$

The third stored parameter is the body attitude rate vector:

$$\text{REQD\_BRATE} = (\text{ROTR\_RATE\_C}) (\overline{\text{PLOS\_C}})$$

where  $\overline{\text{PLOS\_C}}$  is the axis of rotation.

And the fourth parameter stored is the activation time:

$$\text{GMTS\_C} = \text{GMTC}$$

Also for initialization, the calculation of the maneuver completion time should be initialized to register the rotation option start time:

$$\text{MNVR\_TIME\_IC} = 1$$

$$\text{MNVR\_TIME\_FLAG} = 1$$

To complete initialization,  $\text{ROT\_IC}$  is reset:  $\text{ROT\_IC} = 0$ .

The time-varying parameters are updated on each pass.

On the first pass and each pass thereafter, the required eigenangle (EA) is computed from the current rotation rate ( $\text{ROTR\_RATE\_C}$ ), the time of the current attitude (GMTC), and the current attitude option start time (GMTS\_C):

$$\text{EA} = (\text{GMTC} - \text{GMTS\_C}) \text{ROTR\_RATE\_C}$$

$$\text{EA} = \text{MOD}(\text{EA}, 360) \text{RAD\_PER\_DEG}$$

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If the eigenangle exceeds 360 degrees, it is scaled to fall in the 0– to 360–degree range. Next, the body–to–required–body quaternion is computed:

$$Q\_RBOD\_BOD\_S = \text{COS}(EA/2)$$

$$Q\_RBOD\_BOD\_V = -(\overline{PLOS\_C}) \text{SIN}(EA/2)$$

Then the required body quaternion is computed:

CALL QUAT\_MULT

Inputs:             $Q\_RBOD\_BOD\_S$ ,  $Q\_RBOD\_BOD\_V$ ,  $Q\_BODC\_M50\_S$ ,  
                       $Q\_BODC\_M50\_V$

Outputs:            $Q\_RBOD\_M50\_S$ ,  $Q\_RBOD\_M50\_V$

The time tag of the output quaternion is then computed:

$$GMTR = GMTC$$

B. Interface Requirements. The input and output parameters for the universal pointing rotation task are given in Tables 4.3.18–1 and 4.3.18–2.

C. Processing Requirements. Attitude processing is performed by this task every 1.92 seconds. The rate requires computation only on the first pass.

D. Initialization Requirements. This task is initialized by the CYC OPT task.

E. Supplemental Information. The value for RAD\_PER\_DEG is 1.7453293 E–02 rad/deg.



Table 4.3.18-1. Universal Pointing Rotation Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT_PROC	SP	none
V90W2310C	GMTC/T_NOW	Time tag of current body quaternion	ATT_PROC	DP	s
V95U2225C thru V95U2227C	PLOS_C	Current option body vector	CYC OPT	SP	none
V90R2176C	DAP_RATE	Selected DAP maneuver rate	ORBIT DAP	SP	deg/s
V97U0383C	RAD_PER_DEG	Degree to radian conversion factor	CONSTANT	SP	rad/deg
V96U9754C	ROT_IC	Rotation option initial condition indicator	UNIV SEQ, CYC OPT	N/A	none

Table 4.3.18-2. Universal Pointing Rotation Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	CYC OPT	SP	none
V97R2216C thru V95R2218C	REQD_BRATE	Required body attitude rate vector	ORBIT DAP	SP	deg/s
V95W2201C	GMTR	Time tag of required body quaternion	ORBIT DAP	DP	s

#### 4.3.19 Display Support Task (DISP SUP)

This task provides all of the dynamic display variables that appear on the attitude monitor portion of the UNIV PTG display. (Please refer to Figure 4.3.19–1 for the following discussion.)

A. Detailed Requirements. This task provides the dynamic attitude monitor variables (current and required attitude angles, attitude rate, and attitude error) and the maneuver completion time for the current attitude option. All attitude–related quantities are computed as functions of the selected monitor axis.

1. LVLH mode indicator. If the LVLH mode indicator is set ( $LVLH\_MODE = 1$ ), the required body quaternion is set equal to the current body quaternion:

$$Q\_RBOD\_M50\_S = Q\_BOD\_M50\_S$$

$$Q\_RBOD\_M50\_V = Q\_BOD\_M50\_V$$

This causes zero total attitude errors to appear on the display and on the ADI error needles.

2. Total/DAP attitude error calculation. Two types of mutually exclusive attitude errors may be selected: total attitude errors and DAP attitude errors. Total attitude errors are defined as the negative of the product of the eigenangle and eigenaxis extracted from the body–to–required–body quaternion. DAP attitude errors are defined as the phase plane attitude errors.

The total attitude error subtask is used to compute the “fly to” total errors:

CALL ATT ERROR

Inputs:             $Q\_BOD\_M50\_S$ ,  $Q\_BOD\_M50\_V$ ,  
                       $Q\_RBOD\_M50\_S$ ,  $Q\_RBOD\_M50\_V$

Output:             $TOT\_ERR$

The selection of total or DAP attitude errors is indicated by the total/DAP attitude error selection discrete. The values for this discrete are:

$ERR\_SEL = 0$                             DAP attitude errors selected (reset)

$ERR\_SEL = 1$                             Total (GN&C) attitude errors selected (set)

The attitude errors are to be displayed in the “fly-to” sense; therefore, if  $\text{ERR\_SEL} = 0$ , the attitude error variable is set equal to the negative of the DAP attitude errors:

$$\overline{\text{ERR}} = -\text{DAP}\overline{\text{ERR}}$$

Then if  $\text{ERR\_SEL} = 1$ , the attitude error variable is set equal to the total attitude errors:

$$\overline{\text{ERR}} = \text{TOT}\overline{\text{ERR}}$$

3. Monitor axis. The selected monitor axis,  $\text{MON\_AXIS}$ , controls the sense in which certain display parameters are computed.

If  $\text{MON\_AXIS} = 1$ , the monitor axis vector,  $\text{MON\_AXIS\_VEC}$ , and the quaternion from the body reference to the monitor axis,  $\text{Q\_MON\_INRTL}$ , are given the values:

$$\text{MON\_AXIS\_VEC} = \text{VECTOR}(1, 1, 1)$$

$$\text{Q\_MON\_BOD\_S} = 1$$

$$\text{Q\_MON\_BOD\_V} = \text{VECTOR}(0, 0, 0)$$

If  $\text{MON\_AXIS} = 2$ , the values given these parameters are:

$$\text{MON\_AXIS\_VEC} = \text{VECTOR}(-1, -1, 1)$$

$$\text{Q\_MON\_BOD\_S} = 0$$

$$\text{Q\_MON\_BOD\_V} = \text{VECTOR}(0, 0, 1)$$

These parameters are then used to calculate the current and required attitude angles, the attitude errors, and the attitude rates.

4. Current attitude angles. The current orbiter attitude relative to the inertial ADI reference frame is presented as three Euler angles in the roll, pitch, and yaw order. These angles are computed in the Y, Z, X Euler sequence for the selected monitor axis.

The computation of these angles is performed in three steps.

First the quaternion multiplication algorithm is applied twice:

CALL QUAT\_MULT

Inputs:             $\text{Q\_MON\_BOD\_S}$ ,  $\text{Q\_MON\_BOD\_V}$

$\text{Q\_BOD\_M50\_S}$ ,  $\text{Q\_BOD\_M50\_V}$

Outputs:            $\text{Q\_MON\_M50\_S}$ ,  $\text{Q\_MON\_M50\_V}$

CALL QUAT\_MULT

Inputs: Q\_MON\_M50\_S, Q\_MON\_M50\_V  
Q\_M50\_INRTL\_ORB\_S,  
Q\_M50\_INRTL\_ORB\_V

Outputs: Q\_MON\_INRTL\_S, Q\_MON\_INRTL\_V

Finally, the attitude angles subtask is called to compute the required Euler angles:

CALL ATT ANG

Inputs: Q\_MON\_INRTL\_S, Q\_MON\_INRTL\_V  
Outputs: ROLLC, PITCHC, YAWC

5. Required attitude angles. These angles represent the required attitude relative to the inertial reference frame. The computation of the required attitude angles is identical in format to the computation of the current angles.

First, the quaternion multiplication algorithm is applied twice.

CALL QUAT\_MULT

Inputs: Q\_MON\_BOD\_S, Q\_MON\_BOD\_V,  
Q\_RBOD\_M50\_S, Q\_RBOD\_M50\_V

Outputs: Q\_MON\_M50\_S, Q\_MON\_M50\_V

CALL QUAT\_MULT

Inputs: Q\_MON\_M50\_S, Q\_MON\_M50\_V,  
Q\_M50\_INRTL\_ORB\_S,  
Q\_M50\_INRTL\_ORB\_V

Outputs: Q\_MON\_INRTL\_S, Q\_MON\_INRTL\_V

Then the attitude angles subtask is called to compute the required Euler angles:

CALL ATT ANG

Inputs: Q\_MON\_INRTL\_S, Q\_MON\_INRTL\_V  
Outputs: ROLLR, PITCHR, YAWR

6. Displayed attitude error. The attitude error provided to the UNIV PTG display,  $\overline{ATT\_ERR}$ , is calculated as a function of the attitude error variable,  $\overline{ERR}$ , and the monitor vector:

$$\overline{ATT\_ERR} = \text{VECTOR}(\text{ERR\_X} * \text{MON\_AXIS\_VEC\_X}, \text{ERR\_Y} * \text{MON\_AXIS\_VEC\_Y}, \text{ERR\_Z} * \text{MON\_AXIS\_VEC\_Z})$$

7. Attitude rate. The body attitude rate is also displayed as a function of the select monitor axis:

$$\overline{ATT\_RATE} = \text{VECTOR}(\text{BOD\_RATE\_X} * \text{MON\_AXIS\_VEC\_X}, \text{BOD\_RATE\_Y} * \text{MON\_AXIS\_VEC\_Y}, \text{BOD\_RATE\_Z} * \text{MON\_AXIS\_VEC\_Z})$$

8. Maneuver completion time. The maneuver completion time,  $\text{MNVR\_CMPL\_TIME}$ , is calculated for current rotation, tracking, or maneuver attitude options unless the LVLH mode indicator is set. Therefore, if

$\text{OPT\_CUR} \neq 0$                       Current option active

and  $\text{LVLH\_MODE} = 0$                       LVLH mode indicator not set

then the maneuver completion time subtask is called to calculate  $\text{MNVR\_CMPL\_TIME}$ :

CALL CMPLT TIME

Inputs:                      GMT, BASE\_MET,  $\overline{TOT\_ERR}$ , DAP\_RATE,  
DB\_REQUEST(1), ATT\_TOLERANCE,  
MNVR\_TIME\_FLAG, MNVR\_TIME\_IC

Outputs:                      MNVR\_CMPL\_TIME

B. Interface Requirements. The input and output parameters for the display support task are given in Tables 4.3.19-1 and 4.3.19-2.

C. Processing Requirements. This task is processed once every 1.92 seconds.

D. Initialization Requirements. The quaternion  $\text{Q\_M50\_INRTL\_ORB}$  is obtained from K-load and will rotate the INERTIAL frame into the M50 frame.

E. Supplemental Information. In the attitude error and rate display calculations,  $\text{ERR\_X}$ ,  $\text{ERR\_Y}$ , and  $\text{ERR\_Z}$ , are the components of  $\overline{ERR}$ ;  $\text{MON\_AXIS\_VEC\_X}$ ,  $\text{MON\_AXIS\_VEC\_Y}$ , and  $\text{MON\_AXIS\_VEC\_Z}$  are the components of  $\overline{\text{MON\_AXIS\_VEC}}$ ; and  $\text{BOD\_RATE\_X}$ ,  $\text{BOD\_RATE\_Y}$ , and  $\text{BOD\_RATE\_Z}$  are the components of  $\overline{\text{BOD\_RATE}}$ .

Table 4.3.19-1. Display Support Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V93U6868C	MON_AXIS	Selected monitor axis	UNIV PTG DISP	N/A	none
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT PROC	SP	none
V97U2214CC thru V97U2217C	Q_M50_INRTL_ORB	Inertial to M50 quaternion	K-LOAD	SP	none
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	UNIV SEQ	SP	none
V93X6845X	ERR_SEL	Total/DAP attitude error discrete	UNIV PTG DISP	N/A	none
V90H2141C thru V90H2143C	DAP_ERR	DAP phase plane attitude errors	ORBIT DAP	SP	deg
V90R2223C thru V90R2225C	BOD_RATE	Estimated body rates	ORBIT DAP	SP	deg/s
V90X2174X	LVLH_MODE	LVLH mode indicator	ORBIT DAP	N/A	none
V95J7482C	OPT_CUR	Current attitude option indicator	UNIV SEQ	N/A	none

Table 4.3.19-2. Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95H7473C	ROLLC	Current roll angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7474C	PITCHC	Current pitch angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7475C	YAWC	Current yaw angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7467C	ROLLR	Required roll angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7468C	PITCHR	Required pitch angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7484C	YAWR	Required yaw angle (YZX Euler)	UNIV PTG DISP	SP	rad
V95H7490C thru V95H7492C	ATT_ERR	Attitude errors	UNIV PTG DISP	SP	deg
V95R7476C V95R7477C V95R7487C	ATT_RATE	Body attitude rates	UNIV PTG DISP	SP	deg/s
V95W7472C	MNVR_CMPL_TIME	Maneuver completion time	UNIV PTG DISP	DP	s

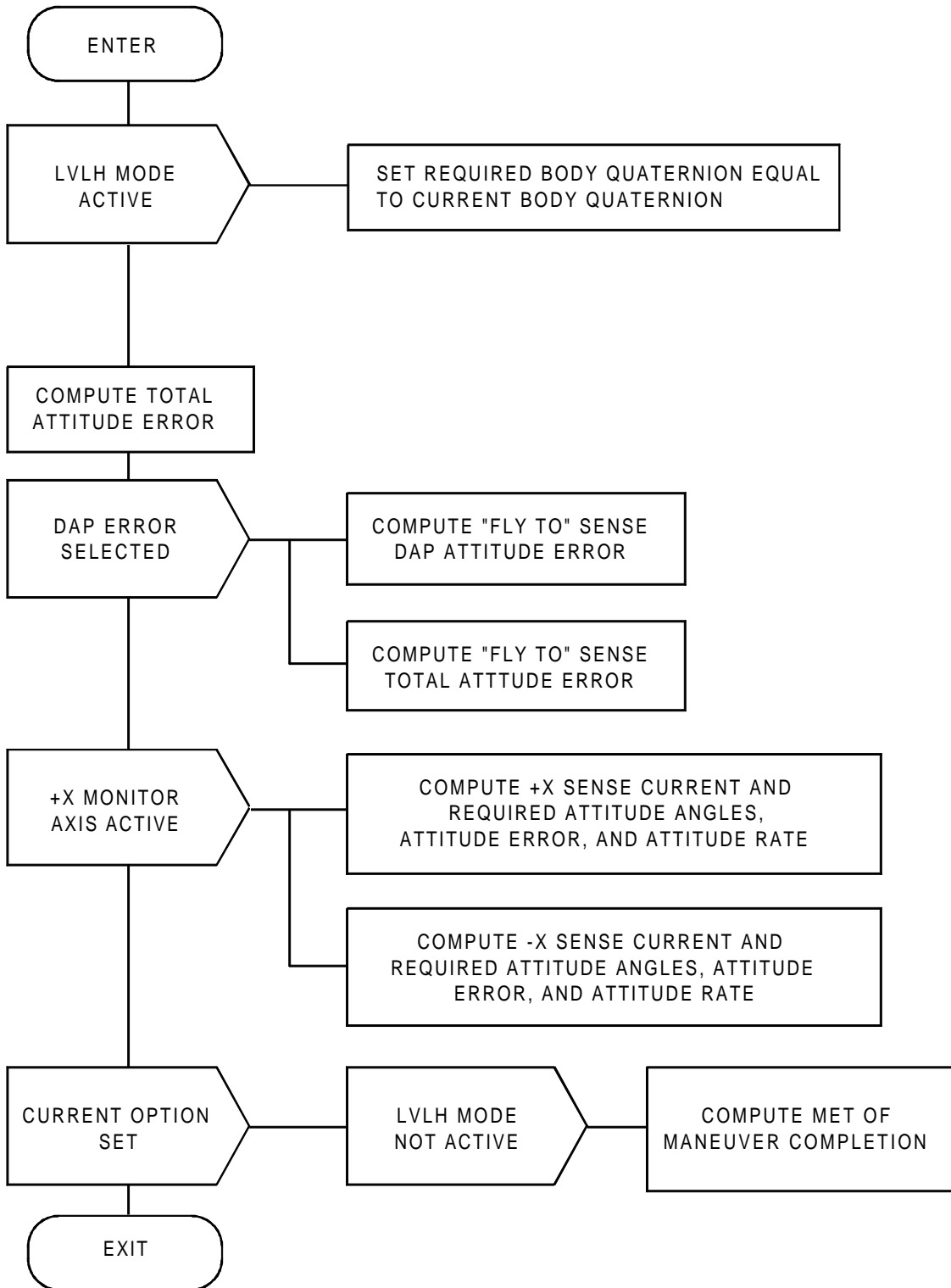


FIGURE 4.3.19-1. Display Support Task Functional Flow

#### 4.3.20 Attitude Angles Subtask (ATT ANG)

This subtask computes a unique Euler angle representation of a given quaternion. The Euler angles are computed for the pitch–yaw–roll (YZX) attitude sequence. The yaw angle is restricted to a range of values from either 0 to 90 degrees or 270 to 359.995 degrees. The detailed flow for this task is illustrated in Appendix A.

Near a yaw angle of either 90 or 270 degrees, multiple solutions are possible for roll and pitch. The solution ambiguity is resolved by selecting a roll angle of zero and solving for the corresponding pitch angle. This allows a time–continuous display of attitude angles which exactly represent the given quaternion. However, an apparent discontinuity in both the pitch and roll attitude angles will occur when the yaw angle comes within a selected tolerance of either 90 or 270 degrees, but that apparent discontinuity also occurs in the attitude angles computed by the ground software.

A. Detailed Requirements. The sine (SYAW) and cosine (CYAW) functions of the yaw attitude angle (YAW) are first computed:

$$SYAW = 2(Q1 Q2 - Q3 QS)$$

$$CYAW = \text{SQRT}(1 - SYAW SYAW)$$

If the cosine of the yaw angle is greater than a given tolerance ( $CYAW > TOL$ ), then the roll and pitch arguments of the four–quadrant arc tangent function are computed as follows:

$$SROLL = -2(Q2 Q3 + Q1 QS)$$

$$CROLL = 1 - 2(Q1 Q1 + Q3 Q3)$$

$$SPITCH = -2(Q1 Q3 + Q2 QS)$$

$$CPITCH = 1 - 2(Q2 Q2 + Q3 Q3)$$

where SROLL and CROLL, and SPITCH and CPITCH are the first and second arguments of the arc tangent function required to compute the roll angle (ROLL) and pitch angle (PITCH) for the given quaternion, respectively.

If the cosine of the yaw angle is less than or equal to a given tolerance ( $CYAW \leq TOL$ ), then the roll and pitch arc tangent arguments are computed as follows:

$$SROLL = 0$$

$$CROLL = 1$$

$$SPITCH = 2(Q1 Q3 - Q2 QS)$$

$$CPITCH = 1 - 2(Q1 Q1 + Q2 Q2)$$



The attitude angles are then computed in radians.

$$\text{PITCH} = \text{ARCTAN2}(-\text{SPITCH}, -\text{CPITCH}) + \text{PI}$$

$$\text{YAW} = \text{ARCTAN2}(-\text{SYAW}, -\text{CYAW}) + \text{PI}$$

$$\text{ROLL} = \text{ARCTAN2}(-\text{SROLL}, -\text{CROLL}) + \text{PI}$$

If any of the above angles are greater than 359.995 degrees (6.283099 radians) after scaling, the angles are set to zero. This will ensure that all displayed attitude angles will assume values from 0 to 359.99 degrees.

B. Interface Requirements. The input and output parameters for the attitude angles subtask are given in Tables 4.3.20-1 and 4.3.20-2.

C. Processing Requirements. This subtask is executed once when invoked by the calling routine.

D. Initialization Requirements. A tolerance parameter is required to initiate the alternate pitch and roll angle calculations. The value of this parameter is TOL = 0.005.

E. Supplemental Information. This subtask is designed to display pitch-yaw-roll attitude angles to an accuracy of two decimal places.

Table 4.3.20-1. Attitude Angles Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	QS	Scalar component of input quaternion	CALLING TASK	SP	none
	Q1	X-vector component of input quaternion	CALLING TASK	SP	none
	Q2	Y-vector component of input quaternion	CALLING TASK	SP	none
	Q3	Z-vector component of input quaternion	CALLING TASK	SP	none
V98U8725C	PI	Ratio of circumference to diameter	CONSTANT	DP	none

Table 4.3.20-2. Attitude Angles Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	ROLL	Roll angle of input quaternion (YZX Euler)	CALLING TASK	SP	rad
	PITCH	Pitch angle of input quaternion (YZX Euler)	CALLING TASK	SP	rad
	YAW	Yaw angle of input quaternion (YZX Euler)	CALLING TASK	SP	rad

#### 4.3.21 Attitude Error Subtask (ATT ERROR)

This subtask computes the total attitude error,  $TOT\_ERR$ , required by the universal pointing display function. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. The error quaternion is first computed as follows:

CALL QUAT\_MULT

Inputs:  $Q\_RBOD\_M50\_S$ ,  $Q\_RBOD\_M50\_V$ ,

$Q\_BOD\_M50\_S$ ,  $-Q\_BOD\_M50\_V$

Outputs:  $Q\_RBOD\_BOD\_S$ ,  $Q\_RBOD\_BOD\_V$

If  $Q\_RBOD\_BOD\_S$  is negative, then the sign of each element of  $Q\_RBOD\_BOD$  is reversed. The total attitude error is computed as follows:

$$VMAG = \text{SQRT}(1 - Q\_RBOD\_BOD\_S^2)$$

If  $VMAG < VMAG\_TOL$ , then the total attitude error is set to zero:

$$TOT\_ERR = 0$$

Otherwise, the total attitude error is computed as follows:

$$RVMAG = \text{DEG\_PER\_RAD}/VMAG$$

$$TOT\_ERR = -2 RVMAG Q\_RBOD\_BOD\_V \text{ ARCCOS}(Q\_RBOD\_BOD\_S)$$

B. Interface Requirements. The input and output parameters for the attitude error subtask are given in Tables 4.3.21-1 and 4.3.21-2.

C. Processing Requirements. This subtask is processed when called.

D. Initialization Requirements. None.

E. Supplemental Information. The variable VMAG is the sine of one-half of the magnitude of the total attitude error. Since attitude error is displayed to two-decimal place accuracy, the minimum value of the total attitude error considered is 0.005 degree. Therefore, the value of VMAG\_TOL is  $0.000043 = \sin(0.005/2)$ .

The value for DEG\_PER\_RAD is 57.29577951 deg/rad.

Table 4.3.21-1. Attitude Error Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V95U2209C thru V95U2212C	Q_RBOD_M50	Required body quaternion	CYC OPT, UNIV SEQ	SP	none
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT_PROC	SP	none
V97U0112C	DEG_PER_RAD	Radians to degrees	CONSTANT	SP	deg/ rad

Table 4.3.21-2. Attitude Error Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	TOT_ERR	Total attitude error	DISP SUP	SP	deg

#### 4.3.22 Maneuver Completion Time Subtask (CMPLT TIME)

This subtask computes the nominal maneuver completion time, MNVR\_CMPL\_TIME, required by the universal pointing display function.

A. Detailed Requirements. The MNVR\_CMPL\_TIME is calculated for the current maneuver, tracking, and rotation options. The completion time computation starts when a current tracking, maneuver, or rotation option is initiated and requires the current time (GMT) and the GMT/MET reference time (BASE\_MET).

Figure 4.3.22-1 illustrates the logic required to calculate the maneuver completion time. This figure does not specify programming requirements.

The maneuver completion time is processed only when the maneuver time flag is set. Consequently, if MNVR\_TIME\_FLAG = 1, the following calculations are performed:

$$\text{MET} = \text{GMT} - \text{BASE\_MET}$$

where MET is the current mission elapsed time.

If the  $\text{ABVAL}(\overline{\text{TOT\_ERR}}) > \text{ATT\_TOLERANCE DB\_REQUEST}(1)$ , where DB\_REQUEST(1) is the selected DAP attitude deadband, the total attitude errors are out of tolerance and the maneuver completion time is actively processed by Item 1. Otherwise, the maneuver is considered complete and Item 2 is processed.

1. First, the maneuver time remaining is computed:

$$\text{MNVR\_TIME} = \text{ABVAL}(\overline{\text{TOT\_ERR}})/\text{DAP\_RATE}$$

Then the maneuver completion time is computed:

$$\text{MNVR\_CMPL\_TIME} = \text{MNVR\_TIME} + \text{MET}$$

2. First, the maneuver time flag is reset:

$$\text{MNVR\_TIME\_FLAG} = 0$$

Second, if the maneuver time initial condition indicator is set (MNVR\_TIME\_IC = 1), then the maneuver completion time is updated to the current MET:

$$\text{MNVR\_CMPL\_TIME} = \text{MET}$$

The last step in the maneuver completion time subtask is to reset the initial condition indicator:

$$\text{MNVR\_TIME\_IC} = 0$$

B. Interface Requirements. The input and output parameters for the maneuver completion time subtask are given in Tables 4.3.22-1 and 4.3.22-2.

C. Processing Requirements. This subtask is processed every 1.92 seconds.

D. Initialization Requirements. The maneuver completion time is initialized to zero. Also it is set to zero in the parameter processing task when the cancel option is executed.

E. Supplemental Information. The maneuver completion time appears on the universal pointing display as hours, minutes, and seconds. The day must therefore be truncated from the final value. The maneuver completion time subtask calculates an approximate time of current maneuver completion for universal pointing attitude options. The completion time will update during the auto and manual attitude modes, especially during acceleration/ deceleration periods, until the total attitude errors are within a given tolerance of the selected DAP attitude deadband. When attitude errors are reduced to within this tolerance in the auto mode, the completion time freezes at its current value and remains frozen until a new current option becomes active. In the manual mode, when errors are within the deadband, the completion time is set equal to the current mission elapsed time (MET) on each cycle. If the error for a completed current option is increased until it is greater than the deadband in the manual mode, the completion time will reflect the maneuver back to the desired attitude. If the total attitude error is within the deadband when an option becomes current, the completion time is set equal to the current MET before its value is frozen. This will always be done for the rotation option. During the DAP manual LVLH mode, the maneuver completion time is frozen.

The value for ATT\_TOLERANCE is 1.1.

Table 4.3.22-1. Maneuver Completion Time Subtask Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V90R2176C	DAP_RATE	Selected DAP maneuver rate	ORBIT DAP	SP	deg/s
	TOT_ERR	Total attitude errors	ATT ERROR	SP	deg
V91W5006C	GMT	Current time	FCOS	DP	s
V91W1996C	BASE_MET	GMT/MET reference time	FCOS	DP	s
V90H2785C	DB_REQUEST(1)	Requested DAP deadband (roll)	ORBIT DAP	SP	deg
V99U7522C	ATT_TOLERANCE	MNVR_CMPL_TIME freeze tolerance	K-LOAD	SP	none
	MNVR_TIME_FLAG	Maneuver time flag	UNIV SEQ	N/A	none
	MNVR_TIME_IC	Maneuver time initial condition indicator	UNIV SEQ	N/A	none

Table 4.3.22-2. Maneuver Completion Time Subtask Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V95W7472C	MNVR_CMPL_TIME	Maneuver completion MET	UNIV PTG	DP	s

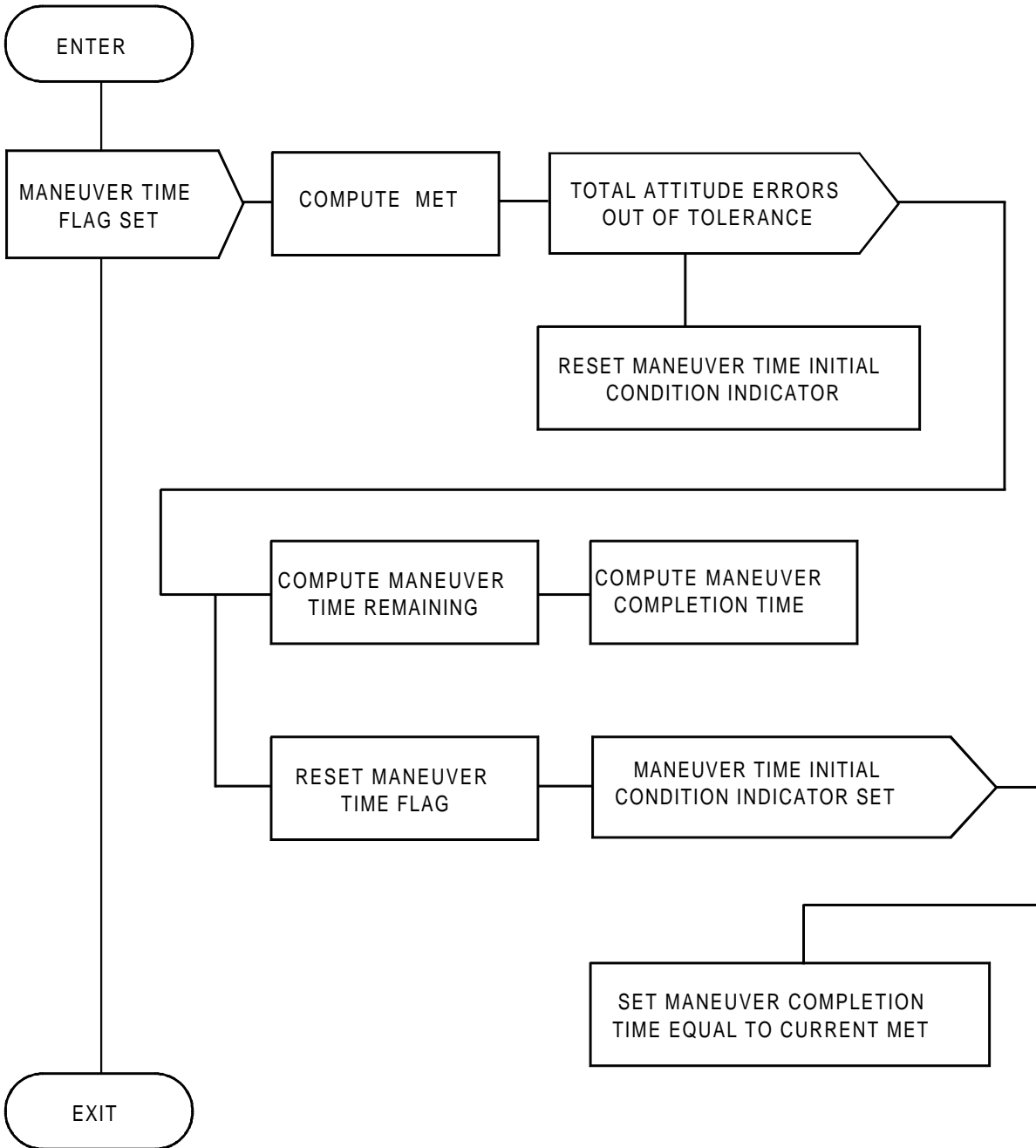


FIGURE 4.3.22-1. Maneuver Completion Time Functional Flow

#### 4.3.23 Rendezvous Target Task (RNDZTGT)

This task provides a desired target line-of-sight for the Ku-band antenna management function in systems management. The detailed flow for this task is illustrated in Appendix A.

A. Detailed Requirements. This task is activated by the UNIV SEQ task when the discrete indicating the selection of this function is set to enable.

$$KU\_SEL = 1$$

As long as this task is active, the rendezvous target vector is computed from the relative position of the orbiter and target,  $\overline{RREL}$ , as:

CALL QUAT\_XFORM

Inputs:  $\overline{RREL}$ , Q\_BOD\_M50\_S, Q\_BOD\_M50\_V

Outputs:  $\overline{RTLOS}$

where  $\overline{RTLOS}$  is the rendezvous target line-of-sight expressed in orbiter body coordinates.

This task is deactivated by the UNIV SEQ task when the discrete indicating the selection of this function is set to inhibit:

$$KU\_SEL = 0$$

B. Interface Requirements. The input and output parameters for the rendezvous target task are given in Tables 4.3.23-1 and 4.3.23-2.

C. Processing Requirements. This task is processed once every 2 seconds after it is activated.

D. Initialization Requirements. None.

Table 4.3.23-1. Rendezvous Target Task Input Parameters					
MSID	Name	Definition	Source	Precision	Units
V90U2240CB thru V90U2243CB	Q_BOD_M50	Current body quaternion	ATT PROC	SP	none
V95H0855C thru V95H0857C	$\overline{RREL}$	Orbiter/target relative position vector	ORB UPP	SP	ft

Table 4.3.23-2. Rendezvous Target Task Output Parameters					
MSID	Name	Definition	Destination	Precision	Units
V95H3893CB thru V95H3895CB	$\overline{RTLOS}$	Rendezvous target body referenced vector	GN&C/SM PL IF	SP	ft

**4.3.24 Parameter Tables for Universal Pointing Processor (G4.213)**

The IDD inputs and outputs are listed in Tables 4.3.24–1 and 4.3.24–2 respectively. K–loads are listed in Table 4.3.24–4. Constants are listed in Table 4.3.24–5. The cross–reference listing is below.

Universal Pointing Processor (G4.213) Cross–Reference Listing			
MSID	Local Name	Source Name	Source
V95H0855C	$\overline{\text{RREL}}$	DEL_R_TARG(1)	ORB UPP
V95H0856C		DEL_R_TARG(2)	
V95H0857C		DEL_R_TARG(3)	
V95L0858C	$\overline{\text{VREL}}$	DEL_V_TARG(1)	ORB UPP
V95L0859C		DEL_V_TARG(2)	
V95L0860C		DEL_V_TARG(3)	
V90W2310CB	GMTC	GMTC/TNOW	ORB ATT PROC
V91W1996C	BASE_MET	T_MET_REF	FCOS
V91W5000C	GMT	CLOCK	FCOS



TABLE 4.3.24-1. INPUT FUNCTIONAL PARAMETERS FOR UNIVERSAL POINTING PROCESSOR (G4.213)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
BODV_ID	V93U6805C	BODY VECTOR ID	UNIV PTG DISP		HXS		93017G	*
BODV_PITCH	V93U6806CB	BODY VECTOR PITCH COORDINATE	UNIV PTG DISP	RAD			93017G	*
BODV_YAW	V93U6807CB	BODY VECTOR YAW COORDINATE	UNIV PTG DISP	RAD			93017G	*
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
DAP_ERR(1)	V90H2143C	BODY ATTITUDE ERROR-ROLL	ORB DAP	DEG	SPL		93017G	*
DAP_ERR(2)	V90H2141C	BODY ATTITUDE ERROR-PITCH	ORB DAP	DEG	SPL		93017G	*
DAP_ERR(3)	V90H2142C	BODY ATTITUDE ERROR-YAW	ORB DAP	DEG	SPL		93017G	*
DAP_RATE	V90R2176C	SELECTED DAP MANEUVER RATE	ORB DAP	DEG/S	SPL		93017G	*
DB_REQUEST(1)	V90H2785C	PHASE PLANE ATT DBD-MAG REQ(ROLL)	ORB DAP	DEG	SPL		93017G	*
DEL_R_TARG(1)	V95H0855C	X-COMP OF ORBITER/TGT REL POS VCTR	ORB UPP	FT	DPL		93017G	*
DEL_R_TARG(2)	V95H0856C	Y-COMP OF ORBITER/TGT REL POS VCTR	ORB UPP	FT	DPL		93017G	*
DEL_R_TARG(3)	V95H0857C	Z-COMP OF ORBITER/TGT REL POS VCTR	ORB UPP	FT	DPL		93017G	*
DEL_V_TARG(1)	V95L0858C	X-COMP OF ORBITER/TGT REL VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
DEL_V_TARG(2)	V95L0859C	Y-COMP OF ORBITER/TGT REL VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
DEL_V_TARG(3)	V95L0860C	Z-COMP OF ORBITER/TGT REL VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
ERR_SEL	V93X6845X	TOTAL/DAP ERROR SELECT FLAG	UNIV PTG DISP		BD		93017G	*
FUT_DCD	V93X6885X	FUTURE OPTION DATA CHANGE	UNIV PTG DISP		BD		93078B	
GMTC/T_NOW	V90W2310CB	M50 TO BODY QUAT TIME	ORB ATT PROC	S			93017G	*
IDAY	V93W6801C	MNVR START TIME(DAYS)	UNIV PTG DISP	D/H/M/S	HXS		93017G	*
Ihour	V93W6802C	MNVR START TIME (HR)	UNIV PTG DISP	HR	HXS		93017G	*
IMIN	V93W6803C	MNVR START TIME (MIN)	UNIV PTG DISP	MIN	HXS		93017G	*
ISEC	V93W6804C	MNVR START TIME (SEC)	UNIV PTG DISP	S	HXS		93017G	*
KU_SEL	V93X6859XA	KU ANTENNA ENA/INH CMD	REL NAV DISP					
LAMP_AUTO	V72X2850XA	FWD DAP AUTO (LIGHT)	ORB DAP				93017G	*
LVLH_MODE	V90X2174X	LVLH MODE INDICATOR	ORB DAP					
MNV_DCD	V93X6884X	FUTURE MANEUVER OPTION DATA CHANGE	UNIV PTG DISP					
MON_AXIS	V93U6868C	MONITOR AXIS INDICATOR	UNIV PTG DISP		VAR			
M_M50TOEF_AT_EPOCH(1,1)	V97U5738C	M50 TO EF TRANS MATRIX ELEM 1,1	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(1,2)	V97U5739C	M50 TO EF TRANS MATRIX ELEM 1,2	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(1,3)	V97U5740C	M50 TO EF TRANS MATRIX ELEM 1,3	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(2,1)	V97U5741C	M50 TO EF TRANS MATRIX ELEM 2,1	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(2,2)	V97U5742C	M50 TO EF TRANS MATRIX ELEM 2,2	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(2,3)	V97U5743C	M50 TO EF TRANS MATRIX ELEM 2,3	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(3,1)	V97U5744C	M50 TO EF TRANS MATRIX ELEM 3,1	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(3,2)	V97U5745C	M50 TO EF TRANS MATRIX ELEM 3,2	RNP MAT COMP	ND	DPL		93090E	
M_M50TOEF_AT_EPOCH(3,3)	V97U5746C	M50 TO EF TRANS MATRIX ELEM 3,3	RNP MAT COMP	ND	DPL		93090E	
OMICRON	V93H6825C	OMICRON	UNIV PTG DISP	RAD	SPL		93017G	*
OPT_CNCL	V93X6871X	MANEUVER TERMINATION	UNIV PTG DISP		BD			
OPT_SEL	V93J6829C	SELECTED ATTITUDE OPTION	UNIV PTG DISP		VAR			
PITCHI	V93H6838C	INPUT INERTIAL PITCH ANGLE	UNIV PTG DISP	RAD	SPL		93017G	*
PREBURN_MNVR_IN_PROGRESS	V90X1589XB	PRE-BURN MNVR-IN-PROGRESS FLAG	ORB DAP				92510E	
Q_BOD_M50(1)/Q_B_M50(1)	V90U2240CB	M50 TO BODY QUAT MEASURED ELEM 1	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(2)/Q_B_M50(2)	V90U2241CB	M50 TO BODY QUAT MEASURED ELEM 2	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(3)/Q_B_M50(3)	V90U2242CB	M50 TO BODY QUAT MEASURED ELEM 3	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(4)/Q_B_M50(4)	V90U2243CB	M50 TO BODY QUAT MEASURED ELEM 4	ORB ATT PROC		SPL		93017G	*
RATE_EST(1)/BOD_RATE(1)	V90R2223C	IMU DERIVED BODY RATE X-AXIS	ORB DAP	DEG/S	SPL		93017G	*

TABLE 4.3.24-1. INPUT FUNCTIONAL PARAMETERS FOR UNIVERSAL POINTING PROCESSOR (G4.213)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
RATE_EST(2)/BOD_RATE(2)	V90R2224C	IMU DERIVED BODY RATE Y-AXIS	ORB DAP	DEG/S	SPL		93017G	*
RATE_EST(3)/BOD_RATE(3)	V90R2225C	IMU DERIVED BODY RATE Z-AXIS	ORB DAP	DEG/S	SPL		93017G	*
RBST_CNCL	V94X0217XA	REBOOST CANCEL	UNIV PTG DISP		BD		92187F	
RBST_CNCL	V94X0217XB	REBOOST CANCEL	ORB DAP		BD		92187F	
RBST_ENA	V90X0442XA	REBOOST ENABLE	ORB DAP		BD		93017G	*
RBST_FUT	V94X0215XA	REBOOST FUTURE STATUS	UNIV PTG DISP		BD		92187F	
RBST_RQST	V94X0214X	REBOOST REQUEST	UNIV PTG DISP		BD		92187F	
RBST_TIME_REMAINING	V90W0443C	REBOOST TIME REMAINING	ORB DAP	S	SPL		92187F	
ROLLI	V93H6837C	INPUT INERTIAL ROLL ANGLE	UNIV PTG DISP	RAD	SPL		93017G	*
ROT_DCD	V93X6883X	FUTURE ROTATION OPTION DATA CHANGE	UNIV PTG DISP					
TGT_ALT	V93H6822C	ALT OF EARTH-FIXED TGT	UNIV PTG DISP	NM	SPL		93017G	*
TGT_DEC	V93H6815CB	DEC OF CELEST TGT	UNIV PTG DISP	RAD			93017G	*
TGT_ID	V93U6810C	TGT VECTOR ID	UNIV PTG DISP		HXS		93017G	*
TGT_LAT	V93H6820C	LAT OF EARTH-FIXED TGT	UNIV PTG DISP	RAD	SPL		93017G	*
TGT_LON	V93H6821C	LONG OF EARTH-FIXED TGT	UNIV PTG DISP	RAD	SPL		93017G	*
TGT_RA	V93H6813CB	TARGET VECTOR RIGHT ASCENSION	UNIV PTG DISP	RAD			93017G	*
THREE_AXIS	V93X6881X	THREE/TWO AXIS TRACKING FLAG	UNIV PTG DISP					
TRK_DCD	V93X6882X	FUTURE TRACKING OPTION DATA CHANGE	UNIV PTG DISP					
T_EPOCH	V97W528C	TIME TAG FOR M_M50TOEF_AT_EPOCH	RNP MAT COMP	S	DPL		93090E	
T_MET_REF	V91M1996P	MET REFERENCE	SYS S/W	S			93017G	*
UR_SUN(1)	V90U4972C	X-COMP SUN UNIT VECTOR-M50	ORB/RND NAV					
UR_SUN(2)	V90U4973C	Y-COMP SUN UNIT VECTOR-M50	ORB/RND NAV					
UR_SUN(3)	V90U4974C	Z-COMP SUN UNIT VECTOR-M50	ORB/RND NAV					
YAWI	V93H6839C	INPUT INERTIAL YAW ANGLE	UNIV PTG DISP	RAD	SPL		93017G	*

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.3.24-2. OUTPUT FUNCTIONAL PARAMETERS FROM UNIVERSAL POINTING PROCESSOR (G4.213)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ATT_ERR(1)	V95H7490C	ROLL ATTITUDE ERROR	DL FMT 22/1 UNIV PTG DISP	DEG	SPL		93017G	*
ATT_ERR(2)	V95H7491C	PITCH ATTITUDE ERROR	DL FMT 22/1 UNIV PTG DISP	DEG	SPL		93017G	*
ATT_ERR(3)	V95H7492C	YAW ATTITUDE ERROR	DL FMT 22/1 UNIV PTG DISP	DEG	SPL		93017G	*
ATT_RATE(1)	V95R7476C	IMU BODY RATE AROUND X-AXIS	DL FMT 22/1 UNIV PTG DISP	DEG/S	SPL		93017G	*
ATT_RATE(2)	V95R7477C	IMU BODY RATE AROUND Y-AXIS	DL FMT 22/1 UNIV PTG DISP	DEG/S	SPL		93017G	*
ATT_RATE(3)	V95R7487C	IMU BODY RATE AROUND Z-AXIS	DL FMT 22/1 UNIV PTG DISP	DEG/S	SPL		93017G	*
AUTO_ALERT	V94X4692X	MNVR TIME-30 SEC & DAP NOT IN AUTO	GAX					
BODV_PITCH	V93U6806CA	BODY VECTOR PITCH COORDINATE	UNIV PTG DISP	RAD			92749B	
BODV_YAW	V93U6807CA	BODY VECTOR YAW COORDINATE	UNIV PTG DISP	RAD			92749B	
GMTR/T_CMD	V95W2201C	GMT OF REQD BODY QUATERNION	ORB DAP	S			89662B	
MNVR_CMPL_TIME	V95W7472C	CURRENT MNVR COMPL MET	UNIV PTG DISP	S	VAR		89662B	
MNVR_TRACK_OPTION	V95X2222X	MANEUVER/TRACKING OPTION DISCRETE	ORB DAP					
OPT_CUR	V95J7482C	CURRENT OPTION INDICATOR	DL FMT 22/1 UNIV PTG DISP		HXS		93017G	*
OPT_FUT	V95J7483C	FUTURE OPTION IND	DL FMT 22/1 UNIV PTG DISP		HXS		93017G	*
PITCHC	V95H7474C	CURRENT INERTIAL PITCH ANGLE	DL FMT 22/1 UNIV PTG DISP	RAD	SPL		93017G	*
PITCHR	V95H7468C	REQD INERTIAL PITCH ANGLE	DL FMT 22/1 UNIV PTG DISP	RAD	SPL		93017G	*
PLOS_C(1)	V95U2225C	X-COMP OF CURRENT BODY VECTOR	REL NAV SPEC					
PLOS_C(2)	V95U2226C	Y-COMP OF CURRENT BODY VECTOR	REL NAV SPEC					
PLOS_C(3)	V95U2227C	Z-COMP OF CURRENT BODY VECTOR	REL NAV SPEC					
Q_RBOD_M50(1)	V95U2209C	M50 TO BODY QUAT REQUIRED ELEM 1	ORB DAP					
Q_RBOD_M50(2)	V95U2210C	M50 TO BODY QUAT REQUIRED ELEM 2	ORB DAP					
Q_RBOD_M50(3)	V95U2211C	M50 TO BODY QUAT REQUIRED ELEM 3	ORB DAP					
Q_RBOD_M50(4)	V95U2212C	M50 TO BODY QUAT REQUIRED ELEM 4	ORB DAP					
RBST_CNCL	V94X0217XC	REBOOST CANCEL	ORB DAP		BD		92187F	
RBST_CUR	V94X0216X	REBOOST CURRENT STATUS	DL FMT 22/1 UNIV PTG DISP		BD		93017G	*
RBST_DURATION	V94W0213CB	REBOOST DURATION	DL FMT 22/1 UNIV PTG DISP	S	SPL		93017G	*
RBST_ENA	V90X0442XB	REBOOST ENABLE	DL FMT 22/1 ORB DAP		BD		93017G	*
RBST_FUT	V94X0215XB	REBOOST FUTURE STATUS	ORB DAP CONFIG DISP DL FMT 22/1 UNIV PTG DISP		BD		93017G	*
RBST_HOUR	V94W0210CB	RBST DURATION HOURS	UNIV PTG DISP	HR	HXS		92187F	
RBST_MIN	V94W0211CB	RBST DURATION MINS	UNIV PTG DISP	MIN	HXS		92187F	
RBST_SEC	V94W0212CB	RBST DURATION SECS	UNIV PTG DISP	S	SPL		92187F	

TABLE 4.3.24-2. OUTPUT FUNCTIONAL PARAMETERS FROM UNIVERSAL POINTING PROCESSOR (G4.213)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
REQD_BRATE(1)	V95R2216C	X-COMP OF REQD BODY ATTITUDE RATE	ORB DAP	DEG/S			89111C	
REQD_BRATE(2)	V95R2217C	Y-COMP OF REQD BODY ATTITUDE RATE	ORB DAP	DEG/S			90882B	
REQD_BRATE(3)	V95R2218C	Z-COMP OF REQD BODY ATTITUDE RATE	ORB DAP	DEG/S			90882B	
ROLLC	V95H7473C	CURRENT INERTIAL ROLL ANGLE	DL FMT 22/1	RAD	SPL		93017G	*
ROLLR	V95H7467C	REQD INERTIAL ROLL ANGLE	UNIV PTG DISP DL FMT 22/1	RAD	SPL		93017G	*
TGT_DEC	V93H6815CA	TARGET VECTOR DECLINATION	UNIV PTG DISP	RAD			92749B	
TGT_RA	V93H6813CA	TARGET VECTOR RIGHT ASCENSION	UNIV PTG DISP	RAD			92749B	
XB	V95H3893CB	X-COMP OF RENDZ TARGET UNIT VECT	GN&C/SM-PL IF	FT				
YAWC	V95H7475C	CURRENT INERTIAL YAW ANGLE	DL FMT 22/1	RAD	SPL		93017G	*
YAWR	V95H7484C	REQD INERTIAL YAW ANGLE	UNIV PTG DISP DL FMT 22/1	RAD	SPL		93017G	*
YB	V95H3894CB	Y-COMP OF RENDZ TARGET UNIT VECT	GN&C/SM-PL IF	FT				
ZB	V95H3895CB	Z-COMP OF RENDZ TARGET UNIT VECT	GN&C/SM-PL IF	FT				
	V93M0509PB	CGZB_28_FLAG_WD1	DL FMT 22/1				93017G	*

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

**Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
(HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec**

TABLE 4.3.24-3. UNIVERSAL POINTING PROCESSOR (G4.213) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
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NO REQUIREMENTS

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.3.24-4. UNIVERSAL POINTING PROCESSOR (G4.213) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
ATT_TOLERANCE MANUEVER COMPLETION TIME FREEZE TOLERANCE	V99U7522C	00	+1.1	E+00	ND	F	S	P G4.213	89901A	
BODV_ID	V93U6805C	00	+1		ND	I	S	P G4.213 G6.27	92749B	
BODV_PITCH	V93U6806C	00	+0.0	E+00	RAD	F	S	P G4.213 G6.27	92749B	
BODV_SCL(1,1) +X AXIS BODY POINTING VECTOR ELEM 1	V96U9715C	00	+0.0	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(1,2) +X AXIS BODY POINTING VECTOR ELEM 2	V96U9716C	00	+0.00	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(2,1) -X AXIS BODY POINTING VECTOR ELEM 1	V96U9717C	00	+3.14159	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(2,2) -X AXIS BODY POINTING VECTOR ELEM 2	V96U9718C	00	+0.0	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(3,1) -Z AXIS BODY POINTING VECTOR ELEM 1	V96U9719C	00	+1.57079	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(3,2) -Z AXIS BODY POINTING VECTOR ELEM 2	V96U9720C	00	+0.0	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(4,1) -Y STAR TRACKER BODY VECTOR ELEM 1	V96U9721C	00	+0.00	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(4,2) -Y STAR TRACKER BODY VECTOR ELEM 2	V96U9722C	00	+4.89687	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(5,1) MANUALLY ENTERED BODY VECTOR ELEM 1	V96U9723C	00	+0.0	E+00	RAD	F	S	P G4.213	92749B	
BODV_SCL(5,2) MANUALLY ENTERED BODY VECTOR ELEM 2	V96U9724C	00	+0.0	E+00	RAD	F	S	P G4.213	92749B	
BODV_YAW	V93U6807C	00	+0.0	E+00	RAD	F	S	P G4.213 G6.27	92749B	
ERR_SEL	V93X6845X	00	ON		ND	D	S	P G4.213	89662B	
IDAY	V93W6801C	00	+0		DAYS	I	S	P G4.213	89662B	
IHOUR	V93W6802C	00	+0		HOURS	I	S	P G4.213	89662B	
IMIN	V93W6803C	00	+0		MIN	I	S	P G4.213	89662B	
ISEC	V93W6804C	00	+0		SEC	I	S	P G4.213	89662B	

TABLE 4.3.24-4. UNIVERSAL POINTING PROCESSOR (G4.213) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
I_STAR_SEL(5,1)	V96U9725C	00	+1.0	E+00 ND	F	S	P	G4.213	59963	
I_STAR_SEL(5,2)	V96U9726C	00	+0.0	E+00 ND	F	S	P	G4.213	59963	
I_STAR_SEL(5,3)	V96U9727C	00	+0.00	E+00 ND	F	S	P	G4.213	59963	
MNVR_TRACK_OPTION	V95X2222X	00	OFF	ND	D	S	P	G4.213	89662B	
MNVR_TRACK_OPTION	V97U5052C	00	B'0000000000000000'	ND	BI		P	G4.213	29641B	
MON_AXIS	V93U6868C	00	+1	ND	I	S	P	G4.213	89662B	
OMICRON	V93H6825C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
OPT_CUR	V95J7482C	00	+0	ND	I	S	P	G4.213	29641B	
OPT_FUT	V95J7483C	00	+0	ND	I	S	P	G4.213	29641B	
OPT_PROC	V97U5061C	00	+0	ND	I	S	P	G4.213	29641B	
PITCHI	V93H6838C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
PLOS_TOL	V96U9712C	00	+9.99848	E-01 ND	F	S	P	G4.213	59963	
Q_M50_INRTL_ORB(1) M50 WRT INERT QUAT ELEM 1	V97U2214CC	00	+1.0	E+00 ND	F	S	P	G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(2) M50 WRT INERT QUAT ELEM 2	V97U2215CC	00	+0.0	E+00 ND	F	S	P	G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(3) M50 WRT INERT QUAT ELEM 3	V97U2216CC	00	+0.0	E+00 ND	F	S	P	G4.158 G4.213 G4.7 G4.97	89590B	
Q_M50_INRTL_ORB(4) M50 WRT INERT QUAT ELEM 4	V97U2217CC	00	+0.0	E+00 ND	F	S	P	G4.158 G4.213 G4.7 G4.97	89590B	
RNG_TOL_UPTG	V96U9714C	00	+1.00	E+02 FEET	F	S	P	G4.213	59963	
ROLLI	V93H6837C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
ROT_IC	V96U9754C	00	OFF	ND	D	S	P	G4.213	89662B	

TABLE 4.3.24-4. UNIVERSAL POINTING PROCESSOR (G4.213) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RTE_LIM	V96U8560C	00	+3.0	E+00 DEG/SEC	F	S	P	G4.213	59963	
TGT_ALT	V93H6822C	00	+0.0	E+00 NMI	F	S	P	G4.213	29641B	
TGT_DEC	V93H6815C	00	+0.0	E+00 RAD	F	S	P	G4.213	92749B	
TGT_ID	V93U6810C	00	+2	ND	I	S	P	G4.213	89662B	
TGT_LAT	V93H6820C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
TGT_LON	V93H6821C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
TGT_RA	V93H6813C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	
THREE_AXIS	V93X6881X	00	ON	ND	D	S	P	G4.213	89662B	
TLOS_TOL	V96U9713C	00	+9.99848	E-01 ND	F	S	P	G4.213	59963	
YAWI	V93H6839C	00	+0.0	E+00 RAD	F	S	P	G4.213 G6.27	92749B	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.



TABLE 4.3.24-5. UNIVERSAL POINTING PROCESSOR (G4.213) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
DEG_PER_RAD RADIAN TO DEGREE CONVERSION FACTOR	V97U0112C	00	+5.72957795131E+01	DEG/RAD	F		S C	A6.9 G4.10 G4.126 G4.127 G4.128 G4.175 G4.20 G4.201 G4.204 G4.208 G4.21 G4.213 G4.220 G4.226 G4.227 G4.23 G4.234 G4.237 G4.24 G4.25 G4.35 G4.36 G4.5 G4.6 G4.66 G4.8 G4.9 G4.97 G5.26 G5.27 V4.10 V4.11 V4.11B V4.11C V4.9A	93090E	

TABLE 4.3.24-5. UNIVERSAL POINTING PROCESSOR (G4.213) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_RADIUS_EQUATOR EARTH EQUATORIAL RADIUS	V97U5324C	00	+2.09257414698E+07	FT	F		D C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.19 G4.20 G4.205 G4.210 G4.211 G4.213 G4.23 G4.236 G4.238 G4.24 G4.25 G5.26 G5.27 V5.1.8	93090E	
EARTH_RATE EARTH'S ROTATIONAL RATE	V97U4379C	00	+7.29211514646E-05	RAD/SEC	F		D C	A6.9 G4.126 G4.127 G4.139 G4.144 G4.148 G4.15 G4.17 G4.19 G4.20 G4.205 G4.21 G4.213 G4.22 G4.236 G4.237 G4.4 G5.26	93090E	

TABLE 4.3.24-5. UNIVERSAL POINTING PROCESSOR (G4.213) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
ELLIPT EARTH'S ELLIPTICITY CONSTANT	V97U5332C	00	+3.352329869 E-03	ND	F		D C	A6.9 G4.126 G4.127 G4.139 G4.144 G4.148 G4.15 G4.19 G4.20 G4.205 G4.213 G4.23 G4.236 G4.237 G4.238 G4.24 G4.25 G5.26 G5.27 V5.1.8	93090E	
FT_PER_NMI NAUTICAL MILE TO FEET CONVERSION	V97U6791C	00	+6.0761155 E+03	FT/NMI	F		S P	A6.9 G4.213 G4.44	90374C	
N TEST COUNTER VALUE TO DECLARE FAILURE	V97U6283C	00	+3	ND	I		S P	G4.213 G4.73	90374C	

TABLE 4.3.24-5. UNIVERSAL POINTING PROCESSOR (G4.213) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PI RATIO OF CIRCUMFERENCE TO DIAMETER	V98U8725C	00	+3.14159265358E+00	ND	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.144 G4.15 G4.158 G4.16 G4.19 G4.2 G4.20 G4.205 G4.209 G4.210 G4.213 G4.220 G4.236 G4.237 G4.3 G4.4 G4.5 G4.97 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.3.24-5. UNIVERSAL POINTING PROCESSOR (G4.213) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RAD_PER_DEG DEGREE TO RADIAN CONVERSION FACTOR	V97U0383C	00	+1.7453293	E-02	RAD/DEG	F	S	C	A6.9	93090E
									G4.1	
									G4.126	
									G4.127	
									G4.128	
									G4.144	
									G4.15	
									G4.158	
									G4.175	
									G4.20	
									G4.201	
									G4.204	
									G4.205	
									G4.209	
									G4.210	
									G4.211	
									G4.213	
									G4.220	
									G4.223	
									G4.226	
									G4.227	
									G4.236	
									G4.237	
									G4.3	
									G4.35	
									G4.36	
									G4.7	
									G4.72	
									G4.9	
									G4.97	
									G5.27	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

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#### 4.4 DEORBIT MANEUVER DISPLAY PROCESSING PRINCIPAL FUNCTION (DEORB MNVR DIP)

The Deorbit Maneuver Display Processing principal function (referenced in Level B, paragraph 4.211) provides software required to support the DEORB MNVR DIP. The Deorbit Maneuver Display provides the crew with the capability to set up maneuvers, adjust target values, monitor maneuvers, and trim burn residuals when required.

Since the DEORB MNVR DIP provides supportive software for the Deorbit Maneuver Display, an understanding of the display is essential to comprehending the details of this section. It is recommended that the Level C FSSR, Display and Controls, Display Formats document be reviewed prior to reading this section. The display format is shown for information only in Figure 4.4-1.

##### 4.4.1 Overview

The DEORB MNVR DIP is active during MM's 301, 302, and 303 and supports the nominal deorbit maneuver and the second OMS maneuver of an abort once around (AOA).

Upon entry into MM 301 (predeorbit coast), the maneuver target and setup data uplinked during OPS 2 (Items 1 through 11) or computed by the AOA/ATO TGT principal function during OPS 1 (Items 1 through 7) are used to initialize the display. If a maneuver target and setup data set (Items 1 through 11) are updated via uplink subsequent to entry into MM 301, the display is reinitialized with the new data set. Data elements included in this category are:

1. TIG Time of ignition (days, hours, minutes, seconds)
2. THETA\_DISP Target earth central angle from the ignition position to the entry interface target position (biased to account for noncentral body forces from planned ignition time to entry interface)
3. HEL\_DISP Target altitude magnitude
4. CI\_DISP Intercept of the vertical velocity versus horizontal velocity target line (biased to account for noncentral body forces from planned ignition time to entry interface)
5. C2\_DISP Slope of the vertical velocity versus horizontal velocity target line
6. WT\_DISP Orbiter weight
7. PROP\_DEP Propellant weight to be expended by the deorbit maneuver with out-of-plane fuel wasting direction specified by sign ( $\pm$ )
8.  $\Delta V_X$ ,  $\Delta V_Y$ , External delta-V velocity-to-be-gained components in  
 $\Delta V_Z$  local vertical local horizontal coordinates at TIG
9. BOTH OMS  
LEFT OMS Propulsion system selected  
RIGHT OMS  
+X RCS

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- 10. TVR\_ROLL Thrust vector roll angle
- 11. VEH\_PITCH  
VEH\_YAW Postmaneuver pitch, yaw, and roll attitude  
VEH\_ROLL

Items 1 through 7 represent a group of protected data whose values must be kept intact during the transition from OPS 1 to OPS 3 for an AOA situation. Items 1 through 11 represent a second group of protected data whose values must be kept intact during the transition from OPS 2 to OPS 3 for a nominal deorbit situation. The desired OMS trim angles are uplinked concurrently with Items 1 through 5. However, these parameters are processed by the ONORBIT DAP (OPS 2) or TRANS DAP (OPS 3).

During MM's 301, 302, and 303, current apogee altitude and current perigee altitudes are cyclically computed.

Upon crew acceptance of the displayed data, a "LOAD" item entry is performed, which transfers the currently displayed target and setup data as a group to deorbit guidance and other software principal functions. In addition, the following premaneuver parameters are calculated for the display.

- 1. Desired ignition attitude (pitch, yaw, and roll angles in ADI inertial coordinate frame; an M50 to commanded body quaternion is also computed as a reference for generation of ADI attitude errors on the dedicated display)
- 2. Velocity-to-go in current body axis coordinates
- 3. Total delta velocity required
- 4. Targeted apogee and perigee altitudes
- 5. Time base time (initiates MSC calculations only; additional crew action is required for this parameter to be displayed)
- 6. Range from entry interface to designated landing site
- 7. Coast time from predicted burnout to entry interface
- 8. PEG 4 velocity-to-go in an LVLH coordinate system at TIG

The vehicle is maneuvered to the desired ignition attitude, which was calculated and displayed when the "LOAD" item entry was made.

The time to go until the attitude maneuver is complete is then calculated within the TRANS DAP, sent to the DEORB MNVR DIP for further processing, and then to the XXXXX MNVR YYYYYY principal function for display. DEORB MNVR DIP sends the preburn maneuver completion time to go (TTG) to the XXXXX MNVR YYYYYY principal function as well as performs a check on MNVR\_CMPL\_TIME\_TGO to determine if the preburn maneuver will be completed prior to 30 seconds before the desired ignition time. If the preburn maneuver will not be completed prior to 30 seconds before the desired ignition time a flag is set to display the TTG field in double overbright. Otherwise, it is displayed in normal intensity (unless the DAP is not in AUTO mode, then it is blanked).



The crew must perform two actions to enable OMS ignition. The first is to arm the OMS engines via cockpit hardware switches. This action is independent of the DEORB MNVR DIP requirements. The second action is crew-entering of a software engine ignition proceed to the DEORB MNVR DIP, achieved by depressing the EXEC button on the keyboard. Depressing the EXEC button subsequent to time of planned ignition minus a K-load (BURN\_ENABLE\_WINDOW) seconds is recognized by the DEORB MNVR DIP as one of two required conditions to allow OMS ignition. The other required condition is that the currently displayed data be consistent with the software recognized data. If these two conditions are satisfied, then an indicator is set to authorize the MSC to allow OMS ignition, i.e., initiate the OMS FIRE SEQ principal function. Maneuvers with the RCS propulsive system assume manual engine ignition and cutoff via the THC and the above actions and conditions do not apply.

Maneuver parameters monitored on the display that are calculated by the DEORB MNVR DIP are the velocity-to-go components in current orbiter body axis coordinates and LVLH coordinates, the velocity-to-go magnitude, the ignition attitude, and the current apogee and perigee altitudes, range from entry interface to landing site, and delta-t coast. Time-to-go values are calculated by the DEORB GUID principal function and current values for the OMS gimbal angles are supplied by the OMS TVC FB SOP principal function. The detailed flow for this time-to-go subtask is illustrated in Appendix A. These two parameter sets are supplied directly to the DEORB MNVR DIP display.

Deorbit Maneuver Display capabilities not supported by the DEORB MNVR DIP principal function are the following:

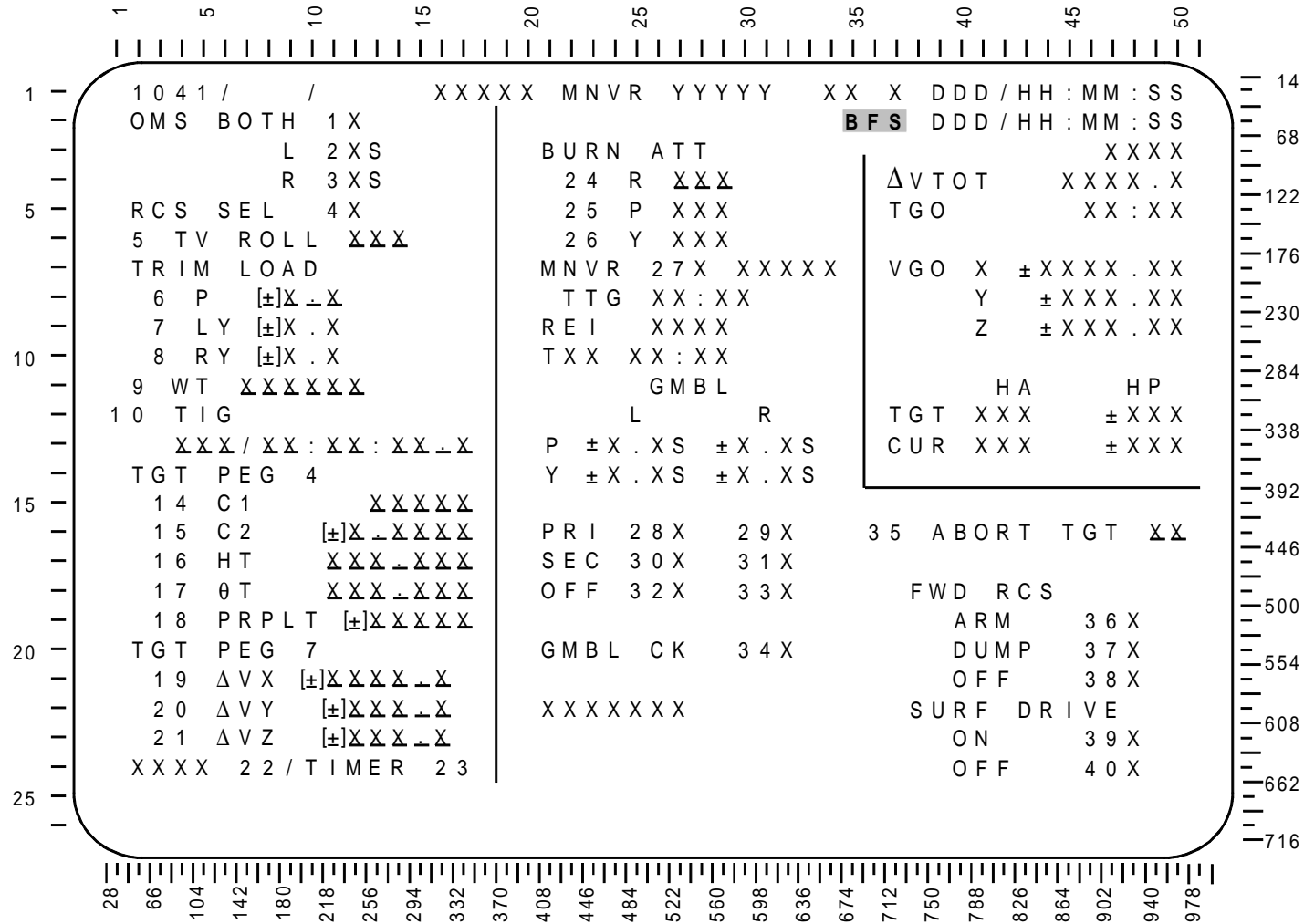
GMBL CK (Item 34)	OMS gimbal drive check initiator
GMBL SEL (Items 28 through 33)	OMS gimbal drive system selection
STATUS PARAMETERS (Items 2 and 3)	Driving of status parameter indicators (M, ↓) for OMS engine selection
SURF DRIVE (Items 39, 40)	Aerosurface drive function

Upon entry into MM 303 (pre-entry monitor), certain display parameters are blanked, the stored post-maneuver commanded attitude is displayed, the calculation of the M50 to commanded body reference quaternion, range from entry interface to the designated landing site, and time to entry interface is performed.

Monitoring for input of new pitch, yaw, and roll values for desired attitude and the corresponding calculation of an M50 to commanded body reference quaternion is performed in MM 301, 302, and 303. Desired attitude input in MM 303 may be by item entry or via uplink.

The functional task organization, logic flow, and data flow for the DEORB MNVR DIP principal function are shown in Figures 4.4.1-1, 4.4.1-2, and 4.4.1-3.

FOR INFORMATION ONLY\*



\*FOR REQUIREMENT PURPOSES SEE JSC 20379

FIGURE 4.4-1. XXXXX MNVR YYYYY Generic Display

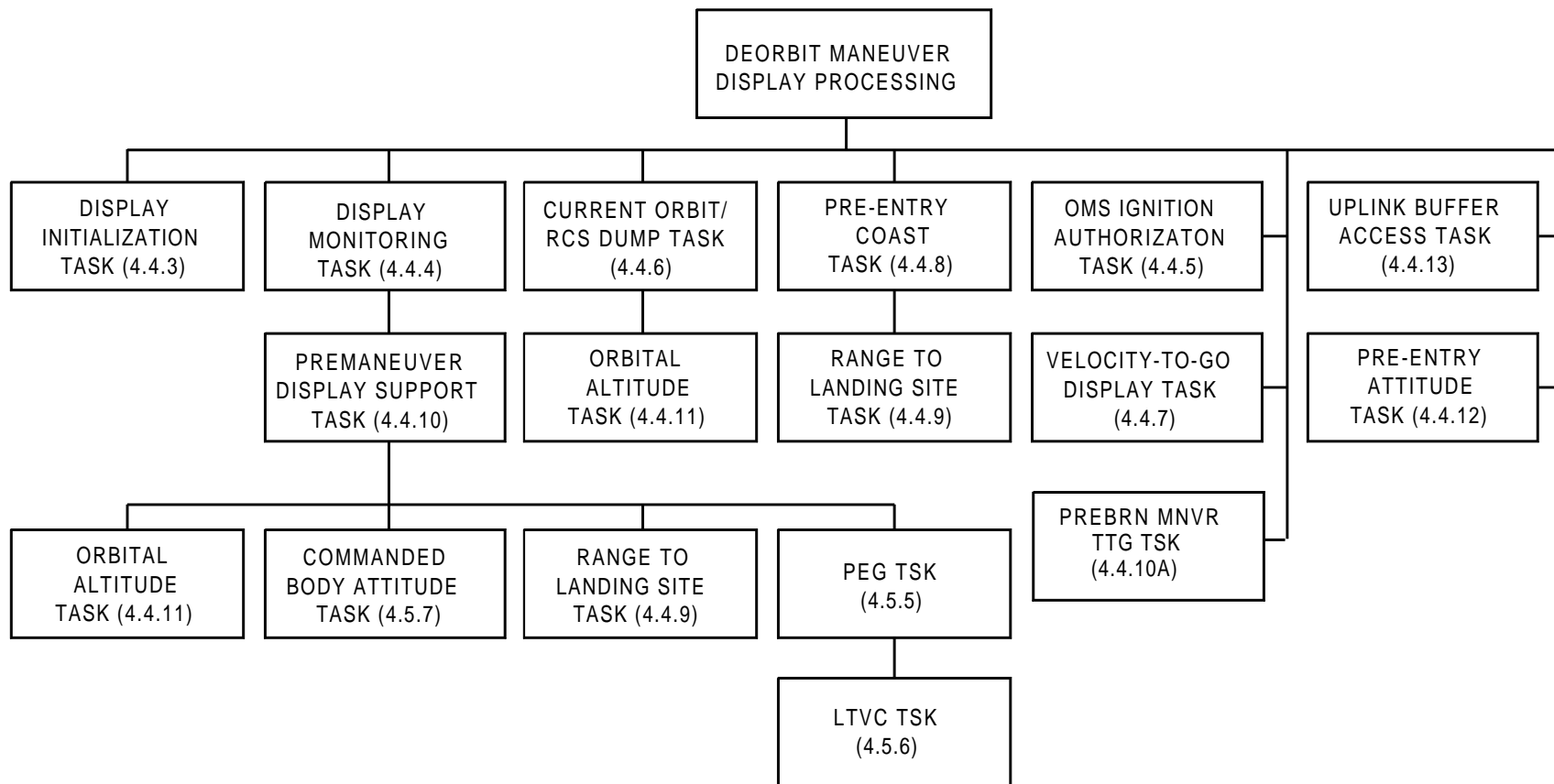


FIGURE 4.4.1-1. Deorbit Maneuver Display Processing Principal Function Task Organization

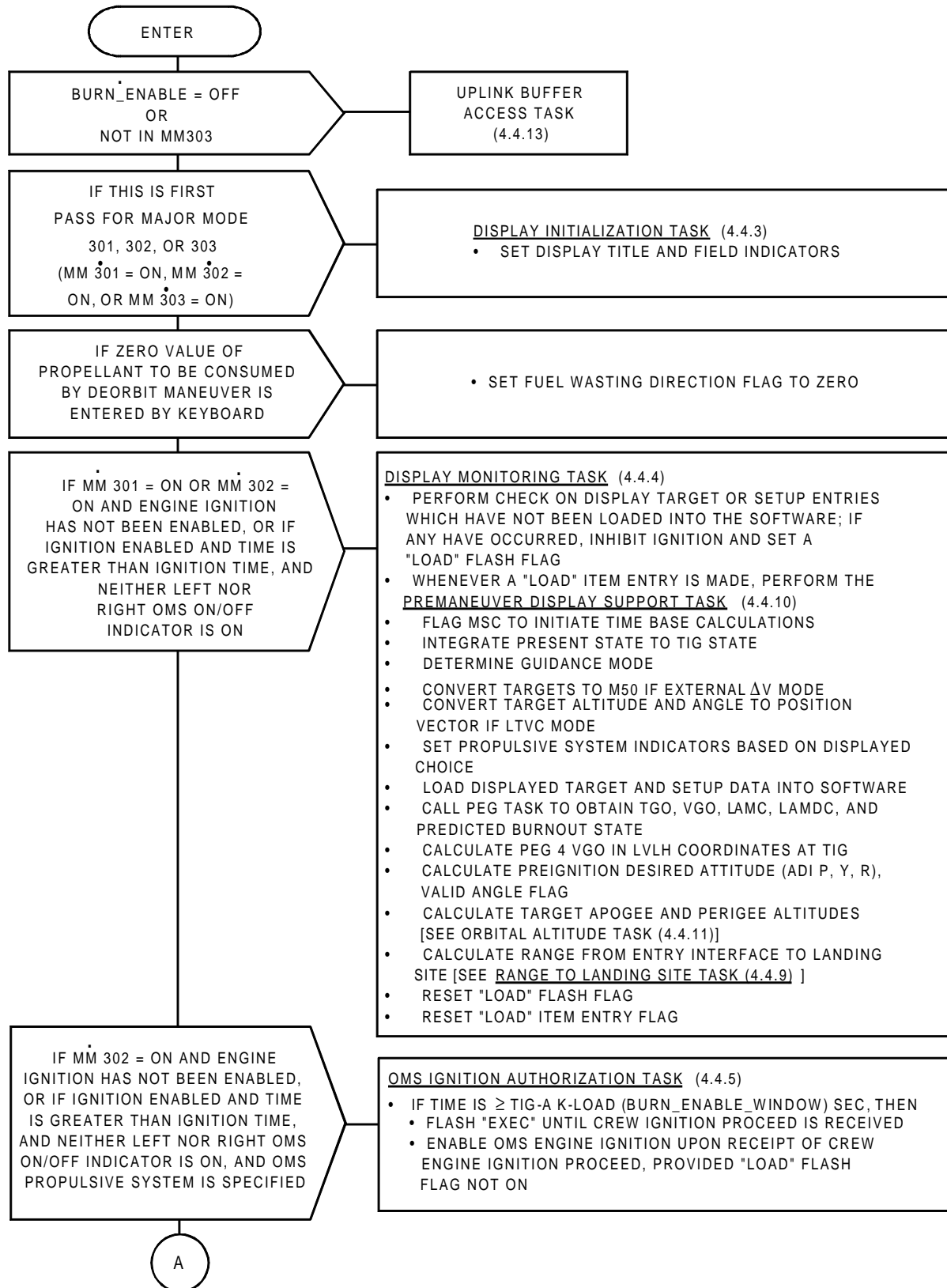


FIGURE 4.4.1-2.(1) Deorbit Maneuver Display Processing Principal Function Flow (Sheet 1 of 2)

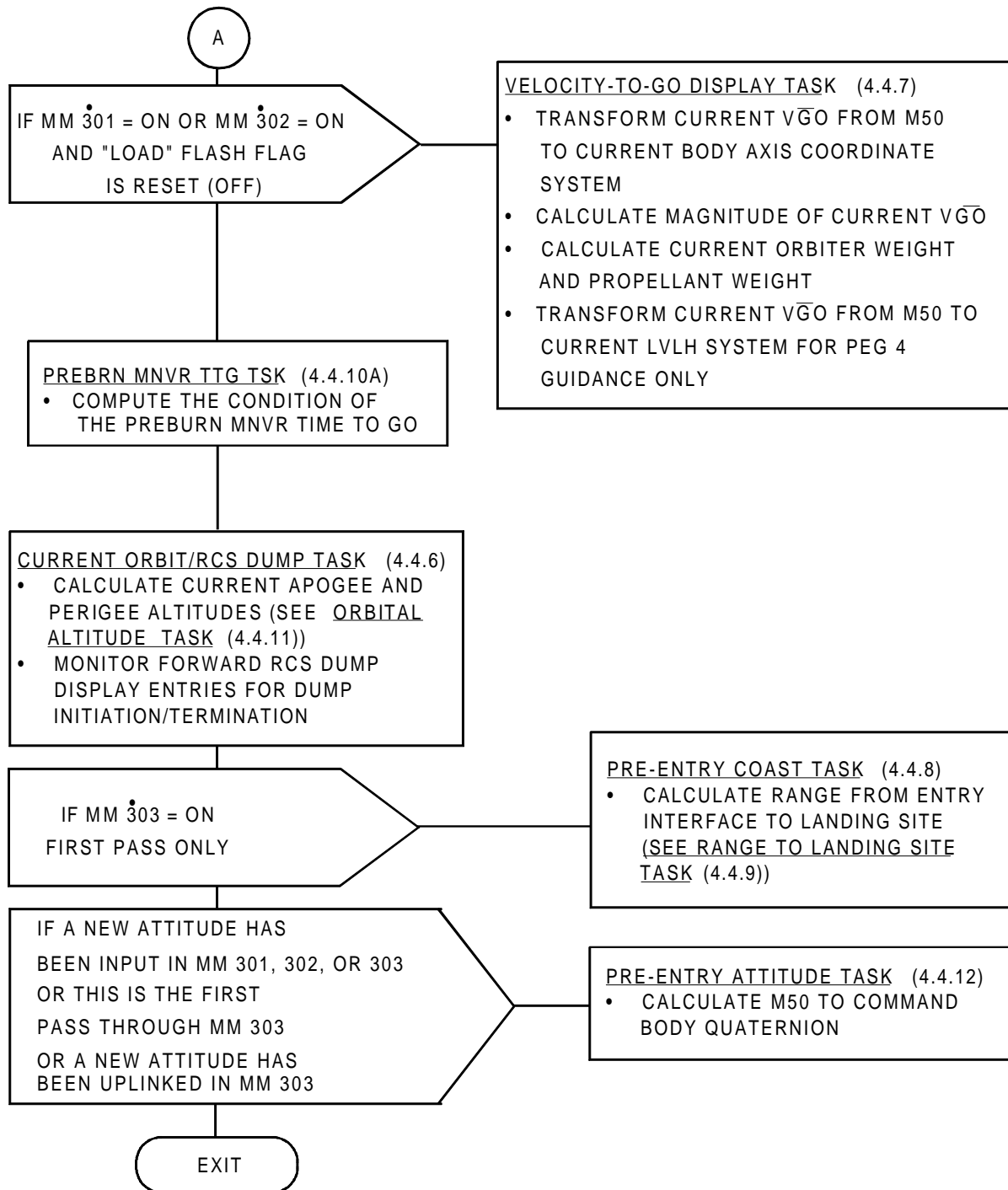
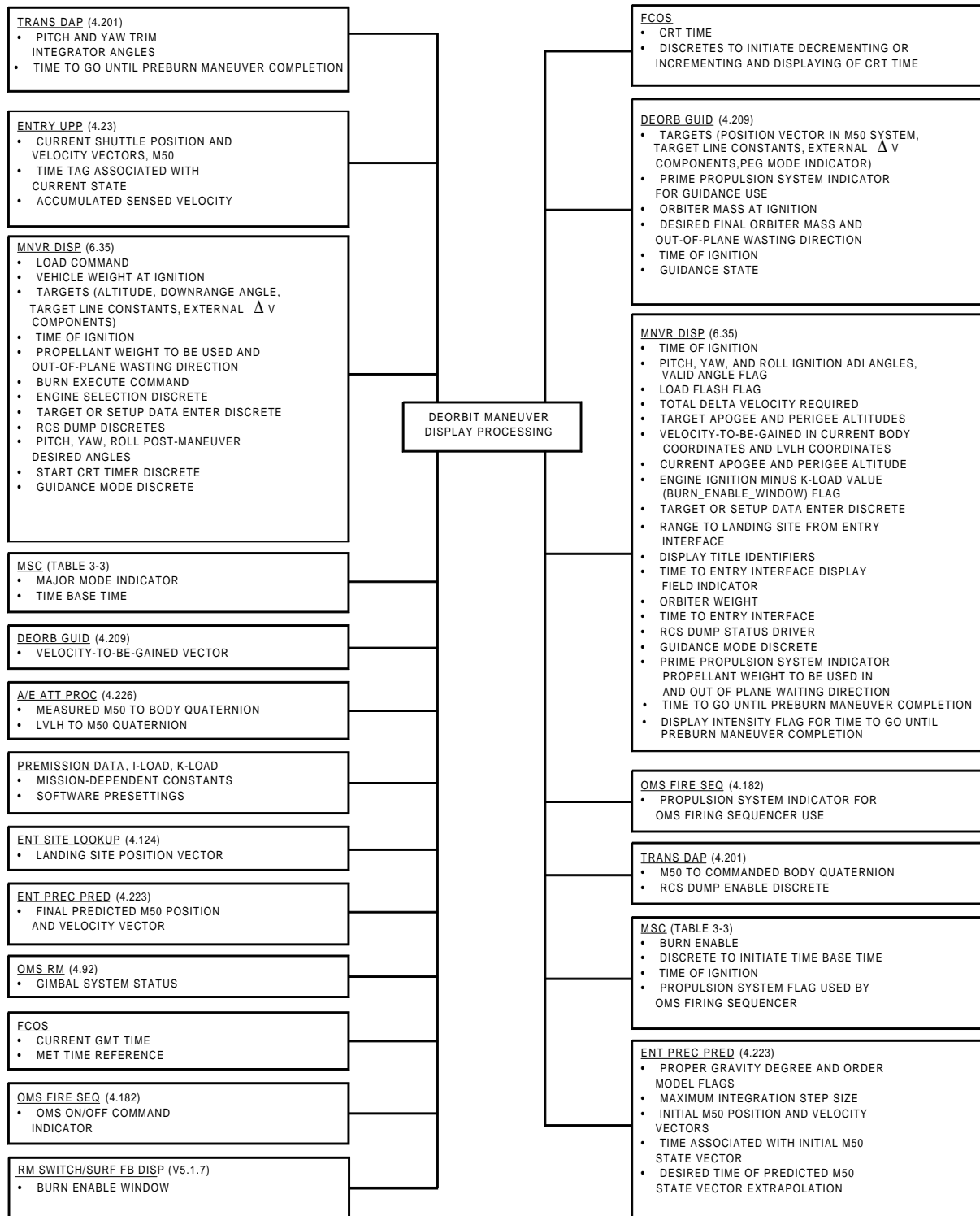


FIGURE 4.4.1-2.(2) Deorbit Maneuver Display Processing Principal Function Flow (Sheet 2 of 2)



NOTE: LEVEL B CPDS SS-P-0002-510 AND LEVEL B CPDS SS-P-0002-550  
 PRINCIPAL FUNCTION NUMBERS ARE SHOWN IN PARENTHESES

FIGURE 4.4.1-3. Deorbit Maneuver Display Processing Data Flow

#### 4.4.2 Deorbit Maneuver Display Processing Sequencing (DEORB MNVR DIP SEQ)

The scheduling of the DEORB maneuver display processing principal function is dependent on certain events defined in the Level B CPDS, Volume 5, Book 1. This principal function will be scheduled at a rate of 0.96 second for the following six events: (1) Event A16B, transition from MM 104 to MM 301, (2) Event A20, transition from MM 105 to MM 301, (3) Event 59, transition from MM 106 to MM 301, (4) Event 85, transition from MM 201 to MM 301, (5) Event E3A, transition from OPS 00 to MM 301, and (6) Event 60H, transition from OPS 8 to MM 301. It will be terminated for the following two events: (1) Event E1, transition from MM 301 to MM 201, and (2) Event E16, transition from MM 303 to MM 304. The deorbit maneuver DIP sequence is illustrated in Figure 4.4.1–3.

The correct sequencing of the tasks defined in the Deorbit Maneuver Display Processing principal function is also dependent on the occurrence of specific events identified in the Level B CPDS SS-P-0002-510. The tasks to be sequenced are:

1. Uplink buffer access task (UL ACCESS TSK, 4.4.13)
2. Display initialization task (DISP INIT TSK, 4.4.3)
3. Display monitoring task (DISP MONIT TSK, 4.4.4)
4. OMS ignition authorization task (OMS IGN AUTHO TSK, 4.4.5)
5. Velocity-to-go display task (VGO DISP TSK, 4.4.7)
6. Pre-entry coast task (PRE-ENT COAST TSK, 4.4.8)
7. Preburn maneuver time to go task (PREBRN MNVR TTG TSK 4.4.10A)
8. Current orbit/RCS dump task (CUR ORBIT/RCS DUMP TSK, 4.4.6)
9. Pre-entry attitude task (PRE-ENT ATT TSK, 4.4.12)

Four additional tasks are defined to reflect a large related group of requirements or a group of requirements that is performed more than once within the other tasks. These additional tasks are:

1. Range to landing site task (RNG TO LS TSK, 4.4.9)
2. Premaneuver display support task (PRE-MAN DISP SUPT TSK, 4.4.10)
3. Orbital altitude task (ORB ALT TSK, 4.4.11)
4. Commanded body attitude task (CMD BDY ATT TSK, 4.5.7)

The first group of tasks must be sequenced as follows and are presented in the correct order of solution.

1. The UL ACCESS TSK is performed repetitively from entry into MM 301 until the exit from MM 302, except during an OMS or guided RCS burn.
2. The DISP INIT TSK is performed once each time MM 301 (Event A16B, A20, 59, 85, E10, or E16B), MM 302 (Event E3), or MM 303 (Event E15) is entered.

- 2a. If a value of zero is entered for propellant weight to be consumed (PROP\_DEP = 0), then set the fuel wasting direction flag (SFUELD) equal to zero in order to terminate fuel wasting.
3. The DISP MONIT TSK is performed repetitively beginning with the transition into MM 301 and ending when MM 302 is exited (Event E10 or E15) or when OMS engine ignition has been enabled (BURN\_ENABLE = ON). If OMS ignition does not occur once the engine ignition criteria have been met [BURN\_ENABLE = ON and current time (T\_GMT) is greater than or equal to time of ignition (TIG)], then the task is reinitiated and processed repetitively until OMS engine ignition is again enabled (BURN\_ENABLE = ON) or the major mode is exited. OMS engine ignition is considered not to have occurred if both the left and right OMS ON/OFF command indicators (OMS\_L\_CMD\_IND, OMS\_R\_CMD\_IND) are not set to ON after TIG by the OMS Firing Sequencer principal function.
4. The OMS IGN AUTHO TSK is performed repetitively for an OMS maneuver (PLUS\_X\_RCS = OFF) beginning with the transition into MM 302 and ending when MM 302 is exited or when OMS engine ignition has been enabled. If OMS ignition does not occur once the engine ignition criteria have been met [BURN\_ENABLE = ON and current time (T\_GMT) is greater than or equal to time of ignition (TIG)], then the task is reinitiated and processed repetitively until OMS engine ignition is again enabled (BURN\_ENABLE = ON) or the major mode is exited. OMS engine ignition is considered not to have occurred if both the left and right OMS ON/OFF command indicators (OMS\_L\_CMD\_IND, OMS\_R\_CMD\_IND) are not set to ON after TIG by the OMS Firing Sequencer principal function.
5. The VGO DISP TSK is performed cyclically in MM's 301 and 302 if "LOAD" FLASH FLAG is set "OFF." If processing is in progress in MM 301 when the transition to MM 302 is made, the processing shall continue in MM 302.
6. The PREBRN MNVR TTG TSK is performed.
7. The CUR ORBIT/RCS DUMP TSK is performed repetitively from entrance into MM 301 until termination of MM 303.
8. The PRE-ENT COAST TSK is performed once on entrance into MM 303.
9. The PRE-ENT ATT TSK is performed once upon entry into MM 303 as well as once whenever a new attitude entry is made (Item 24, 25, 26) in MM 301, 302, and 303 or by uplink in MM 303.

The recommended execution rate for the UL ACCESS TSK, the DISP MONIT TSK, the OMS IGN AUTHO TSK, and VGO DISP TSK is 0.96 second. The recommended execution rate for the PREBRN MNVR TTG TSK in MM301, MM302 is 0.96 seconds and 1.92 seconds in MM303. The recommended rate for the CUR ORBIT portion of CUR ORBIT/RCS DUMP TSK is 1.92 seconds. The RCS DUMP portion is performed on a demand basis. A timeline of these deorbit maneuver DIP subtasks is shown in Figure 4.4.2-1.



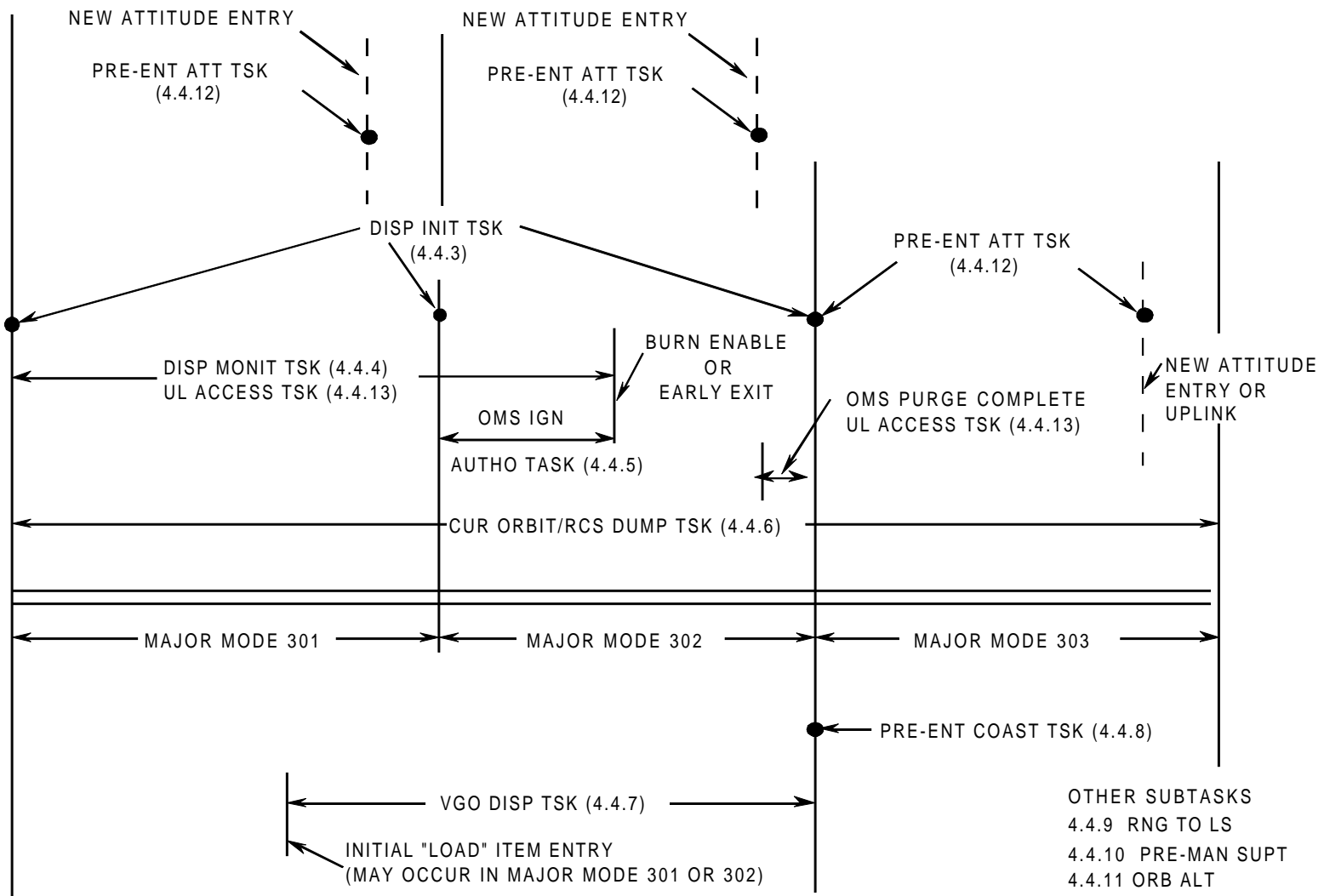


FIGURE 4.4.2-1. DEORB MNVR DIP Subtask Timeline

### 4.4.3 Display Initialization Task (DISP INIT TSK)

The display initialization task generates a display title indicator for the variable portion of the display title (“XXXXX” and “YYYYY” of the XXXXX MNVR YYYYY) and a time to entry interface display label field indicator (TXX\_FLAG). The dynamic display parameters are also blanked upon entry into MM 303.

A. Detailed Requirements. The display initialization task performs the following activities once each time MM’s 301, 302, or 303 is entered.

1. If the major mode is 302 (MM<sup>3</sup>02 = ON) (deorbit execution phase), a display title indicator is generated for the variable portion of the display title (“XXXXX” and “YYYYY” of the XXXXX MNVR YYYYY). The MNVR\_TITLE\_IND is set equal to 10 to indicate that “DEORB MNVR EXEC” is to be the display title.
2. If the major mode is 301 (MM<sup>3</sup>01 = ON; preorbit coast phase) or 303 (MM<sup>3</sup>03 = ON; pre-entry monitor phase), a display title indicator is generated for the variable portion of the display title (“XXXXX” and “YYYYY” of the XXXXX MNVR YYYYY). The MNVR\_TITLE\_IND is set equal to 9 to indicate that “DEORB MNVR COAST” is to be the display title.
3. Upon entry into MM 303, all displayed parameters retain the value they had in MM 302, except for the following parameters whose values must be blanked.

DV_TOT	Magnitude of velocity-to-go
VGO_DISP	Velocity-to-go in current body coordinates
TGT_HA	Target apogee altitude
TGT_HP	Target perigee altitude
TGO	Time-to-go
VGO_LVLH	Velocity-to-go in LVLH coordinates

4. The label field indicator (TXX\_FLAG) for “TXX” is set equal to 0 to indicate that “TFF” for “time of free fall” is to be displayed.

B. Interface Requirements. The input and output parameters for the display initialization task are given in Tables 4.4.3-1 and 4.4.3-2. The detailed flow for DEORB GUID is illustrated in Appendix A.

C. Processing Requirements. The display initialization task is performed once each time MM’s 301, 302, or 303 is entered.

D. Initialization Requirements. None.

Table 4.4.3-1. Display Initialization Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90X8183C	MM301	Major Mode 301 indicator	MSC	N/A	D
V90X8624C	MM302	Major Mode 302 indicator	MSC	N/A	D
V90X8182C	MM303	Major Mode 303 indicator	MSC	N/A	D

Table 4.4.3-2. Display Initialization Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94J4098CB	TXX_FLAG	Indicator for label field	MNVR DISP	N/A	I
V94U4096CA	MNVR_TITLE_IND	Display title indicator	MNVR DISP	N/A	I
V94L3795CC	DV_TOT	Magnitude of velocity-to-go	MNVR DISP	SP	ft/s
V94U3800CC thru V94U3802CC	VGO_DISP	Velocity-to-go in body coordinates	MNVR DISP	SP	ft/s
V94H3798CC	TGT_HA	Targeted apogee	MNVR DISP	SP	NM
V94H3799CC	TGT_HP	Targeted perigee	MNVR DISP	SP	NM
	TGO	Time to go	MNVR DISP	SP	sec
V94L3945CB thru V94L3947CB	VGO_LVLH	Velocity-to-go in LVLH coordinates	MNVR DISP	SP	ft/s

#### 4.4.4 Display Monitoring Task (DISP MONIT TSK)

The display monitoring task performs a series of monitoring activities for the Deorbit Maneuver display, described as follows:

1. Monitors for a "LOAD" item entry and initiates the required processing upon receipt of this entry
2. Provides visual cues (displays character flash indicators) to the crew if the displayed and software loaded data are inconsistent
3. Monitors for a start CRT timer item entry and initiates the required processing upon receipt of this entry

A. Detailed Requirements. The display monitoring task performs the following activities each time it is called.

1. If DATA\_ENTER = ON (indicating data entry), the discrete LOAD\_FLASH must be set to ON.

To ensure OMS engine ignition is only made when the displayed set of target and setup data and the software recognized data are consistent, engine ignition is precluded whenever any of the displayed item entries identified as target and setup data are changed and a subsequent "LOAD" item entry is not made (DATA\_ENTER = ON).

The LOAD\_FLASH = ON condition indicates that "LOAD" is to become a dynamic flashing character set, providing a visual reminder to the crew of the data nonload status. In addition, LOAD\_FLASH = ON is a criterion by which OMS IGN AUTHO TSK (Subsection 4.4.5) precludes setting the discrete BURN\_ENABLE to ON.

The target and setup data group consists of all numbered entries on the DEORB MNVR EXEC DISP (Figure 4.4-1), except for the following: \*

- a. OMS gimbal drive selection (Items 28 thru 33)
- b. Burn attitude (Items 24, 25, 26)
- c. Surf drive (Items 39, 40)
- d. Forward RCS dump (Items 36, 37, 38)
- e. "LOAD" (Item 22)
- f. Start CRT timer (Item 23)
- g. PROP\_DEP (Item 18)

\* For information only

2. If LOAD\_FLASH = ON (indicating LOAD is a dynamic flashing character set) or LOAD\_CMD = ON, then the following activities are performed:
  - a. Reset the discrete for FCOS to display the time to ignition on the CRT:  
CRT\_TIMER\_START = OFF
  - b. Reset the discrete to enable MSC to maintain time base calculations:  
TB\_ENABLE = OFF
3. If the LOAD\_CMD = ON, then the following activities are performed once.
  - a. The premaneuver display support task (PRE-MAN DISP SUPT TSK, Subsection 4.4.10) is performed:  
CALL PRE-MAN DISP SUPT TSK
  - b. The LOAD\_FLASH discrete is set to OFF.
  - c. The LOAD\_CMD discrete is set to OFF (to preclude the above activities from being performed, except as required upon keyboard entry).

- d. The  $\text{DATA\_ENTER}$  discrete is set to OFF.
4. If the  $\text{ST\_CRT\_TIMER} = \text{ON}$  and  $\text{LOAD\_FLASH} = \text{OFF}$ , then the following activities are performed once.
- a. The time to ignition is calculated in seconds to establish a display time base.

$$\text{CRT\_SEC} = \text{TIG} - \text{T\_GMT}$$

- b. If  $\text{CRT\_SEC}$  is positive, set the discrete indicating system software should decrement CRT time:

$$\text{COUNTDOWN} = \text{ON}$$

- c. If  $\text{CRT\_SEC}$  is not positive, set the discrete such that system software increments CRT time and set  $\text{CRT\_SEC}$  to a positive value:

$$\text{COUNTDOWN} = \text{OFF}$$

$$\text{CRT\_SEC} = - \text{CRT\_SEC}$$

- d. Set the discrettes for system software (FCOS) to display the time to ignition:

$$\text{CRT\_TIMER\_START} = \text{ON}$$

- e. Reset the start CRT timer discrete to allow reinitiation of this activity:

$$\text{ST\_CRT\_TIMER} = \text{OFF}$$

B. Interface Requirements. The input and output parameters for the display monitoring task are presented in Table 4.4.4-1 and 4.4.4-2. The flow chart for DISP MONIT TSK is illustrated in Appendix A.

C. Processing Requirements. The display monitoring task is performed from the time MM 301 is entered until positive crew enablement of OMS ignition occurs ( $\text{BURN\_ENABLE} = \text{ON}$ ) or until MM 302 is exited.

D. Initialization Requirements. The following parameters must be set or initialized once upon entering MM 301 as follows:

- |   |  |
|---|--|
| 1. $\text{LOAD\_FLASH} = \text{ON}$     | Discrete to indicate that a "LOAD" character set is to be flashed to indicate inconsistency between displayed and software recognized target and setup data is initially set to a flash condition. |
| 2. $\text{DATA\_ENTER} = \text{OFF}$    | Discrete to indicate that a target or setup data value has been crew-entered is initially set to indicate no crew entry.   |
| 3. $\text{ST\_CRT\_TIMER} = \text{OFF}$ | Discrete to indicate that time of ignition is to be displayed. It is initially set to a non-display condition.   |

4. CRT\_TIMER\_START = OFF      Discretes to initiate decrementation of time-to-ignition  
COUNTDOWN = OFF            are initially set to not perform decrementation.
  
5. TB\_ENABLE = OFF              Discrete to initiate establishment and maintenance of  
ignition time base. It is initially set to not initiate this  
action.

Table 4.4.4-1. Display Monitoring Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V93X6973X	DATA_ENTER	Discrete indicating target or setup data entries have been made	MNVR DISP	N/A	D
V93X6956X	LOAD_CMD	Load command	MNVR DISP	N/A	D
V91W5000C	T_GMT	Current GMT computer time	FCOS	DP	sec
V93X6553X	ST_CRT_TIMER	Start CRT timer flag	MNVR DISP, UL ACCESS TSK	N/A	D
V94W3790C	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	sec
V94X3814X	LOAD_FLASH	Load flash flag	UL ACCESS TSK	N/A	D

Table 4.4.4-2. Display Monitoring Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94X3814XC	LOAD_FLASH	Load flash flag	MNVR DISP, OMS IGN AUTHO TSK	N/A	D
V94W4053CA	CRT_SEC	Seconds to ignition	FCOS	SP	sec
V94W4063XA	CRT_TIMER_START	CRT timer start flag	FCOS	N/A	D
V94X4064XA	COUNTDOWN	CRT timer flag to indicate countdown mode is desired	FCOS	N/A	D
V94X3826XB	TB_ENABLE	Discrete to initiate time base calculations	MSC	N/A	D

#### 4.4.5 OMS Ignition Authorization Task (OMS IGN AUTHO TSK)

The OMS ignition authorization task sets an OMS engine ignition proceed discrete (BURN\_ENABLE) to ON if the following two conditions are satisfied:

1. An "EXEC" keyboard entry has been made subsequent to time of ignition minus a K-load (BURN\_ENABLE\_WINDOW) seconds, signified by EXEC\_CMD = ON.
2. The displayed target and setup data are consistent with the software loaded target and setup data, signified by LOAD\_FLASH = OFF.

A. Detailed Requirements. Positive crew action (pushing the "EXEC" keyboard button, subsequent to planned OMS ignition time minus a K-load (BURN\_ENABLE\_WINDOW) seconds, signified by EXEC\_CMD = ON is required to enable OMS engine ignition (BURN\_ENABLE = ON). Until, the "EXEC" button is pushed, the "EXEC" character set is flashing (TIG\_MINUS5\_FLAG = ON). An additional requirement for enabling engine ignition is the criteria specified in the DISP MONIT TSK (LOAD\_FLASH = OFF). These requirements are depicted in the following logic:

1. If TB\_TIME  $\geq$  a K-load (BURN\_ENABLE\_WINDOW) seconds and LOAD\_FLASH is OFF (indicating a consistent target and setup data group), then proceed to Step 2. Otherwise, EXEC\_CMD and TIG\_MINUS5\_FLAG must be set to OFF values to nullify any previous crew action for enabling OMS ignition and stop the "EXEC" dynamic characters from flashing respectively. The task is then exited.
2. If EXEC\_CMD is ON (indicating crew authorization of OMS ignition), set BURN\_ENABLE to ON (necessary condition for the MSC to allow OMS ignition) and set TIG\_MINUS5\_FLAG to OFF (stop the "EXEC" dynamic characters from flashing). Otherwise, the TIG\_MINUS5\_FLAG must be set to ON (initiate the "EXEC" dynamic characters flash).
3. The flags EXEC\_CMD and BURN\_ENABLE should be reset to off any time the OMS firing sequencer is called to initiate OMS ignition. This will allow the OMS ignition authorization task to be properly sequenced if OMS ignition does not occur and the ignition task is recycled.

B. Interface Requirements. The input and output parameters for the OMS ignition authorization task are given in Tables 4.4.5-1 and 4.4.5-2. The flow chart for OMS IGN AUTHO is illustrated in Appendix A.

C. Processing Requirements. The OMS ignition authorization task is performed from the time MM 302 is entered until positive crew enablement of engine ignition occurs (BURN\_ENABLE = ON) for an OMS maneuver (PLUS\_X\_RCS = OFF).

D. Initialization Requirements. The following parameters must be set or initialized as indicated below.

- |                          |   |
|--------------------------|---|
| 1. EXEC_CMD = OFF        | Discrete indicating "EXEC" button has been pushed is set to indicate a "not pushed" state.  |
| 2. BURN_ENABLE = OFF     | Discrete to allow OMS engine ignition is initially set to disallow OMS engine ignition.   |
| 3. TIG_MINUS5_FLAG = OFF | Discrete to indicate "EXEC" character set is to be flashed to prompt crew for an engine ignition proceed, is initially set to a nonflash condition. |

Table 4.4.5-1. OMS Ignition Authorization Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90W8625C	TB_TIME	Time base time	MSC	SP	sec
V93X1050XA	EXEC_CMD	Burn execute command	MNVR DISP	N/A	D
V94X3814X	LOAD_FLASH	Load flash flag	DISP MONIT TSK	N/A	D
V97U5181C	BURN_ENABLE_WINDOW	Burn Enable Window	K-LOAD, RM SWITCH/ SURF FB DISP	DP	sec

Table 4.4.5-2. OMS Ignition Authorization Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94X3813XC	TIG_MINUS5_FLAG	Engine ignition minus K-load value (BURN_ENABLE_WINDOW) flag	MNVR DISP	N/A	D
V94X3815XC	BURN_ENABLE	Burn enable	MSC	N/A	D



#### 4.4.6 Current Orbit/RCS Dump Task (CUR ORBIT/RCS DUMP TSK)

The current orbit/RCS dump task cyclically computes the current orbit apogee and perigee altitudes and monitors discretes from the display to initiate or terminate forward RCS dump activities.

##### A. Detailed Requirements.

1. The values of current apogee and perigee altitudes are calculated by calling the orbital altitude task (ORB ALT TSK, Subsection 4.4.11). Inputs to this task are the current navigation state (R $\bar{N}$ AV and V $\bar{N}$ AV), which must be assigned to  $\bar{R}$  and  $\bar{V}$ , respectively. Outputs are the apogee altitude (HA) and perigee altitude (HP), which must be assigned to the current apogee altitude (CUR\_HA) and perigee altitude (CUR\_HP), respectively:

CALL ORB ALT TSK

The perigee altitude (H\_PERIGEE) used by the RNG TO LS TSK is set equal to the current perigee altitude (CUR\_HP).

H\_PERIGEE = CUR\_HP

2. The forward RCS propellant dump entries from the display, "ARM," "DUMP," and "OFF" (see Figure 4.4-1) are monitored to enable the transition DAP (TRANS DAP) to initiate or terminate the RCS dump activity upon proper crew input. The requirements for the dump activity to be initiated are (1) the ARM and DUMP items have been crew entered and (2) the inhibit "OFF" item has not been crew entered. Crew item entry of the inhibit "OFF" is sufficient to terminate the dump activity. Additionally, the status of the item entries must be displayed. These requirements are depicted in the following logic.
  - a. An intermediate variable for the display status is set to zero (RCS\_DUMP\_IND = 0).
  - b. A check is made to determine if the dump is inhibited ("OFF" has been entered), indicated by RCS\_INH\_DISP = ON. If RCS\_INH\_DISP = ON, then the following activities are performed:
    - (1) The flag sent to TRANS DAP is set to terminate the RCS dump (RCS\_DUMP\_DAP = OFF).
    - (2) The dump status indicator is set to display inhibit only (RCS\_DUMP\_IND = 3).
  - c. If RCS\_INH\_DISP = OFF, then the following activities are performed:
    - (1) Check the "ARM" discrete and set the appropriate status value. If RCS\_ARM\_DISP = ON, set RCS\_DUMP\_IND = 1.
    - (2) If RCS\_ARM\_DISP = ON, check the "DUMP" discrete and set the appropriate status value. If RCS\_DUMP\_DISP = ON, set RCS\_DUMP\_IND = 2.
    - (3) Check the value of the status variable and set the flag sent to TRANS DAP accordingly. If RCS\_DUMP\_IND = 2, set RCS\_DUMP\_DAP = ON to initiate the RCS dump; otherwise set RCS\_DUMP\_DAP = OFF.

NOTE: When RCS\_INH\_DISP is set to OFF, RCS\_DUMP\_IND will either have a value of 1, indicating only “ARM” is entered or a value of 2, indicating both “ARM” and “DUMP” are entered. A “DUMP” only entry results in no action by the software.

- d. The value of the intermediate variables for the display status is set equal to the output variables that drive the status of the display (RCS\_DUMP\_DRV = RCS\_DUMP\_IND).

The values of the integer variable RCS\_DUMP\_DRV and their meanings are as follows:

0. No indicators on the display
- 1 “ARM” only indicator on the display
2. “ARM” and “DUMP” indicators on the display
- 3 “OFF” only indicator on the display

B. Interface Requirements. The input and output parameters for the current orbit/RCS dump task are given in Tables 4.4.6–1 and 4.4.6–2. The flow chart for CUR ORBIT/RCS Dump TSK is illustrated in Appendix A.

C. Processing Requirements. The current orbit portion of this task is cyclically performed every 1.92 seconds from initiation of MM 301 until termination of MM 303. The RCS dump portion of this task is performed on an as demanded basis.

D. Initialization Requirements. None.

Table 4.4.6-1. Current Orbit/RCS Dump Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V95H0185CC thru V95H0187CC	HA	Apogee altitude	ORB ALT TSK	SP	nmi
	HP	Perigee altitude	ORB ALT TSK	SP	nmi
	$\overline{R}_{NAV}$	Current Shuttle position vector	ENTRY UPP	DP	ft
V95H0190CC thru V95H0192CC	$\overline{V}_{NAV}$	Current Shuttle velocity vector	ENTRY UPP	SP	ft/s
V93X6941X	RCS_ $\dot{A}$ RM_DISP	RCS "ARM" discrete	MNVR DISP	N/A	D
V93X6942X	RCS_ $\dot{D}$ UMP_DISP	RCS "DUMP" discrete	MNVR DISP	N/A	D
V93X6943X	RCS_ $\dot{I}$ NH_DISP	RCS "OFF" discrete	MNVR DISP	N/A	D

Table 4.4.6-2. Current Orbit/RCS Dump Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94H3810CC	$\overline{R}$	Position vector	ORB ALT TSK	DP	ft
	$\overline{V}$	Velocity vector	ORB ALT TSK	SP	ft/s
V94H3811CC	CUR_HA	Current apogee altitude	MNVR DISP	SP	nmi
V94H3811CC	CUR_HP	Current perigee altitude	MNVR DISP	SP	nmi
V94X4059X	RCS_ $\dot{D}$ UMP_DAP	RCS dump enable discrete for TRANS DAP	TRANS DAP	N/A	D
V94X4069C	RCS_ $\dot{D}$ UMP_DRV	RCS dump status driver	MNVR DISP	N/A	I
	H_PERIGEE	Perigee altitude	RNG TO LS TSK	DP	nmi

#### 4.4.7 Velocity-To-Go Display Task (VGO DISP TSK)

The velocity-to-go display task transforms the velocity-to-go vector from mean of 1950 coordinates into current orbiter body axis coordinates (see Section 5, Figure 5.1-2), computes the magnitude of the current velocity-to-go (DV\_TOT), transforms VGO to current LVLH coordinates if current time is greater than time of ignition, and updates propellant to be depleted and orbiter weight.

##### A. Detailed Requirements.

1. The guidance-computed velocity-to-go in mean of 1950 coordinates ( $\overline{VGO}$ ) is transformed to velocity-to-go in current body axis coordinates ( $\overline{VGO\_DISP}$ ) for display. This transformation is accomplished by the use of a quaternion transformation module (QUAT\_XFORM) defined in the Flight Control-Ascent Flight Phase, Level C FSSR and repeated for information only in Part E, Subsection 4.4.10.

CALL QUAT\_XFORM

Inputs: Q\_B\_I,  $\overline{VGO}$

Output:  $\overline{VGO\_DISP}$

The variable Q\_B\_I is the quaternion defining the transformation from mean of 1950 coordinates to current body axis coordinates as computed by the A/E ATT PROC principal function.

2. The PEG 4 guidance-computed velocity-to-go in mean-of-1950 coordinates ( $\overline{VGO}$ ) is transformed to current LVLH coordinates ( $\overline{VGO\_LVLH}$ ) for display. This transformation is accomplished by the use of a quaternion transformation module (QUAT\_XFORM). The LVLH-to-mean-1950 quaternion from the A/E ATT PROC principal function is conjugated prior to calling QUAT\_XFORM.

The velocity-to-go in LVLH ( $\overline{VGO\_LVLH}$ ) is displayed in the PEG 7 target section of the maneuver execute display. For a PEG 4 target load,  $\overline{VGO\_LVLH}$  is computed by the premaneuver display support task with respect to an LVLH coordinate system at the planned time-of-ignition. After the planned time-of-ignition (TIG),  $\overline{VGO\_LVLH}$  is computed for display with respect to the current LVLH coordinate system.

If the guidance mode is not PEG 4 or current time is less than TIG, skip the following step:

CALL QUAT\_XFORM

Inputs: Q\_M50\_LVLH\*,  $\overline{VGO}$

Output:  $\overline{VGO\_LVLH}$

3. The current magnitude of velocity-to-go is calculated:

$$DV\_TOT = ABVAL(\overline{VGO})$$

4. The current orbiter weight is calculated for display:

$$WT\_DISP = M G\_TO\_FPS2$$

5. The current propellant weight to be depleted (including sign) is calculated for display:

$$\text{PROP\_DEP} = \text{SFUELD G\_TO\_FPS2 (M - MBO)}$$

B. Interface Requirements. The input and output parameters for the velocity-to-go display task are given in Tables 4.4.7-1 and 4.4.7-2. The flow chart for VGO DISP TSK is illustrated in Appendix A.

C. Processing Requirements. The velocity-to-go display task is performed every 0.96 second during MM's 301 and 302 if "LOAD" FLASH FLAG is reset (OFF). Steps 2, 3, and 4 are performed on alternate passes of the VGO DISP TSK.

D. Initialization Requirements. None.

Table 4.4.7-1. Velocity-to-Go Display Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90U2240CA thru V90U2243CA	Q_B_I	Quaternion to transform from mean of 1950 coordinates to current vehicle body axis coordinates	A/E ATT PROC	SP	none
V90U1202C V90U1203C V90U1204C	$\bar{V}GO$	Velocity-to-be gained vector in mean 1950 coordinates	GUID INP TSK, PEG TSK	SP	ft/s
V90U1961CC	M	Current vehicle mass	GUID INP TSK	SP	slugs
V94U4086C	MBO	Desired burnout mass	PRE-MAN DISP SUPT TSK	SP	slugs
V94U4057C	SFUELD	Propellant wasting flag to indicate out-of-plane fuel wasting direction	PRE-MAN DISP SUPT TSK	N/A	I
V90U2641CB thru V90U2644CB	$\underline{Q\_M50\_LVLH\_S}$ , $\underline{Q\_M50\_LVLH\_V}$	Quaternion to transform from LVLH to M50 coordinates	A/E ATT PROC	SP	none
V93X6976XD	PEG_MODE_4	Guidance mode discrete	MNVR DISP	N/A	discrete
V94W3790CB	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V97U4393C	G_TO_FPS2	Mass to weight conversion	CONSTANT	SP	ft/s <sup>2</sup>

Table 4.4.7-2. Velocity-to-Go Display Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V94U3800CC V94U3801CC V94U3802CC	$\bar{V}GO\_DISP$	Maneuver velocity-to-be gained in current body axis coordinates	MNVR DISP	SP	ft/s
V94L3795CC	DV_TOT	Total delta velocity required for the maneuver	MNVR DISP	SP	ft/s
V93U6970CC	PROP_DEP	Propellant to be used during maneuver with sign indicating out-of-plane direction	MNVR DISP	SP	lb
V93G6940CE	WT_DISP	Estimates vehicle weight	MNVR DISP	SP	lb
V94L3945CB thru V94L3947CB	$\bar{V}GO\_LVLH$	PEG 4 velocity-to-be-gained in LVLH coordinates	MNVR DISP	SP	ft/s

#### 4.4.8 Pre-entry Coast Task (PRE-ENT COAST TSK)

The pre-entry coast task computes the range from entry interface to the designated landing site and the time to entry interface.

A. Detailed Requirements. The value of range from entry interface to the designated landing site and the time to entry interface is calculated by calling the range to landing site task (RNG TO LS TSK, Subsection 4.4.9). Inputs to this task are the current navigation state ( $\overline{RNAV}$ ,  $\overline{VNAV}$ , TNAV). The current navigation state of  $\overline{RNAV}$ ,  $\overline{VNAV}$ , and TNAV must be assigned to  $\overline{R1}$ ,  $\overline{V1}$ , and T1, respectively.

CALL RNG TO LS TSK

The outputs of the range to landing site task are the earth surface range from entry interface to the designated landing site (REI\_LS) and the time to entry interface (TFF).

B. Interface Requirements. The input and output parameters for the pre-entry coast task are given in Tables 4.4.8-1 and 4.4.8-2. The flow chart for PRE-ENT COAST TSK is illustrated in Appendix A.

C. Processing Requirements. The pre-entry coast task is performed once upon entry of MM 303.

D. Initialization Requirements. None.

Table 4.4.8-1. Pre-entry Coast Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V95H0185CC thru V95H0187CC	$\overline{RNAV}$	Current position vector	ENTRY UPP	DP	ft
V95L0190CC thru V95L0192CC	$\overline{VNAV}$	Current velocity vector	ENTRY UPP	SP	ft/s
V95W0200CE	TNAV	Time associated with $\overline{RNAV}$ , $\overline{VNAV}$	ENTRY UPP	DP	s

Table 4.4.8-2. Pre-entry Coast Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V94H4095C	$\overline{R1}$	Initial position vector	RNG TO LS TSK	DP	ft
	$\overline{V1}$	Initial velocity vector	RNG TO LS TSK	SP	ft/s
	T1	Time associated with $\overline{R1}$ , $\overline{V1}$	RNG TO LS TSK	DP	s
	REI_LS	Range to landing site from entry interface	MNVR DISP	SP	nmi
V94W3796CC	TFF	Time to ENTRY interface	MNVR DISP	SP	s

#### 4.4.9 Range-to-Landing Site Task (RNG TO LS TSK)

The range-to-landing site task computes the earth surface range to the designated landing site from entry interface and the coast time to entry interface.

A. Detailed Requirements. The range to landing site task performs the following activities each time it is called.

1. The initial reference time is stored for calculation of the coast time in Item 12. The output coast time to entry interface (TFF), the range to landing site from entry interface (REI\_LS) and the cycle counter are zeroed.

$$T\_INIT\_LS = T1$$

$$TFF = 0$$

$$REI\_LS = 0$$

$$COUNT\_RNG = 0$$

2. If the perigee altitude (H\_PERIGEE) is greater than a specified altitude (HP\_MAX) or a TAL abort has been declared (TAL\_ABORT\_DECLARED = ON), the range to landing site task is exited.
3. The calculation of the range to landing site from entry interface requires an acceptable entry interface position vector. Items 3 through 9 are processed iteratively until an acceptable state is obtained or a maximum number of iterations is exceeded (in which case the task is exited). Therefore, the iteration counter, COUNT\_RNG, is tested against the maximum allowable, MAX\_RNG, and if greater than the maximum then this task is exited, otherwise Items 3 through 9 are processed iteratively. The current estimate of the state at entry interface ( $\bar{R}1$ ,  $\bar{V}1$ , T1) is used to compute a unit radial direction ( $\bar{U}N\_R$ ), radial component of velocity (R\_DOT), and an altitude (H) above the Fischer ellipsoid. H is computed using the H\_ELLIPSOID module (see Part E, Section 4.5.5). The resulting altitude miss is then computed (H\_MISS) from an unbiased target altitude (H\_TARGET).

$$\bar{U}N\_R = \text{UNIT}(\bar{R}1)$$

$$R\_DOT = \bar{V}1 \cdot \bar{U}N\_R$$

$$H = H\_ELLIPSOID(\bar{R}1)$$

$$H\_MISS = H - H\_TARGET$$

4. The absolute value of H\_MISS is compared to an acceptable tolerance constant (EPS\_H\_MISS) and if the absolute value of H\_MISS is greater than or equal to EPS\_H\_MISS then this indicates that an acceptable estimate of the entry interface state has not been obtained; therefore, the iteration procedure is invoked and Items 5 through 9 are exercised in order to generate an acceptable state at entry interface. The range to landing site is calculated in Items 10 and 11, the coast time to entry interface is calculated in Item 12. If this is the first pass in MM 303, then Item 13 is also performed.



5. The iteration counter (COUNT\_RNG) must be incremented

$$\text{COUNT\_RNG} = \text{COUNT\_RNG} + 1$$

6. The coast time (DT) from the input state vector is computed. If R\_DOT is greater than a prespecified value (R\_DOT\_MAX), then DT is set to a specified value (DT\_EI) and having the same sign as H\_MISS. Otherwise, DT is selected as the middle value of DT\_EI, -DT\_EI, and minus the ratio of H\_MISS divided by R\_DOT.

$$\text{If } R\_DOT > R\_DOT\_MAX, \text{ THEN } DT = \text{SIGN}(H\_MISS) DT\_EI.$$

$$\text{Otherwise, } DT = \text{MIDVAL}(DT\_EI, -H\_MISS/R\_DOT, -DT\_EI)$$

7. An improved estimate of the time to entry interface is computed

$$T2 = T1 + DT$$

8. The input state vector ( $\bar{R}1, \bar{V}1, T1$ ) is propagated to the improved estimate of time at entry interface (T2). This propagation is accomplished by utilizing a navigation precision-state predictor principal function (ENT PREC PRED). In addition to the initial state and time, the ENT PREC PRED function requires inputs of the time interval step-size (DT\_RNG) and integers that determine the gravity model to be assumed. The gravity model flags, GMD\_PRED and GMO\_PRED, must be set to 2 and 0, respectively, to denote that central body and  $J_2$  gravitational forces are to be modeled. The ENT PREC PRED function outputs the propagated state ( $\bar{R}2, \bar{V}2$ ).

$$\text{GMD\_PRED} = 2$$

$$\text{GMO\_PRED} = 0$$

$$T\_INIT = T1$$

$$T\_FINAL = T2$$

$$\bar{R}\_INIT = \bar{R}1$$

$$\bar{V}\_INIT = \bar{V}1$$

$$DT\_MAX = DT\_RNG$$

CALL ENT PREC PRED

$$\bar{R}2 = \bar{R}\_FINAL$$

$$\bar{V}2 = \bar{V}\_FINAL$$

9. The input state is set equal to the propagated state and computations are returned to Item 3.

$$\bar{R}1 = \bar{R}2$$

$$\bar{V}1 = \bar{V}2$$

$$T1 = T2$$

10. The earth-fixed landing site position vector ( $R_{\bar{L}S\_EF}$ ) must be transformed to M50 coordinates. This is accomplished by EARTH\_FIXED\_TO\_M50\_COORD, the coordinate transformation module defined in the Navigation Level C FSSR. Time at entry interface (T1) is the input to this module and the transformation matrix ( $M_{\bar{E}F\_M50}$ ) is the output of this module.

$$M_{\bar{E}F\_M50} = \text{EARTH\_FIXED\_TO\_M50\_COORD}(T1)$$

The  $R_{\bar{L}S\_M50}$  vector can now be calculated as:

$$R_{\bar{L}S\_M50} = (M_{\bar{E}F\_M50}) (R_{\bar{L}S\_EF})$$

11. The earth surface range to the designated landing site ( $REI\_LS$ ) is calculated using the final value of  $UN_{\bar{R}}$  obtained and the landing site position vector ( $R_{\bar{L}S\_M50}$ ):

$$ANG = \text{ARCCOS}((UN_{\bar{R}}) \cdot \text{UNIT}(R_{\bar{L}S\_M50}))$$

$$REI\_LS = ANG \text{ RE NMI\_PER\_FT}$$

where the constant RE is the reference earth radius.

12. The time of free fall (TFF) from the initial input state to reaching entry interface altitude is calculated:

$$TFF = T1 - T\_INIT\_LS$$

13. The time of free fall (TFF) is saved for the display ( $CRT\_SEC = TFF$ ), and discretēs are set to start the CRT timer ( $CRT\_TIMER\_START = ON$ ) and to decrement time ( $COUNTDOWN = ON$ ).

B. Interface Requirements. The input and output parameters for the range to landing site task are given in Tables 4.5.9-1 and 4.5.9-2. The detailed flow chart for RNG to LS TSK is illustrated in Appendix A.

C. Processing Requirements. Items 1 through 12 of this task are performed once when called. Item 13 is performed once during the first pass of MM 303 and every time that state vector is updated during MM 303.

D. Initialization. None.

Table 4.4.9-1. Range-to-Landing Site Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V90H0881CA thru V90H0883CA	$\bar{R}$ _FINAL	Propagated position vector	ENT PREC PRED	DP	ft
V90L0885CA thru V90L0887CA	$\bar{V}$ _FINAL	Propagated velocity vector	ENT PREC PRED	SP	ft/s
V97U5042C	H_TARGET	Unbiased target entry altitude	K-LOAD	SP	ft
V97U5423C	NMI_PER_FT	Feet to nautical-mile conversion factor	CONSTANT	SP	nmi/ft
V97U5031C	EPS_H_MISS	Tolerance on altitude miss allowable	K-LOAD	SP	ft
V97U5324C	RE	Reference earth radius	CONSTANT	SP	ft
	$\bar{R}$ 1	Initial position vector	PRE-ENT COAST TSK, PRE-MAN DISP SUPT TSK	DP	ft
	$\bar{V}$ 1	Initial velocity vector	PRE-ENT COAST TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
	H_PERIGEE	Perigee altitude	PRE-MAN DISP SUPT TSK, CUR ORBIT/RCS DUMP TSK	SP	nmi
V97U5029C	DT_RNG	Maximum integration step size	K-LOAD	SP	s
	T1	Time associated with $\bar{R}$ 1 and $\bar{V}$ 1	PRE-ENT COAST TSK, PRE-MAN DISP SUPT TSK	DP	s
V90H1900CA thru V90H1902CA	R_ $\bar{L}$ S_EF	Earth-fixed landing site position vector	SITE LOOKUP	DP	ft
V97U5176C	HP_MAX	Maximum target perigee altitude. A lower value permits a solution for time to EI and range to landing site	K-LOAD	SP	nmi
V97U5177C	R_DOT_MAX	Radial velocity boundary used in determining a time step for extrapolation to EI	K-LOAD	SP	ft/s
V97U5178C	DT_EI	Maximum time step in extrapolation to entry interface	K-LOAD	SP	s
V97U5179C	MAX_RNG	Maximum number of cycles	K-LOAD	SP	N/A
V90X8658X	TAL_ABORT_ DECLARED	Discrete indicating a TAL abort is in progress	MSC	D	N/A

Table 4.4.9-2. Range-to-Landing Site Task Output Parameters					
MSID NO.	Name	Definition	Destination	Precision	Units/ Type
V94H4095C	REL_LS	Earth surface range from entry interface to the designated landing site	MNVR DISP	SP	nmi
V90H8508CI thru V90H8510CI	$\bar{R}$ _INIT	Initial position vector	ENT PREC PRED	DP	ft
V90L8513CI thru V90L8515CI	$\bar{V}$ _INIT	Initial velocity vector	ENT PREC PRED	SP	ft/s
V90W8512CJ	T_INIT	Time associated with $\bar{R}$ _INIT and $\bar{V}$ _INIT	ENT PREC PRED	DP	s
V90U8500CD	DT_MAX	Maximum integration step size	ENT PREC PRED	SP	s
V90W8506CI	T_FINAL	Time at entry interface	ENT PREC PRED	DP	s
V94W3796CC	TFF	Time to entry interface	MNVR DISP, PRE-MAN DISP SUPT TSK	SP	s
V90U8501CG	GMD_PRED	Gravity model degree flag	ENT PREC PRED	SP	I
V90U8502CG	GMO_PRED	Gravity model order flag	ENT PREC PRED	SP	I
V94W4053CA	CRT_SEC	CRT time in seconds	FCOS	SP	s
V94X4063XA	CRT_TIMER_ START	CRT timer start flag	FCOS	N/A	D
V94X4064XA	COUNTDOWN	CRT timer countdown flag	FCOS	N/A	D

#### 4.4.10 Premaneuver Display Support Task (PRE-MAN DISP SUPT TSK)

The premaneuver display support task provides software that computes parameters required for premaneuver evaluation of the maneuver setup and target information. In addition, the current display values for the target and setup data are transferred to deorbit guidance and other software functions by this task.

A. Detailed Requirements. The premaneuver display support task performs the following activities each time it is called.

1. The current displayed MET value of time of ignition in days, hours, minutes, and seconds referenced to lift-off must be transformed to a GMT time. A GMT value of time of ignition (TIG) in seconds is calculated:

$$TIG = TIG\_SEC + TIG\_MIN 60 + TIG\_HR 3600 + TIG\_DAY 86400 + T\_GMTLO$$

Limit the evaluation of OMS burn to 12 hours in the future and 5 minutes in the past. If  $-300 > TIG - T\_GMT$  or  $TIG - T\_GMT > 43200$ , then display illegal entry on the maneuver execute display and return control to the display monitoring task.

2. A switch ( $TB\_ENABLE$ ) is set, indicating to the MSC that a new time base consistent with the current value of TIG should be established and maintained.

$$TB\_ENABLE = ON$$

3. Before the display parameters required to evaluate a maneuver can be computed, a state vector at ignition must be obtained. This is accomplished by utilizing a navigation precision-state predictor principal function (ENT PREC PRED), which propagates the current state ( $RNAV$ ,  $VNAV$ ,  $TNAV$ ) to the time of ignition (TIG) and outputs the propagated ignition state ( $RGD$ ,  $VGD$ ). Other inputs required by the ENT PREC PRED principal function are the time interval step size (DTMIN) and integers (GMD\_PRED, GMO\_PRED) that determine gravity degree and order models to be assumed. These inputs must both be set to 4 to indicate precise gravity modeling.

$$\bar{R}\_INIT = RNAV$$

$$\bar{V}\_INIT = VNAV$$

$$T\_INIT = TNAV$$

$$T\_FINAL = TIG$$

$$GMD\_PRED = 4$$

$$GMO\_PRED = 4$$

$$DT\_MAX = DTMIN$$

CALL ENT PREC PRED

$$\bar{R}GD = \bar{R}\_FINAL$$

$$\bar{V}GD = \bar{V}\_FINAL$$

4. The guidance mode is determined by testing the current values of the guidance mode discrete LTVC\_MODE. If LTVC\_MODE = ON, then linear terminal velocity constraint guidance is assumed. Otherwise, external delta-V guidance is assumed.

If external delta-V guidance is desired, then the velocity targets are transformed to M50 inertial coordinates from the ignition state local vertical, local horizontal (LVLH) coordinates for input to deorbit guidance. Software modules documented in the Flight Control Level C FSSR are used to perform this transformation. The RV\_TO\_QLVLH module accepts an input state (ignition position and velocity in this case) and outputs the quaternion (Q\_I\_LVLH) to transfer from the ignition state local vertical, local horizontal coordinate system to the mean of 1950 coordinate system. This quaternion is an input to the QUAT\_XFORM module, which transforms the input EXT\_DV\_LVLH vector to the VGO vector required for deorbit guidance. A description of RV\_TO\_QLVLH and QUAT\_XFORM modules are presented, for information only, in Part E of this task.

CALL RV\_TO\_QLVLH

Inputs:  $\overline{RGD}$ ,  $\overline{VGD}$

Output:  $Q\_I\_LVLH$

CALL QUAT\_XFORM

Inputs:  $Q\_I\_LVLH$ ,  $EXT\_DV\_LVLH$

Output:  $\overline{VGO}$

If linear terminal velocity constraint guidance is desired, then the deorbit guidance targets are set equal to the currently displayed values and the target values of altitude (HEL\_DISP) and in-plane angle (THETA\_DISP) from the ignition position to entry interface target position are transformed into an inertial position target vector ( $\overline{RT}$ ) in the M50 coordinate system.

$C1 = C1\_DISP$  Intercept of the vertical velocity versus horizontal velocity target line

$C2 = C2\_DISP$  Slope of the vertical velocity versus horizontal velocity target line

The transformation of altitude and the downrange angle to the M50 position vector ( $\overline{RT}$ ) is accomplished as follows.

- a. Unit vectors in the radial ( $\overline{IR}$ ), out-of-plane ( $\overline{IYO}$ ), and down-range ( $\overline{IDR}$ ) direction are calculated.

$$\overline{IR} = \text{UNIT}(\overline{RGD})$$

$$\overline{IYO} = \text{UNIT}(\overline{VGD} \times \overline{IR})$$

$$\overline{IDR} = \overline{IR} \times \overline{IYO}$$

- b. A unit vector in the direction of the target is calculated:

$$\begin{aligned}\overline{IRT} &= \overline{IR} \cos(\text{THETA\_DISP RAD\_PER\_DEG}) \\ &+ \overline{IDR} \sin(\text{THETA\_DISP RAD\_PER\_DEG})\end{aligned}$$

- c. The magnitude of the target position vector reference to the Fischer ellipsoid (see Part E, Section 4.5.5, for H\_ELLIPSOID function) is calculated:

$$\text{RTMAG} = \text{HEI\_DISP/NMI\_PER\_FT} - \text{H\_ELLIPSOID}(\overline{IRT})$$

- d. The target position vector is calculated:

$$\overline{RT} = \text{RTMAG} \overline{IRT}$$

5. Current orbiter weight is transformed to current orbiter mass for input to deorbit guidance:

$$M = \text{WT\_DISP/G\_TO\_FPS2}$$

6. The desired burnout mass (MBO) for controlling the longitudinal center of gravity and the out-of-plane fuel wasting direction (SFUELD) are calculated:

$$\text{MBO} = M - \text{ABS}(\text{PROP\_DEP})/\text{G\_TO\_FPS2}$$

$$\text{SFUELD} = \text{SIGN}(\text{PROP\_DEP})$$

The value of SFUELD is +1 if the sign of PROP\_DEP is positive to denote fuel wasting is to increase the vector velocity component in the positive orbital angular momentum direction; -1 if the sign of PROP\_DEP is negative to denote fuel wasting is to increase the vector velocity component in the negative orbital angular momentum direction; and 0 if no fuel wasting is to be accomplished.

7. The Deorbit Guidance and OMS Firing Sequencer principal functions and MSC require inputs of a prime propulsion system indicator (PROP\_FLAG\_GUID and PROP\_FLAG\_OFS). Based on the discrete settings input from the Deorbit Maneuver Display, these quantities are set as indicated below:

If BOTH $\dot{O}$ MS = ON, then PROP\_FLAG\_GUID = 1 and PROP\_FLAG\_OFS = 1

If LEFT $\dot{O}$ MS = ON, then PROP\_FLAG\_GUID = 2 and PROP\_FLAG\_OFS = 2

If RIGHT $\dot{O}$ MS = ON, then PROP\_FLAG\_GUID = 2 and PROP\_FLAG\_OFS = 3

If PLUS $\dot{X}$ \_RCS = ON, then PROP\_FLAG\_GUID = 3 and PROP\_FLAG\_OFS = 4

For each of the above configurations the previous value flag for the prime propulsion system must be set to zero.

$$\text{PROP\_FLAG\_OFS\_P} = 0$$

8. The current guidance target values are evaluated by calculating for display the velocity-to-go ( $\overline{VGO}$ ) and time-to-go (TGO) that result from these target values. The powered explicit guidance task (PEG TSK, Subsection 4.5.5) is called in order to calculate these parameters.

CALL PEG TSK

Inputs to the powered explicit guidance task from the DEORB MNVR DIP principal function are:

- a. Ignition state values ( $\overline{RGD}$ ,  $\overline{VGD}$ ,  $TGD = TIG$ )
- b. Linear terminal velocity constraint guidance targets ( $\overline{RT}$ ,  $C1$ , and  $C2$ ) or external delta-V guidance targets ( $\overline{VGO}$ )
- c. Orbiter ignition mass ( $M$ )
- d. Guidance mode flag ( $LTVC\_MODE$ )
- e. Propulsion system flag ( $PROP\_FLAG = PROP\_FLAG\_GUID$ )
- f. Integration step size ( $DT\_LIMIT = DTMIN$ )
- g. Desired final orbiter mass ( $MBO$ )
- h. Out-of-plane fuel wasting direction ( $SFUELD$ )
- i. Maximum number of iterations ( $NMAX = NMAX\_DIP$ )
- j. Steering enable flag ( $SSTEER = ON$ )

Outputs from the powered explicit guidance task to be used by the DEORB MNVR DIP principal function are:

- a. Velocity-to-go ( $\overline{VGO}$ ) and time-to-go (TGO)
- b. Commanded reference thrust orientation parameters ( $\overline{LAMC}$ ,  $\overline{LAMDC}$ ,  $TLAMC$ )
- c. Desired burnout state ( $\overline{RP}$ ,  $\overline{VD}$ ,  $TP$ ) [Predicted burnout position ( $\overline{RP}$ ) is the same as the desired burnout position since the burn-out position is unconstrained – linear terminal velocity constraint guidance only]
- d. Estimated coast time from burnout to entry interface ( $DTCOAST$  – linear terminal velocity constraint guidance only)
- e. Initial and final coasting trajectory states [ $\overline{RC1}$ ,  $\overline{VC1}$ ,  $\overline{RC2}$ ,  $\overline{VC2}$ ] – linear terminal velocity constraint guidance only].

For linear terminal velocity guidance ( $LTVC\_MODE = ON$ ), if PEG did not converge ( $SCONV = OFF$ ), then this task must be exited.



9. Compute the PEG 4 velocity-to-be gained in LVLH coordinates at TIG using the guidance state vector at TIG determined in Step 3.

CALL R\_TO\_QLVLH

Inputs:  $\overline{RGD}$ ,  $\overline{VGD}$

Outputs:  $Q_I\_LVLH\_S$ ,  $Q_I\_LVLH\_V$

CALL QUAT\_XFORM

Inputs:  $-Q_I\_LVLH\_S$ ,  $Q_I\_LVLH\_V$ ,  $\overline{VGO}$

Outputs:  $\overline{VGO\_LVLH}$

10. The desired vehicle attitude at ignition (pitch, yaw, and roll angles based upon the ADI attitude reference) is calculated for display.

The time (T\_CA) at which the M50 inertial to commanded body quaternion is to be commanded is defined, then a call is made to the CMD BDY ATT TSK to compute the desired vehicle attitude at ignition:

T\_CA = TGD

CALL CMD BDY ATT TSK

11. The calculation of target apogee and perigee altitudes (Item 12) and range to the landing site from entry interface with the corresponding coast time (Item 13) requires a predicted burnout state ( $\overline{RP}$ ,  $\overline{VD}$ ).

- a. For linear terminal velocity constraint guidance (LTVC\_MODE = ON), the desired burnout state ( $\overline{RP}$ ,  $\overline{VD}$ ) obtained from PEG (see Item 8) does not contain J2 gravity acceleration during the powered flight. To compensate for this acceleration the ENT PREC PRED principal function is used to propagate the state  $\overline{RC1}$ ,  $\overline{VC1}$  through the time interval TGO with the J2 forces modeled (GMD\_PRED = 2, GMO\_PRED = 0).

GMD\_PRED = 2

GMD\_PRED = 0

T\_FINAL = TGO + TIG

T\_INIT = TIG

$\overline{R\_INIT} = \overline{RC1}$

$\overline{V\_INIT} = \overline{VC1}$

DT\_MAX = DTMIN

CALL ENT PREC PRED

$$\overline{RC3} = \overline{R\_FINAL}$$

$$\overline{VC3} = \overline{V\_FINAL}$$

The output state containing the J2 gravity effects ( $\overline{RC3}$ ,  $\overline{VC3}$ ) is differenced with the PEG derived state with only central body gravity forces ( $\overline{RC2}$ ,  $\overline{VC2}$ ) to obtain the delta position and velocity ( $\overline{RJ2}$ ,  $\overline{VJ2}$ ):

$$\overline{VJ2} = \overline{VC3} - \overline{VC2}$$

$$\overline{RJ2} = \overline{RC3} - \overline{RC2}$$

The desired burnout state is then corrected as follows:

$$\overline{RP} = \overline{RP} + \overline{RJ2}$$

$$\overline{VD} = \overline{VD} + \overline{VJ2}$$

- b. For external delta-V guidance (LTVC<sup>•</sup>MODE = OFF), the initial state ( $\overline{RP}$ ,  $\overline{VD}$ ) is calculated such that when coasted through the burn time (TGO), it will approximate the powered flight burn-out state.

$$\overline{RP} = \overline{RGD} - 0.5 \text{ TGO } \overline{VGO}$$

$$\overline{VD} = \overline{VGD} + \overline{VGO}$$

where ( $\overline{RGD}$ ,  $\overline{VGD}$ ) is the predicted state vector at TIG and  $\overline{VGO}$  is the external delta-V guidance target vector.

12. The target apogee (TGT\_HA) and perigee (TGT\_HP) altitudes are next computed for display by calling the orbit altitude task (ORB ALT TASK, Subsection 4.4.11). The inputs to ORB ALT TSK are the position and velocity vectors ( $\overline{R}$ ,  $\overline{V}$ ) obtained from equivalencing with the state vector ( $\overline{RP}$ ,  $\overline{DV}$ ) computed in Item 11.

CALL ORB ALT TSK

The resulting apogee and perigee altitudes (HA, HP) are then assigned to the target apogee and perigee altitudes (TGT\_HA, TGT\_HP), respectively.

13. The range to the landing site from entry interface (REI\_LS) and the coast time to entry interface (TFF) are computed for display by calling the range to landing site task (RNG TO LS TSK, Subsection 4.4.9).

The input initial position and velocity vectors ( $\overline{R1}$ ,  $\overline{V1}$ ) are the vectors ( $\overline{RP}$ ,  $\overline{VD}$ ) calculated in Item 11.

- a. If linear terminal velocity constraint guidance is specified ( $\text{LTVC\_MODE} = \text{ON}$ ), the input reference time ( $T1$ ) associated with the vectors ( $\overline{RP}$ ,  $\overline{VD}$ ) is defined as:

$$T1 = TP$$

where  $TP$  is the predicted time of engine cutoff as calculated by the powered explicit guidance task.

- b. If external delta-V guidance is specified ( $\text{LTVC\_MODE} = \text{OFF}$ ), the value for  $T1$  is defined as:

$$T1 = TIG$$

- c. The perigee altitude ( $H\_PERIGEE$ ) is assigned the value of the target perigee altitude ( $TGT\_HP$ ):

$$H\_PERIGEE = TGT\_HP$$

- d. The range to landing site task is called:

$$\text{CALL RNG TO LS TSK}$$

If external delta-V guidance is specified ( $\text{LTVC\_MODE} = \text{OFF}$ ) the value of  $TFF$  must be corrected as follows:

$$TFF = TFF - TGO$$

14. If current time ( $TNAV$ ) exceeds the time of ignition ( $TIG$ ), a state associated with  $TNAV$  must be computed to reinitialize the state (central body) maintained by deorbit guidance after  $TIG$ . This is accomplished by utilizing the navigation principal function  $\text{ENT\_PREC\_PRED}$ , which propagates the ignition state ( $\overline{RGD}$ ,  $\overline{VGD}$ ) computed in Item 3 in a central-body field to  $TNAV$  and outputs the propagated state ( $\overline{RGD}$ ,  $\overline{VGD}$ ). Other inputs are the maximum interval step size ( $DTMIN$ ) and integers ( $GMD\_PRED$ ,  $GMO\_PRED$ ) that determine the gravity degree (0) and order (0) models to be used.

Before calling the predictor, the time ( $TGD$ ) associated with  $\overline{RGD}$ ,  $\overline{VGD}$ , and the previous value of accumulated sensed velocity must be set to ensure that the guidance principal function is consistent with this propagation.

$$TGD = TNAV$$

$$\overline{VSP} = \overline{VS}$$

$$GMD\_PRED = 0$$

$$GMO\_PRED = 0$$

$$T\_FINAL = TNAV$$

$$T\_INIT = TIG$$

$$\overline{R\_INIT} = \overline{RGD}$$

$$\bar{V}_{INIT} = \bar{VGD}$$

$$DT_{MAX} = DTMIN$$

CALL ENT PREC PRED

$$\bar{RGD} = \bar{R}_{FINAL}$$

$$\bar{VGD} = \bar{V}_{FINAL}$$

If TNAV is less than or equal to TIG, then the initial guidance state has already been calculated in Item 3 and is equal to the TIG state.

B. Interface Requirements. The input and output parameters for the premaneuver display support task are given in Tables 4.4.10-1 and 4.4.10-2. The detailed flow chart for PRE-MAN DISP SUPT TSK is illustrated in Appendix A.

C. Processing Requirements. The premaneuver display support task is performed once when the LOAD\_CMD is set to ON by keyboard input.

D. Initialization Requirements. None.

E. Supplemental Information. The QUAT\_XFORM module referenced in this task and formally documented in the Flight Control Level C FSSR is presented here for information only. In the following equations,  $Q_{B_I_S}$  and  $Q_{B_I_V}$ , designate the scalar and vector components of the quaternion  $Q_{B_I}$ .

$$Q_{TMPS} = -Q_{B_I_V} \cdot \bar{VGO}$$

$$Q_{TMPV} = -Q_{B_I_S} \bar{VGO} + Q_{B_I_V} \times \bar{VGO}$$

$$\bar{VGO}_{DISP} = -Q_{TMPS} Q_{B_I_V} + Q_{B_I_S} Q_{TMPV} - Q_{TMPV} \times Q_{B_I_V}$$

The RV\_TO\_QLVLH module reference in this task and formally documented in the Flight Control Level C FSSR is presented here for information only:

$$\bar{XZ} = \text{UNIT}(-\bar{RGD})$$

$$\bar{XY} = \text{UNIT}(\bar{VGD} \times \bar{RGD})$$

$$\bar{XX} = \text{UNIT}(\bar{XY} \times \bar{XZ})$$

$$X\bar{M}^* = [\text{MATRIX}(\bar{XX}, \bar{XY}, \bar{XZ})]^T$$

The output quaternion is formed from  $X\bar{M}^*$  by invoking the MAT\_TO\_QUAT module.

Table 4.4.10-1. Premaneuver Display Support Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V93W6944CA thru V93W6947CA	TIG_SEC, TIG_MIN, TIG_HR, TIG_DAY	Time of ignition	MNVR DISP	SP	s,min, hr,day
V93L6950CA thru V93L6952CA	EXT_DV̄_LVLH	External delta-V velocity-to-be-gained vector in local vertical, local horizontal coordinates	MNVR DISP	SP	ft/s
V93G6940CA	WT_DISP	Orbiter weight	MNVR DISP	SP	lb
V93U6968CA	HEI_DISP	Target altitude magnitude	MNVR DISP	SP	nmi
V93U6969CA	THETA_DISP	Target earth central angle from launch site	MNVR DISP	DP	deg
V93U6966CA	C1_DISP	Intercept of target line	MNVR DISP	SP	ft/s
V93U6967CA	C2_DISP	Slope of target line	MNVR DISP	SP	none
V93X6925XA	LEFT_ḐOMS	Left OMS engine select discrete	MNVR DISP	N/A	D
V93X6926XA	RIGHT_ḐOMS	Right OMS engine select discrete	MNVR DISP	N/A	D
V93X6922XA	BOTH_ḐOMS	Both OMS engine select discrete	MNVR DISP	N/A	D
V93X6929XA	PLUS_X_RCS	RCS engine select discrete	MNVR DISP	N/A	D
V93U6970C	PROP_DEP	Weight of propellant to be consumed by the deorbit maneuver (out-of-plane propellant wasting direction specified by sign)	MNVR DISP, UL	SP	lb
V93X6976XC V94X4094X	PEG_ḐMODE_4, LTVC_ḐMODE	Guidance mode discrete based on latest target set	MNVR DISP	N/A	D
V90L2118C thru V90L2120C	VḐO	Velocity-to-be-gained vector in M50 coordinates	PEG TSK	SP	ft/s
V90W1941C	TGO	Time-to-go to thrust cutoff	PEG TSK	SP	s
	SCḐNV	PEG convergence flag	PEG TSK	N/A	D
V90H8508C thru V90H8510C	RḐ1	Initial coasting trajectory position vector for linear terminal velocity constraint guidance	PEG TSK	DP	ft
V90L8513C thru V90L8515C	VḐ1	Initial coasting trajectory velocity vector for linear terminal velocity constraint guidance	PEG TSK	SP	ft/s
	RḐ2	Final coasting trajectory position vector excluding J <sub>2</sub> gravity effects	PEG TSK	DP	ft

Table 4.4.10-1. Premaneuver Display Support Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
	$\overline{VC2}$	Final coasting trajectory velocity vector excluding $J_2$ gravity effects	PEG TSK	SP	ft/s
	TP	Predicted time of engine cutoff	PEG TSK	DP	s
	$\overline{RP}$	Predicted burnout position vector in M50 coordinates	PEG TSK	DP	ft/s
	$\overline{VD}$	Desired burnout velocity vector in M50 coordinates	PEG TSK	SP	ft/s
V95L0210C thru V95L0212C	$\overline{VS}$	Accumulated sensed velocity vector	ENTRY UPP	DP	ft/s
V95H0185CC thru V95H0187CC	$\overline{RNAV}$	Current Shuttle position vector in M50 coordinates	ENTRY UPP	DP	ft
V95L0190CC thru V95L0192CC	$\overline{VNAV}$	Current Shuttle velocity vector in M50 coordinates	ENTRY UPP	SP	ft/s
V90H0881CA thru V90H0883CA	$\overline{R\_FINAL}$	Predicted position vector	ENT PREC PRED	DP	ft
V90L0885CA thru V90L0887CA	$\overline{V\_FINAL}$	Predicted velocity vector	ENT PREC PRED	SP	ft/s
V95W0200CE	TNAV	Time associated with current Shuttle state	ENTRY UPP	DP	s
V91W5000C	T_GMT	Current GMT time	FCOS	DP	s
	HA	Apogee altitude	ORB ALT TSK	SP	nmi
	HP	Perigee altitude	ORB ALT TSK	SP	nmi
V97U4393C	G_TO_FPS2	Gravitational acceleration	CONSTANT	SP	ft/s <sup>2</sup>
V97U0383C	RAD_PER_DEG	Degrees to radian conversion factor	CONSTANT	SP	rad/deg
V97U4370C	DTMIN	Minimum integration step size for gravity prediction	K-LOAD	SP	s
V97U4836C	NMAX_DIP	Maximum number of iterations	K-LOAD	N/A	I
V90W4380C	T_GMTLO	Time of liftoff in GMT	FCOS	DP	s
V97U5423C	NMI_PER_FT	Nautical mile per foot	CONSTANT	SP	nmi/ft
V94W3796GC	TFF	Time to entry interface	RNG_LS_TSK	SP	s

Table 4.4.10-2. Premaneuver Display Support Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
	T_CA	GMT to compute commanded body attitude quaternion	CMD BDY ATT TSK	DP	s
V94H3903CB thru V94H3932CB	$\overline{RGD}$	Guidance position vector	CMD BDY ATT TSK, GUID INP TSK, PEG TSK	DP	ft
V94H3935CB thru V94H3937CB	$\overline{VGD}$	Guidance velocity vector	CMD BDY ATT TSK, GUID INP TSK, PEG TSK	SP	ft/s
V94X4094X	LTVC_MODE	PEG maneuver mode indicator	PEG TSK	N/A	D
V94W3938CB	TGD	Time associated with $\overline{RGD}$ , $\overline{VGD}$	PEG TSK, GUID INP TSK	DP	s
V90H3781CB thru V90H3783CB	$\overline{RT}$	Target position vector in M50 coordinates	PEG TSK	DP	ft
V90H3773CA	C1	Intercept of target line	PEG TSK	SP	ft/s
V94H3774CA	C2	Slope of target line	PEG TSK	SP	none
V94U4086C	MBO	Desired burnout mass	PEG TSK, VGO DISP TSK	SP	slugs
V94U4057C	SFUELD	Propellant wasting flag to indicate out-of-plane fuel wasting direction	PEG TSK, VGO DISP TSK	N/A	I
	PROP_FLAG	Current propulsive system flag	PEG TSK	N/A	I
V90U8500CH	DT_LIMIT	Maximum integration step size for gravity prediction	PEG TSK	SP	s
V90U1961CE	M	Orbiter mass	PEG TSK, GUID INP TSK	SP	slugs
V94X3962XB	PROP_FLAG_ GUID	Prime propulsive system flag for guidance use	GUID INP TSK	N/A	I
V94L3804CB thru V94L3806CB	$\overline{VGO}$	External delta-V target velocity-to-go vector	GUID INP TSK	SP	ft/s
V90U8500CD	DT_MAX	Maximum integration step interval	ENT PREC PRED	SP	s
V90U8501CG	GMD_PRED	Gravity model degree flag	ENT PREC PRED	SP	I
V90U8502CG	GMO_PRED	Gravity model order flag	ENT PREC PRED	SP	I
V90W1941C	TGO	Time-to-go to thrust cutoff	MSC, GUID INP TSK, DISP MONIT TSK, CMD BDY ATT TSK	SP	s

Table 4.4.10-2. Premaneuver Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94W3790CB	TIG	Time of ignition	DEORB GUID, MSC, TLM, PREBRN MNVR TTG TSK, VGO DISP TSK	DP	s
V94H3798CC	TGT_HA	Target apogee altitude	MNVR DISP	SP	nmi
V94H3799CC	TGT_HP	Target perigee altitude	MNVR DISP	SP	nmi
V94H3940CB thru V94H3942CB	$\bar{V}SP$	Previous value of accumulated sensed velocity	GUID INP TSK	DP	ft/s
V94J3791CC	PROP_FLAG_OFS	Prime propulsive system flag	MNVR DISP, OMS FIRE SEQ, MSC, CMD BODY ATT TSK	N/A	I
V90H8508CJ thru V90H8510CJ	$\bar{R}$ _INIT	Initial position vector	ENT PREC PRED	DP	ft
V90L8513CJ thru V90L8515CJ	$\bar{V}$ _INIT	Initial velocity vector	ENT PREC PRED	SP	ft/s
V90W8512CJ	T_INIT	Initial time	ENT PREC PRED	DP	s
V90W8506CI	T_FINAL	Final time	ENT PREC PRED	DP	s
	PROP_FLAG_OFS_P	Previous value of prime propulsion system flag	CMD BDY ATT TSK	N/A	I
	$\bar{R}$ 1	Initial position vector in M50 coordinates	RNG TO LS TSK	DP	ft
	$\bar{V}$ 1	Initial velocity vector in M50 coordinates	RNG TO LS TSK	SP	ft/s
	T1	Time associated with initial state vector	RNG TO LS TSK	DP	s
	$\bar{R}$	Position vector	ORB ALT TSK	DP	ft
	$\bar{V}$	Velocity vector	ORB ALT TSK	SP	ft/s
V94X3826XB	TB_ENABLE	Discrete to initiate time base calculations	MSC	N/A	D
	H_PERIGEE	Perigee altitude	RNG TO LS TSK	DP	nmi
	NMAX	Maximum number of PEG iteration	PEG TSK	N/A	I
V94W3796CC	TFF	Time to entry interface	MNVR DISP	SP	s
	SS $\dot{T}$ EEER	Steering enable flag	PEG TSK	D	none
V94L3945CB thru V94L3947CB	$\bar{V}GO\_LVLH$	PEG4 velocity-to-go in LVLH coordinates	MNVR DISP	SP	ft/s
V93U6909CB	VEH_PITCH	Desired burn attitude in pitch	MNVR DISP, TLM	SP	deg



Table 4.4.10-2. Premaneuver Display Support Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V93U6910CB	VEH_ROLL	Desired burn attitude in roll	MNVR DISP, TLM	SP	deg
V93U6911CB	VEH_YAW	Desired burn attitude in yaw	MNVR DISP, TLM	SP	deg
V90X0414XF	X_FLAG	Valid angle comp flag	MNVR DISP	N/A	D

#### 4.4.10A Preburn Maneuver Time To Go Task (PREBRN MNVR TTG TSK)

This task computes the condition when the nominal preburn maneuver completion time to go, MNVR\_CMPL\_TIME\_TGO, is displayed as double overbright versus normal intensity on the XXXXX MNVR YYYYYY display.

A. Detailed Requirements. The condition of MNVR\_CMPL\_TIME\_TGO is calculated for the current preburn maneuver and displayed as either normal intensity or double overbright in MM:SS format on the XXXXX MNVR YYYYYY display when a MNVR item entry (ITEM 27) has been initiated and the DAP is in AUTO mode.

While MNVR\_CMPL\_TIME\_TGO is being computed via the TRANS DAP (MNVR\_HOLD = ON), the following logic applies:

1. Initialize variables.

TTG = MNVR\_CMPL\_TIME\_TGO

TTG\_FLAG = OFF

2. If the major mode is 302, then check to determine if the preburn maneuver will be completed at least 30 seconds prior to burn ignition.

If the preburn maneuver will not be completed 30 seconds prior to burn ignition, then set the flag to display TTG in double overbright.

If: MM\_302 = ON

AND

TTG + T\_GMT > TIG - 30 SECONDS

Then: TTG\_FLAG = ON

The preburn maneuver display flag is set equal to the flag signifying mnvr or hold state for display processing.

PREBURN\_MNVR\_DISP = MNVR\_HOLD

B. Interface Requirements. The input and output parameters for the time to go task are given in Tables 4.4.10A-1 and 4.4.10A-2.

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C. Processing Requirements. In MM301 and MM302 this task is processed every 0.96 seconds. In Major Mode 303 this task is processed every 1.92 seconds.

D. Initialization Requirements. PREBURN\_MNVR\_DISP is set to zero upon entry into OPS 3.

E. Supplemental Requirements. None.

Table 4.4.10A-1. Preburn Maneuver Time to Go Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/Type
V91W5000C	T_GMT	Current time (GMT)	FCOS	DP	S
V90X8624X	MM_302	Major Mode 302 flag	MSC	N/A	D
V90X2637X	MNVR_HOLD	Flag signifying maneuver or hold state (1 = mnvr)	TRANS DAP	N/A	D
V94W3790CB	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	S
V95W7240CA	MNVR_CMPL_TIME_TGO	Preburn mnvr time to go	TRANS DAP	SP	S

Table 4.4.10A-2. Preburn Maneuver Time to Go Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/Type
V90W2638CC	TTG	Preburn mnvr time to go	MNVR DISP	SP	S
V90X2639XC	TTG_FLAG	TTG display intensity flag	MNVR DISP	N/A	D
V85X9529XC	PREBURN_MNVR_DISP	Preburn maneuver display flag	MNVR DISP	N/A	D

#### 4.4.11 Orbital Altitude Task (ORB ALT TSK)

The orbital altitude task provides software to compute apogee and perigee altitudes above a spherical earth based on an input state ( $\bar{R}$ ,  $\bar{V}$ ). This procedure may be done in single precision.

##### A. Detailed Requirements.

1. Calculate the magnitude of the radius vector (RMAG), the vertical velocity magnitude (RDOT), and the unit radius vector ( $\bar{R}_{UNIT}$ ):

$$RMAG = ABVAL(\bar{R})$$

$$\bar{R}_{UNIT} = \bar{R} / RMAG$$

$$RDOT = \bar{V} \cdot \bar{R}_{UNIT}$$

2. Calculate the two Keplerian elements, the semimajor axis (AM), and the semilatus rectum (P):

$$AM = EARTH\_MU \cdot RMAG / [2 \cdot EARTH\_MU - RMAG (\bar{V} \cdot \bar{V})]$$

$$P = RMAG [2 - (RMAG/AM) - RMAG \cdot RDOT^2 / EARTH\_MU]$$

The constant EARTH\_MU is the earth's gravitational constant.

3. Compute a term to be used repeatedly in subsequent calculations

$$K = J2\_GRAV \cdot RE^2 / (4 \cdot P)$$

where J2\_GRAV is the second gravitational zonal harmonic ( $J_2$ ) for the earth and RE is the reference radius of the earth.

4. Compute the product of the sine of the inclination and the sine of the argument of latitude (MM) and the product of the sine of the inclination and the cosine of the argument of latitude (NN) for adjustment of the Keplerian elements to account for noncentral body gravitational effects:

$$MM = EARTH\_POLE \cdot \bar{R}_{UNIT}$$

$$NN = UNIT(\bar{V} - RDOT \cdot \bar{R}_{UNIT}) \cdot EARTH\_POLE$$

where EARTH\_POLE is the current M50 unit angular momentum vector of the earth.

5. Compute the mean semimajor axis (AM) and the inverse of the mean orbital rate (NU):

$$AM = AM - (J2\_GRAV \cdot RE^2 \cdot AM^2 / RMAG^3) (1 - 3 \cdot MM^2)$$

$$NU = AM \cdot SQRT(AM / EARTH\_MU)$$

6. Compute the adjusted elements: radius (RMAG), vertical velocity (RDOT), and semimajor axis (AM).

$$RMAG = RMAG + K (MM^2 - NN^2)$$

$$RDOT = RDOT + 4 K MM NN/NU$$

$$AM = AM - K(2 - 3 (MM^2 + NN^2))$$

7. Compute two intermediate quantities: the product of the eccentricity and the sine of the eccentric anomaly (M), and the product of the eccentricity and the cosine of the eccentric anomaly (N).

$$M = RMAG RDOT/SQRT(EARTH_MU AM)$$

$$N = 1 - RMAG/AM$$

8. Compute the eccentricity (E):

$$E = SQRT(M^2 + N^2)$$

9. Check the difference in apogee and perigee radii to determine if the orbit is near circular.

$$\text{If } 2 AM E NMI\_PER\_FT < DELT\_H\_CIRC$$

then set the two terms M and N to indicate the true anomaly of zero:

$$M = 0$$

$$N = 1$$

Else, if the orbit is not near circular ( $2 AM E NMI\_PER\_FT \geq DELT\_H\_CIRC$ ), recompute the two terms M and N to be the sine of the true anomaly (M) and the cosine of the true anomaly (N).

$$M = SQRT(1 - E^2) M/[E(1 - N)]$$

$$N = (N - E^2)/[E(1 - N)]$$

10. Compute the correction to apogee and perigee altitudes (DELTA):

$$DELTA = K [(MM^2 - NN^2) (M^2 - N^2) + 4M MM N NN] - RE$$

11. Compute the altitudes of apogee (HA) and perigee (HP).

$$HA = [AM (1 + E) + DELTA] NMI\_PER\_FT$$

$$HP = [AM (1 - E) + DELTA] NMI\_PER\_FT$$

The variable NMI\_PER\_FT is the conversion factor from feet to nautical miles.

B. Interface Requirements. The input and output parameters for the orbital altitude task are given in Tables 4.4.11-1 and 4.4.11-2. The detailed flow chart for ORB ALT TSK is illustrated in Appendix A.

- C. Processing Requirements. The orbital altitude task is performed once when called.
- D. Initialization Requirements. None.
- E. Supplemental Information. This task is similar to the orbital altitude time task (Subsection 4.1).

Table 4.4.11-1. Orbital Altitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
	$\bar{R}$	Position vector	CUR ORB/RCS DUMP TSK, PRE- MAN DISP SUPT TSK	DP	ft
	$\bar{V}$	Velocity vector	CUR ORBIT/RCS DUMP TSK, PRE- MAN DISP SUPT TSK	SP	ft/s
V97U4378C	EARTH_MU	Earth's gravitational constant	CONSTANT	SP	ft <sup>3</sup> /s <sup>2</sup>
V97U4416C	J2_GRAV	The second gravitational zonal harmonic (J <sub>2</sub> ) for the earth	CONSTANT	SP	none
V97U5324C	RE	Earth radius	CONSTANT	SP	ft
V90U0190C thru V90U0192C	EARTH_POLE	M50 unit vector normal to equator pointing north	RNP MAT COMP	DP	none
V97U4832C	DELT_H_CIRC	Maximum difference in apogee and perigee for orbit to be considered circular	K-LOAD	SP	nmi
V97U5423C	NML_PER_FT	Feet to nautical mile conversion factor	CONSTANT	SP	nmi/ft

Table 4.4.11-2. Orbital Altitude Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
	HA	Apogee altitude	CUR ORBIT/RCS DUMP TSK, PRE-MAN DISP SUPT TSK	SP	nmi
	HP	Perigee altitude	CUR ORBIT/RCS DUMP TSK, PRE-MAN DISP SUPT TSK	SP	nmi

#### 4.4.12 Pre-entry Attitude Task (PRE-ENT ATT TSK)

The pre-entry attitude task computes the M50 to commanded body quaternion from the displayed attitude.

A. Detailed Requirements. The ADI to commanded body quaternion,  $Q\_CB\_ADI$ , is computed from the displayed attitude angles which are assumed to be in a pitch, yaw, and roll Euler sequence. The sine and cosine values of half angles are obtained.

$$CTH = \cos(\text{VEH\_PITCH RAD\_PER\_DEG } 0.5)$$

$$STH = \sin(\text{VEH\_PITCH RAD\_PER\_DEG } 0.5)$$

$$CPSI = \cos(\text{VEH\_YAW RAD\_PER\_DEG } 0.5)$$

$$SPSI = \sin(\text{VEH\_YAW RAD\_PER\_DEG } 0.5)$$

$$CPHI = \cos(\text{VEH\_ROLL RAD\_PER\_DEG } 0.5)$$

$$SPHI = \sin(\text{VEH\_ROLL RAD\_PER\_DEG } 0.5)$$

The ADI to commanded body quaternion elements are computed.

$$Q\_CB\_ADI_1 = CPHI CTH CPSI - SPHI STH SPSI$$

$$Q\_CB\_ADI_2 = -SPHI CTH CPSI - CPHI STH SPSI$$

$$Q\_CB\_ADI_3 = -CPHI STH CPSI - SPHI CTH SPSI$$

$$Q\_CB\_ADI_4 = -CPHI CTH SPSI + SPHI STH CPSI$$

The M50 to commanded body quaternion ( $Q\_CB\_M50$ ) is obtained by multiplying the ADI to commanded body quaternion ( $Q\_CB\_ADI$ ) with the conjugate of the I-load ADI to M50 quaternion ( $Q\_M50\_INRTL\_ENT$ ).

CALL QUAT\_MULT

Inputs:  $Q\_CB\_ADI$ ,  $Q\_M50\_INRTL\_ENT$

Output:  $Q\_CB\_M50$

B. Interface Requirements. The input and output parameters for the pre-entry attitude task are given in Tables 4.4.12-1 and 4.4.12-2. The detailed flow chart for PRE-ENT ATT TSK is illustrated in Appendix A.

C. Processing Requirements. This task is performed upon demand.

D. Initialization Requirements. The display values for the postmaneuver required pitch, yaw, and roll attitude angles must be set to the I-load values, if this is the first pass through MM 303, to initialize the display and to allow calculation of the commanded body quaternion.

$$\text{VEH\_PITCH} = \text{VEH\_PITCH\_ENT}$$

$$\text{VEH\_YAW} = \text{VEH\_YAW\_ENT}$$

$$\text{VEH\_ROLL} = \text{VEH\_ROLL\_ENT}$$

Table 4.4.12-1. Pre-Entry Attitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units
V97U5111C	VEH_PITCH_ENT	Initial pitch angle desired post-maneuver in ADI coordinates	I-LOAD <sup>(1)</sup>	SP	deg
V97U5113C	VEH_YAW_ENT	Initial yaw angle desired post-maneuver in ADI coordinates	I-LOAD <sup>(1)</sup>	SP	deg
V97U5112C	VEH_ROLL_ENT	Initial roll angle desired post-maneuver in ADI coordinates	I-LOAD <sup>(1)</sup>	SP	deg
	VEH_PITCH	Pitch angle desired post-maneuver in ADI inertial coordinates	MNVR DISP	SP	deg
	VEH_YAW	Yaw angle desired post-maneuver in ADI inertial coordinates	MNVR DISP	SP	deg
	VEH_ROLL	Roll angle desired post-maneuver in ADI inertial coordinates	MNVR DISP	SP	deg
V97U0383C	RAD_PER_DEG	Constant to convert from degrees to radians	CONSTANT	SP	rad/deg
V97U2214CB thru V97U2217CB	Q_M50_ INRTL_ENT	ADI to M50 quaternion	K-LOAD	SP	none
<sup>(1)</sup> Uplink during OPS 2					

Table 4.4.12-2. Pre-Entry Attitude Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units
V94U3980CF thru V94U3983CF	Q_CB_M50	M50 to commanded body quaternion	TRANS DAP	SP	none

#### 4.4.13 Uplink Buffer Access Task (UL ACCESS TSK)

The uplink buffer access task, upon recognizing that a guidance target data set was uplinked, retrieves the data from the uplink module and resets the required parameters for reinitialization of the display.

A. Detailed Requirements. The uplink access task performs the following activities each time it is called:

1. Interrogates the operational code to determine whether a guidance target data set was updated via uplink. If a data set was updated, the guidance mode discrete is set and the guidance mode target parameters are set to the uplinked values.

- a. If PRE-MAN DISP SUPT TSK 4.4.10 is active, exit this task.

- b. If OP\_CODE = 0010001, and PRE-MAN DISP SUPT TSK 4.4.10 not active set:

$$\text{PEG\_MODE\_4} = \text{OFF}$$
$$\text{EXT\_D}\bar{\text{V}}\text{\_LVLH} = \text{EXT\_D}\bar{\text{V}}\text{\_LVLH\_UL}$$

- c. If OP\_CODE = 0010100, and PRE-MAN DISP SUPT TSK 4.4.10 not active set

$$\text{PEG\_MODE\_4} = \text{ON}$$
$$\text{C1\_DISP} = \text{C1\_UL}$$
$$\text{C2\_DISP} = \text{C2\_UL}$$
$$\text{HEI\_DISP} = \text{HEI\_UL}$$
$$\text{THETA\_DISP} = \text{THETA\_UL}$$
$$\text{PROP\_DEP} = \text{PROP\_DEP\_UL}$$

- d. If OP\_CODE is not equal to either of the above, exit this task.

2. Sets the setup data, which are common to external delta velocity guidance and linear terminal velocity constraint guidance, to their uplinked values:

$$\text{TVR\_ROLL} = \text{TVR\_ROLL\_UL}$$
$$\text{WT\_DISP} = \text{WT\_UL}$$
$$\text{BOTH\_OMS} = \text{BOTH\_OMS\_UL}$$
$$\text{LEFT\_OMS} = \text{LEFT\_OMS\_UL}$$
$$\text{RIGHT\_OMS} = \text{RIGHT\_OMS\_UL}$$
$$\text{PLUS\_X\_RCS} = \text{PLUS\_X\_RCS\_UL}$$
$$\text{VEH\_PITCH\_ENT} = \text{VEH\_PITCH\_UL}$$
$$\text{VEH\_YAW\_ENT} = \text{VEH\_YAW\_UL}$$
$$\text{VEH\_ROLL\_ENT} = \text{VEH\_ROLL\_UL}$$



3. Converts the uplinked time of ignition to the applicable time reference.

$$TIG = TIG\_UL - T\_GMTLO$$

Computes the applicable display time units for the display:

$$TIG\_SEC = MOD(TIG,60)$$

$$TIG\_MIN = TRUNCATE((MOD(TIG,3600))/60)$$

$$TIG\_HR = TRUNCATE((MOD(TIG,86400))/3600)$$

$$TIG\_DAY = TRUNCATE(TIG/86400)$$

4. Resets a discrete (LOAD\_FLASH) to reinitialize the display:

$$LOAD\_FLASH = ON$$

5. Sets the operational code to a nonvalid guidance value to preclude reprocessing the uplinked data on the next call to this task:

$$OP\_CODE = 0$$

B. Interface Requirements. The input and output parameters for the uplink access task are given in Tables 4.4.13-1 and 4.4.13-2. The detailed flow chart for UL ACCESS TSK is illustrated in Appendix A.

C. Processing Requirements. The uplink access task is performed from entry into MM 301 until positive crew enablement of the OMS engine occurs (BURN\_ENABLE= ON) or until MM 302 is exited.

D. Initialization Requirements. None.

Table 4.4.13-1. Uplink Buffer Access Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90W4380C	T_GMTLO	MET start time in GMT time base	FCOS	DP	s
V96J3524C	OP_CODE	Data type operational code	UPLINK	NA	7 bits
V94W3790CD	TIG_UL	Time of ignition	UPLINK	DP	s
V93L6950CF thru V93L6952CF	EXT_DV̄_LVLH_UL	External delta-V LVLH coordinates	UPLINK	SP	ft/s
V93H6936C	TVR_ROLL_UL	Thrust vector roll angle	UPLINK	SP	deg
V93G6940CD	WT_UL	Orbiter weight	UPLINK	SP	lb
V93X6922XB	BOTH_OMS_UL	Propulsive system, both OMS	UPLINK	NA	D
V93X6925XB	LEFT_OMS_UL	Propulsive system, left OMS	UPLINK	NA	D
V93X6926XB	RIGHT_OMS_UL	Propulsive system, right OMS	UPLINK	NA	D
V93X6929XA	PLUS_X_RCS_UL	Propulsive system, +X RCS	UPLINK	NA	D
V93U6909CE	VEH_PITCH_UL	Pitch angle post-maneuver	UPLINK	SP	deg
V93U6911CE	VEH_YAW_UL	Yaw angle post-maneuver	UPLINK	SP	deg
V93U6910CE	VEH_ROLL_UL	Roll angle post-maneuver	UPLINK	SP	deg
V93U6966CD	C1_UL	Target line intercept	UPLINK	SP	ft/s
V93U6967CD	C2_UL	Target line slope	UPLINK	SP	none
V93U6968CD	HEI_UL	Altitude at entry interface	UPLINK	SP	ft
V93U6969CD	THETA_UL	Transfer angle from ignition to entry interface	UPLINK	DP	deg
V93U6970CD	PROP_DEP_UL	Fuel weight maneuver and waste	UPLINK	SP	lb

Table 4.4.13-2. Uplink Buffer Access Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units
V93X6976XB	PEG_MODE_4	Guidance mode indicator	MNVR DISP	NA	D
V94X3814XC	LOAD_FLASH	“LOAD” flash flag	DISP MONIT TSK	NA	D
V93W6944CC thru V93W6947CC	TIG_HR, TIG_MIN, TIG_SEC TIG_DAY	Time of ignition in display format	MNVR DISP	SP	hr, min, s, days
V93L6950CC thru V93L6952CC	EXT_DV_LVLH	External delta-V target vector	MNVR DISP	SP	ft/s
V93H6936CB	TVR_ROLL	Thrust vector roll angle	I-LOAD	SP	deg
V93G6940CE	WT_DISP	Vehicle weight	MNVR DISP	SP	lb
V93X6922XC	BOTH_OMS	Both engines select discrete	MNVR DISP	NA	D
V93X6925XC	LEFT_OMS	Left engine select discrete	MNVR DISP	NA	D
V93X6926XC	RIGHT_OMS	Right engine select discrete	MNVR DISP	NA	D
V93X6929XC	PLUS_X_RCS	RCS engine select discrete	MNVR DISP	NA	D
V97U5111C	VEH_PITCH_ENT	Pitch angle desired in ADI coordinates	I-LOAD	SP	deg
V97U5113C	VEH_YAW_ENT	Yaw angles desired in ADI coordinates	I-LOAD	SP	deg
V97U5112C	VEH_ROLL_ENT	Roll angle desired in ADI coordinates	I-LOAD	SP	deg
V93U6966CB	C1_DISP	Target line intercept	MNVR DISP	SP	ft/s
V93U6967CB	C2_DISP	Target line slope	MNVR DISP	SP	none
	HEI_DISP	Altitude at entry interface	MNVR DISP	SP	ft
V93U6969C	THETA_DISP	Earth’s central angle from ignition to entry interface	MNVR DISP	DP	deg
	PROP_DEP	Propellant weight for maneuver and out-of-plane waste (direction indicated by +/-)	MNVR DISP	SP	lb

**4.4.14 Parameter Tables for Deorbit MNVR DIP (G4.211)**

The IDD inputs and outputs are listed in Tables 4.4.14–1 and 4.4.14–2 respectively. Values for the I–loads are contained in the I–load requirements document (JSC–19350); however, I–load definitions applicable to this principal function are listed in Table 4.4.14–3. K–loads are listed in Table 4.4.14–4. Constants are listed in Table 4.4.14–5. The cross–reference listing is given below.

Deorbit MNVR DIP (G4.211) Cross–Reference Listing		
FSSR Name	Source Name	MSID
HEL_DISP	HTGT_DISP	V93U6968CA
RCS_·AMR_DISP	N/G	V93X6941X
RCS_D·UMP_DISP	N/G	V93X6942X
RCS_IN·H_DISP	N/G	V93X6943X
EXT_DV_LVLH_UL	EXT_DV_LVLH	V93L6950CF
TIG_UL	TIG	V94W3790CD
WT_UL	WT_DISP	V93G6940CD
LEFT_·OMS_UL	LEFT_OMS	V93X6925XB
RIGHT_·OMS_UL	RIGHT_OMS	V93X6926XB
BOTH_·OMS_UL	BOTH_OMS	V93X6922XB
PLUS_X_·RCS_UL	PLUS_X_RCS	V93X6929XB
VEH_PITCH_UL	VEH_PITCH	V93U6909CE
VEH_YAW_UL	VEH_YAW	V93U6911CE
VEH_ROLL_UL	VEH_ROLL	V93U6910CE
C1_UL	C1_DISP	V93U6966CD
C2_UL	C2_DISP	V93U6967CD
THETA_UL	THETA_DISP	V93U6969CD
HEL_UL	HTGT_DISP	V93U6968CD
PROP_DEP_UL	PROP_DEP	V93U6970CD
TVR_ROLL_UL	TVR_ROLL	V93H6936CD
T_GMT	CLOCK	V91W5000CI
R·NAV	R_AVGG(1)	V95H0187CC
	R_AVGG(2)	V95H0188CC
	R_AVGG(3)	V95H0189CC
V·NAV	V_AVGG(1)	V95L0190CC
	V_AVGG(2)	V95L0191CC
	V_AVGG(3)	V95L0192CC
T_NAV	T_STATE	V95W0200CE

Deorbit MNVR DIP (G4.211) Cross-Reference Listing		
FSSR Name	Source Name	MSID
$\bar{V_S}$	V_IMU_OLD(1) V_IMU_OLD(2) V_IMU_OLD(3)	V95L0210CC V95L0211CC V95L0212CC
NMI_PER_FT	NAUTMI_PER_FT	V97U4378C
J_2_GRAV	J2_GRAV	V97U4416C
RE	EARTH_RADIUS_EQUATOR	V97U5324C
N/G = Not given		

TABLE 4.4.14-1. INPUT FUNCTIONAL PARAMETERS FOR DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
BOTH_OMS	V93X6922XA	BOTH OMS ENG SEL	XXXXX MNVR DISP					
BOTH_OMS	V93X6922XB	BOTH OMS ENG SEL	UL					
BURN_ENABLE_WINDOW	V97U5181C	BURN ENABLE WINDOW	RM SWITCH/SURF FB DISP	S	DPL		93023D	
C1_DISP	V93U6966CA	INTERCEPT OF TARGET LINE	XXXXX MNVR DISP	FT/S				
C1_DISP	V93U6966CD	INTERCEPT OF TARGET LINE	UL	FT/S				
C2_DISP	V93U6967CA	SLOPE OF TARGET LINE	XXXXX MNVR DISP					
C2_DISP	V93U6967CD	SLOPE OF TARGET LINE	UL					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
DATA_ENTER	V93X6973X	TGT/SETUP DATA ENTERED FLAG	XXXXX MNVR DISP					
EARTH_POLE(1)	V90U0190C	X-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(2)	V90U0191C	Y-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(3)	V90U0192C	Z-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EXEC_CMD	V93X1050XA	BURN EXECUTE CMD	XXXXX MNVR DISP					
EXT_DV_LVLH(1)	V93L6950CA	EXT DELTA V X-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(1)	V93L6950CF	EXT DELTA V X-COMP	UL	FT/S				
EXT_DV_LVLH(2)	V93L6951CA	EXT DELTA V Y-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(2)	V93L6951CF	EXT DELTA V Y-COMP	UL	FT/S				
EXT_DV_LVLH(3)	V93L6952CA	EXT DELTA V Z-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CF	EXT DELTA V Z-COMP	UL	FT/S				
HTGT_DISP	V93U6968CA	TGT ALTITUDE MAGNITUDE	XXXXX MNVR DISP	NM				
HTGT_DISP	V93U6968CD	TGT ALTITUDE MAGNITUDE	UL	NM				
LEFT_OMS	V93X6925XA	L OMS ENG SEL	XXXXX MNVR DISP					
LEFT_OMS	V93X6925XB	L OMS ENG SEL	UL					
LOAD_CMD	V93X6956X	LOAD COMMAND	XXXXX MNVR DISP		BD		93177D	*
M/CURR_ORB_MASS/MASS	V90U1961CC	CURRENT VEHICLE MASS	DEORB GUID	SLUGS			93090E	
MM_CODE_301/MM_301	V90X8183X	MAJOR MODE 301 FLAG	MSC				93064D	
MM_CODE_302/MM_302	V90X8624X	MAJOR MODE 302 FLAG	MSC				92355B	
MM_CODE_303/MM_303	V90X8182X	MAJOR MODE 303 FLAG	MSC				92355B	
MNVR_CMPL_TIME_TGO	V95W7240CA	PREBURN MNVR TIME TO GO	TRANS DAP	S	SPL		92510E	
MNVR_HOLD	V90X2637X	FLAG SIGNIFYING MNVR OR HOLD STATE	TRANS DAP		BD		92859C	
OMS_L_ON_CMD_IND	V90X8271X	OMS-L ON CMD IND	OMS FIRE SEQ				90120B	
OMS_PITCH_TRIM	V93H6915CD	OMS PITCH TRIM	UL	DEG	SPL		89645A	
OMS_R_ON_CMD_IND	V90X8272X	OMS-R ON CMD IND	OMS FIRE SEQ				90120B	
OMS_YAW_TRIM(1)	V93H6916CD	OMS L YAW TRIM	UL	DEG	SPL		89645A	
OMS_YAW_TRIM(2)	V93H6918CD	OMS R YAW TRIM	UL	DEG	SPL		89645A	
OP_CODE	V96J3524C	OP CODE TO DEFINE CMD LOAD	UL				89590B	
PEG_MODE_4	V93X6976XA	PEG4/PEG7 TGT DATA ENTERED	XXXXX MNVR DISP					
PEG_MODE_4	V93X6976XD	PEG4/PEG 7 TGT DATA ENTERED	UL					
PLUS_X_RCS	V93X6929XA	RCS ENG SEL CMD	XXXXX MNVR DISP					
PLUS_X_RCS	V93X6929XB	RCS ENG SEL CMD	UL					
PROP_DEP	V93U6970CA	OUT OF PLANE PRPLT WASTE	XXXXX MNVR DISP	LB				
PROP_DEP	V93U6970CD	OUT OF PLANE PRPLT WASTE	UL					
Q_BOD_M50(1)/Q_B_I(1)	V90U2240CA	M50 TO BODY QUAT MEASURED ELEM 1	A/E ATT PROC		SPL		93017G	*
Q_BOD_M50(2)/Q_B_I(2)	V90U2241CA	M50 TO BODY QUAT MEASURED ELEM 2	A/E ATT PROC		SPL		93017G	*
Q_BOD_M50(3)/Q_B_I(3)	V90U2242CA	M50 TO BODY QUAT MEASURED ELEM 3	A/E ATT PROC		SPL		93017G	*

TABLE 4.4.14-1. INPUT FUNCTIONAL PARAMETERS FOR DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
Q_BOD_M50(4)/Q_B_I(4)	V90U2243CA	M50 TO BODY QUAT MEASURED ELEM 4	A/E ATT PROC		SPL		93017G	*
Q_M50_LVLH(1)	V90U2641CB	M50 WRT LVLH QUAT 1	A/E ATT PROC				93017G	*
Q_M50_LVLH(2)	V90U2642CB	M50 WRT LVLH QUAT 2	A/E ATT PROC				93017G	*
Q_M50_LVLH(3)	V90U2643CB	M50 WRT LVLH QUAT 3	A/E ATT PROC				93017G	*
Q_M50_LVLH(4)	V90U2644CB	M50 WRT LVLH QUAT 4	A/E ATT PROC				93017G	*
RIGHT_OMS	V93X6926XA	R OMS ENG SEL	XXXXX MNVR DISP					
RIGHT_OMS	V93X6926XB	R OMS ENG SEL	UL					
R_AVGG(1)	V95H0185CC	X-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CC	Y-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CC	Z-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CA	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT			89662B	
R_FINAL(2)	V90H0882CA	Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT				
R_FINAL(3)	V90H0883CA	Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT				
R_LS_EF(1)	V90H1900CA	X-COMP LDG SITE POS VCT-EF COORD	ENT SITE LOOKUP	FT				
R_LS_EF(2)	V90H1901CA	Y-COMP LDG SITE POS VCT-EF COORD	ENT SITE LOOKUP	FT				
R_LS_EF(3)	V90H1902CA	Z-COMP LDG SITE POS VCT-EF COORD	ENT SITE LOOKUP	FT				
ST_CRT_TIMER	V93X6553X	START CRT TIMER CMD	XXXXX MNVR DISP		BD		89461	
TAL_ABORT_DECLARED	V90X8658X	TAL ABORT DECLARED	MSC				93090E	
TB_TIME	V90W8625C	ENGINE IGNITION TIME BASE TIME	MSC	S			89599C	
THETA_DISP	V93U6969CA	TGT INPLN DNRNG ANG FROM LANH	XXXXX MNVR DISP	DEG				
THETA_DISP	V93U6969CD	TGT INPLN DNRNG ANG FROM LANH	UL	RAD				
TIG	V94W3790CD	TIME OF IGNITION	UL	S				
TIG_DAY	V93W6947CA	TIG(DAYS)	XXXXX MNVR DISP	DAYS				
TIG_HR	V93W6944CA	TIG(HOURS)	XXXXX MNVR DISP	HRS				
TIG_MIN	V93W6945CA	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_SEC	V93W6946CA	TIG(SEC)	XXXXX MNVR DISP	S				
TVR_ROLL	V93H6936CD	ROLL ANGLE	UL	DEG				
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CE	TIME TAG ASSOC WITH CURRENT STATE	ENT UPP	S			93017G	*
VEH_PITCH	V93U6909CA	PITCH ANGLE IN ADI INERTIAL COORD	XXXXX MNVR DISP	DEG			93017G	*
VEH_PITCH	V93U6909CE	PITCH ANGLE IN ADI INERTIAL COORD	UL	DEG				
VEH_ROLL	V93U6910CA	ROLL ANGLE IN ADI INERTIAL COORD	XXXXX MNVR DISP	DEG			93017G	*
VEH_ROLL	V93U6910CE	ROLL ANGLE IN ADI INERTIAL COORD	UL	DEG				
VEH_YAW	V93U6911CA	YAW ANGLE IN ADI INERTIAL COORD	XXXXX MNVR DISP	DEG			93017G	*
VEH_YAW	V93U6911CE	YAW ANGLE IN ADI INERTIAL COORD	UL	DEG				
VGO(1)	V90U1202C	X-COMP OF VGO IN M50 COORD	DEORB GUID	FT/S				
VGO(2)	V90U1203C	Y-COMP OF VGO IN M50 COORD	DEORB GUID	FT/S				
VGO(3)	V90U1204C	Z-COMP OF VGO IN M50 COORD	DEORB GUID	FT/S				
V_AVGG(1)	V95L0190CC	X-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CC	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CC	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CA	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_FINAL(2)	V90L0886CA	Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_FINAL(3)	V90L0887CA	Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CC	X-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				
V_IMU_OLD(2)	V95L0211CC	Y-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				

TABLE 4.4.14-1. INPUT FUNCTIONAL PARAMETERS FOR DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
V_IMU_OLD(3)	V95L0212CC	Z-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				
WT_DISP	V93G6940CA	VEHICLE WEIGHT	XXXXX MNVR DISP	LB				
WT_DISP	V93G6940CD	VEHICLE WEIGHT	UL	LBS				
	V93X6941X	FWD RCS ARM CMD	XXXXX MNVR DISP			BD		
	V93X6942X	FWD RCS DUMP CMD	XXXXX MNVR DISP			BD		
	V93X6943X	FWD RCS OFF CMD	XXXXX MNVR DISP			BD		
	V93X6972X	DESIRED R,P,Y DATA ENTER FLAG	XXXXX MNVR DISP					

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**



TABLE 4.4.14-2. OUTPUT FUNCTIONAL PARAMETERS FROM DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
BOTH_OMS	V93X6922XC	BOTH OMS ENG SEL	XXXXX MNVR DISP					
BURN_ENABLE	V94X3815XC	BURN ENABLE	MSC				92876B	
C1	V94H3773CA	INTERCEPT OF TARGET LINE-GUID	DEORB GUID	FT/S				
C1_DISP	V93U6966CB	INTERCEPT OF TARGET LINE	DL FMT 23/1	FT/S			93017G	*
C2	V94H3774CA	SLOPE OF TARGET LINE-GUID	XXXXX MNVR DISP					
C2_DISP	V93U6967CB	SLOPE OF TARGET LINE	DEORB GUID				93017G	*
			DL FMT 23/1					
			XXXXX MNVR DISP					
CRT_COUNTDOWN	V94X4064XA	CRT TIMER COUNTDOWN FLAG	FCOS					
CRT_SEC	V94W4053CA	SECONDS TO IGNITION	FCOS	S				
CRT_TIMER_START	V94X4063XA	CRT TIMER START FLAG	FCOS					
CUR_HA	V94H3810CC	CURRENT APOGEE ALTITUDE	DL FMT 23/1	NM			93017G	*
			XXXXX MNVR DISP					
CUR_HP	V94H3811CC	CURRENT PERIGEE ALTITUDE	DL FMT 23/A	NM			93017G	*
			XXXXX MNVR DISP					
DT_MAX	V90U8500CH	MAX ALLOW TIME STEP SIZE	ENT PREC PRED	S				
DV_TOT	V94L3795CC	TOTAL DELTA V REQD FOR MANEUVER	DL FMT 23/1	FT/S			93017G	*
			XXXXX MNVR DISP					
EXT_DV_LVLH(1)	V93L6950CC	EXT DELTA V X-COMP	DL FMT 23/1	FT/S			93017G	*
			XXXXX MNVR DISP					
EXT_DV_LVLH(2)	V93L6951CC	EXT DELTA V Y-COMP	DL FMT 23/1	FT/S			93017G	*
			XXXXX MNVR DISP					
EXT_DV_LVLH(3)	V93L6952CC	EXT DELTA V Z-COMP	DL FMT 23/1	FT/S			93017G	*
			XXXXX MNVR DISP					
GMD_PRED	V90U8501CG	GRAVITY MODEL DEGREE	ENT PREC PRED					
GMO_PRED	V90U8502CG	GRAVITY MODEL ORDER	ENT PREC PRED					
HTGT_DISP	V93U6968CB	TGT ALTITUDE MAGNITUDE	DL FMT 23/1	NM			93017G	*
			XXXXX MNVR DISP					
LEFT_OMS	V93X6925XC	L OMS ENG SEL	XXXXX MNVR DISP					
LOAD_FLASH	V94X3814XC	LOAD FLASH FLAG	DL FMT 23/A				93017G	*
			XXXXX MNVR DISP					
LTVC_MODE	V94X4094X	PEG MANEUVER MODE INDICATOR	DEORB GUID					
M/CURR_ORB_MASS/WEIGHT	V90U1961CE	CURRENT VEHICLE MASS	DEORB GUID	SLUGS			89250B	
MBO	V94U4086C	DESIRED FINAL ORBITER MASS	DEORB GUID	SLUGS				
MNVR_TITLE_IND	V94U4096CA	DISPLAY TITLE IND	XXXXX MNVR DISP				91072D	
OMSL_ACT_SEL	V93J6904CD	L P/S/OFF GMBL ACTR SEL	OMS RM					
OMSR_ACT_SEL	V93J6906CD	R P/S/OFF GMBL ACTR SEL	OMS RM					
OTREQ	V90X0893XE	OPS TRANSITION REQUEST FLAG	ENT PREC PRED		BD		90121B	
PEG_MODE_4	V93X6976XB	PEG4/PEG7 TGT DATA ENTERED	XXXXX MNVR DISP					
PLUS_X_RCS	V93X6929XC	RCS ENG SEL CMD	XXXXX MNVR DISP					
PREBURN_MNVR_DISP	V85X9529XC	PREBURN MANEUVER DISPLAY FLAG	XXXXX MNVR DISP		BD		92859C	
PROP_DEP	V93U6970CB	OUT OF PLANE PRPLT WASTE	DL FMT 23/1	LB			93017G	*
			XXXXX MNVR DISP					
PROP_FLAG_GUID	V94X3962XB	PRIME PROP SYS FLAG FOR GUID	DEORB GUID					

TABLE 4.4.14-2. OUTPUT FUNCTIONAL PARAMETERS FROM DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
PROP_FLAG_OFS	V94J3791CC	PRIME PROP SYS INDICATOR FLAG	DL FMT 23/A MSC OMS FIRE SEQ				93017G	*
Q_CB_M50_S	V94U3980CF	M50 TO BODY QUAT ELEM 1	TRANS DAP					
Q_CB_M50_V(1)	V94U3981CF	M50 TO BODY QUAT ELEM 2	TRANS DAP					
Q_CB_M50_V(2)	V94U3982CF	M50 TO BODY QUAT ELEM 3	TRANS DAP					
Q_CB_M50_V(3)	V94U3983CF	M50 TO BODY QUAT ELEM 4	TRANS DAP					
RCS_DUMP_DAP/NOSE_DUMP	V94X4059X	RCS DUMP ENABLE DISCRETE	TRANS DAP					
RCS_DUMP_DRV	V94J4069C	RCS DUMP STATUS DRIVER	XXXXX MNVR DISP		VAR			
REI_LS	V94H4095C	RNGE TO LDNG SITE FROM ENTRY I/F	DL FMT 23/1 XXXXX MNVR DISP	NM	SPL		93017G	*
RGD(X)	V94H3930CB	X-COMP OF GUIDANCE POS VEC AT TGD	DEORB GUID	FT			89662B	
RGD(Y)	V94H3931CB	Y-COMP OF GUIDANCE POS VEC AT TGD	DEORB GUID	FT			89662B	
RGD(Z)	V94H3932CB	Z-COMP OF GUIDANCE POS VEC AT TGD	DEORB GUID	FT			89662B	
RIGHT_OMS	V93X6926XC	R OMS ENG SEL	XXXXX MNVR DISP					
RT(X)	V90H3781CB	X-M50 OF POSITION TARGET VECTOR	DEORB GUID	FT				
RT(Y)	V90H3782CB	Y-M50 OF POSITION TARGET VECTOR	DEORB GUID	FT				
RT(Z)	V90H3783CB	Z-M50 OF POSITION TARGET VECTOR	DEORB GUID	FT				
R_INIT(X)	V90H8508CG	X-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
R_INIT(Y)	V90H8509CG	Y-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
R_INIT(Z)	V90H8510CG	Z-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
SFUELD	V94U4057C	OUT OF PLANE FU WASTING DIR	DEORB GUID					
TB_ENABLE	V94X3826XB	TIME BASE TIME INITIATOR FLAG	MSC TLM				92739D	
TFF	V94W3796CC	TIME TO NEXT APSIS/FREE FALL	TLM XXXXX MNVR DISP	S				
TGD	V94W3938CB	TIME ASSOCIATED WITH RGD,VGD	DEORB GUID	S				
TGT_HA	V94H3798CC	TARGET APOGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
TGT_HP	V94H3799CC	TARGET PERIGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
THETA_DISP	V93U6969CB	TGT INPLN DNRNG ANG FROM LANH	DL FMT 23/1 XXXXX MNVR DISP	DEG			93017G	*
TIG	V94W3790CB	TIME OF IGNITION	DEORB GUID DL FMT 23/1 MSC	S			93017G	*
TIG_DAY	V93W6947CC	TIG(DAYS)	XXXXX MNVR DISP	DAYS				
TIG_HR	V93W6944CC	TIG(HOURS)	XXXXX MNVR DISP	HR				
TIG_MIN	V93W6945CC	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_MINUS5_FLAG	V94X3813XC	ENGINE IGNITION MINUS 5 SEC FLAG	XXXXX MNVR DISP					
TIG_SEC	V93W6946CC	TIG(SEC)	XXXXX MNVR DISP	S				
TTG	V90W2638CC	DISPLAY PREBURN MNVR TIME TO GO	XXXXX MNVR DISP	S	SPL		92510E	
TTG_FLAG	V90X2639XC	TTG DISPLAY INTENSITY FLAG	XXXXX MNVR DISP		BD		92510E	
TTX_FLAG_DISP	V94J4098CB	TIME TO XXXXX DISPLAY FIELD IND	XXXXX MNVR DISP					
TVR_ROLL	V93H6936CB	ROLL ANGLE	XXXXX MNVR DISP	DEG				
T_FINAL	V90W8506CC	TIME AT WHICH STATE IS DESIRED	ENT PREC PRED	S				
T_INIT/TNAV,T1,TIG	V90W8512CC	TIME AT BEGINNING OF PRED	ENT PREC PRED	S				

TABLE 4.4.14-2. OUTPUT FUNCTIONAL PARAMETERS FROM DEORBIT MANEUVER DISPLAY PROCESSING (G4.211)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
VEH_PITCH	V93U6909CB	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 23/1 XXXXX MNVR DISP	DEG			93017G	*
VEH_ROLL	V93U6910CB	ROLL ANGLE IN ADI INERTIAL COORD	DL FMT 23/1 XXXXX MNVR DISP	DEG			93017G	*
VEH_YAW	V93U6911CB	YAW ANGLE IN ADI INERTIAL COORD	DL FMT 23/1 XXXXX MNVR DISP	DEG			93017G	*
VGD(X)	V94H3935CB	X-COMP OF GUIDANCE VEL VEC AT TGD	DEORB GUID	FT/S			89662B	
VGD(Y)	V94H3936CB	Y-COMP OF GUIDANCE VEL VEC AT TGD	DEORB GUID	FT/S			89662B	
VGD(Z)	V94H3937CB	Z-COMP OF GUIDANCE VEL VEC AT TGD	DEORB GUID	FT/S			89662B	
VGO(X)	V94L3804CC	X-EXTERNAL DEL V TARGET VECTOR	DEORB GUID TLM	FT/S				
VGO(Y)	V94L3805CC	Y-EXTERNAL DEL V TARGET VECTOR	DEORB GUID TLM	FT/S				
VGO(Z)	V94L3806CC	Z-EXTERNAL DEL V TARGET VECTOR	DEORB GUID TLM	FT/S				
VGO_DISP(X)	V94U3800CC	X-COMP OF VGO OF MNVR-BODY COORD	DL FMT 23/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_DISP(Y)	V94U3801CC	Y-COMP OF VGO OF MNVR-BODY COORD	DL FMT 23/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_DISP(Z)	V94U3802CC	Z-COMP OF VGO OF MNVR-BODY COORD	DL FMT 23/A XXXXX MNVR DISP	FT/S			93017G	*
VGO_LVLH(X)	V94L3945CB	PEG 4 LVLH X-COMP OF VGO	DL FMT 23/1 XXXXX MNVR DISP	FT/S			93017G	*
VGO_LVLH(Y)	V94L3946CB	PEG 4 LVLH Y-COMP OF VGO	DL FMT 23/1 XXXXX MNVR DISP	FT/S			93017G	*
VGO_LVLH(Z)	V94L3947CB	PEG 4 LVLH Z-COMP OF VGO	DL FMT 23/1 XXXXX MNVR DISP	FT/S			93017G	*
VSP(X)	V94H3940CB	X-COMP OF PREV ACCUM IMU VEL	DEORB GUID	FT/S				
VSP(Y)	V94H3941CB	Y-COMP OF PREV ACCUM IMU VEL	DEORB GUID	FT/S				
VSP(Z)	V94H3942CB	Z-COMP OF PREV ACCUM IMU VEL	DEORB GUID	FT/S				
V_INIT(X)	V90L8513CG	X-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
V_INIT(Y)	V90L8514CG	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
V_INIT(Z)	V90L8515CG	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
WT_DISP	V93G6940CE	VEHICLE WEIGHT	ORB/RND NAV SEQ	LBS				
X_FLAG	V90X0414XF V94M3042PC	VALID ANGLE COMP FLAG CGZB_MNVR_DISP_FLAG1	XXXXX MNVR DISP DL FMT 23/A		BD		90763E 93017G	*

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
(HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec

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TABLE 4.4.14-3. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
KLAMDZX	V97U4423C	ND	F	S	D	C	G4.13 G4.209 G4.210 G4.211 G4.3	00	ZF1	90243C	
M	V97U4429C	SLUGS	F	S	M	X	G4.1 G4.158 G4.211	01 02 03 08 09	AMC ZF2 AMC ZF2 AMC	DC2248	
TVR_ROLL	V93H6936C	DEG	F	S	D	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	00	ZF2	91019A	
VEH_PITCH_ENT	V97U5111C	DEG	F	S	M	C	G4.211	00	ZF2	90243C	
VEH_ROLL_ENT	V97U5112C	DEG	F	S	M	C	G4.211	00	ZF2	90243C	
VEH_YAW_ENT	V97U5113C	DEG	F	S	M	C	G4.211	00	ZF2	90243C	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.4.14-4. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
BURN_ENABLE_WINDOW BURN ENABLE WINDOW	V97U5181C	00	-1.5	E+01 SEC	F	D	X	G3.3 G4.158 G4.210 G4.211	92751B	
CBETA_EPS	V97U5127C	00	+9.998480	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89542A	
DELT_H_CIRC	V97U4832C	00	+5.0	E+00 NMI	F	S	A	G4.158 G4.210 G4.211	39534	
DTMIN	V97U4370C	01 02 03	+2.0 +3.00 +2.0	E+00 SEC E+02 E+00	F	S	C	G4.13 G4.158 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	29975A	
DT_EI	V97U5178C	00	+6.00	E+02 SEC	F	S	P	G4.211	39229A	
DT_RNG TIME INTERVAL STEP SIZE	V97U5029C	00	+2.0000000	E+00 SEC	F	S	C	G4.211	59955	
EPS_H_MISS	V97U5031C	00	+5.0000000	E+01 FT	F	S	C	G4.211	59955	
FT1 VACUUM THRUST OF TWO OMS ENGINES	V97U5034C	00	+1.2174000	E+04 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT2 VACUUM THRUST OF ONE OMS ENGINES	V97U5035C	00	+6.0870000	E+03 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT3 VACUUM THRUST OF PRIMARY RCS JETS	V97U5036C	02 03	+1.780 +3.509	E+03 LBS E+03	F	S	P	G4.158 G4.209 G4.211 G4.7	90329C	
HP_MAX	V97U5176C	00	+5.50	E+01 NMI	F	S	P	G4.211	39229A	
H_TARGET UNBIASED TARGET ENTRY INTERFACE ALTITUDE	V97U5042C	00	+4.0000000	E+05 FT	F	S	P	G4.211	90329C	

TABLE 4.4.14-4. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
KMISS FRACTION OF VGO DEFINING PEG CONVERGENCE	V97U4831C	00	+1.0	E-02	ND	F	S	C G4.13 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	90329C	
MAX_RNG MAX CYCLES - RANGE TO L/S TASK	V97U5179C	03	+10		ND	I	S	P G4.211	59955	
NMAX_DIP MAXIMUM PEG CYCLE	V97U4836C	00	+10		ND	I	S	C G4.13 G4.210 G4.211	59955	
NSEG NUMBER OF INTEGRATION STEPS FOR PEG GRAVITY PREDICTION	V97U4447C	01 03	+10 +20		ND	I	S	P G4.13 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	90329C	
ONE_ENG_OMS_PITCH_TRIM OMS ENG PITCH TRIM ANG THRUST -CG	V97U2367C	01 02 03	+4.0 -1.0 -3.1	E-01 E-01 E-01	DEG	F	S	X G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(1) OMS ENG YAW TRIM ANG THRUST - CG	V97U2368C	01 02 03	+5.210000 +5.210000 +5.210000	E+00 E+00 E+00	DEG	F	S	C G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(2) OMS ENG YAW TRIM ANG THRUST - CG	V97U2369C	01 02 03	-5.210000 -5.210000 -5.210000	E+00 E+00 E+00	DEG	F	S	C G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	

TABLE 4.4.14-4. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PITCH_BIAS CONST OMS ENG ELEC PITCH TRIM ANG	V97U4485C	00	+2.7605300	E-01	RAD	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	59955	
Q_M50_INRTL_ENTRY(1)	V97U2214CB	00 03	+1.0	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(2)	V97U2215CB	00 03	+0.0	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(3)	V97U2216CB	00 03	+0.00	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(4)	V97U2217CB	00 03	+0.00	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
R_DOT_MAX	V97U5177C	00	-1.00	E+02	FT/SEC	F	S	P G4.211	39229A	
THRUST_BODY_RCS_X(1) X-COMPONENT OF RCS THRUST DIRECTION	V97U4812C	00	+9.8480780	E-01	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(2) Y-COMPONENT OF RCS THRUST DIRECTION	V97U4813C	00	+0.0	E+00	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(3) Z-COMPONENT OF RCS THRUST DIRECTION	V97U4814C	00	+1.7364820	E-01	ND	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
VEX1 TWO OMS EXHAUST VELOCITY	V97U5114C	00	+1.0136800	E+04	FT/SEC	F	S	P G4.158 G4.209 G4.211 G4.7	90924B	
VEX2 ONE OMS EXHAUST VELOCITY	V97U5115C	00	+1.0136800	E+04	FT/SEC	F	S	P G4.158 G4.209 G4.211 G4.7	90924B	



TABLE 4.4.14-4. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
VEX3 RCS EXHAUST VELOCITY	V97U5116C	00	+8.2327000	E+03 FT/SEC	F		S	P G4.158 G4.209 G4.211 G4.7	90329C	
YAW_BIAS CNST OMS ENG ELEC YAW TRIM ANGLE	V97U4829C	00	+1.134460	E-01 RAD	F		S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89541	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.4.14-5. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_MU EARTH GRAVITATIONAL CONSTANT	V97U4378C	00	+1.40764487566E+16	FT**3/SEC**2	F		D C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.2 G4.205 G4.209 G4.210 G4.211 G4.224 G4.236 G4.3 G4.4 G5.10 G5.24 G5.26 G5.27	93090E	
EARTH_RADIUS_EQUATOR EARTH EQUATORIAL RADIUS	V97U5324C	00	+2.09257414698E+07	FT	F		D C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.19 G4.20 G4.205 G4.210 G4.211 G4.213 G4.23 G4.236 G4.238 G4.24 G4.25 G5.26 G5.27 V5.1.8	93090E	

TABLE 4.4.14-5. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
G_2_FPS2 MASS-TO-WEIGHT CONVERSION	V97U4393C	00	+3.2174049	E+01	LB/SLUG	F	S	P A6.9 G4.13 G4.148 G4.158 G4.210 G4.211 G4.5	90374C	
J2_GRAV J2 GRAVITY HARMONIC	V97U4416C	00	+1.0826271	E-03	LB/SLUG	F	S	P A6.9 G4.158 G4.210 G4.211	90374C	
NAUTMI_PER_FT FEET TO NAUTICAL MILES CONVERSION FACTOR	V97U5423C	00	+1.6457884	E-04	NMI/FT	F	S	C A6.9 G4.127 G4.144 G4.158 G4.19 G4.20 G4.205 G4.21 G4.210 G4.211 G4.220 G4.23 G4.237 G4.24 G4.25 G4.8 G5.27	93090E	

TABLE 4.4.14-5. DEORBIT MANEUVER DISPLAY PROCESSING (G4.211) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RAD_PER_DEG DEGREE TO RADIAN CONVERSION FACTOR	V97U0383C	00	+1.7453293	E-02	RAD/DEG	F	S	C A6.9 G4.1 G4.126 G4.127 G4.128 G4.144 G4.15 G4.158 G4.175 G4.20 G4.201 G4.204 G4.205 G4.209 G4.210 G4.211 G4.213 G4.220 G4.223 G4.226 G4.227 G4.236 G4.237 G4.3 G4.35 G4.36 G4.7 G4.72 G4.9 G4.97 G5.27	93090E	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

## 4.5 DEORBIT GUIDANCE PRINCIPAL FUNCTION (DEORB GUID)

The Deorbit Guidance principal function (referenced in Level B, CPDS, Principal Function 4.209) provides guidance requirements for the deorbit maneuver execute major mode (MM 302). Since the requirements of this section are interrelated with the requirements for the Deorbit Maneuver Display Processing principal function (DEORB\_MNVR\_DIP), it is recommended that Section 4.4 be read prior to this section.

### 4.5.1 Overview

DEORBIT GUID is active during the deorbit maneuver execute major mode beginning at a K-load value (BURN\_ENABLE\_WINDOW) seconds prior to ignition and ending at the transition out of the deorbit maneuver execute major mode, usually into the pre-entry monitor major mode (MM 303), or upon the entry of new target data or a LOAD item on the maneuver display (Event E11C).

The primary requirement of this principal function is to perform an externally targeted (by ground or crew) maneuver that provides a satisfactory trajectory at the entry interface. The primary guidance algorithm used for the deorbit maneuver is the linear terminal velocity constraint, in which a desired relationship between horizontal and vertical velocity components is achieved at a desired position. The alternate guidance algorithm available is external delta-V, in which the thrust is directed along the velocity-to-be-gained vector until the specified velocity change has been achieved. After cutoff, a secondary algorithm cyclically decrements any residual velocity while this residual is manually trimmed with the translational hand controller (THC). The details of the linear terminal velocity constraint and external delta-V guidance requirements are described in Subsection 4.5.6.

The externally computed targets, prime propulsive system flag, and orbiter mass are input to DEORB GUID from the DEORB MNVR DIP. Engine ON command indicators from the OMS FIRE SEQ are monitored internal to guidance and the initial propulsive system flag is updated to allow transition across an engine failure, so that if an OMS fails during a two-OMS burn, guidance will allow the completion of the maneuver with the remaining OMS. If both OMS fail during the maneuver or nominal OMS cutoff occurs, guidance continues, allowing the maneuver to be manually completed, if desired, using the +X RCS. In any case, the velocity-to-be-gained vector is decremented and output to the DEORB MNVR DIP for display. Time-to-go is also output for display. For an OMS maneuver, the time of engine cutoff is computed and output to the MSC with a flag to initiate countdown to engine cutoff.

A typical timeline of guidance-related events for the deorbit maneuver execute major mode is as follows:

1. Guidance calculations are initiated.
2. Engine ignition occurs and attitude errors are removed by the transition DAP using guidance commands.
3. If an engine failure occurs, guidance updates propulsive system parameters to achieve the same target.
4. Time of engine cutoff is computed for the OMS/RCS maneuver.
5. Engine cutoff occurs.
6. Velocity residuals are trimmed.

7. The maneuver execute major mode is exited by crew action.

Figures 4.5.1-1, 4.5.1-2, and 4.5.1-3 illustrate the deorbit guidance task organization, functional flow, and data flow.

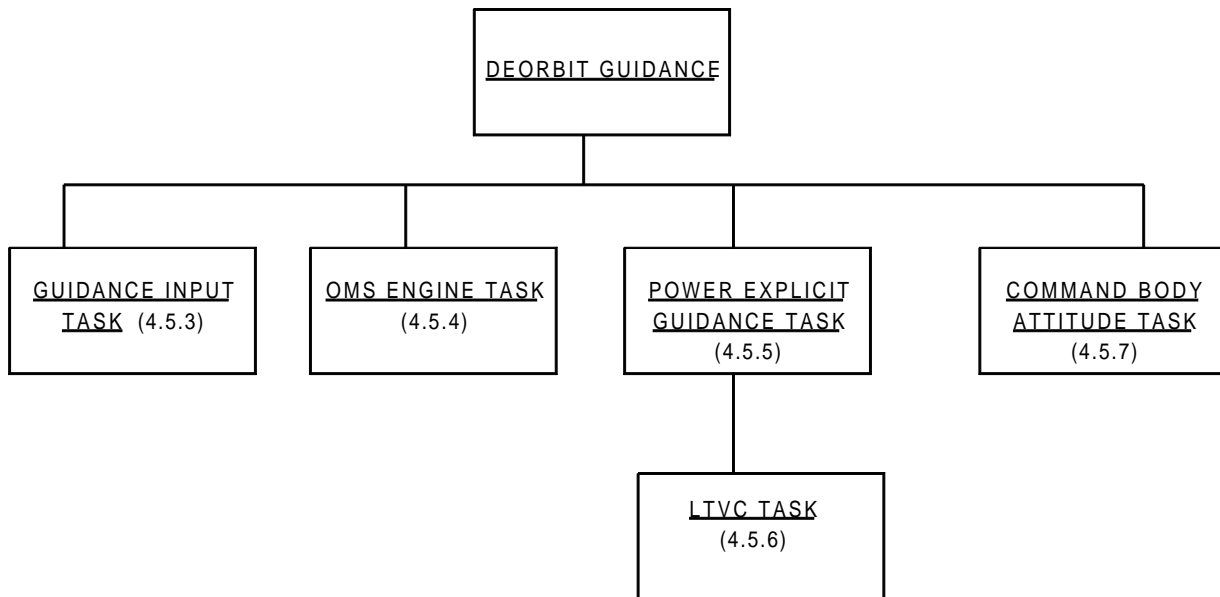


FIGURE 4.5.1-1. Deorbit Guidance Principal Function Task Organization

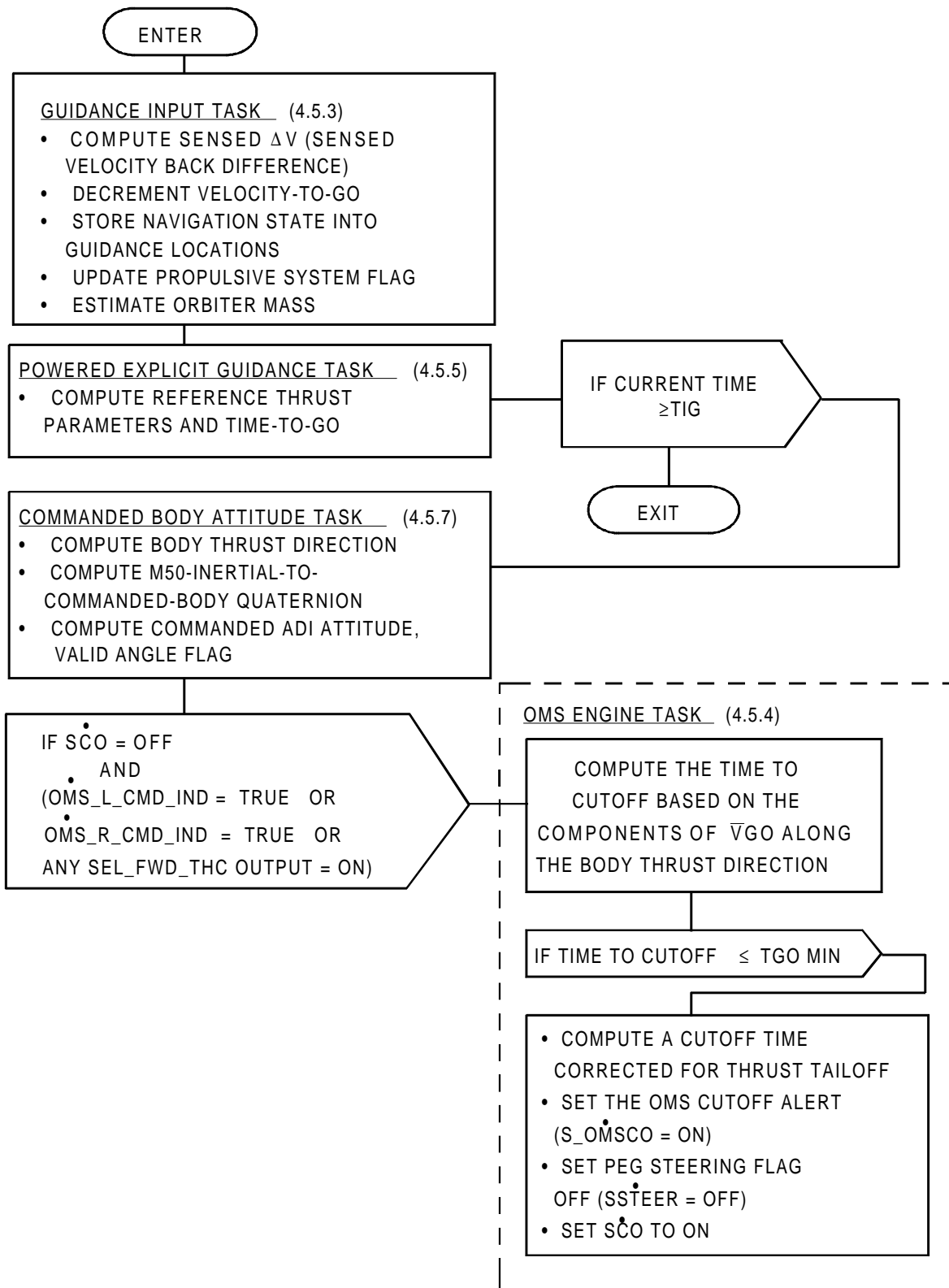
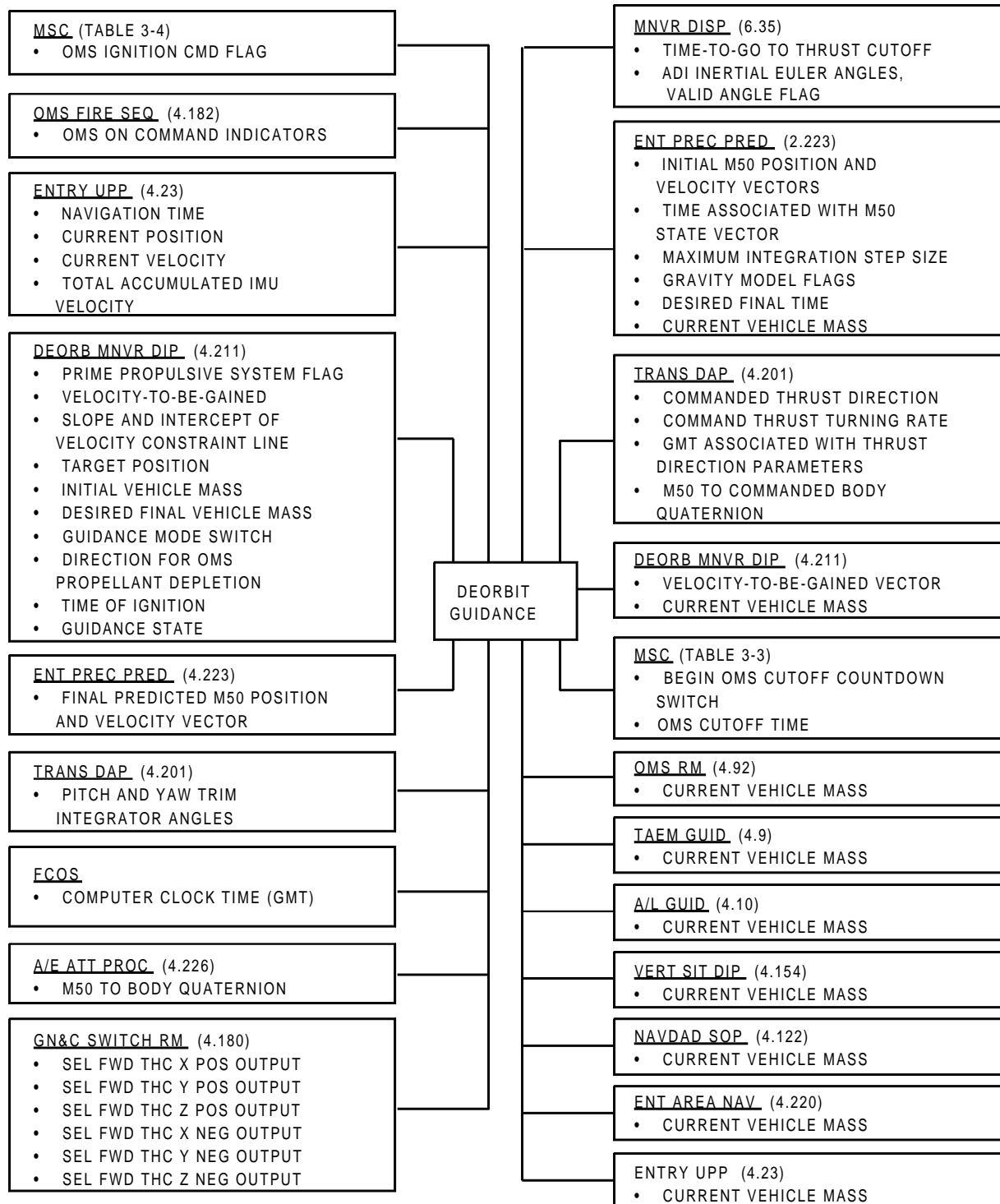


FIGURE 4.5.1-2. Deorbit Guidance Principal Function Functional Flow



NOTE: LEVEL B CPDS SS-P-0002-510 PRINCIPAL FUNCTION NUMBERS ARE SHOWN IN PARENTHESES.

FIGURE 4.5.1-3. Deorbit Guidance Data Flow



#### 4.5.2 Deorbit Guidance Sequencing

The correct sequencing of some of the tasks defined in the Deorbit Guidance principal function are dependent on the occurrence of specific events. These events are identified in the Level B CPDS SS-P-0002-510. The tasks to be sequenced are:

1. Guidance input task (GUID INP TSK, 4.5.3)
2. Powered explicit guidance task (PEG TSK, 4.5.5)
3. Commanded body attitude task (CMD BDY ATT TSK, 4.5.7)
4. OMS engine task (OMS TSK, 4.5.4)

The guidance input task is performed on every guidance pass, followed by the powered explicit guidance task, commanded body attitude task, and the OMS engine task.

The following detailed sequencing requirements are performed in the following order every 0.96 second.

1. The guidance input task is initiated when Deorbit Guidance is initiated and is terminated when Deorbit Guidance is terminated.
2. The powered explicit guidance task is initiated when Deorbit Guidance is initiated and is terminated when Deorbit Guidance is terminated.
3. The commanded body attitude task is initiated at time of ignition (TIG) and terminated when Deorbit Guidance is terminated.
4. The OMS engine task is initiated at ignition (OMS L or R CMD IND = TRUE or any forward THC output is ON, and current time  $\geq$  TIG) and is terminated after the cutoff flag is set (SCO = ON).

A deorbit guidance subtask timeline is shown in Figure 4.5.2-1. A detailed deorbit guidance sequencing flowchart is shown in Appendix A.

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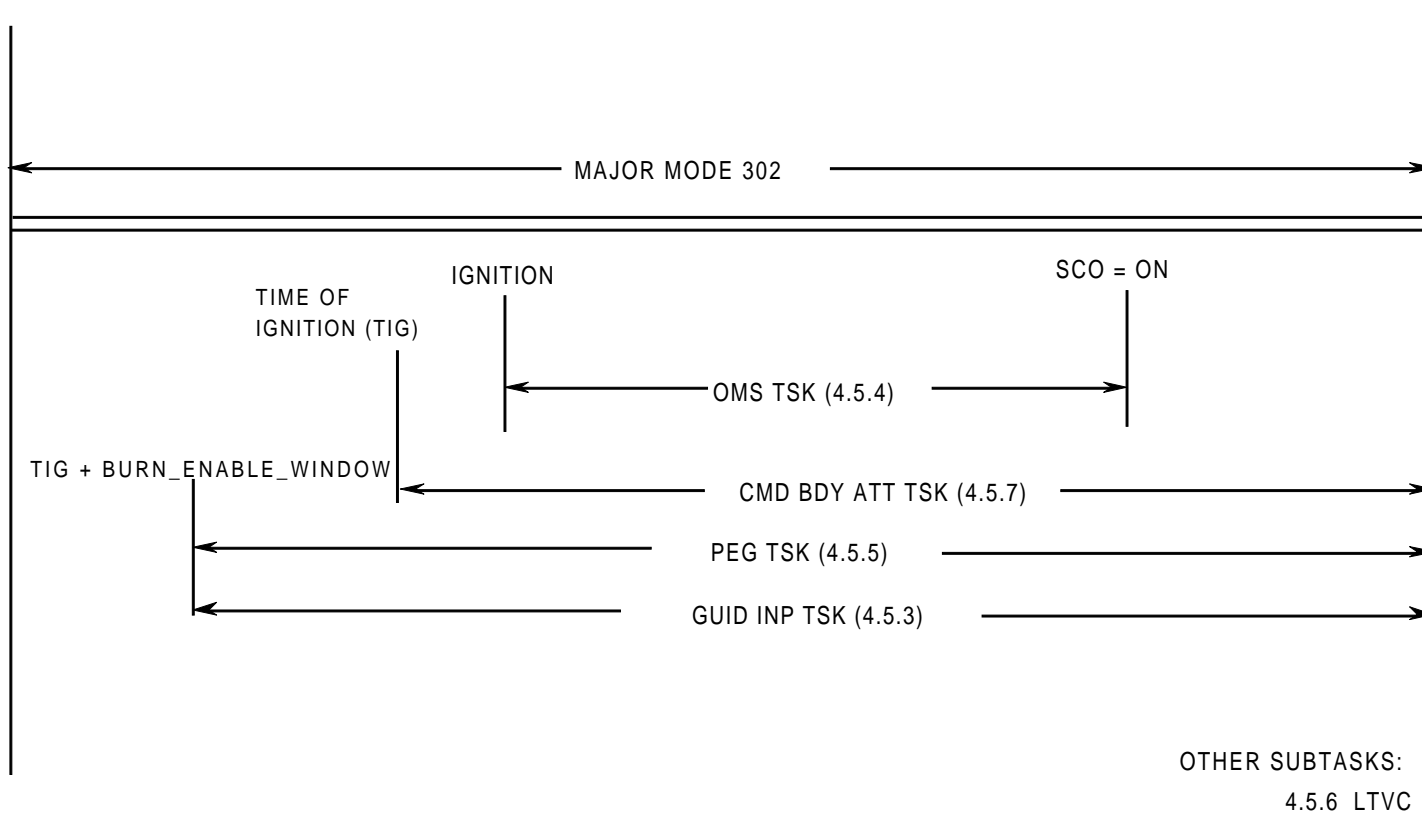


FIGURE 4.5.2-1. Deorbit Guidance Subtask Timeline

### 4.5.3 Guidance Input Task (GUID INP TSK)

The guidance input task performs the following eight functions:

1. Decrements velocity-to-go by the accumulated IMU-sensed velocity change since the last pass
2. Computes the time elapsed since the last pass
3. Stores the navigated state (position, velocity, and time) into guidance locations or propagates the ignition state to the current time conically
4. Monitors the OMS ON command indicators and updates the propulsive system flag when an engine is shut down
5. Estimates vehicle mass
6. Determines the time to compute attitude quaternion
7. Determines the propulsive system for attitude quaternion computation
8. Sets maximum integration step size for gravity prediction

#### A. Detailed Requirements.

1. The velocity-to-go is decremented by the accumulated IMU-sensed velocity change since the previous pass. To do this, the following three steps are performed.
  - a. The saved past value of the accumulated IMU-sensed velocity ( $\overline{VSP}$ ) is subtracted from the current value ( $\overline{VS}$ ) to obtain the change since the last guidance pass ( $\overline{DVS}$ ):

$$\overline{DVS} = \overline{VS} - \overline{VSP}$$

- b. Velocity-to-go ( $\overline{VGO}$ ) is decremented:

$$\overline{VGO} = \overline{VGO} - \overline{DVS}$$

After engine cutoff,  $\overline{VGO}$  becomes the velocity residual to be manually trimmed.

- c. The current value of the accumulated IMU-sensed velocity vector is saved for the next pass.

$$\overline{VSP} = \overline{VS}$$

2. The guidance time (TGD) is set equal to the current navigation time (TNAV), the elapsed time since the last pass (DTGD) is computed, and the current time is saved for the next pass (TGDP):

$$TGD = TNAV$$

$$DTGD = TGD - TGDP$$

$$TGDP = TGD$$

3. The guidance position and velocity vectors are updated, in one of two ways, as follows:

Prior to ignition ( $TGD \leq TIG$ ) or if  $FIRST\_PASS\_FLAG = ON$ , the guidance position ( $\overline{RGD}$ ) and velocity ( $\overline{VGD}$ ) are set equal to the current navigation position and velocity:

$$\overline{RGD} = \overline{RNAV}$$

$$\overline{VGD} = \overline{VNAV}$$

Reset the  $FIRST\_PASS\_FLAG$  if it is ON.

The conic state propagation method used after ignition must have an initial value for the central body gravity acceleration. It is computed as follows:

$$\overline{GCB} = -EARTH\_MU \overline{RGD} / [ABVAL(\overline{RGD})^3]$$

After ignition ( $TGD > TIG$ ), the guidance state is propagated conically to prevent compensating for oblate effects twice—once in the offset target values and once in the integration of the actual state. This propagation is as follows.

- a.  $\overline{RGD}$  is propagated through time interval  $DTGD$ , based on an average velocity value calculated from the current sensed velocity increment ( $\overline{DVS}$ ) and the central body gravitational acceleration ( $\overline{GCB}$ ).

$$\overline{RGD} = \overline{RGD} + DTGD [\overline{VGD} + 0.5 (\overline{DVS} + \overline{GCB} DTGD)]$$

- b. The new central body gravitational acceleration ( $\overline{GCB\_NEW}$ ) is computed:

$$\overline{GCB\_NEW} = -EARTH\_MU \overline{RGD} / [ABVAL(\overline{RGD})^3]$$

- c.  $\overline{VGD}$  is propagated through the time interval  $DTGD$  considering the current sensed velocity increment and the average central body gravity acceleration contribution:

$$\overline{VGD} = \overline{VGD} + \overline{DVS} + 0.5 (\overline{GCB} + \overline{GCB\_NEW}) DTGD$$

- d.  $\overline{GCB}$  is stored for the next pass:

$$\overline{GCB} = \overline{GCB\_NEW}$$

4. If OMS ignition has been commanded, the OMS engine ON command indicators are monitored and the current propulsive system flag ( $PROP\_FLAG$ ) is updated when an engine is shut down. A flag that indicates which propulsion system (left OMS, right OMS, both OMS, or +X RCS) is active ( $PROP\_FLAG\_OFS$ ) must also be set to determine the thrust direction in body coordinates for subsequent commanded body attitude calculations:

If  $OMS\_IGNITION\_CMD = ON$ , then

If  $OMS\_L\_ON\_CMD\_IND = ON$  and  $OMS\_R\_ON\_CMD\_IND = OFF$ , then

$$PROP\_FLAG = 2 \text{ and } PROP\_FLAG\_OFS = 2$$

If  $OMS\_L\_ON\_CMD\_IND = OFF$  and  $OMS\_R\_ON\_CMD\_IND = ON$ , then

$$\text{PROP\_FLAG} = 2 \text{ and } \text{PROP\_FLAG\_OFS} = 3$$

If  $\text{OMS\_}\dot{\text{L}}\text{\_ON\_CMD\_IND} = \text{OFF}$  and  $\text{OMS\_}\dot{\text{R}}\text{\_ON\_CMD\_IND} = \text{OFF}$ , then

$$\text{PROP\_FLAG} = 3 \text{ and } \text{PROP\_FLAG\_OFS} = 4$$

where  $\text{OMS\_}\dot{\text{L}}\text{\_ON\_CMD\_IND}$  and  $\text{OMS\_}\dot{\text{R}}\text{\_ON\_CMD\_IND}$  are discretely set to ON in the OMS FIRE SEQ principal function when the left or right OMS engines, respectively, are commanded to fire. Propulsive system flag values and the corresponding propulsive system configuration assumed are:

$\text{PROP\_FLAG} = 1$	2 OMS
$\text{PROP\_FLAG} = 2$	1 OMS
$\text{PROP\_FLAG} = 3$	4 +X ACC RCS

- Beginning at the time of ignition (TIG), the current orbiter mass is estimated based on the exhaust velocity of the current propulsive system ( $\text{VEX}_{\text{PROP\_FLAG}}$ ), indicated by PROP\_FLAG, and the change in sensed velocity, as follows:

$$M = M \text{ EXP}(-\text{ABVAL}(\overline{\text{DVS}})/\text{VEX}_{\text{PROP\_FLAG}})$$

where the initial mass is obtained from the DEORB MNVR DIP principal function.

- Set the time to compute the commanded body attitude quaternion ( $\text{Q\_CB\_M50}$ ) equal to the current time:

$$\text{T\_CA} = \text{T\_GMT}$$

- The maximum integration step size ( $\text{DT\_LIMIT}$ ) for the gravity prediction in PEG is set:

$$\text{DT\_LIMIT} = \text{DTMAX}$$

B. Interface Requirements. The input and output parameters for the guidance input task are given in Tables 4.5.3-1 and 4.5.3-2. A detailed flowchart for GUID INP TSK is illustrated in Appendix A.

C. Processing Requirements. The guidance input task is performed prior to any other guidance task every 0.96 seconds from Deorbit Guidance initiation to Deorbit Guidance termination.

D. Initialization Requirements. The following values must be initialized:

$$\overline{\text{VSP}} = \overline{\text{VS}}$$

$$\text{TGDP} = \text{TNAV}$$

$$\text{NMAX} = \text{N\_MAX}$$

$$\text{T\_CUTOFF} = 0$$

PROP\_FLAG = PROP\_FLAG\_GUID

O $\dot{M}$ S\_IGNITION\_CMD = OFF

The following values must be initialized the first time this task is executed following a load:

1. NMAX = N\_MAX, T\_CUTOFF = 0, S $\dot{C}$ O = OFF, PROP\_FLAG = PROP\_FLAG\_GUID, O $\dot{M}$ S\_IGNITION\_CMD = OFF.
2. For guidance time (TGD) greater than time of ignition (TIG)

TGDP = TGD

G $\bar{C}$ B = -EARTH\_MU R $\bar{G}$ D/(ABVAL(R $\bar{G}$ D))<sup>3</sup>

For TGD ≤ TIG

TGDP = TNAV

V $\bar{S}$ P =  $\bar{V}$ S

FIRST\_PASS\_FLAG = ON

E. Supplemental Information. The variable V $\bar{G}$ D must be represented in such a manner that the least significant bit for each component is less than 0.005 ft/sec.

Table 4.5.3-1. Guidance Input Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V94L3804CB thru V94L3806CB	V $\bar{G}$ O	Velocity vector of external delta-V guidance target in M50 coordinates	PRE-MAN DISP SUPT TSK, PEG TSK	SP	ft/s
V95H0185CF thru V95H0187CF	R $\bar{N}$ AV	Position vector in M50 coordinates	ENTRY UPP	DP	ft
V95L0190CF thru V95L0192CF	V $\bar{N}$ AV	Velocity vector in M50 coordinates	ENTRY UPP	SP	ft/s
V95L0210CB thru V95L0212CB	V $\bar{S}$	Total accumulated IMU velocity vector in M50 coordinates	ENTRY UPP	DP	ft/s
V95W0200CF	TNAV	Time associated with R $\bar{N}$ AV, V $\bar{N}$ AV, V $\bar{S}$	ENTRY UPP	DP	s
V90U1961CJ	M	Orbiter mass	PRE-MAN DISP SUPT TSK	SP	slugs
V97U4445C	N_MAX	Maximum number of iterations	K-LOAD	N/A	I

Table 4.5.3-1. Guidance Input Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V94X3962XB	PROP_FLAG_GUID	Prime propulsion system indicator for guidance use	PRE-MAN DISP SUPT TSK	N/A	I
V97U5114C	VEX <sub>1</sub>	Nominal effective exhaust velocity for maneuver with 2 OMS engines	K-LOAD	SP	ft/s
V97U5115C	VEX <sub>2</sub>	Nominal effective exhaust velocity for maneuver with 1 OMS engine	K-LOAD	SP	ft/s
V97U5116C	VEX <sub>3</sub>	Nominal effective exhaust velocity for maneuver with RCS engines	K-LOAD	SP	ft/s
V94W3790CC	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V97U4378C	EARTH_MU	Earth's gravitational constant	CONSTANT	SP	ft <sup>3</sup> /s <sup>2</sup>
V91W5000C	T_GMT	CLOCK_COMPUTER(GMT)	FCOS	DP	s
V97U4369C	DTMAX	Maximum integration step size	K-LOAD	SP	s
V90X8271X	OMS_L_ÖN_CMD_IND	Left OMS ON command indicator	OMS FIRE SEQ	N/A	D
V90X8272X	OMS_R_ÖN_CMD_IND	Right OMS ON command indicator	OMS FIRE SEQ	N/A	D
V90X8190X	ÖMS_IGNITION_CMD	OMS ignition command flag	MSC	N/A	D
V94H3938C	TGD	Time associated with $\overline{RGD}$ , $\overline{VGD}$	PRE-MAN DISP SUPT TSK	DP	s
V94H3930CB V94H3931CB V94H3932CB	$\overline{RGD}$	Vehicle position vector input to PEG	PRE-MAN DISP SUPT TSK	DP	ft
V94H3935CB V94H3936CB V94H3937CB	$\overline{VGD}$	Vehicle velocity vector input to PEG	PRE-MAN DISP SUPT TSK	SP	ft/s
V94H3940CB V94H3941CB V94H2942CB	$\overline{VSP}$	Previous value of accumulated sensed velocity vector	PRE-MAN DISP SUPT TSK	DP	ft/s



Table 4.5.3-2. Guidance Input Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90U1202C thru V90U1204C	$\overline{VGO}$	Velocity to-be-gained vector in M50 coordinates	PEG TSK, VGO DISP TSK	SP	ft/s
V94H3930CB thru V94H3932CB	$\overline{RGD}$	Vehicle position vector in M50 coordinates	PEG TSK, CMD BDY ATT TSK	DP	ft
V94H3935CB thru V94H3937CB	$\overline{VGD}$	Vehicle velocity vector in M50 coordinates	PEG TSK, CMD BDY ATT TSK	SP	ft/s
V94W3938CB	TGD	Time associated with $\overline{RGD}$ and $\overline{VGD}$	PEG TSK, OMS TSK	DP	s
	DTGD	Elapsed time since last guidance pass	TGO DISP TSK	SP	s
	PROP_FLAG	Propulsive system indicator	PEG TSK, OMS TSK	N/A	I
V90U1961CC	M	Current vehicle mass	PEG TSK, OMS RM, TAEM GUID, A/L GUID, AREA NAV, NAVDAD SOP, VGO DISP TSK, VERT SIT DIP	SP	slugs
V94J3791C	NMAX	Maximum number of iterations	PEG TSK	N/A	I
	PROP_FLAG_ OFS	Prime propulsive system flag	CMD BDY ATT TSK	N/A	I
	T_CA	GMT to compute commanded body attitude	CMD BDY ATT TSK	DP	s
	DT_LIMIT	Maximum integration step size for gravity prediction	PEG TSK	SP	s
	T_CUTOFF	Time of cutoff	OMS TSK	DP	s
	$\dot{SCO}$	Cutoff flag	OMS TSK	N/A	D

#### 4.5.4 OMS Engine Task (OMS TSK)

The OMS engine task computes the OMS engine cutoff time and sets the switch to initiate the engine cutoff sequence.

##### A. Detailed Requirements.

1. Compute the time to cutoff (TGO\_CUTOFF) by first transforming the thrust body vector computed in the commanded body attitude task from body coordinates using the Q\_B\_I quaternion. TGO\_CUTOFF is then computed using the component of  $\overline{VGO}$  along this M50 thrust direction, TGO, and the magnitude of  $\overline{VGO}$ .

CALL QUAT\_XFORM

Inputs:  $(-Q_{B_I_S}, Q_{\overline{B_I_V}}, \overline{THRUST\_BODY})$

Outputs:  $(\overline{THRUST\_M50})$

$TGO\_CUTOFF = TGO (\overline{THRUST\_M50} \cdot \overline{VGO}) / ABVAL(\overline{VGO})$

2. If time to cutoff (TGO\_CUTOFF) is less than or equal to TGO\_MIN, then a cutoff time corrected for thrust tailoff is computed, the OMS cutoff alert is set, the PEG steering flag is turned off, and the cutoff flag is set.

If  $TGO\_CUTOFF \leq TGO\_MIN$ ,

$T\_CUTOFF = TGD + TGO\_CUTOFF - TCO\_BIAS$

$S\_O\dot{M}SCO = ON$

$S\dot{S}TEER = OFF$

$S\dot{C}O = ON$

B. Interface Requirements. The input and output parameters for the OMS engine task are given in Tables 4.5.4-1 and 4.5.4-2. A detailed flowchart for OMS TSK is illustrated in Appendix A.

C. Processing Requirements. The OMS engine task is performed after the guidance task every 0.96 second from ignition (OMS L or R CMD IND = TRUE or any forward THC output is ON, and current time  $\geq$  TIG) until  $S\dot{C}O = ON$ .

D. Initialization Requirements. The following value must be initialized:

$S\_O\dot{M}SCO = OFF$

Table 4.5.4-1.OMS Engine Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V94W3938CB	TGD	Current guidance time	GUID INP TSK	DP	s
	TGO	Time-to-go until thrust termination	PEG TSK	SP	s
V97U4665C	TGO_MIN	Value of TGO_CUTOFF when steering outputs are inhibited	K-LOAD	SP	s
V97U4662C	TCO_BIAS	Bias for OMS thrust tailoff	K-LOAD	SP	s
V90U2240CA thru V90U2243CA	Q_B_I_S, Q_B_I_V	M50-to-measured-body quaternion	A/E ATT PROC	SP	none
	THRUST_BODY	Unit engine thrust direction in body coordinates	CMD BDY ATT TSK	SP	none
V90U1202C thru V90U1204C	VGO	M50 velocity-to-be-gained vector	PEG TSK	SP	ft/s
	S $\dot{C}$ O	Cutoff flag	GUID INP TSK	N/A	D

Table 4.5.4-2.OMS Engine Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90X2035XB	S_O $\dot{M}$ SCO	Switch indicating countdown to engine cutoff should begin	MSC, TLM	N/A	D
V90W2034CB	T_CUTOFF	OMS cutoff time	MSC	DP	s
V90W1941CD	TGO	Time-to-go until thrust termination	MNVR DISP, TGO DISP TSK, TLM	SP	s
	S $\dot{S}$ TEER	Steering enable flag	PEG TSK	N/A	D

#### 4.5.5 Powered Explicit Guidance Task (PEG TSK)

The powered explicit guidance (PEG) task computes the reference thrust vector, reference thrust turning rate vector, a corresponding reference time, and time-to-go until thrust termination for the explicitly guided Shuttle deorbit maneuver. The PEG task consists of two guidance modes that are designed to satisfy all currently defined Shuttle powered flight maneuver guidance requirements for the deorbit mission phase. These modes are defined as follows:

- Linear terminal velocity constraint. This mode constrains the cutoff velocity such that the subsequent coasting trajectory passes through a specified target position vector with a specified linear relationship between the vertical and horizontal components of velocity at the target. The target conditions are the end-of-coast target position vector and the intercept and slope constants defining the target velocity constraint line. This is the mode normally used for the deorbit maneuver.
- External delta-V. This mode is designed to guide the vehicle through a constant desired thrust attitude maneuver that achieves a specified velocity change. The targeting for this mode is performed externally. The guidance input is a desired inertial velocity-to-be gained vector. No corrections are made for misses in desired terminal conditions at entry interface. This mode is used only for a contingency deorbit.

The calculations necessary for linear terminal velocity constraint guidance are divided into several subtasks (numbered 3 through 9) and are presented in the correct order of solution. Due to the simplicity of external delta-V guidance, these calculations are partitioned into a single separate subfunction. An estimated acceleration is required prior to solving either algorithm. This quantity is computed in Item 1.

##### A. Detailed Requirements.

1. Current acceleration subtask. The current estimated acceleration is required to be input to both the linear terminal velocity constraint and external delta-V guidance algorithms. It is computed as a function of the nominal thrust of the current propulsive system ( $FT_{PROP\_FLAG}$ ) and the current orbiter mass (M):

$$ATR = FT_{PROP\_FLAG}/M$$

2. External delta-V subtask. The purpose of the external delta-V subtask is to solve the guidance problem for guided Shuttle maneuvers when the PEG external delta-V mode is specified. The equations necessary to provide this PEG mode are also contained in the other subtask descriptions of this section but are presented separately for clarity.

The magnitude of the velocity-to-be gained ( $\overline{VGO}$ ) is calculated.

$$VGOMAG = ABVAL(\overline{VGO})$$

The value of VGOMAG is tested for a zero value. If VGOMAG is zero, then PEG is to be exited.

The time-to-go parameter (TGO) is calculated as a function of the effective exhaust velocity (VEX) for the propulsive system indicated by PROP\_FLAG, the current estimated acceleration (ATR), and VGOMAG.

$$VRATIO = VGOMAG / (6 VEX_{PROP\_FLAG})$$

$$TGO = VGOMAG / (ATR (1 + 3 VRATIO + 3 VRATIO^2))$$

The guidance inputs to TRANS DAP are updated. These inputs are the desired thrust vector (L $\bar{A}MC$ ), the desired thrust vector rate (L $\bar{A}MDC$ ), and the time to which these vectors are referenced (TLAMC). The parameters L $\bar{A}MDC$  and TLAMC are initialized to zero and never updated. The parameter L $\bar{A}MC$  is calculated as follows:

$$L\bar{A}MC = \bar{V}GO / VGOMAG$$

3. Time-to-go subtask. The purpose of this subtask is to calculate the total time-to-go until engine cutoff, TGO. The time-to-go parameter is a function of the current magnitude of the velocity-to-be-gained (VGOMAG), the effective exhaust velocity (VEX) of the thrusting engines (indicated by PROP\_FLAG), and the current estimated acceleration (ATR).

The updated magnitude of velocity-to-go (VGOMAG) is first calculated.

$$VGOMAG = ABVAL(\bar{V}GO)$$

The value of VGOMAG is tested for a zero value. If VGOMAG is zero, then PEG is to be exited. Otherwise, the calculations for time-to-go are as follows:

- a. An updated value of time-to-go is then calculated:

$$VRATIO = VGOMAG / (6 VEX_{PROP\_FLAG})$$

$$TGO = VGOMAG / (ATR(1 + 3 VRATIO + 3 VRATIO^2))$$

- b. The predicted time of engine cutoff is calculated:

$$TP = TGD + TGO$$

4. Thrust integral subtask. The purpose of this subtask is to evaluate various time integrals of force over mass, with a constant force magnitude assumed. These integrals are necessary to the prediction equations of PEG. The values of VRATIO, magnitude of velocity-to-go (VGOMAG), and time-to-go (TGO) are required to calculate the value of these integrals.

$$JOL = 0.5 TGO (1 + VRATIO)$$

$$S = 0.5 VGOMAG TGO (1 - VRATIO)$$

$$QPRIME = -VGOMAG TGO^2 / 12$$

5. Reference thrust vectors subtask. The purpose of this subtask is to determine the reference thrust vectors  $\bar{L}AM$  and  $\bar{L}AMD$ .  $\bar{L}AM$  is a unit vector in the direction of velocity-to-be-gained,  $\bar{V}GO$ , which has been defined previously.  $\bar{L}AMD$  is the desired thrust vector turning rate.  $\bar{L}AM$  and  $\bar{L}AMD$  are calculated as follows:

$$\bar{L}AM = \bar{V}GO / \bar{V}GOMAG$$

$$\bar{L}AMD = LAMDZX (\bar{L}AM \times \bar{I}Y)$$

LAMDZX is the component of the unit thrust vector turning rate in the desired target plane and is computed during initialization only.  $\bar{I}Y$  is the unit vector normal to the predicted cutoff plane and is computed in the velocity-to-be-gained subtask from the previous pass.

6. Burnout state vector prediction subtask. This subtask calculates the predicted burnout position ( $\bar{R}P$ ) and burnout velocity,  $\bar{V}P$ . Noncentral body forces are accounted for in this prediction.

Since burnout position is not constrained, the value of range-to-be-gained can be calculated from previously defined parameters as:

$$\bar{R}GO = (\bar{L}AMD)(QPRIME) + (S) (\bar{L}AM)$$

The gravity integrals are calculated as follows: The ENT PREC PRED uses the input state values  $\bar{R}C1$ ,  $\bar{V}C1$ , and TGD along with TP and DTAVG and outputs the extrapolated values of  $\bar{R}C2$  and  $\bar{V}C2$  (position and velocity vectors). Since the noncentral body forces effect for both the powered flight and the coasting flight is already compensated for by the offset entry target position ( $\bar{R}T$ ) and linear terminal velocity constraint intercept constant (C1), the call to the ENT PREC PRED is performed with the gravity model degree and order flags (GMD\_PRED, GMO\_PRED) set to zero to indicate that the noncentral body forces are not to be included in the prediction.

The details of this requirement are contained in the following paragraphs, which denote the calculations for determining ENT PREC PRED input. The initial state vector input to the ENT PREC PRED routing is a function of the current guidance state vectors ( $\bar{R}GD$  and  $\bar{V}GD$ ), the range-to-be-gained ( $\bar{R}GO$ ), the velocity-to-be-gained ( $\bar{V}GO$ ), and time-to-go (TGO):

$$\bar{R}C1 = \bar{R}GD - (\bar{R}GO/10) - (\bar{V}GO)(TGO)/30$$

$$\bar{V}C1 = \bar{V}GD + (6/5)(\bar{R}GO/TGO) - (\bar{V}GO/10)$$

Because of the possible variance in total time over which to integrate (TGO), the integration step size must be bounded between a maximum time increment (DT\_LIMIT) and a minimum time increment (DTMIN). The nominal value of this time increment will be calculated as (TGO/NSEG), where NSEG is the number of intervals desired. The time interval step size is determined as the middle value of the three as:

$$DTAVG = MIDVAL(DT\_LIMIT, TGO/NSEG, DTMIN)$$

The values of GMO\_PRED and GMD\_PRED must be set to zero to denote that the noncentral body forces are not included in the extrapolation.

$$\text{GMO\_PRED} = 0$$

$$\text{GMD\_PRED} = 0$$

The ENT PREC PRED routine is then called to extrapolate the input state ( $\overline{\text{RC}}1$ ,  $\overline{\text{VC}}1$ ) from current time (TGD) to the predicted nominal cutoff time (TP), which is computed in the time-to-go subtask.

$$\text{T\_INIT} = \text{TGD}$$

$$\text{T\_FINAL} = \text{TP}$$

$$\overline{\text{R}}\_INIT = \overline{\text{RC}}1$$

$$\overline{\text{V}}\_INIT = \overline{\text{VC}}1$$

$$\text{DT\_MAX} = \text{DTAVG}$$

$$\text{CALL ENT PREC PRED}$$

$$\overline{\text{RC}}2 = \overline{\text{R}}\_FINAL$$

$$\overline{\text{VC}}2 = \overline{\text{V}}\_FINAL$$

After the final extrapolated position ( $\overline{\text{RC}}2 = \overline{\text{R}}\_FINAL$ ) and velocity vectors ( $\overline{\text{VC}}2 = \overline{\text{V}}\_FINAL$ ) are obtained, the first and second gravity integrals may then be evaluated. The following equations are, by definition, the gravity integrals over a coasting trajectory and represent the requirements for gravity estimation.

$$\overline{\text{V}}\text{GRAV} = \overline{\text{VC}}2 - \overline{\text{VC}}1$$

$$\overline{\text{R}}\text{GRAV} = \overline{\text{RC}}2 - \overline{\text{RC}}1 - (\overline{\text{VC}}1)(\text{TGO})$$

The predicted burnout position can now be calculated as:

$$\overline{\text{RP}} = \overline{\text{RGD}} + (\overline{\text{VGD}})(\text{TGO}) + \overline{\text{RGRAV}} + \overline{\text{RGO}}$$

The predicted burnout velocity is similarly calculated as:

$$\overline{\text{VP}} = \overline{\text{VGD}} + \overline{\text{VGRAV}} + \overline{\text{VGO}}$$

7. Velocity-to-be-gained subtask. The velocity-to-be-gained subtask employs the linear terminal velocity constraint task (see Subsection 4.5.6) to obtain the required velocity ( $\overline{\text{VD}}$ ) at an initial position to intercept a target position such that a specified linear relationship between the terminal vertical and horizontal velocity components is satisfied; that is,

$$\text{V}_{\text{VERTICAL}} = \text{C1} + \text{C2 V}_{\text{HORIZONTAL}}$$

The initial position input to the linear terminal velocity constraint function is the desired cutoff position. This required velocity is then used to compute a velocity miss ( $\overline{VMISS}$ ) as the difference between predicted cutoff velocity ( $\overline{VP}$ ) and the required velocity ( $\overline{VD}$ ). This velocity miss is then used to compute a new velocity-to-be-gained ( $\overline{VGO}$ ).

The deorbit maneuver requires the target position vector to be in the predicted cutoff plane. The target position vector ( $\overline{RT}$ ) is projected into the predicted cutoff plane by the following equation:

$$\begin{aligned}\overline{IY} &= \text{UNIT}(\overline{VP} \times \overline{RP}) \\ \overline{RT} &= \overline{RT} - (\overline{RT} \cdot \overline{IY}) \overline{IY}\end{aligned}$$

The target position vector is defined at entry interface. Therefore, the vector must be adjusted in magnitude to be consistent with the desired geodetic altitude, HEI, at entry interface. This will be accomplished by the following equations:

$$\begin{aligned}\text{RTMAG} &= \text{ABVAL}(\overline{RT}) \\ \overline{RT} &= (\text{RTMAG} - \text{H\_ELLIPSOID}(\overline{RT}) + \text{HEI})\overline{RT}/\text{RTMAG}\end{aligned}$$

where H\_ELLIPSOID denotes a navigation software function for determining the altitude above the Fischer ellipsoid of the argument vector,  $\overline{RT}$  (see part E, Supplemental Information).

At this point, the PEG task is required to execute the linear terminal velocity constraint (LTVC) task. Inputs to the LTVC task are as follows:

C1	Intercept of target velocity constraint line
C2	Slope of target velocity constraint line
$\overline{RP}$	Predicted thrust cutoff inertial position vector
$\overline{RT}$	Target inertial position vector
$\overline{IY}$	Negative of desired unit angular momentum vector

Outputs of LTVC TSK are as follows:

THETA	Transfer angle from predicted thrust cutoff to entry interface target
$\overline{VD}$	Desired thrust cutoff inertial velocity vector
FLAG	Guidance Error Indicator Flag

If the value of the guidance error indicator flag is nonzero, then an error occurred in the LTVC task and, hence, the PEG task must be exited. Otherwise, the remaining PEG task requirements are to be completed.

The time required to traverse the transfer angle must be computed as:

$$\text{DTCOAST} = \text{THETA}/\text{THETA\_DOT}$$



A scalar damping factor, RHOMAG, is required in the computation of  $\overline{VGO}$ . It is computed by the equation:

$$RHOMAG = 1/[1 + 0.75 TGO/(DTCOAST)]$$

The velocity miss vector is computed as the difference between the predicted and required velocities:

$$\overline{VMISS} = \overline{VP} - \overline{VD}$$

The velocity-to-be-gained vector ( $\overline{VGO}$ ) is corrected as follows:

$$\overline{VGO} = \overline{VGO} - (RHOMAG) (\overline{VMISS})$$

8. Velocity-to-be-gained fuel depletion correction subtask. The purpose of this subtask is to correct the magnitude of the velocity-to-be-gained vector to the desired velocity-to-be-gained for depleting excess OMS propellant. The correction is performed in an out-of-plane direction specified by an input flag, SFUELD (-1, 0, or +1).

Compute the in-plane velocity-to-be-gained vector:

$$\overline{VGIP} = \overline{VGO} - (\overline{VGO} \cdot \overline{IY}) \overline{IY}$$

$$\overline{VGO} = \overline{VGIP}$$

If SFUELD is nonzero, then the following is performed:

- a. Compute the required velocity to deplete excess OMS propellant, based on current vehicle mass (M) and the desired vehicle burnout mass (MBO), provided M is greater than MBO

$$VGOD = VEX_{PROP\_FLAG} (\text{LOG}(M/MBO))$$

However, if  $M \leq MBO$ , then  $VGOD = 0$

- b. Compute the square of the magnitude of the desired out-of plane velocity component:

$$VGOYS = VGOD^2 - \overline{VGIP} \cdot \overline{VGIP}$$

- c. If VGOYS is greater than zero, then correct  $\overline{VGO}$  as follows:

$$\overline{VGO} = \overline{VGIP} - (SFUELD) \text{SQRT}(VGOYS) \overline{IY}$$

9. Convergence check subtask. The purpose of this subtask is to test if the VGO is converged and to set a flag (SCONV) based on the outcome of this test. This is accomplished by the following steps:

- a. Compute the magnitude of  $\overline{VGO}$ :

$$VGOMAG = \text{ABVAL}(\overline{VGO})$$

- b. Determine whether or not  $\overline{VGO}$  is converged. If  $ABVAL(\overline{VMISS}) \leq (KMISS)$  ( $VGOMAG$ ), then the guidance convergence switch ( $SC\dot{O}NV$ ) is set to ON. If the steering enable flag is on ( $S\dot{S}TEER = ON$ ), then the commanded thrust parameters are set equal to the reference thrust parameters calculated previously, and the corresponding reference time is calculated. These reference parameters are input to the TRANS DAP.

$$\overline{LAMC} = \overline{LAM}$$

$$\overline{LAMDC} = \overline{LAMD}$$

$$TLAMC = TGD + JOL$$

Otherwise ( $|\overline{VMISS}| > K_{MISS} VGOMAG$ ),  $SC\dot{O}NV$  is set to OFF.  $K_{MISS}$  is a predetermined constant multiplier term.

B. Interface Requirements. The input and output parameters for the PEG task guidance task are given in Tables 4.5.5-1 and 4.5.5-2. The detailed flow for LTVC PEG Subtask is illustrated in Appendix A.

C. Processing Requirements. For external delta-V guidance ( $LTVC\dot{M}ODE = OFF$ ), only the first two subtasks must be processed each time PEG TSK is called. For linear terminal velocity constraint guidance ( $LTVC\dot{M}ODE = ON$ ), Subtasks 1 and 3 through 9 must be executed iteratively until either the PEG convergence criteria are satisfied ( $SC\dot{O}NV = ON$ ), as determined by the convergence check subtask, or the maximum number of iterations allowed ( $NMAX$ ) is exceeded without satisfying the convergence criteria, in which case PEG is exited.

D. Initialization Requirements. The following paragraphs specify the initialization requirements for both the external delta-V and the linear terminal velocity constraint modes.

The following parameters must be initialized for external delta-V.

$\overline{LAMDC} = 0$ , set desired thrust vector turning rate for external delta-V to zero

$TLAMC = 0$ , set reference thrust vector time to zero

$SC\dot{O}NV = ON$ , set convergence discrete to ON

The following parameters are required to be initialized as indicated for linear terminal velocity constraint guidance mode.

$\overline{RP} = \overline{RGD}$ , set predicted burnout position to current position

$\overline{VP} = \overline{VGD}$ , set predicted burnout velocity to current velocity

$TP = TGD$ , set predicted burnout time to current time

Calculate the component of unit thrust vector turning rate in the desired target plane as a fraction (K\_LAMDXZ) of the orbital turning rate

$$\text{THETA\_DOT} = \text{SQRT}(\text{EARTH\_MU}/\text{ABVAL}(\overline{\text{RGD}})^3)$$

$$\text{LAMDXZ} = \text{THETA\_DOT} \text{ KLAMDXZ}$$

TGO = 0, set time-to-go to 0.0

HEI = H\_ELLIPSOID( $\overline{\text{RT}}$ ), calculate geodetic target altitude

$\overline{\text{VGO}} = 0$ , set velocity-to-be-gained to  $\overline{0}$

Compute initial estimate of  $\overline{\text{VGO}}$  by performing the velocity-to-be-gained subtask and then the velocity-to-be-gained for fuel depletion subtask.

E. Supplemental Information. The navigation function routine, H\_ELLIPSOID, is used by PEG and is described as follows for information only. This routine is not a part of the guidance requirements. The value for the parameter H\_ELLIPSOID is calculated as a function of the input argument vector,  $\overline{\text{RT}}$ :

$$\text{H\_ELLIPSOID}(\overline{\text{RT}}) = \text{ABVAL}(\overline{\text{RT}}) - \frac{(1 - \text{ELLIPT}) \text{ EARTH\_RADIUS\_EQUATOR}}{\sqrt{1 + ((1 - \text{ELLIPT})^2 - 1) (1 - (\text{UNIT}(\overline{\text{RT}}) \bullet \text{EARTH\_POLE})^2)}}$$

The parameters appearing in this equation are defined as:

ELLIPT = Earth's ellipticity constant

EARTH\_RADIUS\_EQUATOR = Earth's equatorial radius

EARTH\_POLE = Unit vector in direction of earth's axis of rotation

Table 4.5.5-1. Powered Explicit Guidance Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units/ Type
V94H3773CA	C1	Intercept of target velocity constraint line	PRE-MAN DISP SUPT TSK	SP	ft/s
V94H3774CA	C2	Slope of target velocity constraint line	PRE-MAN DISP SUPT TSK	SP	none
	DT_LIMIT	Minimum integration time step for state prediction	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	s
V97U4378C	EARTH_MU	Gravitational constant for earth	CONSTANT	DP	ft <sup>3</sup> /s <sup>2</sup>
	FLAG	Error indication flag	LTVC TSK	N/A	I
V97U4423C	KLAMDZX	Fraction of local orbital turning rate to be used as the PEG inplane thrust vector turning rate	I-LOAD	SP	none
V97U4831C	KMISS	Prepermission-determined decimal fraction of VGO magnitude to determine PEG convergence	K-LOAD	SP	none
V94X4094X	LTVC_MODE	Guidance mode flag = ON, linear terminal velocity constraint mode = OFF, external delta-V mode	PRE-MAN DISP SUPT TSK	N/A	D
V90U1961CD	M	Estimated vehicle mass	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	slugs
V94U4086C	MBO	Desired final mass	PRE-MAN DISP SUPT TSK	SP	slugs
	NMAX	Maximum number of iterations allowed	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
V97U4447C	NSEG	Number of integration time steps for state prediction	K-LOAD	N/A	I
V94X3962XB	PROP_FLAG	Propulsion system flag = 1, two OMS engines burn = 2, one OMS engine burn = 3, +X RCS engine burn	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
V94H3930CB thru V94H3932CB	$\bar{R}_D$	Vehicle position vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	ft
V90H3781CB thru V90H3783CV	$\bar{R}_T$	Target position vector in M50 coordinates	PRE-MAN DISP SUPT TSK	DP	ft

Table 4.5.5-1. Powered Explicit Guidance Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V94U4057C	SFUELD	Fuel wasting flag indicating if fuel wasting is desired and, if so, the out-of-plane wasting direction = 0, not desired = +1, desired in direction of angular momentum vector = -1, desired in direction opposite to angular momentum vector	PRE-MAN DISP SUPT TSK	N/A	I
V97U4370C	DTMIN	Minimum integration time step for state prediction	K-LOAD	SP	s
V94W3938CB	TGD	Time associated with $\bar{R}GD$ and $\bar{V}GD$	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	s
V97U5114C	VEX <sub>1</sub>	Total effective exhaust velocity for one OMS engine	K-LOAD	SP	ft/s
V97U5115C	VEX <sub>2</sub>	Total effective exhaust velocity for one OMS engine	K-LOAD	SP	ft/s
V97U5116C	VEX <sub>3</sub>	Total effective exhaust velocity for +X RCS engine	K-LOAD	SP	ft/s
V94H3935CB thru V94H3937CB	$\bar{V}GD$	Vehicle velocity vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
V90L2118C thru V90L2120C	$\bar{V}GO$	Velocity-to-be-gained vector in M50 coordinates	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
	$\bar{V}D$	Desired thrust cutoff velocity vector in M50 coordinates	LTVC TSK	SP	ft/s
	SSTEER	Steering enable flag	PRE-MAN DISP SUPT TSK, OMS TSK	D	none
V97U5034C	FT <sub>1</sub>	Nominal vacuum thrust for maneuver with two OMS engines	K-LOAD	SP	lbs
V97U5035C	FT <sub>2</sub>	Nominal vacuum thrust for maneuver with one OMS engine	K-LOAD	SP	lbs
V97U5036C	FT <sub>3</sub>	Nominal vacuum thrust for maneuver with four +X RCS engines	K-LOAD	SP	lbs
	THETA	Transfer angle from burnout to entry interface	LTVC TSK	DP	rad
V90H0881CA thru V90H0883CA	$\bar{R}_{FINAL}$	Predicted position vector	ENT PREC PRED	DP	ft

Table 4.5.5-1. Powered Explicit Guidance Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V90L0885CA thru V90L0887CA	$\bar{V}$ _FINAL	Predicted position vector	ENT PREC PRED	SP	ft/s

Table 4.5.5-2. Powered Explicit Guidance Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94H3773CA	C1	Intercept of target velocity constraint line	LTVC TSK	SP	ft/s
V94H3774CA	C2	Slope of target velocity constraint line	LTVC TSK	SP	none
V90U1954CD thru V90U1956CD	$\overline{L}AMC$	Unit reference commanded thrust direction vector in M50 coordinates	TRANS DAP, CMD BDY ATT TSK	SP	none
V90U1957CD thru V90U1959CD	$\overline{L}AMDC$	Reference commanded thrust direction turning rate vector in M50 coordinates	TRANS DAP, CMD BDY ATT TSK	SP	rad/s
V90W1953CD	TLAMC	GMT associated with reference commanded thrust vector $\overline{L}AMC$ and $\overline{L}AMDC$	TRANS DAP, CMD BDY ATT TSK	DP	s
	$\overline{I}Y$	Negative of the desired unit angular momentum vector in M50 coordinates	LTVC TSK	SP	none
	$\overline{R}P$	Predicted thrust cutoff position vector in M50 coordinates	LTVC TSK, PRE- MAN DISP SUPT TSK	DP	ft
V90H3781CB thru V90H3783CB	$\overline{R}T$	Target position vector in M50 coordinates	LTVC TSK	DP	ft
V90X1971XC	SCONV	Discrete indicating whether PEG is converged (ON) or not (OFF)	PRE-MAN DISP SUPT TSK, TLM	N/A	D
V90W1941CD	TGO	Time-to-go until engine cutoff	OMS TSK, MNVR DISP, TLM, PRE- MAN DISP SUPT TSK	SP	s
V90L2118C thru V90L2120C	$\overline{V}GO$	Velocity-to-be-gained vector in M50 coordinates	GUID INP TSK, VGO DISP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
	$\overline{V}D$	Desired burnout velocity vector	PRE-MAN DISP SUPT TSK	SP	ft/s
V90U8500CI	DT_MAX	Maximum integration step size	ENT PREC PRED	SP	s
V90U8501CF	GMD_PRED	Gravity model degree flag	ENT PREC PRED	N/A	I
V90U8502CF	GMO_PRED	Gravity model order flag	ENT PREC PRED	N/A	I
V90H8508CF thru V90H8510CF	$\overline{R}C1$	Initial M50 position vector coasting trajectory	PRE-MAN DISP SUPT TSK	DP	ft
V90L8513CF thru V90L8515CF	$\overline{V}C1$	Initial M50 velocity vector coasting trajectory	PRE-MAN DISP SUPT TSK	SP	ft/s

Table 4.5.5-2. Powered Explicit Guidance Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V90W8512CF	TGD	Time associated with initial coasting state vector	ENT PREC PRED	DP	s
V90W8506CF	TP	Predicted time of thrust cutoff	ENT PREC PRED, PRE-MAN DISP SUPT TSK	DP	s
V90H0881CA thru V90H0883CA	$\overline{RC}2$	Final coasting trajectory position vector excluding $J_2$ gravity effects in M50 coordinates	PRE-MAN DISP SUPT TSK	DP	ft
V90L0885CA thru V90L0887CA	$\overline{VC}2$	Final coasting trajectory velocity vector excluding $J_2$ gravity effects in M50 coordinates	PRE-MAN DISP SUPT TSK	SP	ft/s
V90W8506CI	T_FINAL	Time at which predicted state is desired	ENT PREC PRED	DP	s
V90W8512CJ	T_INIT	Time at the beginning of prediction	ENT PREC PRED	DP	s

#### 4.5.6 Linear Terminal Velocity Constraint Task (LTVC TSK)

The linear terminal velocity constraint (LTVC) task computes the conic velocity required to transfer from a predicted inertial cutoff position to an inertial target position while satisfying a linear relationship between the radial and horizontal velocity components at the target position.

A. Detailed Requirements. The parameters that describe the geometry of the desired transfer are defined and calculated as follows:

Compute the predicted thrust burnout and target position magnitudes as:

$$R0\_MAG = ABVAL(\overline{RP})$$

$$R1\_MAG = ABVAL(\overline{RT})$$

Compute the normalized delta altitude as:

$$K = (R1\_MAG - R0\_MAG)/R0\_MAG$$

Compute the transfer angle from burnout to entry interface as:

$$Z = R0\_MAG R1\_MAG - (\overline{RP} \cdot \overline{RT})$$

If Z is greater than  $(R0\_MAG R1\_MAG) EP\_TRANSFER$  then calculate the following:

$$W = ((\overline{RT} \times \overline{RP}) \cdot \overline{IY}) / Z.$$

$$THETA = PI + ARCTAN2(-2 W, 1 - W^2)$$

where W is the cotangent of half the transfer angle, theta.

The required normalized constants for the velocity calculations are computed as follows:



$$A = K (1 + W^2) + 2 (1 - C2 W)$$

$$B = C1 W$$

$$C = 2 \text{ EARTH\_MU/R1\_MAG}$$

$$D = B^2 + A C$$

If D is less than zero ( $D < 0$ ), no solution exists, and an indicator ( $\text{FLAG} = 1$ ) is set for PEG and the LTVC task is exited. Otherwise, the remaining LTVC task requirements must be completed and the PEG error indicator must be reset.

The required horizontal and radial velocity components at entry interface are computed as:

$$\text{VH1} = C/[\text{SQRT}(D) - B]$$

$$\text{VR1} = C1 + C2 \text{ VH1}$$

The desired burnout inertial velocity vector is computed as:

$$\vec{V}_D = \frac{(K W \text{ VH1} - \text{VR1}) \vec{R}_P + (1 + K) \text{ VH1} (\vec{R}_P \times \vec{I}_Y)}{R0\_MAG}$$

Reset the indicator for PEG to zero ( $\text{FLAG}=0$ ).

Otherwise, the angle between the desired thrust cutoff position vector and plane-projected target vector is small, an indicator ( $\text{FLAG} = 1$ ) is set for PEG and the LTVC task is exited.

B. Interface Requirements. The input and output parameters for the guidance internal task are given in Tables 4.5.6-1 and 4.5.6-2.

C. Processing Requirements. This task will be called as required by the PEG TSK (Section 4.5.5). All subtasks within this function are processed, when required, every cycle.

D. Initialization Requirements. None.

Table 4.5.6-1. Linear Terminal Velocity Constraint Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V94H3773CA	C1	Intercept of target velocity constraint line	PEG TSK	SP	ft/s
V94H3774CA	C2	Slope of target velocity constraint line	PEG TSK	SP	none
V97U4378C	EARTH_MU	Gravitational constant for the earth	CONSTANT	SP	ft <sup>3</sup> /s <sup>2</sup>
V96U7514C	EP_ TRANSFER	Tolerance for near zero transfer angle.	I-LOAD	SP	none
V98U8725C	PI	Ratio of circumference to diameter	CONSTANT	DP	none
	$\bar{I}Y$	Negative of the desired unit angular momentum vector in M50 coordinates	PEG TSK	SP	none
	$\bar{R}P$	Predicted thrust cutoff position vector in M50 coordinates	PEG TSK	DP	ft
V90H3781CB thru V90H3783CB	$\bar{R}T$	Target position vector in M50 coordinates	PEG TSK	DP	ft

Table 4.5.6-2. Linear Terminal Velocity Constraint Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
	FLAG	Error indicator flag	PEG TSK	N/A	I
	$\bar{V}D$	Desired thrust cutoff velocity vector in M50 coordinates	PEG TSK	SP	ft/s
	THETA	Transfer angle from burnout to entry interface	PEG TSK	DP	rad

#### 4.5.7 Commanded Body Attitude Task (CMD BDY ATT TSK)

The commanded body attitude task computes a quaternion relating body axes to the M50 coordinate system initially for use in computing a preburn attitude alignment and cyclically for use in computing attitude error for the ADI. This task also computes the desired vehicle burn attitude cyclically during the burn.

A. Detailed Requirements. An M50 inertial to commanded body quaternion is computed based upon a unit thrust vector in the body axis coordinate system ( $\overline{\text{THRUST\_BODY}}$ ), the desired thrust orientation vector ( $\overline{\text{UF}}$ ), the roll reference vector ( $\overline{\text{ROLL\_REF}}$ ), and the desired thrust vector roll angle ( $\text{TVR\_ROLL}$ ). This quaternion also serves as the reference attitude for the generation of attitude errors.

The body fixed thrust direction is assumed to remain fixed throughout a maneuver if an engine reconfiguration does not occur. Therefore, a new body fixed thrust direction must be computed if any of the following conditions occurs:

- A new target set is evaluated.
- An engine fails during the maneuver.
- Nominal cutoff of an OMS burn occurs

These conditions are satisfied each time the current propulsion system flag is set or reset.

1. If  $\text{PROP\_FLAG\_OFS} \neq \text{PROP\_FLAG\_OFS\_P}$  (i.e., the engine configuration has changed), then the body fixed thrust direction is computed as follows:
  - a. If an OMS engine configuration is to be used ( $\text{PROP\_FLAG\_OFS} < 4$ ), the  $\overline{\text{THRUST\_BODY}}$  unit vector is calculated as a function of OMS trim angles referenced to the body axis coordinate system. These OMS trim angles are related to the desired OMS trim angles through constant bias terms. These bias terms transform the desired OMS trim angles from an electrical null reference to a body axis reference.
    - (1) Compute the OMS yaw and pitch trim angles. For premaneuver calculations ( $\text{PROP\_FLAG\_OFS\_P} = 0$ ), the trim angles are input from the TRANS DAP principal function. If an engine fails during the maneuver, the trim angles are updated with K-loads for one engine:

(a) If ( $\text{PROP\_FLAG\_OFS\_P} = 0$ ), then:

$$\text{YAW\_TRIM}_1 = \text{OMS\_YAW\_TRIM}_1$$

$$\text{YAW\_TRIM}_2 = \text{OMS\_YAW\_TRIM}_2$$

$$\text{PITCH\_TRIM} = \text{OMS\_PITCH\_TRIM}$$

(b) If ( $\text{PROP\_FLAG\_OFS\_P} \neq 0$ ), then:

$$\text{YAW\_TRIM}_1 = \text{ONE\_ENG\_OMS\_YAW\_TRIM}_1$$

$$\text{YAW\_TRIM}_2 = \text{ONE\_ENG\_OMS\_YAW\_TRIM}_2$$

$$\text{PITCH\_TRIM} = \text{ONE\_ENG\_OMS\_PITCH\_TRIM}$$

- (2) Next, compute the OMS yaw body angles. The subscript (1) denotes LEFT OMS and (2) denotes RIGHT OMS.

$$\text{OMS\_YAW\_BODY}_1 = \text{YAW\_TRIM}_1 \text{ RAD\_PER\_DEG} + \text{YAW\_BIAS}$$

$$\text{OMS\_YAW\_BODY}_2 = \text{YAW\_TRIM}_2 \text{ RAD\_PER\_DEG} - \text{YAW\_BIAS}$$

- (3) Set the subscript limits (J1, J2) for the appropriate OMS system selected:

Set J1 = 1, J2 = 2.

If PROP\_FLAG\_OFS = 2, then J2 = 1 (left OMS).

If PROP\_FLAG\_OFS = 3, then J1 = 2 (right OMS).

- (4) Convert the pitch trim values to a body reference and compute the OMS thrust body vector for each OMS:

$$\text{OMS\_PITCH\_BODY} = \text{PITCH\_BIAS} - \text{PITCH\_TRIM RAD\_PER\_DEG}$$

Do for J = J1 TO J2.

$$\text{C\_YAW} = \text{COS}(\text{OMS\_YAW\_BODY}_j)$$

$$\text{THRUST\_BODY\_OMS}_j = \text{VECTOR} (\text{COS}(\text{OMS\_PITCH\_BODY}) \text{C\_YAW}, \\ \text{SIN}(\text{OMS\_YAW\_BODY}_j), \\ \text{SIN}(\text{OMS\_PITCH\_BODY}) \text{C\_YAW})$$

The resultant thrust body vectors are summed and unitized:

$$\overline{\text{THRUST\_BODY}} = \text{UNIT}((2 - \text{J1}) \text{THRUST\_BODY\_OMS}_1 + \\ (\text{J2} - 1) \text{THRUST\_BODY\_OMS}_2)$$

- b. If the +X RCS is to be the engine configuration (PROP\_FLAG\_OFS = 4), the resultant body unit thrust vector is set equal to a K-load quantity ( $\overline{\text{THRUST\_BODY\_RCS\_X}}$ ):

$$\overline{\text{THRUST\_BODY}} = \overline{\text{THRUST\_BODY\_RCS\_X}}$$

- c. After computing the body fixed thrust direction for either OMS or RCS, PROP\_FLAG\_OFS\_P must be set equal to PROP\_FLAG\_OFS

$$\text{PROP\_FLAG\_OFS\_P} = \text{PROP\_FLAG\_OFS}$$

2. The commanded unit thrust vector ( $\overline{\text{UF}}$ ) at the desired time (T\_CA) is calculated from the  $\overline{\text{LAMC}}$ ,  $\overline{\text{LAMDC}}$ ,  $\overline{\text{TLAMC}}$  parameters:

$$\overline{\text{UF}} = \text{UNIT}[\overline{\text{LAMC}} + \overline{\text{LAMDC}} (\text{T\_CA} - \overline{\text{TLAMC}})]$$

3. The M50-to-commanded-body quaternion is computed. If the desired time is less than or equal to time of ignition ( $T_{CA} \leq TIG$ ), then perform the following calculations:

- a. The roll reference vector ( $\overline{RÖLL\_REF}$ ) defined to be the unit radius vector is calculated:

$$\overline{RÖLL\_REF} = \text{UNIT}(\overline{RGD})$$

where  $\overline{RGD}$  is the radius vector used by guidance to solve for  $\overline{LÄMDC}$ ,  $\overline{LÄMDC}$ , and  $\overline{TLAMC}$ .

The cosine of the angle ( $\overline{CBETA}$ ) between the roll reference vector ( $\overline{RÖLL\_REF}$ ) and the desired thrust vector ( $\overline{UF}$ ) is computed:

$$\overline{CBETA} = (\overline{RÖLL\_REF}) \cdot (\overline{UF})$$

- b. If the magnitude of  $\overline{CBETA}$  is greater than  $\overline{CBETA\_EPS}$ , a K-load quantity, then a different roll reference vector must be used.

If  $\text{ABS}(\overline{CBETA}) > \overline{CBETA\_EPS}$ , then  $\overline{RÖLL\_REF} = -\text{SIGN}(\overline{CBETA}) \overline{VGD}$ .

- c. The preburn attitude matrix ( $\overline{MTP}$ ) is then computed:

$$\overline{YN} = \text{UNIT}(\overline{THRUST\_BODY}_3, 0, -\overline{THRUST\_BODY}_1)$$

$$\overline{YT} = \text{UNIT}(\overline{UF} \times \overline{RÖLL\_REF}) \text{SIN}(\overline{TVR\_ROLL\_RAD\_PER\_DEG}) - \overline{UF} \times$$

$$\text{UNIT}(\overline{UF} \times \overline{RÖLL\_REF}) \text{COS}(\overline{TVR\_ROLL\_RAD\_PER\_DEG})$$

$$\overline{MTP}^* = \text{MATRIX}(\overline{THRUST\_BODY}, \overline{THRUST\_BODY} \times \overline{YN}, -\overline{YN})$$

$$\overline{MTP}^* = \overline{MTP}^{*T} \text{MATRIX}(\overline{UF}, \overline{UF} \times \overline{YT}, -\overline{YT})$$

- d. The M50-to-commanded-body quaternion ( $\overline{Q\_CB\_M50\_S}$ ,  $\overline{Q\_CB\_M50\_V}$ ) is computed by calling the `MAT_TO_QUAT` utility routine:

CALL `MAT_TO_QUAT`

Input:  $\overline{MTP}^*$

Outputs:  $\overline{Q\_CB\_M50\_S}$ ,  $\overline{Q\_CB\_M50\_V}$

4. If the desired time is greater than the time of ignition ( $T_{CA} > TIG$ ), the M50-to-commanded-body quaternion is computed as follows:

- a. The commanded unit thrust vector is transformed into current body coordinates by calling the `QUAT_XFORM` utility routine

CALL `QUAT_XFORM`

Inputs:  $\overline{Q\_B\_I\_S}$ ,  $\overline{Q\_B\_I\_V}$ ,  $\overline{UF}$

Outputs:  $\overline{UFB}$

- b. Obtain the difference of  $\overline{\text{THRUST\_BODY}}$  and  $\overline{\text{UFB}}$

$$\overline{\text{YN}} = \overline{\text{UFB}} - \overline{\text{THRUST\_BODY}}$$

- c. If the magnitude of  $\overline{\text{YN}}$  is less than 0.001, then no attitude change is required; hence, set the body-to-commanded-body quaternion to identity:

$$\text{If } \text{ABVAL}(\overline{\text{YN}}) < 0.001, \text{ then } \text{Q\_CB\_B\_S} = 1, \overline{\text{Q\_CB\_B\_V}} = 0$$

- d. If  $\text{ABVAL}(\overline{\text{YN}}) \geq 0.001$ , then:

- (1) Construct the single rotation axis

$$\overline{\text{SRA}} = \text{UNIT}(0, \text{YN}_3, -\text{YN}_2)$$

$$\text{If } \overline{\text{SRA}} \cdot \overline{\text{UFB}} < 0, \text{ then } \overline{\text{SRA}} = -\overline{\text{SRA}}$$

- (2) Compute the body-to-commanded-body quaternion

$$\overline{\text{ATB}} = (\overline{\text{SRA}} \times \overline{\text{THRUST\_BODY}}) \times \overline{\text{SRA}}$$

$$\overline{\text{B}} = \text{UNIT}(\overline{\text{ATB}} + 0.5 \overline{\text{YN}})$$

$$\overline{\text{ATB}} = \text{UNIT}(\overline{\text{ATB}})$$

$$\text{Q\_CB\_B\_S} = \overline{\text{B}} \cdot \overline{\text{ATB}}$$

$$\overline{\text{Q\_CB\_B\_V}} = ((\overline{\text{B}} \times \overline{\text{ATB}}) \cdot \overline{\text{SRA}}) \overline{\text{SRA}}$$

- e. Compute the M50-to-commanded-body quaternion by calling the QUAT\_MULT utility routine:

CALL QUAT\_MULT

Inputs:             $\text{Q\_CB\_B\_S}$ ,  $\overline{\text{Q\_CB\_B\_V}}$ ,  $\text{Q\_B\_I\_S}$ ,  $\overline{\text{Q\_B\_I\_V}}$

Outputs:           $\text{Q\_CB\_M50\_S}$ ,  $\overline{\text{Q\_CB\_M50\_V}}$

5. The ADI-to-commanded-body quaternion ( $\text{Q\_CB\_ADI\_S}$ ,  $\overline{\text{Q\_CB\_ADI\_V}}$ ) is obtained by multiplying the M50-to-commanded-body quaternion with the I-load ADI to M50 quaternion ( $\text{Q\_M50\_INRTL\_ENTRY}$ ):

CALL QUAT\_MULT

Inputs:             $\text{Q\_CB\_M50\_S}$ ,  $\overline{\text{Q\_CB\_M50\_V}}$ , ( $\text{Q\_M50\_V}$ ,  
                          $\text{Q\_M50\_INRTL\_ENTRY}$ )

Outputs:           $\text{Q\_CB\_ADI\_S}$ ,  $\overline{\text{Q\_CB\_ADI\_V}}$

6. The resulting quaternion ( $Q\_CB\_ADI\_S$ ,  $\overline{Q\_CB\_ADI\_V}$ ) is used in deriving the sines and cosines of the Euler angles by the QUAT\_TO\_ADI\_ANG module as documented in the Flight Control, Level C FSSR.

CALL QUAT\_TO\_ADI\_ANG

Inputs:  $Q\_CB\_ADI\_S$ ,  $\overline{Q\_CB\_ADI\_V}$

Outputs: PTCHSINE, PTCHCOS, YAWSINE, YAWCOS,  
ROLLSINE, ROLLCOS, X\_FLAG

7. If X\_FLAG is ON, compute the burn attitude.

$$VEH\_PITCH = \text{ARCTAN2}(-PTCHSINE, -PTCHCOS)/\text{RAD\_PER\_DEG} + 180$$

$$VEH\_YAW = \text{ARCTAN2}(-YAWSINE, -YAWCOS)/\text{RAD\_PER\_DEG} + 180$$

$$VEH\_ROLL = \text{ARCTAN2}(-ROLLSINE, -ROLLCOS)/\text{RAD\_PER\_DEG} + 180$$

If X\_FLAG is OFF, an attitude singularity exists and only the yaw burn attitude is computed.

If YAWSINE  $\geq$  0, then VEH\_YAW = 90

If YAWSINE < 0, then VEH\_YAW = 270

B. Interface Requirements. The input and output parameters for the commanded body attitude task are given in Tables 4.5.7-1 and 4.5.7-2. The detailed flowchart of CMD BDY ATT TSK is illustrated in Appendix A.

C. Processing Requirements. The commanded body attitude task is performed once each time the premaneuver display support task (4.4.10) is called and cyclically when current time (T\_GMT) exceeds time of ignition (TIG) and terminated at the termination of Deorbit Guidance.

D. Initialization Requirements. None.

Table 4.5.7-1. Commanded Body Attitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V93H6915CC	OMS_PITCH_TRIM	OMS pitch angle	TRANS DAP	SP	deg
V93H6916CC	OMS_YAW_TRIM <sub>1</sub>	Left OMS yaw angle	TRANS DAP	SP	deg
V93H6918CC	OMS_YAW_TRIM <sub>2</sub>	Right OMS yaw angle	TRANS DAP	SP	deg
V94J3791CC	PROP_FLAG_OFS	Prime propulsion system indicator	GUID INP TSK, PRE-MAN DISP SUPT TSK	N/A	I
	PROP_FLAG_ OFS_P	Previous value of prime propulsion system indicator	PRE-MAN DISP SUPT TSK	N/A	I
V97U4812C thru V97U4814C	THRUST_BODY_ RCS_X	Unit body thrust vector for the 4+X RCS propulsive system in body coordinates	K-LOAD	SP	none
V90U1954CD thru V90U1956CD	LAMC	Unit desired thrust direction vector in M50 coordinates	PEG TSK	SP	none
V90U1957CD thru V90U1959CD	LAMDC	Desired thrust direction turning rate in M50 coordinates	PEG TSK	SP	rad/s
V90W1953CD	TLAMC	GMT associated with reference thrust vectors (LAMC, LAMDC)	PEG TSK	DP	s
	T_CA	GMT time to compute commanded body attitude	PRE-MAN DISP SUPT TSK, GUID INP TSK	DP	s
V94H3930CB thru V94H3932CB	RGD	Vehicle position vector input to PEG	GUID INP TSK, PRE-MAN DISP SUPT TSK	DP	ft
V94H3935CB thru V94H3937CB	VGD	Vehicle velocity vector input to PEG	GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	ft/s
V93H6936C	TVR_ROLL	Thrust vector roll angle	I-LOAD	SP	rad
V97U4485C	PITCH_BIAS	Constant bias term to convert OMS engine electrical null pitch trim angles to the body axis reference	K-LOAD	SP	rad
V97U4829C	YAW_BIAS	Constant bias term to convert OMS engine electrical null yaw trim angles to the body axis reference	K-LOAD	SP	rad
V97U0383C	RAD_PER_DEG	Degree-to-radian conversion factor	CONSTANT	SP	rad/ deg
V97U5127C	CBETA_EPS	Tolerance for roll reference vector orientation	CONSTANT = 0.999848	SP	none
V90U2240CA thru V90U2243CA	Q_B_I_S, Q_B_I_V	M50 to body quaternion	A/E ATT PROC	SP	none
V94W3790CB	TIG	Time of ignition	PRE-MAN DISP SUPT TSK	DP	s
V97U2368C	ONE_ENG_OMS_ YAW_TRIM <sub>1</sub>	*Left OMS engine yaw trim angle for one engine	K-LOAD	SP	deg



Table 4.5.7-1. Commanded Body Attitude Task Input Parameters					
MSID No.	Name	Definition	Source	Precision	Units/ Type
V97U2369C	ONE_ENG_OMS_ YAW_TRIM <sub>2</sub>	*Right OMS engine yaw trim angle for one engine	K-LOAD	SP	deg
V97U2367C	ONE_ENG_OMS_ PITCH_TRIM	*Pitch trim angle for one engine	K-LOAD	SP	deg
V97U2214CB thru V97U2217CB	Q_M50_ INRTL_ENTRY	ADI-to-M50 quaternion	K-LOAD	SP	none
*This K-load is shared with the Transition DAP principal function (4.201).					

Table 4.5.7-2. Commanded Body Attitude Task Output Parameters					
MSID No.	Name	Definition	Destination	Precision	Units/ Type
V94U3980CB thru V94U3983CB	Q_CB_M50_S, Q_CB_M50_V	M50 to commanded body quaternion	PRE-MAN DISP SUPT TSK, TRANS DAP	SP	none
	THRUST_BODY	Unit engine thrust direction in body coordinates	OMS TSK	SP	none
V93U6909CJ V93U6911CJ V93U6910CJ	VEH_PITCH VEH_YAW VEH_ROLL	Desired vehicle burn attitudes in ADI coordinates	MNVR DISP, TLM	SP	deg
V90X0414XD	X_FLAG	Valid angle comp flag	MNVR DISP	D	none

**4.5.8 Parameter Tables for Deorbit Guidance (G4.209)**

The IDD inputs and outputs are listed in Tables 4.5.8-1 and 4.5.8-2 respectively. Values for the I-loads are contained in the I-load requirements document (JSC-19350); however, I-load definitions applicable to this principal function are listed in Table 4.5.8-3. K-loads are listed in Table 4.5.8-4. Constants are listed in Table 4.5.8-5. The cross-reference listing is given below.

Deorbit Guidance (G4.209) Cross-Reference Listing		
FSSR Name	Source Name	MSID
T_NAV	T_STATE	V95W0200CE
R $\bar{N}$ NAV	R_AVGG	V95H0185CC thru V95H0187CC
V $\bar{N}$ NAV	V_AVGG	V95L0190CC thru V95L0192CC
T_GMT	CLOCK	V91W5000C1
V $\bar{S}$	V_IMU_OLD	V95L0210CC thru V95L0212CC

TABLE 4.5.8-1. INPUT FUNCTIONAL PARAMETERS FOR DEORBIT GUIDANCE (G4.209)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
C1	V94H3773CA	INTERCEPT OF TARGET LINE-GUID	DEORB MNVR DIP	FT/S				
C2	V94H3774CA	SLOPE OF TARGET LINE-GUID	DEORB MNVR DIP					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
EARTH_POLE(1)	V90U0190C	X-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(2)	V90U0191C	Y-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
EARTH_POLE(3)	V90U0192C	Z-COMP UNIT VCTR ALONG EARTH AXIS	RNP MAT COMP	ND	DPL		93090E	
LTVC_MODE	V94X4094X	PEG MANEUVER MODE INDICATOR	DEORB MNVR DIP					
M/CURR_ORB_MASS/WEIGHT	V90U1961CE	CURRENT VEHICLE MASS	DEORB MNVR DIP	SLUGS			89250B	
MBO	V94U4086C	DESIRED FINAL ORBITER MASS	DEORB MNVR DIP	SLUGS				
OMS_IGNITION_CMD	V90X8190XA	OMS IGNITION COMMAND FLAG	MSC		BD		90007G	
OMS_L_ON_CMD_IND	V90X8271X	OMS-L ON CMD IND	OMS FIRE SEQ				90120B	
OMS_PITCH_TRIM	V93H6915CC	OMS PITCH TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
OMS_R_ON_CMD_IND	V90X8272X	OMS-R ON CMD IND	OMS FIRE SEQ				90120B	
OMS_YAW_TRIM(1)	V93H6916CC	OMS L YAW TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
OMS_YAW_TRIM(2)	V93H6918CC	OMS R YAW TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
PROP_FLAG_GUID	V94X3962XB	PRIME PROP SYS FLAG FOR GUID	DEORB MNVR DIP					
Q_BOD_M50(1)/Q_B_I(1)	V90U2240CA	M50 TO BODY QUAT MEASURED ELEM 1	A/E ATT PROC		SPL		93017G	*
Q_BOD_M50(2)/Q_B_I(2)	V90U2241CA	M50 TO BODY QUAT MEASURED ELEM 2	A/E ATT PROC		SPL		93017G	*
Q_BOD_M50(3)/Q_B_I(3)	V90U2242CA	M50 TO BODY QUAT MEASURED ELEM 3	A/E ATT PROC		SPL		93017G	*
Q_BOD_M50(4)/Q_B_I(4)	V90U2243CA	M50 TO BODY QUAT MEASURED ELEM 4	A/E ATT PROC		SPL		93017G	*
RGD(X)	V94H3930CB	X-COMP OF GUIDANCE POS VEC AT TGD	DEORB MNVR DIP	FT			89662B	
RGD(Y)	V94H3931CB	Y-COMP OF GUIDANCE POS VEC AT TGD	DEORB MNVR DIP	FT			89662B	
RGD(Z)	V94H3932CB	Z-COMP OF GUIDANCE POS VEC AT TGD	DEORB MNVR DIP	FT			89662B	
RT(X)	V90H3781CB	X-M50 OF POSITION TARGET VECTOR	DEORB MNVR DIP	FT				
RT(Y)	V90H3782CB	Y-M50 OF POSITION TARGET VECTOR	DEORB MNVR DIP	FT				
RT(Z)	V90H3783CB	Z-M50 OF POSITION TARGET VECTOR	DEORB MNVR DIP	FT				
R_AVGG(1)	V95H0185CC	X-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CC	Y-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CC	Z-COMP OF CUR SHUTTLE POS VCTR M50	ENT UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CA	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT			89662B	
R_FINAL(2)	V90H0882CA	Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT				
R_FINAL(3)	V90H0883CA	Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED	FT				
SFUELD	V94U4057C	OUT OF PLANE FU WASTING DIR	DEORB MNVR DIP					
TGD	V94W3938CB	TIME ASSOCIATED WITH RGD,VGD	DEORB MNVR DIP	S				
THC_FSN(1)	V90X7694X	SEL FWD THC NEG X OUTPUT	GN&C SW RM		BD		93017G	*
THC_FSN(2)	V90X7695X	SEL FWD THC NEG Y OUTPUT	GN&C SW RM		BD		93017G	*
THC_FSN(3)	V90X7696X	SEL FWD THC NEG Z OUTPUT	GN&C SW RM		BD		93017G	*
THC_FSP(1)	V90X7697X	SEL FWD THC POS X OUTPUT	GN&C SW RM		BD		93017G	*
THC_FSP(2)	V90X7698X	SEL FWD THC POS Y OUTPUT	GN&C SW RM		BD		93017G	*
THC_FSP(3)	V90X7699X	SEL FWD THC POS Z OUTPUT	GN&C SW RM		BD		93017G	*
TIG	V94W3790CB	TIME OF IGNITION	DEORB MNVR DIP	S			93017G	*
T_STATE	V95W0200CE	TIME TAG ASSOC WITH CURRENT STATE	ENT UPP	S			93017G	*
VGD(X)	V94H3935CB	X-COMP OF GUIDANCE VEL VEC AT TGD	DEORB MNVR DIP	FT/S			89662B	
VGD(Y)	V94H3936CB	Y-COMP OF GUIDANCE VEL VEC AT TGD	DEORB MNVR DIP	FT/S			89662B	
VGD(Z)	V94H3937CB	Z-COMP OF GUIDANCE VEL VEC AT TGD	DEORB MNVR DIP	FT/S			89662B	
VGO(X)	V94L3804CC	X-EXTERNAL DEL V TARGET VECTOR	DEORB MNVR DIP	FT/S				

TABLE 4.5.8-1. INPUT FUNCTIONAL PARAMETERS FOR DEORBIT GUIDANCE (G4.209)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
VGO(Y)	V94L3805CC	Y-EXTERNAL DEL V TARGET VECTOR	DEORB MNVR DIP	FT/S				
VGO(Z)	V94L3806CC	Z-EXTERNAL DEL V TARGET VECTOR	DEORB MNVR DIP	FT/S				
VSP(X)	V94H3940CB	X-COMP OF PREV ACCUM IMU VEL	DEORB MNVR DIP	FT/S				
VSP(Y)	V94H3941CB	Y-COMP OF PREV ACCUM IMU VEL	DEORB MNVR DIP	FT/S				
VSP(Z)	V94H3942CB	Z-COMP OF PREV ACCUM IMU VEL	DEORB MNVR DIP	FT/S				
V_AVGG(1)	V95L0190CC	X-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CC	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CC	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ENT UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CA	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_FINAL(2)	V90L0886CA	Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_FINAL(3)	V90L0887CA	Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CC	X-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				
V_IMU_OLD(2)	V95L0211CC	Y-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				
V_IMU_OLD(3)	V95L0212CC	Z-COMP OF CURRENT ACCUM IMU VEL	ENT UPP	FT/S				
	V90X8163X	DEORBIT GUIDANCE INITIATE FLAG	MSC				89599C	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.5.8-2. OUTPUT FUNCTIONAL PARAMETERS FROM DEORBIT GUIDANCE (G4.209)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
DT_MAX	V90U8500CF	MAX ALLOW TIME STEP SIZE	ENT PREC PRED	S				
GMD_PRED	V90U8501CF	GRAVITY MODEL DEGREE	ENT PREC PRED					
GMO_PRED	V90U8502CF	GRAVITY MODEL ORDER	ENT PREC PRED					
LAMC(X)	V90U1954CD	X-COMP OF M50 REF THR VECTOR	TRANS DAP					
LAMC(Y)	V90U1955CD	Y-COMP OF M50 REF THR VECTOR	TRANS DAP					
LAMC(Z)	V90U1956CD	Z-COMP OF M50 REF THR VECTOR	TRANS DAP					
LAMDC(X)	V90U1957CD	X-M50 DESIRED THR TRNING RATE VCTR	TRANS DAP	RAD/S				
LAMDC(Y)	V90U1958CD	Y-M50 DESIRED THR TRNING RATE VCTR	TRANS DAP	RAD/S				
LAMDC(Z)	V90U1959CD	Z-M50 DESIRED THR TRNING RATE VCTR	TRANS DAP	RAD/S				
M/CURR_ORB_MASS/MASS	V90U1961CC	CURRENT VEHICLE MASS	A/L GUID	SLUGS			93090E	
			AEROJET DAP					
			D/L NAV SEQ					
			DEORB MNVR DIP					
			ENT AREA NAV					
			ENT BRG SPEC					
			ENT UPP					
			NAVDAD SOP					
			OMS RM					
			TAEM GUID					
			VERT SIT DIP					
OTREQ	V90X0893XF	OPS TRANSITION REQUEST FLAG	ENT PREC PRED		BD		90121B	
Q_CB_M50_S	V94U3980CB	M50 TO BODY QUAT ELEM 1	TLM					
			TRANS DAP					
Q_CB_M50_V(1)	V94U3981CB	M50 TO BODY QUAT ELEM 2	TLM					
			TRANS DAP					
Q_CB_M50_V(2)	V94U3982CB	M50 TO BODY QUAT ELEM 3	TLM					
			TRANS DAP					
Q_CB_M50_V(3)	V94U3983CB	M50 TO BODY QUAT ELEM 4	TLM					
			TRANS DAP					
R_INIT(X)	V90H8508CF	X-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
R_INIT(Y)	V90H8509CF	Y-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
R_INIT(Z)	V90H8510CF	Z-COMP SHUTTLE POS VECTR AT T_INIT	ENT PREC PRED	FT				
SCONV	V90X1971XC	PEG CONVERGENCE DISCRETE	DL FMT 23/1				93017G	*
S_OMSCO	V90X2035XB	OMS CUTOFF ALERT DISCRETE	DL FMT 23/1				93017G	*
			MSC					
TCUTOFF	V90W2034CB	DESIRED CUTOFF TIME	MSC	S				
			TLM					
TGO	V90W1941CD	TIME TO GO TO VELOCITY CUTOFF	DL FMT 23/1	S			93017G	*
			XXXXX MNVR DISP					
TLAMC	V90W1953CD	TIME ASSOC W REF THR VECTOR	TRANS DAP	S				
T_FINAL	V90W8506CF	TIME AT WHICH STATE IS DESIRED	ENT PREC PRED	S				
T_INIT/TGD	V90W8512CF	TIME AT BEGINNING OF PRED	ENT PREC PRED	S				
VEH_PITCH	V93U6909CJ	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 23/1	DEG			93017G	*
			XXXXX MNVR DISP					
VEH_ROLL	V93U6910CJ	ROLL ANGLE IN ADI INERTIAL COORD	DL FMT 23/1	DEG			93017G	*
			XXXXX MNVR DISP					

TABLE 4.5.8-2. OUTPUT FUNCTIONAL PARAMETERS FROM DEORBIT GUIDANCE (G4.209)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
VEH_YAW	V93U6911CJ	YAW ANGLE IN ADI INERTIAL COORD	DL FMT 23/1 XXXXX MNVR DISP	DEG			93017G	*
VGO(1)	V90U1202C	X-COMP OF VGO IN M50 COORD	DEORB MNVR DIP	FT/S				
VGO(2)	V90U1203C	Y-COMP OF VGO IN M50 COORD	DEORB MNVR DIP	FT/S				
VGO(3)	V90U1204C	Z-COMP OF VGO IN M50 COORD	DEORB MNVR DIP	FT/S				
V_INIT(X)	V90L8513CF	X-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
V_INIT(Y)	V90L8514CF	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
V_INIT(Z)	V90L8515CF	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ENT PREC PRED	FT/S				
X_FLAG	V90X0414XD	VALID ANGLE COMP FLAG	XXXXX MNVR DISP		BD		90763E	
	V90M2926PB	CGEB_FLT_LG1_FLAG2_MFE	DL FMT 23/1				93017G	*
	V90M3142PC	CGGB_MC16_GUID_TGT_FLAG	DL FMT 23/1				93017G	*

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

**Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
(HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec**

TABLE 4.5.8-3. DEORBIT GUIDANCE (G4.209) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
EP_TRANSFER	V96U7514C	ND	F	S	D	P	G4.209 G4.3 G5.10	00	ZFW	93182B	*
KLAMDZX	V97U4423C	ND	F	S	D	C	G4.13 G4.209 G4.210 G4.211	00	ZF1	90243C	
TVR_ROLL	V93H6936C	DEG	F	S	D	C	G4.3 G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	00	ZF2	91019A	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.5.8-4. DEORBIT GUIDANCE (G4.209) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
CBETA_EPS	V97U5127C	00	+9.998480	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89542A	
DTMAX MAX STEP SIZE, ASC PREC PRED	V97U4369C	00	+1.00	E+20 SEC	F	S	C	G4.13 G4.2 G4.209 G4.3 G4.4 G4.5	89990E	
DTMIN	V97U4370C	01 02 03	+2.0 +3.00 +2.0	E+00 E+02 E+00 SEC	F	S	C	G4.13 G4.158 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	29975A	
FT1 VACUUM THRUST OF TWO OMS ENGINES	V97U5034C	00	+1.2174000	E+04 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT2 VACUUM THRUST OF ONE OMS ENGINES	V97U5035C	00	+6.0870000	E+03 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
FT3 VACUUM THRUST OF PRIMARY RCS JETS	V97U5036C	02 03	+1.780 +3.509	E+03 E+03 LBS	F	S	P	G4.158 G4.209 G4.211 G4.7	90329C	
KMISS FRACTION OF VGO DEFINING PEG CONVERGENCE	V97U4831C	00	+1.0	E-02 ND	F	S	C	G4.13 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	90329C	
NSEG NUMBER OF INTEGRATION STEPS FOR PEG GRAVITY PREDICTION	V97U4447C	01 03	+10 +20	ND	I	S	P	G4.13 G4.2 G4.209 G4.210 G4.211 G4.3 G4.4	90329C	



TABLE 4.5.8-4. DEORBIT GUIDANCE (G4.209) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
N_MAX MAXIMUM NUMBER OF PEG ITERATION	V97U4445C	00	+1	ND	I	S	P	G4.2 G4.209 G4.3 G4.4	90329C	
ONE_ENG_OMS_PITCH_TRIM OMS ENG PITCH TRIM ANG THRUST -CG	V97U2367C	01 02 03	+4.0 -1.0 -3.1	E-01 E-01 E-01	DEG	F	S	X G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(1) OMS ENG YAW TRIM ANG THRUST - CG	V97U2368C	01 02 03	+5.2100000 +5.2100000 +5.2100000	E+00 E+00 E+00	DEG	F	S	C G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
ONE_ENG_OMS_YAW_TRIM(2) OMS ENG YAW TRIM ANG THRUST - CG	V97U2369C	01 02 03	-5.2100000 -5.2100000 -5.2100000	E+00 E+00 E+00	DEG	F	S	C G4.158 G4.201 G4.209 G4.210 G4.211 G4.3 G4.35 G4.7	90353G	
PITCH_BIAS CONST OMS ENG ELEC PITCH TRIM ANG	V97U4485C	00	+2.7605300	E-01	RAD	F	S	C G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	59955	
Q_M50_INRTL_ENTRY(1)	V97U2214CB	00 03	+1.0	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(2)	V97U2215CB	00 03	+0.0	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(3)	V97U2216CB	00 03	+0.00	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	
Q_M50_INRTL_ENTRY(4)	V97U2217CB	00 03	+0.00	E+00	ND	F	S	C G4.209 G4.211 G4.226	89688B	

TABLE 4.5.8-4. DEORBIT GUIDANCE (G4.209) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
TCO_BIAS OMS CUTOFF TIME BIAS	V97U4662C	00	+3.98	E-01 SEC	F	S	C	G4.209 G4.3 G4.7	90329C	
TGO_MIN MIN TIME-TO-GO THRUST TERMINATE	V97U4665C	00	+6.0000000	E+00 SEC	F	S	C	G4.209 G4.3 G4.7	89542A	
THRUST_BODY_RCS_X(1) X-COMPONENT OF RCS THRUST DIRECTION	V97U4812C	00	+9.8480780	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(2) Y-COMPONENT OF RCS THRUST DIRECTION	V97U4813C	00	+0.0	E+00 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
THRUST_BODY_RCS_X(3) Z-COMPONENT OF RCS THRUST DIRECTION	V97U4814C	00	+1.7364820	E-01 ND	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	90329C	
VEX1 TWO OMS EXHAUST VELOCITY	V97U5114C	00	+1.0136800	E+04 FT/SEC	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
VEX2 ONE OMS EXHAUST VELOCITY	V97U5115C	00	+1.0136800	E+04 FT/SEC	F	S	P	G4.158 G4.209 G4.211 G4.7	90924B	
VEX3 RCS EXHAUST VELOCITY	V97U5116C	00	+8.2327000	E+03 FT/SEC	F	S	P	G4.158 G4.209 G4.211 G4.7	90329C	
YAW_BIAS CNST OMS ENG ELEC YAW TRIM ANGLE	V97U4829C	00	+1.134460	E-01 RAD	F	S	C	G4.158 G4.209 G4.210 G4.211 G4.3 G4.7	89541	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.5.8-5. DEORBIT GUIDANCE (G4.209) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_MU EARTH GRAVITATIONAL CONSTANT	V97U4378C	00	+1.40764487566E+16	FT**3/SEC**2	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.2 G4.205 G4.209 G4.210 G4.211 G4.224 G4.236 G4.3 G4.4 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.5.8-5. DEORBIT GUIDANCE (G4.209) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PI RATIO OF CIRCUMFERENCE TO DIAMETER	V98U8725C	00	+3.14159265358E+00	ND	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.144 G4.15 G4.158 G4.16 G4.19 G4.2 G4.20 G4.205 G4.209 G4.210 G4.213 G4.220 G4.236 G4.237 G4.3 G4.4 G4.5 G4.97 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.5.8-5. DEORBIT GUIDANCE (G4.209) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
RAD_PER_DEG DEGREE TO RADIAN CONVERSION FACTOR	V97U0383C	00	+1.7453293	E-02	RAD/DEG	F	S	C A6.9 G4.1 G4.126 G4.127 G4.128 G4.144 G4.15 G4.158 G4.175 G4.20 G4.201 G4.204 G4.205 G4.209 G4.210 G4.211 G4.213 G4.220 G4.223 G4.226 G4.227 G4.236 G4.237 G4.3 G4.35 G4.36 G4.7 G4.72 G4.9 G4.97 G5.27	93090E	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

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## 4.6 ORBIT TARGETING SPECIALIST FUNCTION

The Orbit Targeting Specialist function defines software to support maneuver targeting for rendezvous and close-in operations. Implementation of this software provides the crew with support to reduce crew workload, to reduce RCS propellant usage, and to fly a special trajectory. The maneuver targeting software consists of two-impulse Lambert software and two-impulse Clohessy Wiltshire (CW) software, each capable of targeting to an offset position. Access and control of the software will be through the keyboard and the ORBIT\_TGT display.

### 4.6.1 Overview

The Orbit Targeting Specialist function gives the orbiter crew the capability to generate targeted maneuvers to generate vehicle motion from a given position to a desired target-referenced relative position. Profile examples that could utilize this targeting function include NCC, TPI, TPM, TPF, braking, station keeping, transition, approach, and separation. The targeted maneuver outputs of this specialist function will be available for display to the crew and as inputs to the maneuver execution software functions, including the maneuver guidance function.

The targeting algorithm computes either maneuver of a two-maneuver set. The initial maneuver of the set is targeted to achieve a given position relative to the target vehicle in a given delta-time. The second maneuver is targeted to null the orbiter's velocity relative to a target-centered rotating reference frame.

The targeting algorithm has as inputs a set of constraints, denoted as a target set, that are selected by crew action via the Orbit Targeting Specialist function display (Figure 4.6.1-1). The selected target set can be one of 40 sets available in the I-load or from ground uplink. The crew has the capability via display input to modify a selected target set and have the appropriate I-load changed accordingly.

In general, a sequence of rendezvous maneuvers, braking maneuvers, station keeping maneuvers, or transition maneuvers can be performed by selecting the appropriate target set, computing the solution, executing the indicated maneuver, and then repeating the process for each remaining maneuver in the sequence.

The following sections describe the detailed logic and equations necessary to support orbit operations targeting.

The specifications for the Orbit Targeting Specialist function are presented as a set of modular tasks. These tasks are listed below and numbered with corresponding section numbers of this document in which the detailed requirements are presented.

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The organization of the tasks is shown in Figure 4.6.1–2. The main control is in the executive task (PROX\_EXEC). The executive calls other tasks which monitor the status and provide for display and guidance interfacing. It also calls one of two targeting supervisory tasks to compute either a maneuver using CW equations or a Lambert maneuver (PROX\_TGT\_SUP and PROX\_TGT\_SUP\_LAMB, respectively). A general data flow of the Orbit Targeting Specialist function is shown in Figure 4.6.1–3.

To facilitate understanding of the data flow interfaces, all Orbit Targeting Specialist function variables are placed in one of the five common packages:

1. PROX\_WORLD\_COMMON contains all variables which are passed between the specialist function and other GN&C functions.
2. PROX\_DIP\_COMMON contains all variables that are passed between the specialist function and the ORBIT\_TGT\_DIP.
3. PROX\_ILOAD\_COMMON contains all variables that are input data to the specialist function.
4. PROX\_VARIABLES\_COMMON contains all variables internal to the specialist function.
5. PROX\_LAMVAR\_COMMON contains variables internal to the Lambert routines of the specialist function.

The specific contents of each of these common packages are listed in Tables 4.6.1–1 through 4.6.1–5. The common packages available to each of the Orbit Targeting Specialist function modules are shown in Figure 4.6.1–4. The precisions of those variables, which are used internally among the Orbit Targeting subtasks, are given in Table 4.6.1–6.

The Orbit Targeting principal function input and output parameters, as well as I-load/K-load parameters, are given in Section 4.6.24.

In the following sections each of the function modules is explained, and specific I/O variables for each module are listed.



- 4.6.2 Proximity Operations Targeting Executive Task (PROX\_EXEC)
- 4.6.3 Proximity Operations Targeting Status Task (PROX\_STAT)
- 4.6.4 Proximity Operations Targeting Target Set Select Task (PROX\_TGT\_SEL)
- 4.6.5 Proximity Operations Targeting Initialization Task (PROX\_INIT)
- 4.6.6 Proximity Operations Targeting Guidance Quantity Transfer Task (PROX\_TRANS)
- 4.6.7 Proximity Operations Targeting Supervisory Logic Task (PROX\_TGT\_SUP)
- 4.6.8 Proximity Operations Targeting Supervisory Lambert Logic Task (PROX\_TGT\_SUP\_LAMB)
- 4.6.9 Proximity Operations Targeting Start Timer Task (PROX\_STIME)
- 4.6.10 Maneuver to Offset Targeting Task (OFFSET\_TGT)
- 4.6.11 Relative State Compute Task (REL\_COMP)
- 4.6.12 Proximity Operations Targeting Output Display Load Task (PROX\_DISP\_LOAD)
- 4.6.13 Time Conversion Task (TIME\_CONVRT)
- 4.6.14 Delta Time Compute Task (DT\_COMP)
- 4.6.15 Omega Delta Time Compute Task (OMEGA\_DT\_COMP)
- 4.6.16 Elevation Angle Search Task (TELEV)
- 4.6.17 Precision Velocity Required Task (PREVR)
- 4.6.18 Elevation Angle Computation Task (COMELE)
- 4.6.19 Elevation Angle Iteration Task (ELITER)
- 4.6.20 Lambert Conic–Velocity–Required Task (LAMBERT)
- 4.6.21 State Vector Update Task (UPDATVP)
- 4.6.22 Newton–Raphson Iteration Task (ITERV)
- 4.6.23 Orbiter LVLH Transformation Task (ORBLV)

Table 4.6.1-1.PROX\_WORLD\_COMMON

Symbol	Precision	Definition	Type	Units
CLOCK	DP	Current time (GMT)	F	s
BASE_MET	DP	GMT/MET reference time	F	s
$\Delta \bar{V}$ _LVLH_GUID	SP	Delta-V vector of current maneuver	F(3)	ft/s
GUID_FLAG	—	Current maneuver guidance option flag	D	—
DT_ST_TIMER	SP	Time to be counted down	F	s
CRT_TIME	—	CRT timer start/stop discrete	D	—
CRT_UPDOWN	—	CRT time up/down discrete	D	—
T_STATE	DP	Time tag for M50 vectors	F	s
$\bar{R}$ _AVGG	DP	Orbiter position M50 vectors	F(3)	ft
$\bar{V}$ _AVGG	DP	Orbiter velocity M50 vectors	F(3)	ft/s
$\bar{R}$ _TARGET	DP	Target position M50 vector	F(3)	ft
$\bar{V}$ _TARGET	DP	Target velocity M50 vector	F(3)	ft/s
S_ROTATE_GUID	SP	Rotation flag for near 180° transfers	I	—
$\bar{R}$ _OFFSET_GUID	DP	Offset position vector	F(3)	ft
T_OFFSET_GUID	DP	Time of offset position vector (MET)	F	s
TIG_GUID_DAY	SP	MET ignition time of current maneuver - DAY	I	day
TIG_GUID_HR	SP	MET ignition time of current maneuver - HR	I	hr
TIG_GUID_MIN	SP	MET ignition time of current maneuver - MIN	I	min
TIG_GUID_SEC	SP	MET ignition time of current maneuver - SEC	I	s
GMD_PRED	SP	Gravity model degree flag	I	—
GMO_PRED	SP	Gravity model order flag	I	—
ATM	SP	Attitude mode flag	I	—
PRED_STEP	SP	Minimum integration step size	F	s
DMP	—	Drag model flag	D	—
VMP	—	Vent model flag	D	—
PRED_ORB_MASS	SP	On-orbit predictor drag MASS	F	slugs
PRED_ORB_CD	SP	On-orbit predictor drag CD	F	—
PRED_ORB_AREA	SP	On-orbit predictor drag AREA	F	ft <sup>2</sup>
$\bar{R}$ _PRED_IN	DP	Input inertial position vector to UPDATVP	F(3)	ft
$\bar{V}$ _PRED_IN	DP	Input inertial velocity vector to UPDATVP	F(3)	ft/s
$\bar{R}$ _PRED_FINAL	DP	Output inertial position vector to UPDATVP	F(3)	ft
$\bar{V}$ _PRED_FINAL	DP	Output inertial velocity vector to UPDATVP	F(3)	ft/s
T_PRED_IN	DP	Time of the input state to UPDATVP (GMT)	F	s
T_PRED_FINAL	DP	Time of the output state to UPDATVP (GMT)	F	s
M	SP	Orbiter mass for PREVR	F	slugs

Table 4.6.1-1.PROX_WORLD_COMMON				
Symbol	Precision	Definition	Type	Units
B $\dot{A}$ CKGROUND_ CALC	—	Background calculations in progress	D	—
START_ B $\dot{A}$ CKGROUND	—	Begin targeting calculations flag	D	—
E $\dot{V}$ ENT_67	—	Transition into Major Mode 202	D	—
L $\dot{O}$ AD_FLASH	—	MNVR_DIP load flash flag	D	—
A $\dot{L}$ ARM_A	—	ALARM discrete requesting “TGT ITER” be displayed	D	—
A $\dot{L}$ ARM_B	—	ALARM discrete requesting “TGT EL ANG” be displayed	D	—
A $\dot{L}$ ARM_C	—	ALARM discrete requesting “TGT ITER” be displayed	D	—
A $\dot{L}$ ARM_D	—	ALARM discrete requesting “TGT DELTA T” be displayed	D	—
$\bar{D}$ _DRAG	SP	Vehicle drag acceleration vector	F(3)	ft/s <sup>2</sup>

Table 4.6.1-2.PROX\_DIP\_COMMON

Symbol	Precision	Definition	Type	Units
PROX_Ḑ1_STAR_STATUS	—	T1 maneuver compute star flag	D	—
PROX_Ḑ2_STAR_STATUS	—	T2 maneuver compute star flag	D	—
PROX_PĀST_STATUS	—	Maneuver past time status flag	D	—
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	I	—
DISP_PROX_DT	SP	Displayed delta time between T1 and T2	F	min
DISP_EL_ANG	SP	Displayed target elevation angle at T1	F	deg
DISP_T1_X̄	DP	Displayed orbiter relative position at T1	F(3)	ft
DISP_T1_X̄D	DP	Displayed orbiter relative velocity at T1	F(3)	ft/s
DISP_T1_DAY	SP	Displayed T1 time - DAY	I	day
DISP_T1_HR	SP	Displayed T1 time - HR	I	hr
DISP_T1_MIN	SP	Displayed T1 time - MIN	I	min
DISP_T1_SEC	SP	Displayed T1 time - SEC	F	s
DISP_T2_DAY	SP	Displayed T2 time - DAY	I	day
DISP_T2_HR	SP	Displayed T2 time - HR	I	hr
DISP_T2_MIN	SP	Displayed T2 time - MIN	I	min
DISP_T2_SEC	SP	Displayed T2 time - SEC	F	s
DISP_T2_XOFF	DP	Displayed orbiter desired relative X position at T2	F	ft
DISP_T2_YOFF	DP	Displayed orbiter desired relative Y position at T2	F	ft
DISP_T2_ZOFF	DP	Displayed orbiter desired relative Z position at T2	F	ft
DISP_DV̄	SP	Displayed maneuver LVLH-velocity vector	F(3)	ft/s
DISP_DV_MAG	SP	Displayed maneuver velocity magnitude	F	ft/s
PROX_ḐITEM_21TO24_STATUS	—	Items 21 through 24 data entry status flag	D	—
PROX_ḐITEM_1_STATUS	—	Item 1 data entry status flag	D	—
PROX_ḐITEM_2TO20_STATUS	—	Items 2 through 20 data entry status flag	D	—
PROX_ḐITEM_25_STATUS	—	Item 25 data entry status flag	D	—
PROX_ḐITEM_26_STATUS	—	Item 26 data entry status flag	D	—
PROX_ḐITEM_27_STATUS	—	Item 27 data entry status flag	D	—
PROX_ḐITEM_28_STATUS	—	Item 28 data entry status flag	D	—
PROX_LOAD_FLASH	—	“LOAD” flash status flag	D	—
PROX_BASE_DAY	SP	Targeting base time - DAY	I	day
PROX_BASE_HR	SP	Targeting base time - HR	I	hr
PROX_BASE_MIN	SP	Targeting base time - MIN	I	min
PROX_BASE_SEC	SP	Targeting base time - SEC	F	s
DISP_TMAN_TIME	DP	Displayed maneuver time	F	s
DISP_TMAN_DAY	SP	Displayed maneuver time - day	I	day

Table 4.6.1-2.PROX\_DIP\_COMMON

Symbol	Precision	Definition	Type	Units
DISP_TMAN_HR	SP	Displayed maneuver time – hour	I	hr
DISP_TMAN_MIN	SP	Displayed maneuver time – min	I	min
DISP_TMAN_SEC	SP	Displayed maneuver time – sec	F	s
MAN_TGT	SP	Target set for which maneuver was computed	I	—
DSP_MISS	SP	Target miss distance	F	ft

Table 4.6.1-3.PROX_ILOAD_COMMON				
Symbol	Precision	Definition	Type	Units
T1_ILOAD_ARRAY	SP	T1 time for target sets (times are relative to prox ops base time)	F(40)	min
DT_ILOAD_ARRAY	SP	Delta times from T1 maneuver to T2 maneuver for target sets	F(40)	min
EL_ILOAD_ARRAY	SP	Maneuver elevation angle	F(40)	rad
XOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset X position for target sets	F(40)	ft
YOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset Y position for target sets	F(40)	ft
ZOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset Z position for target sets	F(40)	ft
PROX_DTMIN	DP	Tolerance on minimum time in the future to compute a prox ops maneuver solution	F	s
PROX_DTMIN_LAMB	SP	Tolerance on minimum time in the future to compute a Lambert maneuver solution	F	s
BASE_START_DAY	SP	Referenced base time for T1_ILOAD_ARRAY - DAY	I	day
BASE_START_HR	SP	Referenced base time for T1_ILOAD_ARRAY - HR	I	hr
BASE_START_MIN	SP	Referenced base time for T1_ILOAD_ARRAY - MIN	I	min
BASE_START_SEC	SP	Referenced base time for T1_ILOAD_ARRAY - SEC	F	s
PI	DP	Mathematical constant (Level A)	F	—
EL_TOL	SP	Tolerance between computed and desired elevation angle	F	rad
LAMB_ILOAD	—	Target mode discretcs	D(40)	—
EL_DH_TOL	SP	Elevation angle–differential altitude incompatibility tolerance	F	ft
R_TOL	SP	Convergence tolerance in terminal point offset iteration	F	ft
EARTH_MU	DP	Earth gravitational constant (Level A)	F	ft <sup>3</sup> /s <sup>2</sup>
N_MAX_ITER	SP	Maximum allowed number of iterations	I	—
CONE	SP	Angular tolerance used to determine if the transfer angle is near 180°	F	rad
DEL_T_MAX	SP	Maximum step size used during any given iteration in ELITER	F	s
DU	SP	Small deviation to prevent orbit from being almost parabolic	F	—
EP_TRANSFER	SP	Parameter to test if transfer angle is close to 0°	F	—
EPS_U	SP	Parameter to test convergence of the Newton–Raphson iteration	F	—
N MIN	SP	Minimum allowed number of iterations	I	—
DEL_X_GUESS	SP	ΔX guess to be used in iterator if no prediction is possible	F(2)	s
IC_MAX	SP	Maximum allowed number of iterations	I	—
DEL_X_TOL	SP	Tolerance of dependent variable to ensure that a slope exists	F(2)	—
GMD_I	SP	Gravity model degree flag	I	—
GMO_I	SP	Gravity model order flag	I	—

Table 4.6.1-3.PROX_ILOAD_COMMON				
Symbol	Precision	Definition	Type	Units
ATM_I	SP	Attitude mode flag	I(2)	—
DTMIN_I	SP	Minimum integration step size	F	s
DMP_I	SP	Drag model flag	I(2)	—
VMP_I	SP	Vent model flag	I(2)	—
PRED_ORB_CD_I	SP	On-orbit predictor drag parameter - CD	F	—
PRED_ORB_AREA_I	SP	On-orbit predictor drag parameter - AREA	F	ft <sup>2</sup>
THRUST	SP	Thrust of the propulsion system for PREVR	F	lb
R_TOL_CW	SP	CW iteration tolerance	F	—

Table 4.6.1-4.PROX_VARIABLES_COMMON				
Symbol	Precision	Definition	Type	Units
T1_TIG	DP	T1 maneuver time (MET)	F	s
T2_TIG	DP	T2 maneuver time (MET)	F	s
PROX_T_CURRENT	DP	Current MET time	F	s
PROX_BASE_TIME	DP	Prox ops base time	F	s
DAY	SP	Converted time for TIME_CONVRT - DAY	I	day
HR	SP	Converted time for TIME_CONVRT - HR	I	hr
MIN	SP	Converted time for TIME_CONVRT - MIN	I	min
SEC	SP	Converted time for TIME_CONVRT - SEC	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	F	min
COMP_T2_XOFF	DP	Computational desired X position at T2	F	ft
COMP_T2_YOFF	DP	Computational desired Y position at T2	F	ft
COMP_T2_ZOFF	DP	Computational desired Z position at T2	F	ft
TIME_CONVERT_FLAG	SP	Time conversion flag	I	—
TIME_SEC	DP	Conversion time	F	s
$\overline{DV}$ _LVLH	SP	Impulsive maneuver in LVLH reference frame	F(3)	ft/s
TIME_PROX	DP	Time tag for M50 state (assumed MET)	F	s
USE_Ω_DT	—	Use the WT calculation flag	D	—
USE_DISP_REL_STATE	—	Use displayed relative state flag	D	—
COMP_ $\overline{X}$	DP	Computation relative position	F(3)	ft
COMP_ $\overline{XD}$	DP	Computation relative velocity	F(3)	ft/s
OMEGA_PROX	DP	Orbital angular rate of target	F	rad/s
$\overline{RS}$ _M50_PROX	DP	Prox ops orbiter M50 position vector	F(3)	ft
$\overline{RT}$ _M50_PROX	DP	Prox ops target M50 position vector	F(3)	ft
$\overline{VS}$ _M50_PROX	DP	Prox ops orbiter M50 velocity vector	F(3)	ft/s
$\overline{VT}$ _M50_PROX	DP	Prox ops target M50 velocity vector	F(3)	ft/s
EL_ANG	SP	Desired elevation angle at TPI	F	rad
S_ROTATE	SP	Rotation flag for near 180° transfers	I	—
$\overline{R}$ _OFFSET	DP	Offset position vector	F(3)	ft
T_OFFSET	DP	Time of offset position vector (MET)	F	s
$\dot{I}$ NER_TO_LVC	—	Inertial to curvilinear conversion flag	D	—
$\overline{R}$ _REL	DP	LVLH curvilinear position vector from REL_COMP	F(3)	ft
$\overline{V}$ _REL	DP	LVLH curvilinear velocity vector from REL_COMP	F(3)	ft/s
$\overline{DV}$	SP	Delta-velocity vector from OFFSET_TGT	F(3)	ft/s
DT_OFFTGT	SP	Transfer time for OFFSET_TGT	F	s
$\overline{X}$ _OFFTGT	DP	T1 relative position vector for OFFSET_TGT	F(3)	ft
$\overline{XD}$ _OFFTGT	SP	T1 relative velocity vector for OFFSET_TGT	F(3)	ft/s
$\overline{X2}$ _OFFTGT	DP	T2 relative position vector for OFFSET_TGT	F(3)	ft
$\overline{R}$ _S_INER	DP	Input Shuttle inertial position for REL_COMP	F(3)	ft



Table 4.6.1-4.PROX\_VARIABLES\_COMMON

Symbol	Precision	Definition	Type	Units
$\bar{V}_S_{INER}$	DP	Input Shuttle inertial velocity for REL_COMP	F(3)	ft/s
$\bar{R}_T_{INER}$	DP	Input target inertial position for REL_COMP	F(3)	ft
$\bar{V}_T_{INER}$	DP	Input target inertial velocity for REL_COMP	F(3)	ft/s
T_MAN	DP	Time of the computed maneuver (MET)	F	s
DIFF_DR	SP	Differential drag acceleration magnitude	F	ft/s <sup>2</sup>
$\dot{L}\dot{A}M\dot{B}$	—	Target mode discrete	D	—
$\dot{A}L\dot{A}R\dot{M} KILL$	—	Stop computations flag	D	—

Table 4.6.1-5.PROX\_LAMVAR\_COMMON

Symbol	Precision	Definition	Type	Units
$\bar{R}_S_{T1TIG}$	DP	Inertial position vector of Shuttle at T1_TIG for PREVR	F(3)	ft
$\bar{V}_S_{T1TIG}$	DP	Inertial velocity vector of Shuttle at T1_TIG for PREVR	F(3)	ft/2
$\bar{R}_S_{T2TIG}$	DP	Inertial position vector of Shuttle at T2_TIG for PREVR	F(3)	ft
S_OPTION	SP	Spacecraft flag for UPDATVP	I	—
TTPI	DP	Predicted time of TPI (MET)	F	s
$\bar{R}_S_{OUT}$	DP	Shuttle position vector	F(3)	ft
$\bar{V}_S_{OUT}$	DP	Shuttle velocity vector	F(3)	ft/s
$\bar{R}_T_{OUT}$	DP	Target position vector	F(3)	ft
$\bar{V}_T_{OUT}$	DP	Target velocity vector	F(3)	ft/s
$\bar{V}_S_{REQUIRED}$	DP	Velocity required at the maneuver time	F(3)	ft/s
$\bar{R}_S_{IPO}$	DP	Initial position offset of Shuttle from PREVR	F(3)	ft
$\bar{R}_S_{COM}$	DP	Shuttle inertial position for COMELE	F(3)	ft
$\bar{V}_S_{COM}$	DP	Shuttle inertial velocity for COMELE	F(3)	ft/s
$\bar{R}_T_{COM}$	DP	Target inertial position for COMELE	F(3)	ft
EL_ANG_COM	SP	Computed elevation angle from COMELE	F	rad
$\bar{U}_N$	DP	Unit normal along the Shuttle angular momentum vector	F(3)	—
DEL_T_TRAN	SP	Transfer time from PREVR	F	s
IC	SP	Iteration counter to ITERV	I	—
X_DEP	DP	Dependent variable to ITERV	F	—
X_IND	DP	Independent variable to ITERV	F	—
X_DEP_PRIME	DP	Previous value of the dependent variable to ITERV	F	—
X_IND_PRIME	DP	Previous value of the independent variable to ITERV	F	—
SFAIL	SP	Flag set if maximum number of iterations occurred	I	—
ERR	DP	Dependent variable in search for elevation angle	F	—
ERR_PRIME	DP	Previous value of the dependent variable in search for elevation angle	F	—
TTPI_PRIME	DP	Previous value of the independent variable in search for elevation angle (MET)	F	s
$\bar{R}_S$	DP	Input inertial position of Shuttle to ORBLV	F(3)	ft
$\bar{V}_S$	DP	Input inertial velocity of Shuttle to ORBLV	F(3)	ft/s
$\bar{D}_V_{LVLH}$	SP	Shuttle-centered LVLH maneuver	F(3)	ft/s
$\bar{D}_V_{INER}$	SP	Inertial maneuver to ORBLV	F(3)	ft/s
FIRST_JUMP	SP	Guess in jump of independent variable	F	—
DY_TOL	SP	Tolerance on zero slope	F	—

Table 4.6.1-6. Precisions of Internal Variables					
	Definition	Symbol	Precision		
4.6.2	PROX_EXEC	RT_MAG	DP		
		$\bar{V}TAN$	DP		
4.6.4	PROX_TGT_SEL	I_INDEX	SP		
4.6.5	PROX_INIT	I_INDEX	SP		
4.6.7	PROX_TGT_SUP	TIG_MIN	DP		
4.6.8	PROX_TGT_SUP_LAMB	TIG_MIN	DP		
4.6.10	OFFSET_TGT	W	DP		
		S	DP		
		C	DP		
		C1	DP		
		K	DP		
		MAT	DP		
		STATE	DP		
		V_TI_NEED	DP		
		T	DP		
		4.6.11	REL_COMP	RT_MAG	DP
				MAT_M50_LVIR	DP
				OMEGA_LV_PROX	DP
				$\bar{V}TAN$	DP
OMEGA_PROX	DP				
RTS_M50	DP				
VTS_M50	DP				
RTS_LVIR	DP				
VTS_LVIR	DP				
RTS_LV	DP				
VTS_LV	DP				
ZCON	DP				
THETA	DP				
4.6.15	OMEGA_DT_COMP	THETA_DOT	DP		
		T	DP		
		XD1	DP		
		YD1	DP		
		ZD1	DP		
		W	DP		
		XO	DP		
		YO	DP		
		ZO	DP		
		X1	DP		
Y1	DP				

Table 4.6.1-6. Precisions of Internal Variables			
Definition	Symbol	Precision	
4.6.16	TELEV	Z1	DP
		ALPHA	DP
		A	DP
		B	DP
		C	DP
		D	DP
		E	DP
		F	DP
		G1	DP
		H	DP
		J	DP
		L	DP
		M	DP
		COS	DP
		SIN	DP
		TAN	DP
		DELTA_H	DP
		T_SAVE	DP
		NW	SP
		ERR_DH	SP
	ERR_DH_PRIME	SP	
	ERR_EL	SP	
	ERR_EL_PRIME	SP	
4.6.17	PREVR	VG	SP
		VG_MAG	SP
		ALPHA	DP
		ORB_RATE	DP
		UN_REF	DP
		ACC	SP
		R_MISS	DP
		SBETA	DP
		CBETA	DP
		BBEF	DP
		BAFT	DP
		RS_TERMINAL	DP
		VS_TERMINAL	DP
4.6.20	LAMBERT	N	SP
		R0	DP
		R1	DP
		R0_MAG	DP

Table 4.6.1-6. Precisions of Internal Variables		
Definition	Symbol	Precision
	RI_MAG	DP
	R_PARABOLA	DP
	V_PARABOLA	DP
	Z	DP
	VH	DP
	LAMBDA	DP
	N	SP
	U	DP
	U_MIN	DP
	U_MAX	DP
	T_MIN	SP
	T_TILDA_DESIRED	DP
	X1	DP
	Y	DP
	F	DP
	W	DP
	G1	DP
	T_TILDA	DP
	S_TILDA	DP
	T_TILDA_ERROR	DP
	U_STEP	DP
	VR	DP
	COEF	DP
4.6.22	ITERV	DEL_X_IND
		DEL_X_DEP
		SLOPE
4.6.23	ORBLV	RS_MAG
		MAT_M50_LVIR
		$\bar{V}$ TAN
		OMEGA_LV_PROX
		RST_M50
		VST_M50
		RST_LVIR
		VST_LVIR
4.6.18	COMELE	A
		B
		D
		E

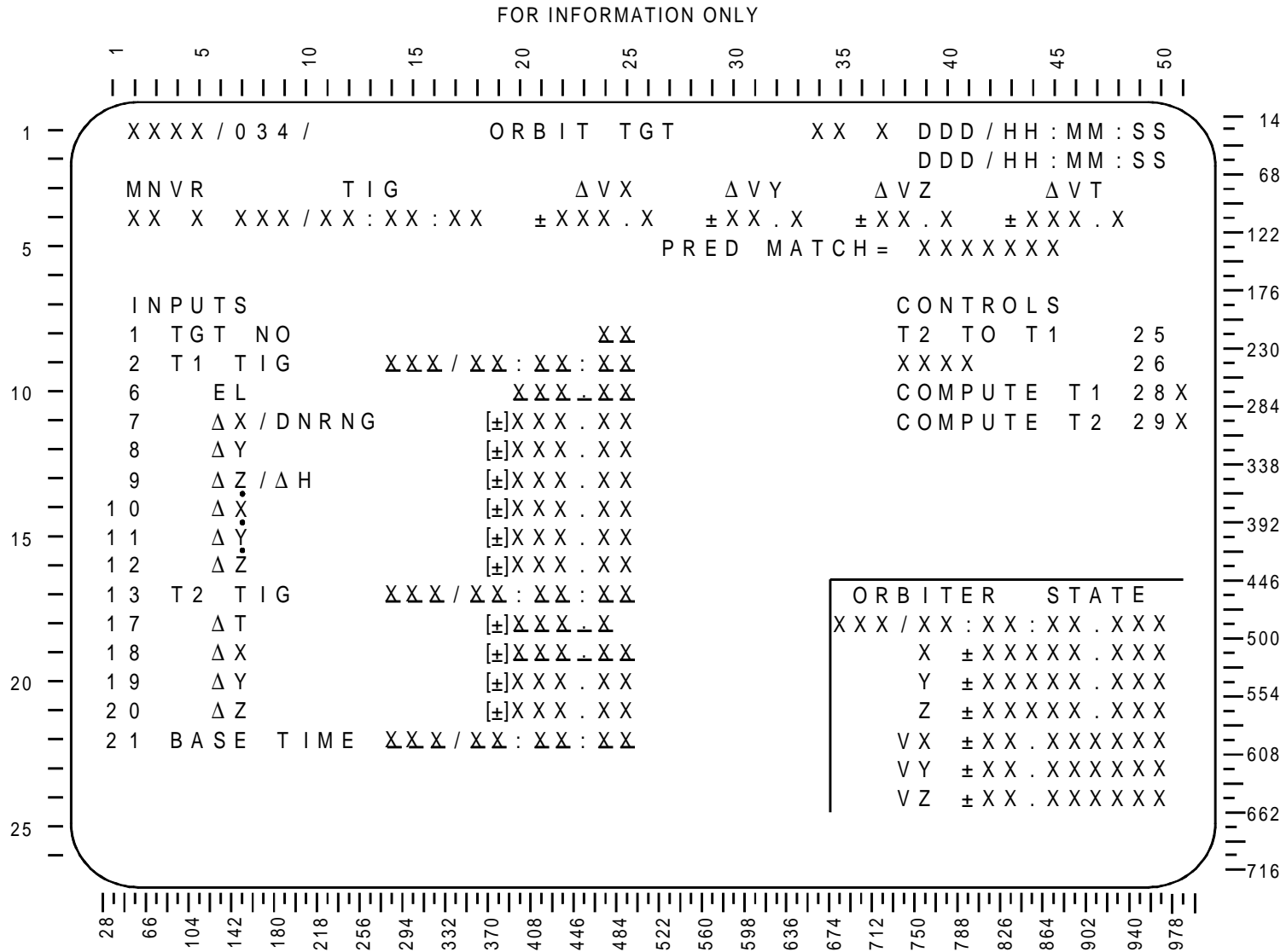


FIGURE 4.6.1-1. Orbit Targeting Specialist Function Generic Display

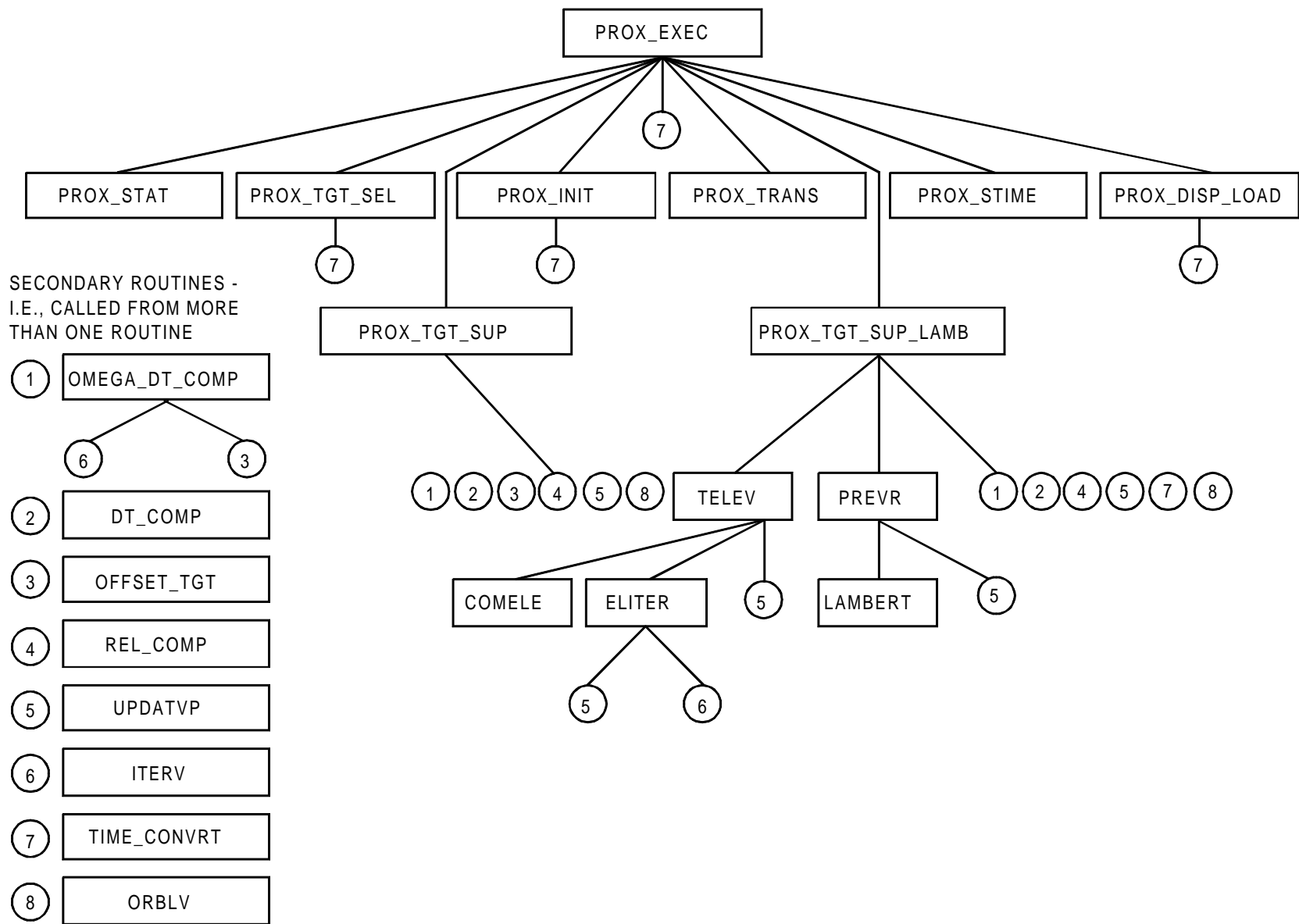


FIGURE 4.6.1-2. Orbit Targeting Specialist Function Task Organization

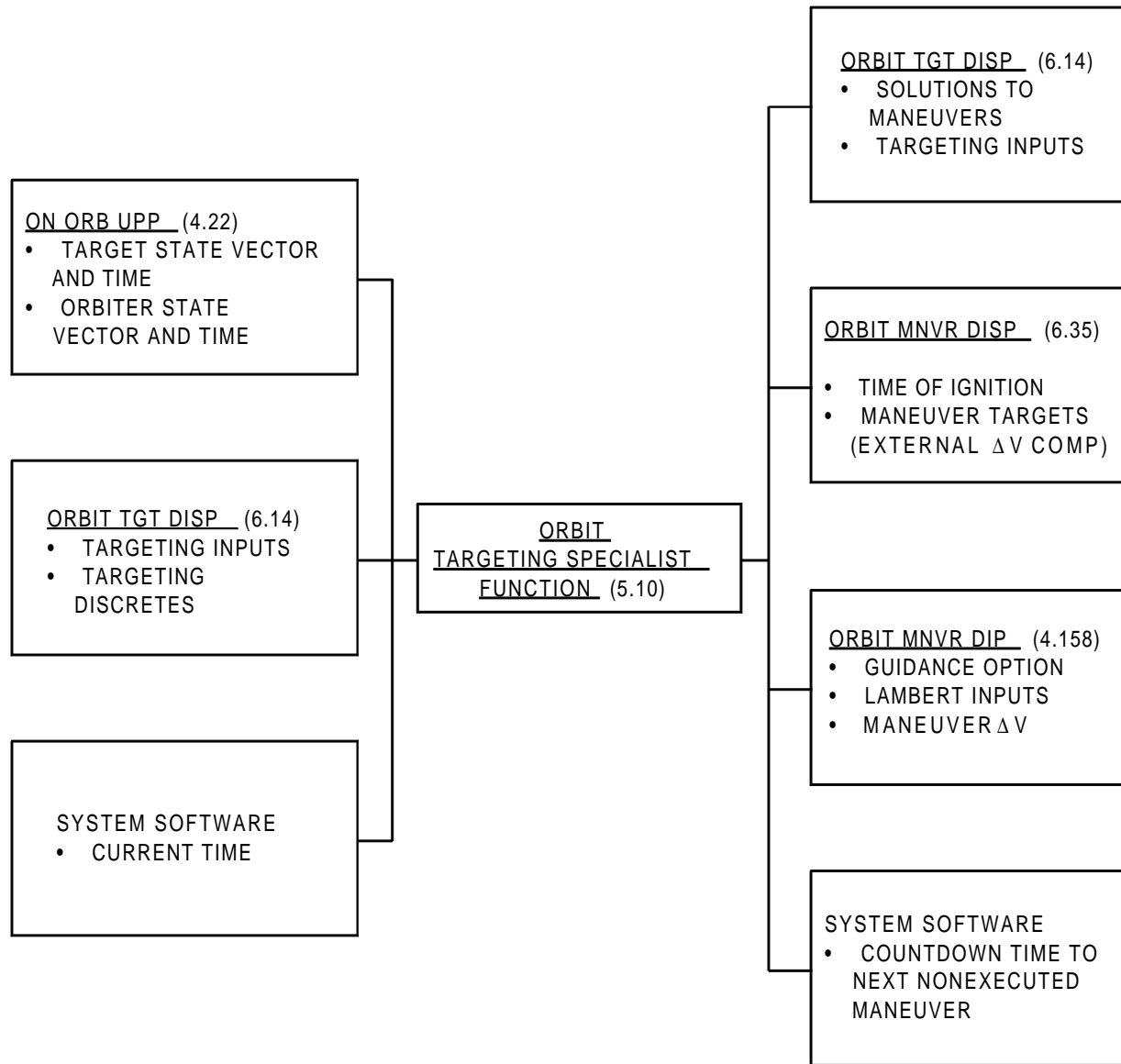


FIGURE 4.6.1-3. Orbit Targeting Specialist Function Data Flow



		PROX_WORLD_COMMON	PROX_DIP_COMMON	PROX_ILOAD_COMMON	PROX_VARIABLES_COMMON	PROX_LAMVAR_COMMON
1	PROX_EXEC	•	•	•	•	
2	PROX_STAT	•	•		•	
3	PROX_TGT_SEL		•	•	•	
4	PROX_INIT		•	•	•	
5	PROX_TRANS	•	•		•	
6	PROX_TGT_SUP	•	•	•	•	•
7	PROX_TGT_SUP_LAMB	•	•	•	•	
8	PROX_STIME	•	•			
9	OFFSET_TGT				•	
10	REL_COMP				•	
11	PROX_DISP_LOAD		•		•	
12	TIME_CONVRT				•	•
13	DT_COMP				•	•
14	OMEGA_DT_COMP		•	•	•	•
15	TELEV	•	•	•	•	•
16	PREVR	•	•	•	•	•
17	COMELE			•		•
18	ELITER	•		•		•
19	LAMBERT	•		•	•	•
20	UPDATVP	•		•		•
21	ITERV			•		
22	ORBLV				•	

FIGURE 4.6.1-4. Common Package Allocations for Function Modules

#### 4.6.2 Proximity Operations Targeting Executive Task (PROX\_EXEC)

This cyclically executed module is the top-level module of the Orbit Targeting Specialist function. It performs the following functions:

1. Initializes data
2. Responds to the crew changes in the display area
3. Sets status discretely for display items to be flashed and display items to carry stars
4. Transfers target set data between the I-load buffers and the display and computational buffers
5. Calls the task to compute the relative state
6. Calls the appropriate targeting supervisory logic task
7. Calls the task to load the output display data buffers
8. Calls the task to load the guidance buffers with data for the upcoming maneuver
9. Calls the task to load the time management buffer with the time to be counted down to the next maneuver

This module design assumes that a higher-level software calls or schedules PROX\_EXEC whenever the specialist function is called by a crew request. It is assumed that the higher-level software will cycle PROX\_EXEC at a 1.04 Hz frequency until the crew terminates the specialist function.

A. Detailed Requirements. The following steps are required to perform the orbit targeting function.

1. Perform a logic test to determine if this is the first pass through the executive.

If first pass (PROX\_FIRST\_PASS\_STATUS = ON)

- a. Set the prox base time to the I-load values by setting up the inputs and calling the time conversion task (TIME\_CONVRT). The TIME\_CONVRT detailed requirements are presented in Subsection 4.6.13.

TIME\_CONVERT\_FLAG = 1

DAY = BASE\_START\_DAY

HR = BASE\_START\_HR

MIN = BASE\_START\_MIN

SEC = BASE\_START\_SEC

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, DAY, HR, MIN, SEC

Output: TIME\_SEC

- b. Put the base time into the display.

PROX\_BASE\_DAY = BASE\_START\_DAY

PROX\_BASE\_HR = BASE\_START\_HR

PROX\_BASE\_MIN = BASE\_START\_MIN

PROX\_BASE\_SEC = BASE\_START\_SEC

- c. Initialize T1\_TIG and T2\_TIG.

T1\_TIG = 0

T2\_TIG = 0

- d. Initialize the compute in progress status flags.

PROX\_T1\_STAR\_STATUS = OFF

PROX\_T2\_STAR\_STATUS = OFF

START\_BACKGROUND = OFF

BACKGROUND\_CALC = OFF

- e. Set the first pass status off.

PROX\_FIRST\_PASS\_STATUS = OFF

2. Perform a logic test to determine if the crew made an entry to Items 21, 22, 23, or 24.

If an entry was made (PROX\_ITEM\_21TO24\_STATUS = ON), set the LOAD to flash (PROX\_LOAD\_FLASH = ON).

3. Call the proximity operations targeting status task (Subsection 4.6.3) to set the maneuver status flag to on or off position if the maneuver TIG time is prior to or past current time. The inputs and outputs are listed in Tables 4.6.3-1 and 4.6.3-2.

CALL PROX\_STAT

4. Perform a logic test to determine if the crew has made an entry to Item 1. If so, (PROX\_ITEM\_1\_STATUS = ON):

- a. Call the proximity operations target set select task (Subsection 4.6.4) to load input display buffer and computation buffer from the I-load buffer.

CALL PROX\_TGT\_SEL

- b. Set PROX\_ITEM\_1\_STATUS = OFF

5. Perform a logic test to determine if the crew executed Item 25. If an execution was made (PROX\_ITEM\_25\_STATUS = ON):

- a. Transfer the T2 maneuver time data in the computation buffer to the T1 maneuver time computational buffer slots.

T1\_TIG = T2\_TIG

- b. Transfer the T2 maneuver time data in the computation buffer to the T1 maneuver time display buffer slots.

TIME\_CONVERT\_FLAG = 0

TIME\_SEC = T1\_TIG

CALL TIME\_CONVRT

Inputs:           TIME\_CONVERT\_FLAG, TIME\_SEC

Outputs:          DAY, HR, MIN, SEC

DISP\_T1\_DAY = DAY

DISP\_T1\_HR = HR

DISP\_T1\_MIN = MIN

DISP\_T1\_SEC = SEC

- c. Set the status flag to off.

PROX\_ITEM\_25\_STATUS = OFF

6. Perform a logic test to determine if the crew made any entries to Items 2 through 20.

- a. If entry was made (PROX\_ITEM\_2TO20\_STATUS = ON), set flag to flash "LOAD".

PROX\_LOAD\_FLASH = ON

7. Perform a logic test to determine if the crew executed Item 26. If execution was made (PROX\_ITEM\_26\_STATUS = ON):

- a. Convert the input data display buffer items and store in the computational data buffers and the I-load data buffers. The conversion is performed by the proximity operations targeting initialization task (Subsection 4.6.5). The inputs and outputs are presented in Tables 4.6.5-1 and 4.6.5-2.

- b. Set status flags to the off condition.

PROX\_ITEM\_2TO20\_STATUS = OFF

PROX\_ITEM\_21TO24\_STATUS = OFF

PROX\_LOAD\_FLASH = OFF

PROX\_ITEM\_26\_STATUS = OFF

8. Perform a logic test to determine if the crew executed Item 28.

If (PROX\_ITEM\_28\_STATUS = ON):

- a. If COMP\_PROX\_DT = 0 and T2\_TIG = 0, then set ALARM FLAG (ALARM\_D) to ON and go to Step 8d.

- b. Set the compute T1 star status flag to on.

PROX\_T1\_STAR\_STATUS = ON

- c. Perform a logic test to see if all of the computational buffers for T1 relative state are zero (COMP\_X = 0, 0, 0, and COMP\_XD = 0, 0, 0) or if the T1 maneuver time is in the past (T1\_TIG < PROX\_T\_CURRENT).

(1) If so, set USE\_DISP\_REL\_STATE = OFF.

(2) If not, set USE\_DISP\_REL\_STATE = ON.

- d. Set Item 28 to off.

PROX\_ITEM\_28\_STATUS = OFF

9. Perform a logical test to determine if the crew executed Item 29.

If (PROX\_ITEM\_29\_STATUS = ON):

- a. Set the compute T2 star status flag to on.

PROX\_T2\_STAR\_STATUS = ON

- b. Set the use relative display to off.

USE\_DISP\_REL\_STATE = OFF

- c. Set the Item 29 status to off.

PROX\_ITEM\_29\_STATUS = OFF

10. Perform a logic test to determine if the compute T1 or compute T2 solutions were requested and if no targeting calculations are presently being done.

If a request was made [(PROX\_T1\_STAR\_STATUS = ON or PROX\_T2\_STAR\_STATUS = ON) and BACKGROUND\_CALC = OFF], then set START\_BACKGROUND = ON which signals the MNVR\_DIP to set the LOAD\_FLASH to ON.

11. If the background calculations are scheduled to begin (START\_BACKGROUND = ON) and either the MNVR\_DIP load flash flag is ON (LOAD\_FLASH = ON) or if not in MM 202 (EVENT\_67 = OFF), then set the BACKGROUND\_CALC to ON and START\_BACKGROUND to OFF and execute the following logic:

- a. Retrieve the current orbiter and target state vectors from ON\_ORB\_UPP.

$$\bar{R}_S_{M50\_PROX} = \bar{R}_{AVGG}$$

$$\bar{V}_S_{M50\_PROX} = \bar{V}_{AVGG}$$

$$\bar{R}_T_{M50\_PROX} = \bar{R}_{TARGET}$$

$$\bar{V}_T_{M50\_PROX} = \bar{V}_{TARGET}$$

- b. Retrieve the ON\_ORB\_UPP nav state time tag (T\_STATE) assumed GMT.

$$TIME\_PROX = T\_STATE - BASE\_MET$$

- c. Convert the orbital angular rate from the target inertial vector.

$$RT\_MAG = ABVAL(\bar{R}_T_{M50\_PROX})$$

$$\bar{V}_TAN = \bar{V}_T_{M50\_PROX} - UNIT(\bar{R}_T_{M50\_PROX}) \left[ \frac{\bar{R}_T_{M50\_PROX}}{RT\_MAG} \cdot \bar{V}_T_{M50\_PROX} \right]$$

$$OMEGA\_PROX = ABVAL(\bar{V}_TAN) / RT\_MAG$$

- d. Initialize the stop computations flag (ALARM\_KILL) to OFF to allow the computations to proceed.

$$ALARM\_KILL = OFF$$

- e. Determine whether a Lambert or a CW calculation will be performed and call the appropriate targeting supervisory logic.

If LAMB = ON, call PROX\_TGT\_SUP\_LAMB. Otherwise, call PROX\_TGT\_SUP

- f. If (ALARM\_KILL = ON), then set the status flags to OFF, (PROX\_T1\_STAR\_STATUS = OFF and PROX\_T2\_STAR\_STATUS = OFF) set DSP\_MISS equal to 999999.0, set the background calculations flag to OFF (BACKGROUND\_CALC = OFF), and exit this task. Otherwise, continue with step 11g.

- g. Call the prox ops status task (Subsection 4.6.3).
- h. Call the proximity operations targeting output display load (Subsection 4.6.12) to transfer the computed output data to the display buffers. The inputs and outputs are listed in Tables 4.6.12-1 and 4.6.12-2.
- i. Set the status flags to off.  
$$\text{PROX\_T1\_STAR\_STATUS} = \text{OFF}$$
$$\text{PROX\_T2\_STAR\_STATUS} = \text{OFF}$$
- j. Call the proximity operations targeting start timer task (Subsection 4.6.9) and compute the time to the upcoming maneuver and place it in the time management buffer. The inputs and outputs are listed in Tables 4.6.9-1 and 4.6.9-2.
- k. Transfer the maneuver execution data to the guidance buffer or array. This transfer is performed by the proximity operations guidance quantity transfer task (Subsection 4.6.6). The inputs and outputs for the task are listed in Tables 4.6.6-1 and 4.6.6-2.
- l. Set the background calculations flag to OFF ( $\text{BACKGROUND\_CALC} = \text{OFF}$ ).

B. Interface Requirements. The input and output parameters for the proximity operations targeting executive task are given in Tables 4.6.2-1 and 4.6.2-2. A flow diagram of PROX\_EXEC is given in Appendix A.

C. Processing Requirements. The specialist function will be called on crew demand and will be cycled thereafter at a 1-Hz rate until the crew terminates the specialist function. The display data will be in the main memory so that when the specialist function is recalled the display will contain the data present when the display was last deactivated.

When either a Compute T1 (Item 28) or a Compute T2 (Item 29) entry is made via the keyboard, Lambert calculations performed by the MNVR\_DIP should be terminated. Such calculations are assumed to be terminated when either the LOAD\_FLASH flag is set to ON or if not in MM 202. This requirement protects against orbit targeting and MNVR\_DIP both trying to access the same Lambert subtask at the same time.

While the BACKGROUND\_CALC is ON, maneuver computations are performed. These calculations can be performed “in the background” while the executive continues to be cycled thus allowing for more frequent updates of the PROX\_PAST\_STATUS\_FLAG.

D. Initialization Requirements. The keyboard status flags will be initially set by the orbit targeting DIP I-load values. The output data in the upper portion of the display will be zero until an initial compute is performed. The input data (Items 2 through 20) will be zero initially. Initialization of Items 1 through 20 will occur from execution of Item 26 and Item 28 or 29. The initialization of Items 21 through 24 will be by I-load values. PROX\_FIRST\_PASS\_STATUS will be initialized to ON.

Table 4.6.2-1. Proximity Operations Targeting Executive Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
T_STATE	DP	Time tag for M50 vectors	ON_ORB_UPP (4.22)	F	s
$\bar{R}$ _AVGG	DP	Orbiter position M50 vectors	ON_ORB_UPP (4.22)	F(3)	ft
$\bar{V}$ _AVGG	SP	Orbiter velocity M50 vectors	ON_ORB_UPP (4.22)	F(3)	ft/s
$\bar{R}$ _TARGET	DP	Target position M50 vectors	ON_ORB_UPP (4.22)	F(3)	ft
$\bar{V}$ _TARGET	SP	Target velocity M50 vectors	ON_ORB_UPP (4.22)	F(3)	ft/s
PROX_ITEM_21TO24_STATUS	—	Items 21 through 24 data entry status flag	PROX_INIT ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_2TO20_STATUS	—	Items 2 through 20 data entry status flag	PROX_INIT ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_1_STATUS	—	Item 1 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_25_STATUS	—	Item 25 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_26_STATUS	—	Item 26 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_28_STATUS	—	Item 28 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_29_STATUS	—	Item 29 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
BASE_START_DAY	SP	Reference base time for T1_ILOAD_ARRAY	ILOAD	I	day
BASE_START_HR	SP	Reference base time for T1_ILOAD_ARRAY	ILOAD	I	hr
BASE_START_MIN	SP	Reference base time for T1_ILOAD_ARRAY	ILOAD	I	min
BASE_START_SEC	SP	Reference base time for T1_ILOAD_ARRAY	ILOAD	F	s
LAMB	—	Target mode discrete	PROX_TGT_SEL	D	—
PROX_T_CURRENT	DP	Current MET time	PROX_STAT	F	s
DAY	SP	Converted time (day) for TIMECV	TIME_CONVRT	I	day
HR	SP	Converted time (hr) for TIMECV	TIME_CONVRT	I	hr
MIN	SP	Converted time (min) for TIMECV	TIME_CONVRT	I	min
SEC	SP	Converted time (sec) for TIMECV	TIME_CONVRT	F	s
ALARM_KILL	—	Stop computations flag	OFFSET_TGT OMEGA_DT_COMP LAMBERT	D	—
TIME_SEC	DP	Conversion time	TIME_CONVRT	F	s
LOAD_FLASH	—	MNVR DIP load flash flag	MNVR_DIP	D	—
EVENT_67	—	Major mode transition flag	MSC	D	—
COMP_X	DP	Computational relative position	PROX_TGT_SEL PROX_INIT PROX_TGT_SUP PROX_TGT_SUP_LAMB	F(3)	ft



Table 4.6.2-1. Proximity Operations Targeting Executive Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
COMP_XD	DP	Computational relative velocity	PROX_TGT_SEL PROX_INIT PROX_TGT_SUP PROX_TGT_SUP_LAMB	F(3)	ft/s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SEL PROX_INIT	F	min
T2_TIG	DP	T2 MANEUVER TIME (MET)	PROX_INIT	F	s

Table 4.6.2-2. Proximity Operations Targeting Executive Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
PROX_T1_STAR_STATUS	—	T1 maneuver compute star flag	PROX_TGT_SUP PROX_TGT_SUP_LAMB	D	—
PROX_T2_STAR_STATUS	—	T2 maneuver compute star flag	ORBIT_TGT_DISP (6.14)	D	—
DISP_T1_DAY	SP	T1 time (day)	PROX_INIT ORBIT_TGT_DISP (6.14)	I	day
DISP_T1_HR	SP	T1 time (hr)	PROX_INIT ORBIT_TGT_DISP (6.14)	I	hr
DISP_T1_MIN	SP	T1 time (min)	PROX_INIT ORBIT_TGT_DISP (6.14)	I	min
DISP_T1_SEC	SP	T1 time (sec)	PROX_INIT ORBIT_TGT_DISP (6.14)	I	s
PROX_ITEM_1_STATUS	—	Item 1 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_25_STATUS	—	Item 25 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_26_STATUS	—	Item 26 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_28_STATUS	—	Item 28 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_29_STATUS	—	Item 29 data entry status flag	ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_21to24_STATUS	—	Items 21 through 24 data entry status flag	PROX_INIT	D	—
PROX_ITEM_2to20_STATUS	—	Items 2 through 20 data entry status flag	PROX_INIT	D	—
PROX_LOAD_FLASH	—	“LOAD” flash status flag	ORBIT_TGT_DISP (6.14)	D	—
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP PROX_TGT_SUP_LAMB PROX_DISP_LOAD DT_COMP PREVR	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP PROX_TGT_SUP_LAMB PROX_DISP_LOAD DT_COMP PREVR	F	s
PROX_BASE_DAY	SP	Prox ops base time - day	PROX_INIT ORBIT_TGT_DISP (6.14)	I	day
PROX_BASE_HR	SP	Prox ops base time - hr	PROX_INIT ORBIT_TGT_DISP (6.14)	I	hr
PROX_BASE_MIN	SP	Prox ops base time - min	PROX_INIT ORBIT_TGT_DISP (6.14)	I	min
PROX_BASE_SEC	SP	Prox ops base time - sec	PROX_INIT ORBIT_TGT_DISP (6.14)	F	s
PROX_BASE_TIME	DP	Prox ops base time	PROX_STAT PROX_INIT	F	s
DAY	SP	Converted time (day) for TIMECV	TIME_CONVRT	I	day

Table 4.6.2-2. Proximity Operations Targeting Executive Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
HR	SP	Converted time (hr) for TIMECV	TIME_CONVRT	I	hr
MIN	SP	Converted time (min) for TIMECV	TIME_CONVRT	I	min
SEC	SP	Converted time (sec) for TIMECV	TIME_CONVRT	F	s
TIME_CONVERT_FLAG	SP	Time conversion flag	TIME_CONVRT	I	—
TIME_SEC	DP	Conversion time	TIME_CONVRT	F	s
TIME_PROX	DP	Time tag for M50 state (assumed MET)	PROX_TGT_SUP PROX_TGT_SUP_LAMB TELEV	F	s
USE_DISP_REL_STATE	—	Use displayed relative state flag	PROX_TGT_SUP PROX_TGT_SUP_LAMB	D	—
OMEGA_PROX	DP	Orbital angular rate of target	OFFSET_TGT REL_PRED REL_COMP OMEGA_DT_COMP	F	rad/s
$\bar{R}_S$ _M50_PROX	DP	Prox ops orbiter M50 position vector	PROX_TGT_SUP PROX_TGT_SUP_LAMB TELEV	F(3)	ft
$\bar{V}_S$ _M50_PROX	SP	Prox ops orbiter M50 velocity vector	PROX_TGT_SUP PROX_TGT_SUP_LAMB TELEV	F(3)	ft/s
$\bar{R}_T$ _M50_PROX	DP	Prox ops target M50 position vector	PROX_TGT_SUP PROX_TGT_SUP_LAMB TELEV	F(3)	ft
$\bar{V}_T$ _M50_PROX	SP	Prox ops target M50 velocity vector	PROX_TGT_SUP PROX_TGT_SUP_LAMB TELEV	F(3)	ft/s
BACKGROUND_CALC	—	Background calculations in progress	MNVR_DIP	D	—
START_BACKGROUND	—	Begin targeting calculations flag	MNVR_DIP	D	—
ALARM_D	—	Alarm flag denoting transfer time problem	GAX (4.110)	D	—
ALARM_KILL	—	Stop computations flag	PROX_TGT_SUP PROX_TGT_SUP_LAMP OFFSET_TGT OMEGA_DI_COMP LAMBERT PREVR	D	—
DSP_MISS	SP	Target miss distance	ORB_TGT_DISP (6.14)	F	ft

### 4.6.3 Proximity Operations Targeting Status Task (PROX\_STAT)

This task sets the maneuver status flag if the maneuver ignition time is prior to current time.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting status task:

1. Compute an MET current time.

$$\text{PROX\_T\_CURRENT} = \text{CLOCK} - \text{BASE\_MET}$$

2. Perform a logical test to determine if the maneuver exists and if it is in the past.

If the maneuver exists and it is in the past ( $T\_MAN \geq 0$  and  $\text{PROX\_T\_CURRENT} > T\_MAN$ ), set the past status flag to on

$$\text{PROX\_PAST\_STATUS} = \text{ON}$$

Otherwise, set it to off

$$\text{PROX\_PAST\_STATUS} = \text{OFF}$$

B. Interface Requirements. The input and output parameters for the proximity operations targeting status task are listed in Tables 4.6.3-1 and 4.6.3-2. A flow diagram of PROX\_STAT is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.3-1. Proximity Operations Targeting Status Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
CLOCK	DP	Current time (GMT)	FCOS	F	s
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
T_MAN	DP	Time of the computed maneuver (MET)	PROX_TGT_SUP PROX_TGT_SUP_LAMB	F	s

Table 4.6.3-2. Proximity Operations Targeting Status Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
PROX_PAST_STATUS	—	Maneuver past time status flag	PROX_TRANS PROX_STIME	D	—
PROX_T_CURRENT	DP	Current MET time	PROX_EXEC PROX_TGT_SUP PROX_TGT_SUP_LAMB	F	s

#### 4.6.4 Proximity Operations Targeting Target Set Select Task (PROX\_TGT\_SEL)

This task loads the inputs into the display and computational buffers from the selected set of I-load values.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting target set select task.

Let the array index equal the target set number ( $I\_INDEX = PROX\_TGT\_SET\_NO$ ), load that value of the array to define the desired set.

$$\left. \begin{array}{l} T1\_ILOAD\_ARRAY(I\_INDEX) \\ DT\_ILOAD\_ARRAY(I\_INDEX) \\ EL\_ILOAD\_ARRAY(I\_INDEX) \\ XOFF\_ILOAD\_ARRAY(I\_INDEX) \\ YOFF\_ILOAD\_ARRAY(I\_INDEX) \\ ZOFF\_ILOAD\_ARRAY(I\_INDEX) \end{array} \right\} = \text{the desired set in the I-load arrays}$$

1. Load the computation data buffers where

$$\begin{aligned} I\_INDEX &= PROX\_TGT\_SET\_NO \\ T1\_TIG &= PROX\_BASE\_TIME + 60 T1\_ILOAD\_ARRAY(I\_INDEX) \\ COMP\_PROX\_DT &= DT\_ILOAD\_ARRAY(I\_INDEX) \\ EL\_ANG &= EL\_ILOAD\_ARRAY(I\_INDEX) \\ COMP\_T2\_XOFF &= XOFF\_ILOAD\_ARRAY(I\_INDEX) \\ COMP\_T2\_YOFF &= YOFF\_ILOAD\_ARRAY(I\_INDEX) \\ COMP\_T2\_ZOFF &= ZOFF\_ILOAD\_ARRAY(I\_INDEX) \\ \dot{L}\dot{\Lambda}MB &= \dot{L}\dot{\Lambda}MB\_ILOAD(I\_INDEX) \end{aligned}$$

2. Load the display and computation buffers for T1 relative position and the display buffers for T2 time with zeros.

$$\begin{aligned} DISP\_T2\_DAY &= 0 \\ DISP\_T2\_HR &= 0 \\ DISP\_T2\_MIN &= 0 \\ DISP\_T2\_SEC &= 0 \\ DISP\_T1\_X &= 0,0,0 \\ DISP\_T1\_XD &= 0,0,0 \\ COMP\_X &= 0,0,0 \\ COMP\_XD &= 0,0,0 \end{aligned}$$

3. Convert the computational T1 maneuver time, which is in MET, to days, hours, minutes, seconds by calling the time conversion task (TIME\_CONVRT). TIME\_CONVRT detailed requirements are presented in Subsection 4.6.13.

TIME\_CONVERT\_FLAG = 0

TIME\_SEC = T1\_TIG

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, TIME\_SEC

Outputs: DAY, HR, MIN, SEC

4. Load the display data buffers where I\_INDEX = PROX\_TGT\_SET\_NO.

DISP\_T1\_DAY = DAY

DISP\_T1\_HR = HR

DISP\_T1\_MIN = MIN

DISP\_T1\_SEC = SEC

DISP\_PROX\_DT = DT\_ILOAD\_ARRAY(I\_INDEX)

DISP\_EL\_ANG = (180/PI) EL\_ILOAD\_ARRAY(I\_INDEX)

DISP\_T2\_XOFF = XOFF\_ILOAD\_ARRAY(I\_INDEX)/1000

DISP\_T2\_YOFF = YOFF\_ILOAD\_ARRAY(I\_INDEX)/1000

DISP\_T2\_ZOFF = ZOFF\_ILOAD\_ARRAY(I\_INDEX)/1000

B. Interface Requirements. The input and output parameters for the proximity operations targeting target set select task are listed in Tables 4.6.4-1 and 4.6.4-2. A flow diagram of PROX\_TGT\_SEL is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.4-1. Proximity Operations Targeting Target Set Select Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	ORBIT_TGT_DISP (6.14)	I	—
T1_ILOAD_ARRAY	SP	T1 time for target sets	PROX_INIT, ILOAD	F(40)	min
DT_ILOAD_ARRAY	SP	Delta time from T1 maneuver to T2 maneuver for target sets	PROX_INIT, ILOAD	F(40)	min
EL_ILOAD_ARRAY	SP	Maneuver elevation angle	PROX_INIT, ILOAD	F(40)	rad
XOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (X) for target sets	PROX_INIT, ILOAD	F(40)	ft
YOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (Y) for target sets	PROX_INIT, ILOAD	F(40)	ft
ZOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (Z) for target sets	PROX_INIT, ILOAD	F(40)	ft
DAY	SP	Converted time (day) for TIMECV	TIME_CONVRT	I	day
HR	SP	Converted time (hr) for TIMECV	TIME_CONVRT	I	hr
MIN	SP	Converted time (min) for TIMECV	TIME_CONVRT	I	min
SEC	SP	Converted time (sec) for TIMECV	TIME_CONVRT	F	s
PI	DP	Mathematical constant	CONSTANT	F	—
LAMB_ILOAD	—	Target mode discrete	ILOAD	D(40)	—
PROX_BASE_TIME	DP	PROX OPS base time	PROX_EXEC PROX_INIT PROX_TGT_SUP_ LAMB	F	s

Table 4.6.4-2. Proximity Operations Targeting Target Set Select Task Output Parameters					
Symbol	Precision	Definition	Destintation	Type	Units
DISP_PROX_DT	SP	Displayed delta time between T1 and T2	PROX_INIT ORBIT_TGT_DISP (6.14)	F	min
DISP_T1_X	DP	Orbiter relative position at T1	PROX_INIT ORBIT_TGT_DISP (6.14)	F(3)	Kft
DISP_T1_XD	SP	Orbiter relative velocity at T1	PROX_INIT ORBIT_TGT_DISP (6.14)	F(3)	ft/s
DISP_T1_DAY	SP	T1 time – day	PROX_INIT ORBIT_TGT_DISP (6.14)	I	day
DISP_T1_HR	SP	T1 time – hr	PROX_INIT ORBIT_TGT_DISP (6.14)	I	hr
DISP_T1_MIN	SP	T1 time – min	PROX_INIT ORBIT_TGT_DISP (6.14)	I	min
DISP_T1_SEC	SP	T1 time – sec	PROX_INIT ORBIT_TGT_DISP (6.14)	F	s



Table 4.6.4-2. Proximity Operations Targeting Target Set Select Task Output Parameters

Symbol	Precision	Definition	Destintation	Type	Units
DISP_T2_DAY	SP	T2 time – day	PROX_INIT ORBIT_TGT_DISP (6.14)	I	day
DISP_T2_HR	SP	T2 time – hr	PROX_INIT ORBIT_TGT_DISP (6.14)	I	hr
DISP_T2_MIN	SP	T2 time – min	PROX_INIT ORBIT_TGT_DISP (6.14)	I	min
DISP_T2_SEC	SP	T2 time – sec	PROX_INIT ORBIT_TGT_DISP (6.14)	F	s
DISP_T2_XOFF	DP	Orbiter desired relative position (X) at T2	PROX_INIT ORBIT_TGT_DISP (6.14)	F	ft
DISP_T2_YOFF	DP	Orbiter desired relative position (Y) at T2	PROX_INIT ORBIT_TGT_DISP (6.14)	F	ft
DISP_T2_ZOFF	DP	Orbiter desired relative position (Z) at T2	PROX_INIT ORBIT_TGT_DISP (6.14)	F	ft
DISP_EL_ANG	SP	Displayed target elevation angle at T1	PROX_INIT ORBIT_TGT_DISP (6.14)	F	deg
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP PROX_TGT_SUP_LAMB PROX_DISP_LOAD DT_COMP PREVR	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SUP PROX_TGT_SUP_LAMB PROX_DISP_LOAD DT_COMP PROX_EXEC	F	min
COMP_X̄	DP	Computational relative position	PROX_EXEC PROX_INIT PROX_TGT_SUP PROX_TGT_SUP_LAMB	F(3)	ft
COMP_XD̄	DP	Computational relative velocity	PROX_EXEC PROX_INIT PROX_TGT_SUP PROX_TGT_SUP_LAMB	F(3)	ft/s
COMP_T2_XOFF	DP	Computational desired position (X) at T2	PROX_TGT_SUP PROX_TGT_SUP_LAMB OMEGA_DT_COMP	F	ft
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	PROX_TGT_SUP PROX_TGT_SUP_LAMB OMEGA_DT_COMP	F	ft
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	PROX_TGT_SUP PROX_TGT_SUP_LAMB OMEGA_DT_COMP	F	ft
TIME_CONVERT_FLAG	SP	Time conversion flag	TIME_CONVRT	I	—

Table 4.6.4-2. Proximity Operations Targeting Target Set Select Task Output Parameters

Symbol	Precision	Definition	Destintation	Type	Units
TIME_SEC	DP	Conversion time	TIME_CONVRT	F	s
EL_ANG	SP	Desired elevation angle at TPI	PROX_TGT_SUP_LAMB TELEV	F	rad
LAMB	—	Target mode discrete	PROX_EXEC	D	—

#### 4.6.5 Proximity Operations Targeting Initialization Task (PROX\_INIT)

This task performs conversions on the input data display buffer items and stores the results in computational data buffers and I-load data buffers.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting initialization task.

1. Did crew request a change to the base time (PROX\_ITEM\_2ITO24\_STATUS = ON or PROX\_ITEM\_2TO20\_STATUS = OFF)? If so, put the displayed base time into the computational buffer:

TIME\_CONVERT\_FLAG = 1

DAY = PROX\_BASE\_DAY

HR = PROX\_BASE\_HR

MIN = PROX\_BASE\_MIN

SEC = PROX\_BASE\_SEC

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, DAY, HR, MIN, SEC

Outputs: TIME\_SEC

PROX\_BASE\_TIME = TIME\_SEC

2. If PROX\_ITEM\_2TO20\_STATUS is ON or PROX\_ITEM\_2ITO24\_STATUS = OFF:
  - a. Load the offset position and delta-time computation buffers and I-load buffers. The I-load buffers index value is determined by the selected target set (I\_INDEX = PROX\_TGT\_SET\_NO).

COMP\_T2\_XOFF = 1000 DISP\_T2\_XOFF

COMP\_T2\_YOFF = 1000 DISP\_T2\_YOFF

COMP\_T2\_ZOFF = 1000 DISP\_T2\_ZOFF

COMP\_PROX\_DT = DISP\_PROX\_DT

EL\_ANG = DISP\_EL\_ANG PI/180

XOFF\_ILOAD\_ARRAY(I\_INDEX) = 1000 DISP\_T2\_XOFF

YOFF\_ILOAD\_ARRAY(I\_INDEX) = 1000 DISP\_T2\_YOFF

ZOFF\_ILOAD\_ARRAY(I\_INDEX) = 1000 DISP\_T2\_ZOFF

DT\_ILOAD\_ARRAY(I\_INDEX) = DISP\_PROX\_DT

EL\_ILOAD\_ARRAY(I\_INDEX) = EL\_ANG

- b. Load the computation relative position and velocity buffers.

$$\text{COMP\_}\bar{X} = 1000 \text{ DISP\_T1\_}\bar{X}$$

$$\text{COMP\_}\bar{X}\text{D} = \text{DISP\_T1\_}\bar{X}\text{D}$$

- c. Convert the display T1 time and display T2 time and load the computation and I-load buffers.

- (1) Call the time conversion task (TIME\_CONVRT) to convert display T1 time to total seconds. TIME\_CONVRT detailed requirements are presented in Subsection 4.6.13.

TIME\_CONVERT\_FLAG = 1

DAY = DISP\_T1\_DAY

HR = DISP\_T1\_HR

MIN = DISP\_T1\_MIN

SEC = DISP\_T1\_SEC

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, DAY, HR, MIN, SEC

Outputs: TIME\_SEC

- (2) Load the T1 time in the computation and I-load buffers.

T1\_TIG = TIME\_SEC

T1\_ILOAD\_ARRAY(I\_INDEX) = (TIME\_SEC-PROX\_BASE\_TIME)/60

(Note: I\_INDEX = PROX\_TGT\_SET\_NO)

- (3) Call the time conversion task (TIME\_CONVRT) to convert display T2 time to total seconds.

DAY = DISP\_T2\_DAY

HR = DISP\_T2\_HR

MIN = DISP\_T2\_MIN

SEC = DISP\_T2\_SEC

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, DAY, HR, MIN, SEC

Outputs: TIME\_SEC

- (4) Load the T2 time in the computation array.

T2\_TIG = TIME\_SEC

B. Interface Requirements. The input and output parameters for the proximity operations targeting initialization task are listed in Tables 4.6.5-1 and 4.6.5-2. A flow diagram of PROX\_INIT is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.5-1. Proximity Operations Targeting Initialization Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	ORBIT_TGT_DISP (6.14)	I	—
DISP_PROX_DT	SP	Displayed delta time between T1 and T2	PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	F	min
DISP_T1_X̄	DP	Orbiter relative position at T1	PROX_TGT_SEL, PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	Kft
DISP_T1_XD̄	SP	Orbiter relative velocity at T1	ORBIT_TGT_DISP (6.14)	F(3)	ft/s
DISP_T1_DAY	SP	Displayed T1 time – day	PROX_EXEC, PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	day
DISP_T1_HR	SP	Displayed T1 time – hr	PROX_EXEC, PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	hr
DISP_T1_MIN	SP	Displayed T1 time – min	PROX_EXEC, PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	min
DISP_T1_SEC	SP	Displayed T1 time – sec	PROX_EXEC, PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	F	s
DISP_T2_DAY	SP	Displayed T2 time – day	PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	day
DISP_T2_HR	SP	Displayed T2 time – hr	PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	hr
DISP_T2_MIN	SP	Displayed T2 time – min	PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	I	min
DISP_T2_SEC	SP	Displayed T2 time – sec	PROX_TGT_SEL, PROX_DISP_LOAD, ORBIT_TGT_DISP (6.14)	F	s
DISP_T2_XOFF	DP	Orbiter desired relative position (X) at T2	PROX_TGT_SEL, ORBIT_TGT_DISP (6.14)	F	Kft
DISP_T2_YOFF	DP	Orbiter desired relative position (Y) at T2	PROX_TGT_SEL, ORBIT_TGT_DISP (6.14)	F	Kft
DISP_T2_ZOFF	DP	Orbiter desired relative position (Z) at T2	PROX_TGT_SEL, ORBIT_TGT_DISP (6.14)	F	Kft
DISP_EL_ANG	SP	Displayed target elevation angle at T1	PROX_TGT_SEL, ORBIT_TGT_DISP (6.14)	F	deg

Table 4.6.5-1. Proximity Operations Targeting Initialization Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
PROX_ITEM_21TO24_STATUS	—	Items 21 through 24 data entry status flag	PROX_EXEC, ORBIT_TGT_DISP (6.14)	D	—
PROX_ITEM_2TO20_STATUS	—	Items 2 through 20 data entry status flag	PROX_EXEC, ORBIT_TGT_DISP (6.14)	D	—
PROX_BASE_DAY	SP	Targeting base time – day	PROX_TGT_SUP_LAMB, ORBIT_TGT_DISP (6.14)	I	day
PROX_BASE_HR	SP	Targeting base time – hr	PROX_TGT_SUP_LAMB, ORBIT_TGT_DISP (6.14)	I	hr
PROX_BASE_MIN	SP	Targeting base time – min	PROX_TGT_SUP_LAMB, ORBIT_TGT_DISP (6.14)	I	min
PROX_BASE_SEC	SP	Targeting base time – sec	PROX_TGT_SUP_LAMB, ORBIT_TGT_DISP (6.14)	F	s
PROX_BASE_TIME	DP	Prox ops base time	PROX_EXEC, PROX_TGT_SUP_LAMB	F	s
TIME_SEC	DP	Conversion time	TIME_CONVRT	F	s

Table 4.6.5-2. Proximity Operations Targeting Initialization Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
T1_ILOAD_ARRAY	SP	T1 time for target sets (times are relative to prox ops base time)	TELEV, PROX_TGT_SEL, PROX_TGT_SUP_LAMB	F(40)	min
EL_ILOAD_ARRAY	SP	Maneuver elevation angle	PROX_TGT_SEL	F(40)	rad
DT_ILOAD_ARRAY	SP	Delta times for T1 maneuver to T2 maneuver for target sets	PROX_TGT_SEL, OMEGA_DT_COMP	F(40)	min
XOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (X) for target sets	PROX_TGT_SEL, OMEGA_DT_COMP	F(40)	ft
YOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (Y) for target sets	PROX_TGT_SEL, OMEGA_DT_COMP	F(40)	ft
ZOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position (Z) for target sets	PROX_TGT_SEL, OMEGA_DT_COMP	F(40)	ft
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD, DT_COMP PREVR	F	s
PROX_BASE_TIME	DP	Prox ops base time	PROX_STAT	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD, DT_COMP, PREVR, PROX_EXEC	F	s
DAY	SP	Converted time (day) for TIMECV	TIME_CONVRT	I	day
HR	SP	Converted time (hr) for TIMECV	TIME_CONVRT	I	hr
MIN	SP	Converted time (min) for TIMECV	TIME_CONVRT	I	min
SEC	SP	Converted time (sec) for TIMECV	TIME_CONVRT	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD, DT_COMP, PROX_EXEC	F	min
COMP_T2_XOFF	DP	Computational desired position (X) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft



Table 4.6.5-2. Proximity Operations Targeting Initialization Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft
TIME_CONVERT_FLAG	SP	Time conversion flag	TIME_CONVRT	I	—
EL_ANG	SP	Desired elevation angle at TPI	PROX_TGT_SUP_LAMB, TELEV	F	rad
COMP_X̄	DP	Computation relative position	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F(3)	ft
COMP_X̄D	SP	Computation relative velocity	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s

#### 4.6.6 Proximity Operations Targeting Guidance Quantity Transfer Task (PROX\_TRANS)

This task sets the quantities required to perform the maneuver. The delta-V velocity maneuver (called DELTA\_V\_LVLH\_GUID) is defined in terms of the orbiter-centered LVLH coordinate system.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting guidance quantity transfer task:

1. Perform a logical test to see if the maneuver has been executed. If it has not been executed (PROX\_PAST\_STATUS = OFF), then:

- a. Set TIG\_GUID\_DAY = DISP\_TMAN\_DAY.

$$\text{TIG\_GUID\_HR} = \text{DISP\_TMAN\_HR}$$

$$\text{TIG\_GUID\_MIN} = \text{DISP\_TMAN\_MIN}$$

$$\text{TIG\_GUID\_SEC} = \text{DISP\_TMAN\_SEC}$$

- b. Set DELTA\_V\_LVLH\_GUID = DV\_LVLH.

- c. Test to see if the maneuver is a Lambert maneuver. If so (GUID\_FLAG = ON), set:

$$\text{S\_ROTATE\_GUID} = \text{S\_ROTATE}$$

$$\bar{\text{R}}\_OFFSET\_GUID = \bar{\text{R}}\_OFFSET$$

$$\text{T\_OFFSET\_GUID} = \text{T\_OFFSET} + \text{BASE\_MET}$$

B. Interface Requirements. The input and output parameters for the proximity operations targeting guidance quantity transfer task are given in Tables 4.6.6-1 and 4.6.6-2. A flow diagram of PROX\_TRANS is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.6-1. Proximity Operations Targeting Guidance Quantity Transfer Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
$\dot{G}UID\_FLAG$	—	Current maneuver guidance option flag	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	D	—
$\dot{P}ROX\_PAST\_STATUS$	—	Maneuver past time status flag	PROX_STAT	D	—
$\overline{D}V\_LVLH$	SP	Impulsive maneuver in LVLH reference frame	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s
S_ROTATE	SP	Rotation flag for near 180° transfers	PREVR	I	—
$\overline{R}\_OFFSET$	DP	Offset position vectors	PREVR	F(3)	ft
$\overline{T}\_OFFSET$	DP	Time of offset position vector (MET)	PREVR	F	s
DISP_TMAN_DAY	SP	Maneuver time for display (day)	PROX_DISP_LOAD	I	day
DISP_TMAN_HR	SP	Maneuver time for display (hr)	PROX_DISP_LOAD	I	hr
DISP_TMAN_MIN	SP	Maneuver time for display (min)	PROX_DISP_LOAD	I	min
DISP_TMAN_SEC	SP	Maneuver time for display (sec)	PROX_DISP_LOAD	F	s
BASE_MET	DP	GMT/MET reference time	FCOS	F	s

Table 4.6.6-2. Proximity Operations Targeting Guidance Quantity Transfer Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
DELTA_V_LVLH_GUID	SP	Delta-V vector of current maneuver	ORBIT_MNVR_DISP (6.35)	F(3)	ft/s
S_ROTATE_GUID	SP	Rotation flag for near 180° transfers	ORBIT_MNVR_DIP (4.158)	I	—
R_OFFSET_GUID	DP	Offset position vectors	ORBIT_MNVR_DIP (4.158)	F(3)	ft
T_OFFSET_GUID	DP	Time of offset position vector (GMT)	ORBIT_MNVR_DIP (4.158)	F	s
TIG_GUID_DAY	SP	Ignition time of current maneuver (day)	ORBIT_MNVR_DISP (6.35)	I	day
TIG_GUID_HR	SP	Ignition time of current maneuver (hr)	ORBIT_MNVR_DISP (6.35)	I	hr
TIG_GUID_MIN	SP	Ignition time of current maneuver (min)	ORBIT_MNVR_DISP (6.35)	I	min
TIG_GUID_SEC	SP	Ignition time of current maneuver (sec)	ORBIT_MNVR_DISP (6.35)	F	s

#### 4.6.7 Proximity Operations Targeting Supervisory Logic Task (PROX\_TGT\_SUP)

This task is scheduled and executed following a crew execution of Item 28 or Item 29 for a non-Lambert targeted maneuver. This task is the top-level supervisory module for performing the subtask required to compute the maneuver delta-velocity vector using closed form CW equations.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting supervisory logic task.

1. Set the CW singularity alarm flag to off.

$$\dot{A}LARM\_C = OFF$$

2. Compute the minimum time of ignition.

$$TIG\_MIN = PROX\_T\_CURRENT + PROX\_DTMIN$$

3. If the crew did not request the compute T1 function, then compute the T2 maneuver:

If (PROX\_T1\_STAR\_STATUS = OFF) then:

- a. Compare TIG\_MIN to T2\_TIG.

If  $TIG\_MIN \geq T2\_TIG$ , set  $T2\_TIG = TIG\_MIN$ .

- b. Compute the T2 maneuver after an inertial propagation.

- (1) Propagate states inertially, and interchange the orbiter and target state vectors so that REL\_COMP will compute a Shuttle-centered LVC relative state.

$$T\_PRED\_IN = TIME\_PROX + BASE\_MET$$

$$T\_PRED\_FINAL = T2\_TIG + BASE\_MET$$

CALL UPDATVP

Inputs:  $\overline{RS\_M50\_PROX}$

$\overline{VS\_M50\_PROX}$

T\_PRED\_IN

T\_PRED\_FINAL

S\_OPTION = 1

Outputs:  $\overline{R\_T\_INER}$

$\overline{V\_T\_INER}$

CALL UPDATVP

Inputs:  $\overline{RT\_M50\_PROX}$

$\overline{VT\_M50\_PROX}$

$S\_OPTION = 2$

Outputs:  $\overline{R\_S\_INER}$

$\overline{V\_S\_INER}$

- (2) Convert states to a Shuttle-centered LVC relative state.

CALL REL\_COMP

Inputs:  $\overline{R\_S\_INER}$

$\overline{V\_S\_INER}$

$\overline{R\_T\_INER}$

$\overline{V\_T\_INER}$

$INER\_TO\_LVC (= ON)$

Outputs:  $\overline{R\_REL}$

$\overline{V\_REL}$

- (3) Compute orbiter-centered maneuver:

$DV\_LVLH = \overline{V\_REL}$

- c. Compute the maneuver time:

$T\_MAN = T2\_TIG$

- d. Set DSP\_MISS = 0.

4. If the crew did request a T1 computation ( $PROX\_T1\_STAR\_STATUS = ON$ ), then execute the T1 maneuver calculations:

- a. Compute the transfer time or T2\_TIG:

CALL DT\_COMP

Inputs:  $T1\_TIG$   
 $T2\_TIG$   
 $COMP\_PROX\_DT$

Outputs:  $T2\_TIG$   
 $COMP\_PROX\_DT$   
 $USE\_OMEGA\_DT$

- b. If  $TIG\_MIN > T1\_TIG$ , then:
- (1) Set  $T1\_TIG = TIG\_MIN$ .
  - (2) If  $USE\_OMEGA\_DT = OFF$ , then compute a new transfer time:  

$$COMP\_PROX\_DT = (T2\_TIG - T1\_TIG)/60$$
  - (3) Set  $USE\_DISP\_REL\_STATE = OFF$ .
- c. Propagate states inertially to  $T1\_TIG$  and compute differential drag:

- (1)  $T\_PRED\_IN = TIME\ PROX + BASE\_MET$

$$T\_PRED\_FINAL = T1\_TIG + BASE\_MET$$

CALL UPDATVP

Inputs:         $\overline{RS\_M50\_PROX}$   
                    $\overline{VS\_M50\_PROX}$   
                    $T\_PRED\_IN$   
                    $T\_PRED\_FINAL$   
                    $S\_OPTION (= 1)$

Outputs:        $\overline{R\_S\_INNER}$   
                    $\overline{V\_S\_INNER}$   
                    $\overline{D\_DRAG}$

$$\text{Set } \overline{DRAG\_ACCEL\_ORB} = \overline{D\_DRAG}$$

- (2) CALL UPDATVP

Inputs:         $\overline{RT\_M50\_PROX}$   
                    $\overline{VT\_M50\_PROX}$   
                    $S\_OPTION (= 2)$

Outputs:        $\overline{R\_T\_INNER}$   
                    $\overline{V\_T\_INNER}$   
                    $\overline{D\_DRAG}$

$$\text{Set } \overline{DRAG\_ACCEL\_TGT} = \overline{D\_DRAG}$$

- (3) Set  $\overline{R\_TGT1} = \overline{R\_T\_INNER}$  and  $\overline{V\_TGT1} = \overline{V\_T\_INNER}$ .

$$(4) \text{ DIFF\_DR} = \text{ABVAL}[\overline{\text{DRAG\_ACCEL\_TGT}} - \overline{\text{DRAG\_ACCEL\_ORB}}].$$

- d. If ( $\text{USE\_DISP\_REL\_STATE} = \text{OFF}$ ), then compute the relative state at T1\_TIG:

CALL REL\_COMP

Inputs:  $\overline{\text{R\_S\_INER}}$   
 $\overline{\text{V\_S\_INER}}$   
 $\overline{\text{R\_T\_INER}}$   
 $\overline{\text{V\_T\_INER}}$   
 $\text{INER\_TO\_LVC} (= \text{ON})$

Outputs:  $\overline{\text{R\_REL}}$   
 $\overline{\text{V\_REL}}$

Set  $\overline{\text{COMP\_X}} = \overline{\text{R\_REL}}$

$\overline{\text{COMP\_XD}} = \overline{\text{V\_REL}}$

- e. At this point,  $\overline{\text{COMP\_X}}$  and  $\overline{\text{COMP\_XD}}$  represent the relative state at T1 to be used in the upcoming targeting computations. If ( $\text{USE\_DISP\_REL\_STATE} = \text{ON}$ ), then compute a Shuttle inertial vector:

CALL REL\_COMP

Inputs:  $\overline{\text{R\_REL}} (= \overline{\text{COMP\_X}})$   
 $\overline{\text{V\_REL}} (= \overline{\text{COMP\_XD}})$   
 $\overline{\text{R\_T\_INER}} (= \overline{\text{R\_TGT1}})$   
 $\overline{\text{V\_T\_INER}} (= \overline{\text{V\_TGT1}})$   
 $\text{INER\_TO\_LVC} (= \text{OFF})$

Outputs:  $\overline{\text{R\_S\_INER}}$   
 $\overline{\text{V\_S\_INER}}$

- f. Compute display quantities:

$$\text{DISP\_T1\_X} = \overline{\text{COMP\_X}} / 1000$$

$$\text{DISP\_T1\_XD} = \overline{\text{COMP\_XD}}$$

- g. Redefine vectors.

Set  $\overline{\text{R\_ORB1}} = \overline{\text{R\_S\_INER}}$



$$\bar{V}_{ORB1} = \bar{V}_S \text{ INER}$$

- h. If ( $USE_{\dot{\Omega}} \text{ OMEGA\_DT} = \text{ON}$ ), then

CALL OMEGA\_DT\_COMP

Inputs:             $COMP_{\bar{X}}$   
  
                      $COMP_{T2\_XOFF}$   
  
                      $COMP_{T2\_YOFF}$   
  
                      $COMP_{T2\_ZOFF}$   
  
                      $X\_OFF\_ILOAD\_ARRAY$   
  
                      $Y\_OFF\_ILOAD\_ARRAY$   
  
                      $Z\_OFF\_ILOAD\_ARRAY$   
  
                      $DT\_ILOAD\_ARRAY$   
  
                      $OMEGA\_PROX$

Outputs:            $COMP\_PROX\_DT, ALARM\_KILL$

If ( $ALARM\_KILL = \text{OFF}$ ), then set  $T2\_TIG = T1\_TIG + 60 \text{ COMP\_PROX\_DT}$

- i. If ( $ALARM\_KILL = \text{ON}$ ), then proceed to Step 5. Otherwise, propagate target to  $T2\_TIG$ .

$$T\_PRED\_IN = T1\_TIG + \text{BASE\_MET}$$

$$T\_PRED\_FINAL = T2\_TIG + \text{BASE\_MET}$$

CALL UPDATVP

Inputs:             $\bar{R}_T \text{ INER}$   
  
                      $\bar{V}_T \text{ INER}$   
  
                      $T\_PRED\_IN$   
  
                      $T\_PRED\_FINAL$   
  
                      $S\_OPTION (= 2)$

Outputs:            $\bar{R}_T \text{ TGT2}$   
  
                      $\bar{V}_T \text{ TGT2}$

- j. Begin T1 maneuver computations by initializing parameters for the iteration:

$$I\_LOW = 0$$

$$N = 0$$

$$D\_MISS1 = 1.E6$$

$$D\_MISS2 = 2.E6$$

$$\overline{DV\_REQ\_R} = 0.$$

$$\overline{XD\_OFF} = COMP\_X\overline{D}$$

$$\overline{X\_OFF} = COMP\_X\overline{X}$$

$$X2\_OFF(1) = COMP\_T2\_XOFF$$

$$X2\_OFF(2) = COMP\_T2\_YOFF$$

$$X2\_OFF(3) = COMP\_T2\_ZOFF$$

$$DT\_OFF = COMP\_PROX\_DT$$

$$R\_MAX = R\_TOL\_CW \text{ ABVAL}(X2\_OFF)$$

If ( $R\_MAX > 1000$  ft)  $R\_MAX = 1000$  ft; if ( $R\_MAX < 1$  ft)  $R\_MAX = 1$  ft

- k. Begin iterations. Execute the following computations until the error in the arrival point is less than a tolerance ( $ERR < R\_MAX$ ) or maximum number of iterations has been achieved ( $N \geq N\_MAX\_ITER$ ):

- (1) Compute velocity required to get from  $\overline{X\_OFF}$  to  $\overline{X2\_OFF}$  in  $DT\_OFF$ :

CALL OFFSET\_TGT

Inputs:  $\overline{X\_OFF}$

$\overline{X2\_OFF}$

$\overline{XD\_OFF}$

DIFF\_DR

DT\_OFF

Outputs:  $\overline{DV}$ , ALARM\_KILL

If ( $\text{ALARM\_KILL} = \text{ON}$ ), then stop iterations and proceed to Step 5. Otherwise,  
set  $\overline{\text{DV\_REQ\_R}} = \overline{\text{DV\_REQ\_R}} + \overline{\text{DV}}$

- (2) Convert post-maneuver relative state to an orbiter inertial state.

$$\overline{\text{V\_REL}} = \overline{\text{DV\_REQ\_R}} + \text{COMP\_}\overline{\text{X}}\text{D}$$

CALL REL\_COMP

Inputs:            $\overline{\text{R\_REL}}$  (= COMP\_ $\overline{\text{X}}$ )  
                   $\overline{\text{V\_REL}}$   
                   $\overline{\text{R\_TGT1}}$   
                   $\overline{\text{V\_TGT1}}$   
                   $\text{INER}\dot{\text{R}}_{\text{TO\_LVC}}$  (= OFF)

Outputs:           $\overline{\text{R\_S\_INER}}$ ,  $\overline{\text{V\_S\_INER}}$

Set  $\overline{\text{VS\_REQ}} = \overline{\text{V\_S\_INER}}$

- (3) Propagate orbiter state to T2\_TIG.

$$\text{T\_PRED\_IN} = \text{T1\_TIG} + \text{BASE\_MET}$$

$$\text{T\_PRED\_FINAL} = \text{T2\_TIG} + \text{BASE\_MET}$$

CALL UPDATVP

Inputs:            $\overline{\text{R\_S\_INER}}$   
                   $\overline{\text{V\_S\_INER}}$   
                   $\text{T\_PRED\_IN}$   
                   $\text{T\_PRED\_FINAL}$   
                   $\text{S\_OPTION}$  (= 1)

Outputs:           $\overline{\text{R\_S\_INER}}$   
                   $\overline{\text{V\_S\_INER}}$

- (4) Convert to a relative state centered at the target.

CALL REL\_COMP

Inputs:            $\bar{R}_S_{INER}$   
                    $\bar{V}_S_{INER}$   
                    $\bar{R}_{TGT2}$   
                    $\bar{V}_{TGT2}$   
                    $INER\dot{R}_{TO\_LVC}$  (= ON)  
 Outputs:          $\bar{R}_{REL}$

- (5) Compute the relative state miss vector and then the error magnitude:

$$ERR\_Q(1) = COMP\_T2\_XOFF - R\_REL(1)$$

$$ERR\_Q(2) = COMP\_T2\_YOFF - R\_REL(2)$$

$$ERR\_Q(3) = COMP\_T2\_ZOFF - R\_REL(3)$$

$$ERR = ABVAL(\bar{ERR\_Q})$$

$$DSP\_MISS = ERR$$

- (6) Check for convergence or divergence. Divergence is determined by two subsequently increasing miss distances.

If  $[(ERR > D\_MISS1) \text{ and } (D\_MISS1 > D\_MISS2)]$ , then set the alarm flag ( $ALARM\_C = ON$ ) and proceed to Step 1 (lowercase L).

- (7) Set  $D\_MISS2 = D\_MISS1$  and then  $D\_MISS1 = ERR$ .

- (8) Check to see if the changes to the maneuver ( $\bar{DV}$ ) are small. Stop iterations if three consecutive iterations each change  $\bar{DV}$  by less than 0.05 fps:

(a)  $DV\_MAG = ABVAL(\bar{DV})$

- (b) If  $(DV\_MAG \geq 0.05 \text{ fps})$

    then: set  $I\_LOW = 0$

    else:  $I\_LOW = I\_LOW + 1$

if  $(I\_LOW \geq 3)$

    then: Stop iterations. Go to Step 1 (lowercase L).

- (9) If  $[(ERR > R\_MAX) \text{ and } (N < N\_MAX\_ITER)]$ , then make the following assignments:

$$\overline{X\_OFF} = 0.0$$

$$\overline{XD\_OFF} = 0.0$$

$$\overline{X2\_OFF} = \overline{ERR\_Q}$$

$$N = N + 1$$

$$DIFF\_DR = 0$$

- l. If max iterations have occurred ( $N \geq N\_MAX\_ITER$ ), set an alarm flag:

$$\dot{A}LARM\_C = ON$$

- m. Change inertial delta-V to an orbiter-centered LVLH delta-V.

$$\text{Set } \overline{DV\_INNER} = \overline{VS\_REQ} - \overline{V\_ORB1}.$$

CALL ORBLV

Inputs:  $\overline{R\_ORB1}$

$\overline{V\_ORB1}$

$\overline{DV\_INNER}$

Output:  $\overline{DV\_LVLH}$

- n. Set the maneuver time.

$$T\_MAN = T1\_TIG$$

5. Set the guidance flag.

$$\dot{G}UID\_FLAG = OFF$$

B. Interface Requirements. The input and output parameters for the proximity operations targeting supervisory logic task are listed in Tables 4.6.7-1 and 4.6.7-2. A flow diagram of PROX\_TGT\_SUP is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. Set  $\dot{A}LARM\_D = OFF$  upon call.

E. Supplemental Information. DSP\_MISS values on the orbit targeting display will be updated at 2.08 Hz.

Table 4.6.7-1. Proximity Operations Targeting Supervisory Logic Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
PROX_T1_STAR_STATUS	—	T1 maneuver compute star flag	PROX_EXEC ORBIT_TGT_DSP (6.14)	D	—
PROX_DTMIN	DP	Tolerance on minimum time in the future to compute a prox ops maneuver solution	ILOAD	F	s
T1_TIG	DP	T1 maneuver time (MET)	PROX_EXEC, PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_EXEC, PROX_INIT, PROX_TGT_SUP_LAMB, DT_COMP	F	s
PROX_T_CURRENT	DP	Current MET time	PROX_STAT	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB, DT_COMP, OMEGA_DT_COMP	F	min
COMP_T2_XOFF	DP	Computational desired position (X) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB	F	ft
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB	F	ft
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB	F	ft
TIME_PROX	DP	Time tag for M50 state (assume MET)	PROX_EXEC, PROX_INIT	F	s
USE_OMEGA_DT	—	Use the WT calculation flag	PROX_TGT_SUP_LAMB, DT_COMP	D	—
USE_DISP_REL_STATE	—	Use displayed relative state flag	PROX_EXEC, PROX_TGT_SUP_LAMB	D	—
COMP_X	DP	Computation relative position	PROX_INIT, PROX_TGT_SUP_LAMB, PROX_TGT_SEL	F(3)	ft
COMP_XD	DP	Computation relative velocity	PROX_INIT, PROX_TGT_SUP_LAMB, PROX_TGT_SEL	F(3)	ft/s
R_S_M50_PROX	DP	Prox ops orbiter M50 position vector	PROX_EXEC	F(3)	ft
R_T_M50_PROX	DP	Prox ops target M50 position vector	PROX_EXEC	F(3)	ft

Table 4.6.7-1. Proximity Operations Targeting Supervisory Logic Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
$\bar{V}_S$ _M50_PROX	DP	Prox ops orbiter M50 velocity vector	PROX_EXEC	F(3)	ft/s
$\bar{V}_T$ _M50_PROX	DP	Prox ops target M50 velocity vector	PROX_EXEC	F(3)	ft/s
$\bar{D}$ _DRAG	SP	Drag acceleration vector	ONORB_PRED (4.224)	F(3)	ft/s <sup>2</sup>
R_TOL_CW	SP	Iteration tolerance	ILOAD	F	—
$\bar{R}$ _REL	DP	LVLH curvilinear position vector from REL_COMP	REL_COMP	F(3)	ft
$\bar{V}$ _REL	DP	LVLH curvilinear velocity vector from REL_COMP	REL_COMP	F(3)	ft/s
$\bar{D}V$	SP	Delta velocity vector from OFFSET_TGT	OFFSET_TGT	F(3)	ft/s
ALARM_KILL	—	Stop computations flag	PROX_EXEC, OFFSET_TGT, OMEGA_DT_COMP	D	—
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
N_MAX_ITER	SP	Maximum allowed number of iterations	ILOAD	I	—

Table 4.6.7-2. Proximity Operations Targeting Supervisory Logic Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
GUID_FLAG	—	Current maneuver guidance option flag	ORBIT_MNVR_DIP (4.158), PROX_TRANS	D	—
T_MAN	DP	Time of the computed maneuver (MET)	PROX_STAT, PROX_TRANS, PROX_STIME, PROX_DISP_LOAD	F	s
DISP_T1 $\bar{X}$	DP	Orbiter relative position at T1	PROX_INIT, ORBIT_TGT_DISP (6.14)	F(3)	ft
DISP_T1 $\bar{X}D$	DP	Orbiter relative velocity at T1	PROX_INIT, ORBIT_TGT_DISP (6.14)	F(3)	ft/s
T1_TIG	DP	T1 maneuver time (MET)	PROX_DISP_LOAD, DT_COMP, PREVR	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_DISP_LOAD, DT_COMP, PREVR	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SUP_LAMB, PROX_DISP_LOAD, DT_COMP	F	min
COMP_T2_XOFF	DP	Computational desired position (X) at T2	PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft

Table 4.6.7-2. Proximity Operations Targeting Supervisory Logic Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F	ft
$\overline{DV}_{LVLH}$	SP	Impulsive maneuver in LVLH reference frame	PROX_TRANS, PROX_DISP_LOAD	F(3)	ft/s
USE_DISP_REL_STATE	—	Use displayed relative state flag	PROX_TGT_SUP_LAMB	D	—
COMP $\overline{X}$	DP	Computation relative position	PROX_TGT_SUP_LAMB, OMEGA_DT_COMP	F(3)	ft
COMP $\overline{X}D$	DP	Computation relative velocity	PROX_TGT_SUP_LAMB	F(3)	ft/s
$\overline{INER}_{TO\_LVC}$	—	Inertial to curvilinear conversion flag	REL_COMP	D	—
DT_OFF	SP	Transfer time for OFFSET_TGT	OFFSET_TGT	F	s
$\overline{X}_{OFF}$	DP	T1 relative position vector for OFFSET_TGT	OFFSET_TGT	F(3)	ft
$\overline{XD}_{OFF}$	SP	T1 relative velocity vector for OFFSET_TGT	OFFSET_TGT	F(3)	ft/s
$\overline{X2}_{OFF}$	DP	T2 relative position vector for OFFSET_TGT	OFFSET_TGT	F(3)	ft
$\overline{R}_{S\_INER}$	DP	Input Shuttle inertial position for REL_COMP	REL_COMP	F(3)	ft
$\overline{V}_{S\_INER}$	DP	Input Shuttle inertial velocity for REL_COMP	REL_COMP	F(3)	ft/s
$\overline{R}_{T\_INER}$	DP	Input target inertial position for REL_COMP	REL_COMP	F(3)	ft
$\overline{V}_{T\_INER}$	DP	Input target inertial velocity for REL_COMP	REL_COMP	F(3)	ft/s
DIFF_DR	SP	Differential drag acceleration magnitude	OFFSET_TGT	F	ft/s <sup>2</sup>
ALARM_C	—	Alarm flag for C-W singularity	GAX (4.110)	D	—
DSP_MISS	SP	Miss distance	ORBIT_TGT_DISP (6.14)	F	ft
S_OPTION	SP	Spacecraft flag for UPDATVP	UPDATVP	I	—
ALARM_D	—	Transfer time alarm	OFFSET_TGT	D	—
ALARM_KILL	—	Stop computations flag	PROX_EXEC	D	—



#### 4.6.8 Proximity Operations Targeting Supervisory Lambert Logic Task (PROX\_TGT\_SUP\_LAMB)

This task is scheduled and executed following a crew execution of Item 28 or Item 29 if Lambert targeting is requested, LAMB = ON. This task is the top-level supervisory module for performing the subtask required to compute the maneuver delta-velocity vector with Lambert equations.

A. Detailed Requirements. The following steps are required to compute maneuvers.

1. Set the ALARM flags to OFF (ALARM\_A = OFF; ALARM\_B = OFF).
2. Compute minimum time to ignition.

$$TIG\_MIN = PROX\_T\_CURRENT + PROX\_DTMIN\_LAMB$$

3. Check Compute T1 flag:
  - a. If PROX\_T1\_STAR\_STATUS = OFF, then compute the T2 maneuver.
    - (1) If T2\_TIG < TIG\_MIN, set T2\_TIG = TIG\_MIN.
    - (2) Update Shuttle and target inertial states from the present time to T2\_TIG and compute the maneuver.

Interchange the orbiter and target state vectors so that REL\_COMP will compute a Shuttle-centered LVC relative state.

$$S\_OPTION = 1$$

$$\bar{R}\_PRED\_IN = \bar{RS}\_M50\ PROX$$

$$\bar{V}\_PRED\_IN = \bar{VS}\_M50\ PROX$$

$$T\_PRED\_IN = TIME\_PROX + BASE\_MET$$

$$T\_PRED\_FINAL = T2\_TIG + BASE\_MET$$

CALL UPDATVP

Inputs: S\_OPTION,  $\bar{R}\_PRED\_IN$ ,  $\bar{V}\_PRED\_IN$ , T\_PRED\_IN,  
T\_PRED\_FINAL

Outputs:  $\bar{R}\_PRED\_FINAL$ ,  $\bar{V}\_PRED\_FINAL$

$$\bar{R}\_T\_INER = \bar{R}\_PRED\_FINAL; \bar{V}\_T\_INER = \bar{V}\_PRED\_FINAL$$

$$S\_OPTION = 2$$

$$\bar{R}\_PRED\_IN = \bar{RT}\_M50\_PROX$$

$$\bar{V}\_PRED\_IN = \bar{VT}\_M50\_PROX$$

CALL UPDATVP

Inputs:  $S\_OPTION$ ,  $\bar{R}\_PRED\_IN$ ,  $\bar{V}\_PRED\_IN$ ,  
 $T\_PRED\_IN$ ,  $T\_PRED\_FINAL$

Outputs:  $\bar{R}\_PRED\_FINAL$ ,  $\bar{V}\_PRED\_FINAL$

$\bar{R}\_S\_INER = \bar{R}\_PRED\_FINAL$

$\bar{V}\_S\_INER = \bar{V}\_PRED\_FINAL$

- (3) Convert to a Shuttle-centered curvilinear state.

$\dot{I}NER\_TO\_LVC = ON$

CALL REL\_COMP

Inputs:  $\bar{R}\_T\_INER$ ,  $\bar{V}\_T\_INER$

$\bar{R}\_S\_INER$ ,  $\bar{V}\_S\_INER$

$\dot{I}NER\_TO\_LVC$

Outputs:  $\bar{R}\_REL$ ,  $\bar{V}\_REL$

- (4) Null relative velocity. Determine maneuver time. Set guidance flag for external DV.

$\bar{D}V\_LVLH = + \bar{V}\_REL$

$T\_MAN = T2\_TIG$

$DSP\_MISS = 0$

$G\dot{U}ID\_FLAG = OFF$

- b. If  $PROX\_T\dot{I}\_STAR\_STATUS = ON$ , compute the T1 maneuver.

- (1) If elevation angle ( $EL\_ANG$ ) is  $\neq 0$  and the seed value is in the future ( $T1\_TIG > PROX\_T\_CURRENT$ ), then determine T1 time from elevation angle search:

- (a) Compute time of elevation angle.

CALL TELEV

Inputs:  $\bar{R}S\_M50\_PROX$

$\bar{V}S\_M50\_PROX$

$\bar{R}T\_M50\_PROX$

$\bar{V}T\_M50\_PROX$

$TIME\_PROX$

EL\_ANG

PI

EL\_TOL, EL\_DH\_TOL

Outputs: TTPI,

$\overline{RS\_OUT}$ ,  $\overline{VS\_OUT}$ ,  $\overline{RT\_OUT}$ ,  $\overline{VT\_OUT}$

$\overline{RS\_T1TIG} = \overline{RS\_OUT}$

$\overline{VS\_T1TIG} = \overline{VS\_OUT}$

$T1\_TIG = TTPI$

(b) Find relative state.

$\overline{R\_S\_INNER} = \overline{RS\_OUT}$

$\overline{V\_S\_INNER} = \overline{VS\_OUT}$

$\overline{R\_T\_INNER} = \overline{RT\_OUT}$

$\overline{V\_T\_INNER} = \overline{VT\_OUT}$

$\dot{I}NER\_TO\_LVC = ON$

CALL REL\_COMP

Inputs:  $\overline{R\_S\_INNER}$ ,  $\overline{V\_S\_INNER}$ ,

$\overline{R\_T\_INNER}$ ,  $\overline{V\_T\_INNER}$ ,

$\dot{I}NER\_TO\_LVC$

Outputs:  $\overline{R\_REL}$ ,  $\overline{V\_REL}$

$COMP\_X = \overline{R\_REL}$

$COMP\_XD = \overline{V\_REL}$

(c) Display relative state.

$DISP\_T1\_X = \overline{R\_REL}/1000$

$DISP\_T1\_XD = \overline{V\_REL}$

(d) Change basetime in display and computational buffer. Change ILOAD.

$T1\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO) = 0$

$PROX\_BASE\_TIME = T1\_TIG$

TIME\_CONVERT\_FLAG = 0

TIME\_SEC = T1\_TIG

CALL TIME\_CONVRT

Inputs:           TIME\_CONVERT\_FLAG,  
                  TIME\_SEC

Outputs:          DAY, HR, MIN, SEC

PROX\_BASE\_DAY = DAY

PROX\_BASE\_HR = HR

PROX\_BASE\_MIN = MIN

PROX\_BASE\_SEC = SEC

- (e) Compute T2\_TIG and COMP\_PROX\_DT from the T1\_TIG being used.

CALL DT\_COMP

Inputs:           T1\_TIG, T2\_TIG, COMP\_PROX\_DT

Outputs:          T2\_TIG, COMP\_PROX\_DT, USE\_ΩDT

- (2) If elevation angle (EL\_ANG) = 0, or the seed value is in the past (T1\_TIG ≤ PROX\_T\_CURRENT), use the T1 time given for the maneuver time.

- (a) Given T1\_TIG, compute T2\_TIG or COMP\_PROX\_DT.

CALL DT\_COMP

Inputs:           T1\_TIG, T2\_TIG, COMP\_PROX\_DT

Outputs:          T2\_TIG, COMP\_PROX\_DT

USE\_ΩDT

- (b) Compare T1\_TIG to the minimum time of ignition (TIG\_MIN). If T1\_TIG < TIG\_MIN:

1. Set T1\_TIG = TIG\_MIN.

2. Check if USE\_ΩDT is off. If it is, then the maneuver transfer time will be adjusted so that the next maneuver will be on time:

$$\text{COMP\_PROX\_DT} = (\text{T2\_TIG} - \text{T1\_TIG})/60$$

3. Set the USE\_DISP\_REL\_STATE flag to off.

(c) Update the target state to T1\_TIG:

$$S\_OPTION = 2$$

$$\overline{R\_PRED\_IN} = \overline{RT\_M50\_PROX}$$

$$\overline{V\_PRED\_IN} = \overline{VT\_M50\_PROX}$$

$$T\_PRED\_IN = TIME\_PROX + BASE\_MET$$

$$T\_PRED\_FINAL = T1\_TIG + BASE\_MET$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ ,  $T\_PRED\_IN$ ,  
 $T\_PRED\_FINAL$ ,  $S\_OPTION$

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{R\_T\_INER} = \overline{R\_PRED\_FINAL}$$

$$\overline{V\_T\_INER} = \overline{V\_PRED\_FINAL}$$

(d) Check the  $\dot{USE\_DISP\_REL\_STATE}$  flag.

1. If  $\dot{USE\_DISP\_REL\_STATE}$  is ON, compute the Shuttle inertial state at T1:

$$\dot{INER\_TO\_LVC} = OFF$$

$$\overline{R\_REL} = COMP\_X$$

$$\overline{V\_REL} = COMP\_XD$$

CALL REL\_COMP

Inputs:  $\overline{R\_REL}$ ,  $\overline{V\_REL}$ ,  $\dot{INER\_TO\_LVC}$ ,  
 $\overline{R\_T\_INER}$ ,  $\overline{V\_T\_INER}$

Outputs:  $\overline{R\_S\_INER}$ ,  
 $\overline{V\_S\_INER}$

$$\overline{RS\_T1TIG} = \overline{R\_S\_INER}$$

$$\overline{VS\_T1TIG} = \overline{V\_S\_INER}$$

2. If  $\dot{USE\_DISP\_REL\_STATE}$  is OFF, update the present Shuttle states to T1\_TIG, convert to curvilinear coordinates, and display:

a. Update the Shuttle inertial state.

S\_OPTION = 1

$\bar{R}_{PRED\_IN} = \bar{RS\_M50\_PROX}$

$\bar{V}_{PRED\_IN} = \bar{VS\_M50\_PROX}$

CALL UPDATVP

Inputs: S\_OPTION,  $\bar{R}_{PRED\_IN}$ ,  $\bar{V}_{PRED\_IN}$ ,  
T\_PRED\_IN, T\_PRED\_FINAL

Outputs:  $\bar{R}_{PRED\_FINAL}$ ,  $\bar{V}_{PRED\_FINAL}$

$\bar{RS\_T1TIG} = \bar{R}_{PRED\_FINAL}$

$\bar{VS\_T1TIG} = \bar{V}_{PRED\_FINAL}$

$\bar{R\_S\_INER} = \bar{R}_{PRED\_FINAL}$

$\bar{V\_S\_INER} = \bar{V}_{PRED\_FINAL}$

- b. Convert to LVLH curvilinear coordinates.

$\dot{I}NER\_TO\_LVC = ON$

CALL REL\_COMP

Inputs:  $\bar{R\_T\_INER}$ ,  $\bar{V\_T\_INER}$   
 $\bar{R\_S\_INER}$ ,  $\bar{V\_S\_INER}$   
 $\dot{I}NER\_TO\_LVC$

Outputs:  $\bar{R\_REL}$ ,  $\bar{V\_REL}$

- c. Load the computation buffers at T1\_TIG for possible use in OMEGA\_DT\_COMP later.

$COMP\_X = \bar{R\_REL}$

$COMP\_XD = \bar{V\_REL}$

- d. Load the display buffers at T1\_TIG.

$DISP\_T1\_X = \bar{R\_REL}/1000$

$DISP\_T1\_XD = \bar{V\_REL}$

- (3) Check the USE\_Ω\_DT flag. If it is on, there is insufficient information to determine T2\_TIG and COMP\_PROX\_DT. Compute this information instead by use of the “wt-calculation”:

- (a) Compute the transfer time:

CALL OMEGA\_DT\_COMP

Inputs:           COMP\_X̄  
                   COMP\_T2\_XOFF  
                   COMP\_T2\_YOFF  
                   COMP\_T2\_ZOFF  
                   XOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1)  
                   YOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1)  
                   ZOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1)  
                   DT\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1)  
                   OMEGA\_PROX

Outputs:          COMP\_PROX\_DT, ALARM\_KILL

- (b) If (ALARM\_KILL = OFF), then compute T2\_TIG:

$T2\_TIG = T1\_TIG + 60 \text{ COMP\_PROX\_DT}$

- (4) If (ALARM\_KILL = OFF), then update the target inertial state from T1\_TIG. Otherwise, exit this task.

S\_OPTION = 2

$\overline{R\_PRED\_IN} = \overline{R\_T\_INER}$

$\overline{V\_PRED\_IN} = \overline{V\_T\_INER}$

$T\_PRED\_IN = T1\_TIG + \text{BASE\_MET}$

$T\_PRED\_FINAL = T2\_TIG + \text{BASE\_MET}$

CALL UPDATVP

Inputs:            $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ , T\_PRED\_IN, T\_PRED\_FINAL

Outputs:           $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$\overline{R\_T\_INER} = \overline{R\_PRED\_FINAL}$

$\overline{V\_T\_INER} = \overline{V\_PRED\_FINAL}$

- (5) Compute the Shuttle inertial state at T2.

$$\bar{R}_{REL} = \begin{matrix} \text{COMP\_T2\_XOFF} \\ \text{COMP\_T2\_YOFF} \\ \text{COMP\_T2\_ZOFF} \end{matrix}$$

$$\dot{I}NER\_TO\_LVC = OFF$$

CALL REL\_COMP

Inputs:  $\bar{R}_{T\_INER}, \bar{V}_{T\_INER}, \bar{R}_{REL}$

$\dot{I}NER\_TO\_LVC$

Outputs:  $\bar{R}_{S\_INER}$

$$\bar{RS}_{T2TIG} = \bar{R}_{S\_INER}$$

- (6) Do the Lambert problem using the precision velocity required routine.

CALL PREVR

Inputs:  $T1\_TIG, T2\_TIG, \bar{RS}_{T1TIG}, \bar{VS}_{T1TIG}, \bar{RS}_{T2TIG}$

Outputs:  $\bar{VS}_{REQUIRED}$

$\bar{RS}_{IPO}$

$\bar{RS}_{OFFSET}, T\_OFFSET$

$S\_ROTATE, \dot{A}LARM\_KILL$

- (7) If ( $\dot{A}LARM\_KILL = OFF$ ), then compute the LVLH Shuttle-centered maneuver. Otherwise, exit this task.

$$\bar{RS} = \bar{RS}_{T1TIG}$$

$$\bar{VS} = \bar{VS}_{T1TIG}$$

$$\bar{DV}_{INER} = \bar{VS}_{REQUIRED} - \bar{VS}$$

CALL ORBLV

Inputs:  $\bar{RS}, \bar{VS}, \bar{DV}_{INER}$

Outputs:  $\bar{DV}_{LVLH}$

$$T\_MAN = T1\_TIG$$

$$\dot{G}UID\_FLAG = ON$$



- (8) If USE\_DISP\_REL\_STATE is ON, then ensure that the maneuver will not be executed with LAMBERT guidance.

GUID\_FLAG = OFF

- B. Interface Requirements. The input and output parameters for the proximity operations targeting supervisory Lambert logic task are listed in Tables 4.6.8-1 and 4.6.8-2. A flow diagram of PROX\_TGT\_SUP\_LAMB is given in Appendix A.
- C. Processing Requirements. Perform once per call.
- D. Initialization Requirements. Set ALARM\_D = OFF upon call.
- E. Supplemental Information. DSP\_MISS values on the orbit targeting display will be updated at 2.08 Hz.

Table 4.6.8-1. Proximity Operations Targeting Supervisory Lambert Logic Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
PROX_T1_STAR_STATUS	—	T1 maneuver compute star flag	PROX_EXEC	D	—
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	ORBIT_TGT_DISP (6.14)	I	—
T1_TIG	DP	T1 maneuver time (MET)	PROX_EXEC, PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_EXEC, PROX_INIT, PROX_TGT_SUP, DT_COMP	F	s
PROX_T_CURRENT	DP	Current MET TIME	PROX_STAT	F	s
DAY	SP	Converted time (day) for TIMECV	TIME_CONVRT	I	day
HR	SP	Converted time (hr) for TIMECV	TIME_CONVRT	I	hr
MIN	SP	Converted time (min) for TIMECV	TIME_CONVRT	I	min
SEC	SP	Converted time (sec) for TIMECV	TIME_CONVRT	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP, DT_COMP, OMEGA_DT_COMP	F	min
COMP_T2_XOFF	DP	Computational desired position (X) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F	ft
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F	ft
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F	ft
TIME_PROX	DP	Time tag for the M50 state (assumed MET)	PROX_EXEC, PROX_INIT	F	s
EL_ANG	SP	Desired elevation angle at TPI	PROX_TGT_SEL, PROX_INIT	F	rad
USE_OMEGA_DT	—	Use the WT calculation flag	DT_COMP	D	—
USE_DISP_REL_STATE	—	Use displayed relative state flag	PROX_EXEC, PROX_TGT_SUP	D	—
COMP_X	DP	Computational relative position	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F(3)	ft

Table 4.6.8-1. Proximity Operations Targeting Supervisory Lambert Logic Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
COMP_XD	SP	Computational relative velocity	PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP	F(3)	ft/s
$\bar{R}_S$ _M50_PROX	DP	Prox ops orbiter M50 position vector	PROX_EXEC	F(3)	ft
$\bar{V}_S$ _M50_PROX	DP	Prox ops orbiter M50 velocity vector	PROX_EXEC	F(3)	ft/s
$\bar{R}_T$ _M50_PROX	DP	Prox ops target M50 position vector	PROX_EXEC	F(3)	ft
$\bar{V}_T$ _M50_PROX	DP	Prox ops target M50 velocity vector	PROX_EXEC	F(3)	ft/s
R_PRED_FINAL	DP	Output inertial position vector	UPDATVP	F(3)	ft
V_PRED_FINAL	DP	Output inertial velocity vector	UPDATVP	F(3)	ft/s
TTPI	DP	Predicted time of TPI (MET)	TELEV	F	s
$\bar{R}_S$ _OUT	DP	Shuttle position vector	TELEV	F(3)	ft
$\bar{V}_S$ _OUT	DP	Shuttle velocity vector	TELEV	F(3)	ft/s
$\bar{R}_T$ _OUT	DP	Target position vector	TELEV	F(3)	ft
$\bar{V}_T$ _OUT	DP	Target velocity vector	TELEV	F(3)	ft/s
$\bar{V}_S$ _REQUIRED	SP	Velocity required at the maneuver time	PREVR	F(3)	ft/s
$\bar{R}_S$ _IPO	DP	Initial position offset of Shuttle	PREVR	F(3)	ft
$\bar{R}$ _REL	DP	LVLH curvilinear position vector	REL_COMP	F(3)	ft
$\bar{V}$ _REL	DP	LVLH curvilinear velocity vector	REL_COMP	F(3)	ft/s
$\bar{R}_S$ _INER	DP	Input Shuttle inertial position vector	REL_COMP	F(3)	ft
$\bar{V}_S$ _INER	DP	Input Shuttle inertial velocity vector	REL_COMP	F(3)	ft/s
D $\bar{V}$ _LVLH	SP	Shuttle-centered LVLH relative target maneuver	ORBLV	F(3)	ft/s
PROX_DTMIN_LAMB	SP	Tolerance on minimum time in the future to compute a Lambert maneuver solution	ILOAD	F	s
ALARM_KILL	—	Stop computations flag	PROX_EXEC, OMEGA_DT_COMP, OFFSET_TGT, LAMBERT	D	—

Table 4.6.8-2. Proximity Operations Targeting Supervisory Lambert Logic Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
GUID_FLAG	—	Current maneuver guidance option flag	PROX_TRANS, ORBIT_MNVR_DIP (4.158)	D	—
T_MAN	DP	Ignition time of maneuver (MET)	PROX_STAT, PROX_TRANS, PROX_STIME, PROX_DISP_LOAD	F	s
DISP_T1_X̄	DP	Orbiter relative position at T1	PROX_INIT, ORB_TGT_DISP (6.14)	F(3)	ft
DISP_T1_X̄D	DP	Orbiter relative position at T2	PROX_INIT, ORB_TGT_DISP (6.14)	F(3)	ft/s
PROX_BASE_DAY	SP	Targeting base time – day	PROX_INIT, ORB_TGT_DIP (6.14)	I	day
PROX_BASE_HR	SP	Targeting base time – hr	PROX_INIT, ORB_TGT_DIP (6.14)	I	hr
PROX_BASE_MIN	SP	Targeting base time – min	PROX_INIT, ORB_TGT_DIP (6.14)	I	min
PROX_BASE_SEC	SP	Targeting base time – sec	PROX_INIT, ORB_TGT_DIP (6.14)	F	s
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP, PROX_DISP_LOAD, DT_COMP, PREVR	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP, PROX_DISP_LOAD, DT_COMP, PREVR	F	s
PROX_BASE_TIME	DP	Prox ops base time	PROX_STAT, PROX_INIT	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_DISP_LOAD, DT_COMP	F	min
COMP_T2_XOFF	DP	Computational desired position (X) at T2	OMEGA_DT_COMP	F	ft
COMP_T2_YOFF	DP	Computational desired position (Y) at T2	OMEGA_DT_COMP	F	ft
COMP_T2_ZOFF	DP	Computational desired position (Z) at T2	OMEGA_DT_COMP	F	ft
TIME_CONVERT_FLAG	SP	Time conversion flag	TIME_CONVRT	I	—
TIME_SEC	DP	Conversion time	TIME_CONVRT	F	s
DV_LVLH	SP	Impulsive maneuver in LVLH reference frame	PROX_TRANS, PROX_DISP_LOAD	F(3)	ft/s
EL_ANG	SP	Desired elevation angle	TELEV	F	rad

Table 4.6.8-2. Proximity Operations Targeting Supervisory Lambert Logic Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
USE_DISP_REL_STATE	—	Use display relative state flag	PROX_TGT_SUP	D	—
COMP_X	DP	Computation relative position	PROX_TGT_SUP, OMEGA_DT_COMP	F(3)	ft
COMP_XD	DP	Computation relative velocity	PROX_TGT_SUP	F(3)	ft/s
INER_TO_LVC	—	Inertial to curvilinear conversion flag	REL_COMP	D	—
R_S_INER	DP	Input Shuttle inertial position	REL_COMP	F(3)	ft
V_S_INER	DP	Input Shuttle inertial velocity	REL_COMP	F(3)	ft/s
R_T_INER	DP	Input target inertial position	REL_COMP	F(3)	ft
V_T_INER	DP	Input target inertial velocity	REL_COMP	F(3)	ft/s
RS_T1TIG	DP	Inertial position vector of Shuttle at T1	PREVR	F(3)	ft
VS_T1TIG	DP	Inertial velocity vector of Shuttle at T1	PREVR	F(3)	ft/s
RS_T2TIG	DP	Inertial position vector of Shuttle at T2	PREVR	F(3)	ft
R_PRED_IN	DP	Input inertial position vector	UPDATVP	F(3)	ft
V_PRED_IN	DP	Input inertial velocity vector	UPDATVP	F(3)	ft/s
S_OPTION	SP	Spacecraft flag in UPDATVP	UPDATVP	I	—
T_PRED_IN	DP	Time of input state in GMT	UPDATVP	F	s
T_PRED_FINAL	DP	Time of output state in GMT	UPDATVP	F	s
R_REL	DP	LVLH curvilinear position vector	REL_COMP	F(3)	ft
V_REL	DP	LVLH curvilinear velocity vector	REL_COMP	F(3)	ft/s
T1_ILOAD_ARRAY	SP	Time for the target set relative to base time (MET)	PROX_TGT_SEL, TELEV	F	min
RS	DP	Input inertial pos of Shuttle	ORBLV	F(3)	ft
VS	DP	Input inertial vel of Shuttle	ORBLV	F(3)	ft/s
DV_INER	SP	Inertial maneuver	ORBLV	F(3)	ft/s
ALARM_A	—	Alarm flag for iterations	GAX (4.110)	D	—
ALARM_B	—	Alarm flag for elevation angle	GAX (4.110)	D	—
DSP_MISS	SP	Target miss distance	ORBIT_TGT_DISP (6.14)	F	ft
ALARM_D	—	Transfer time alarm	LAMBERT	D	—
ALARM_KILL	—	Stop computations flag	PROX_EXEC	D	—

#### 4.6.9 Proximity Operations Targeting Start Timer Task (PROX\_STIME)

This task sets the display time to count down to.

A. Detailed Requirements. The following steps are required to perform this task.

1. Perform a test to see if the maneuver has been executed (PROX\_PAST\_STATUS = ON).
  - a. If PROX\_PAST\_STATUS = ON, set CRT\_TIME = OFF.
  - b. If PROX\_PAST\_STATUS = OFF, calculate the delta-time between the current time and the maneuver time and set the CRT timer status flags:

$$DT\_ST\_TIMER = T\_MAN + BASE\_MET - CLOCK$$

$$CRT\_TIME = ON$$

$$CRT\_UPDWN = ON$$

B. Interface Requirements. The input and output parameters for the proximity operations targeting start timer task are listed in Tables 4.6.9-1 and 4.6.9-2. A flow diagram of PROX\_STIME is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.9-1. Proximity Operations Targeting Start Timer Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
T_MAN	DP	Time of the computed maneuver (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
PROX_PAST_STATUS	—	Maneuver past time status flag	PROX_STAT	D	—
CLOCK	DP	Current time (GMT)	FCOS	F	s

Table 4.6.9-2. Proximity Operations Targeting Start Timer Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
DT_ST_TIMER	SP	Time to be counted down	ORBIT_TGT_DISP (6.14)	F	s
CRT_TIME	—	CRT timer start/stop discrete	ORBIT_TGT_DISP (6.14)	D	—
CRT_UPDWN	—	CRT timer up/down discrete	ORBIT_TGT_DISP (6.14)	D	—

#### 4.6.10 Maneuver to Offset Targeting Task (OFFSET\_TGT)

This task computes an LVLH maneuver delta-velocity vector to achieve the desired offset position in the specified delta time.

A. Detailed Requirements. The following steps are required to perform the maneuver to offset targeting task.

1. Compute the T1 maneuver delta velocity vector.

$$W = \text{OMEGA\_PROX}$$

$$T = 60 \text{ DT\_OFFTGT}$$

$$S = \text{SIN}(W T)$$

If  $|S| < 10^{-8}$ ; set  $S = 10^{-8}$

$$C = \text{COS}(W T)$$

$$C1 = 1 - C$$

$$K = W / (8 - 8 C - 3 S W T)$$

If  $|1/K| \geq \text{EP\_TRANSFER}$ , continue. Otherwise, set  $\text{ALARM\_D} = \text{ON}$ , set  $\text{ALARM\_KILL} = \text{ON}$ , and exit this task.

$$\mathbf{MAT} = \begin{bmatrix} -KS & 0 & K(14C1 - 6WTS) & KS & 0 & -2KC1 & -T/2 \\ 0 & -CW/S & 0 & 0 & W/S & 0 & 0 \\ -2KC1 & 0 & K(3CWT - 4S) & 2KC1 & 0 & K(4S - 3WT) & [KT/W(8S - 3WT(1+C)) - 2/W] \end{bmatrix}$$

$$\bar{\text{STATE}}_{1,2,3} = \bar{\text{X}}_{\text{OFFTGT}}$$

$$\bar{\text{STATE}}_{4,5,6} = \bar{\text{X}}_{2\text{OFFTGT}}$$

$$\bar{\text{STATE}}_7 = \text{DIFF\_DR}$$

If  $C1 < \text{EP\_TRANSFER}$  then set  $\text{MAT}_{22} = \text{MAT}_{25} = 0$  else if  $|S| < \text{SIN}(\text{CONE})$  then set  $\text{MAT}_{22} = \text{MAT}_{25} = 0$ .

$$\bar{\text{V}}_{\text{T1\_NEED}} = \mathbf{MAT} \bar{\text{STATE}}$$

$$\bar{\text{DV}} = \bar{\text{V}}_{\text{T1\_NEED}} - \bar{\text{X}}_{\text{D\_OFFTGT}}$$

If  $|\text{MAT}_{22}| < 10^{-7}$ ; set  $\bar{\text{DV}}_2 = 0$

B. Interface Requirements. The input and output parameters for the maneuver to offset targeting task are listed in Tables 4.6.10-1 and 4.6.10-2. A flow diagram of OFFSET\_TGT is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. Set  $\dot{Z}ERO = OFF$  upon call.

E. Supplemental Information. If  $ALARM\_D = ON$ , send warning message to GAX: "TGT DELTA T."

Table 4.6.10-1. Maneuver to Offset Targeting Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
OMEGA_PROX	DP	Orbital angular rate of target	PROX_EXEC	F	rad/s
DT_OFFFTGT	SP	Transfer time	OMEGA_DT_COMP, PROX_TGT_SUP	F	min
$\bar{X}$ _OFFFTGT	DP	T1 relative position vector	OMEGA_DT_COMP, PROX_TGT_SUP	F(3)	ft
$\bar{X}D$ _OFFFTGT	SP	T1 relative velocity vector	OMEGA_DT_COMP, PROX_TGT_SUP	F(3)	ft/s
$\bar{X}2$ _OFFFTGT	DP	T2 relative position vector	OMEGA_DT_COMP, PROX_TGT_SUP	F(3)	ft
DIFF_DR	SP	Differential acceleration	OMEGA_DT_COMP, PROX_TGT_SUP	F	ft/s <sup>2</sup>
EP_TRANSFER	SP	Tolerance for near 0 transfer	ILOAD	F	—
CONE	SP	Tolerance for near 180 transfer	ILOAD	F	rad
$ALARM\_D$	—	Alarm flag for transfer time	PROX_TGT_SUP	D	—
$ALARM\_KILL$	—	Stop computations flag	PROX_EXEC	D	—

Table 4.6.10-2. Maneuver to Offset Targeting Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
$\bar{D}V$	SP	Delta-velocity vector	PROX_TGT_SUP, OMEGA_DT_COMP	F(3)	ft/s
$ALARM\_D$	—	Alarm flag for transfer time	GAX (4.110)	D	—
$ALARM\_KILL$	—	Stop computations flag	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, PROX_EXEC, OMEGA_DT_COMP	D	—



#### 4.6.11 Relative State Compute Task (REL\_COMP)

This task computes the state of the orbiter in a target-centered local vertical rotating curvilinear coordinate system using the earth-centered inertial (M50) states of the orbiter and the target, or performs the reverse transformation, depending on an input flag.

A. Detailed Requirements. The following steps are required to perform this task.

1. Find RT\_MAG:  $RT\_MAG = ABVAL(\bar{R}_T\_INER)$ .
2. Compute the transformation matrix from M50 inertial frame to the local vertical inertial rectangular coordinate frame (LVIR):

$$\overset{*}{M}AT\_M50\_LVIR = \begin{bmatrix} \text{UNIT}((\bar{R}_T\_INER \times \bar{V}_T\_INER) \times \bar{R}_T\_INER)^T \\ -\text{UNIT}(\bar{R}_T\_INER \times \bar{V}_T\_INER)^T \\ -\text{UNIT}(\bar{R}_T\_INER)^T \end{bmatrix}$$

3. Determine the orbital angular rate vector in LVLH coordinates:

$$\bar{V}TAN = \bar{V}_T\_INER - \text{UNIT}(\bar{R}_T\_INER) \frac{(\bar{R}_T\_INER \bullet \bar{V}_T\_INER)}{RT\_MAG}$$

$$OMEGA\_PROX = ABVAL(\bar{V}TAN)/RT\_MAG$$

$$\overline{OMEGA\_LV\_PROX} = OMEGA\_PROX \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix}$$

4. Determine if the transformation to be done is from inertial M50 coordinates to the local vertical curvilinear target-centered coordinates (LVC), i.e. INER\_TO\_LVC = ON.

a. If  $\dot{INER\_TO\_LVC} = ON$ , do:

- (1) Compute the relative M50 state of the orbiter with respect to the target.

$$\bar{R}TS\_M50 = \bar{R}_S\_INER - \bar{R}_T\_INER$$

$$\bar{V}TS\_M50 = \bar{V}_S\_INER - \bar{V}_T\_INER$$

- (2) Convert these states to a target-centered local vertical inertial rectangular coordinate frame (LVIR).

$$\bar{R}TS\_LVIR = \overset{*}{M}AT\_M50\_LVIR \bar{R}TS\_M50$$

$$\bar{V}TS\_LVIR = \overset{*}{M}AT\_M50\_LVIR \bar{V}TS\_M50$$

- (3) Convert the LVIR relative states to a target-centered local vertical rotating rectangular coordinate frame (LV).

$$\overline{\text{RTS}}_{LV} = \overline{\text{RTS}}_{LVIR}$$

$$\overline{\text{VTS}}_{LV} = \overline{\text{VTS}}_{LVIR} - (\overline{\text{OMEGA}}_{LV\_PROX} \times \overline{\text{RTS}}_{LVIR})$$

- (4) Convert the LV relative states to a target-centered local vertical rotating curvilinear coordinate frame (LVC).

$$\text{ZCON} = \text{RT\_MAG} - \text{RTS}_{LV_3}$$

$$\text{THETA} = \text{ATAN}(\text{RTS}_{LV_1}/\text{ZCON})$$

$$\overline{\text{R}}_{REL} = \begin{bmatrix} \text{RT\_MAG THETA} \\ \text{RTS}_{LV_2} \\ \text{RT\_MAG} - \text{ZCON} / \text{COS}(\text{THETA}) \end{bmatrix}$$

$$\text{THETA\_DOT} = \text{COS}^2(\text{THETA})(\text{VTS}_{LV_1} \text{ZCON} + \text{RTS}_{LV_1} \text{VTS}_{LV_3})/(\text{ZCON})^2$$

$$\overline{\text{V}}_{REL} = \begin{bmatrix} \text{RT\_MAG THETA\_DOT} \\ \text{VTS}_{LV_2} \\ \text{VTS}_{LV_3} - \text{THETA\_DOT} \text{RTS}_{LV_1} / \text{COS}(\text{THETA}) \end{bmatrix}$$

- b. If  $\dot{\text{INER\_TO\_LVC}} = \text{OFF}$ , convert from target-centered LVC curvilinear coordinates to M50 inertial coordinates.

- (1) Compute internal variables.

$$\text{THETA} = \text{R\_REL}_1/\text{RT\_MAG}$$

$$\text{THETA\_DOT} = \text{V\_REL}_1/\text{RT\_MAG}$$

$$\text{ZCON} = \text{RT\_MAG} - \text{R\_REL}_3$$

- (2) Convert to local vertical target-centered rotating rectangular coordinates (LV).

$$\overline{\text{RTS}}_{LV} = \begin{bmatrix} \text{ZCON SIN}(\text{THETA}) \\ \text{R\_REL}_2 \\ \text{RT\_MAG} - \text{ZCON COS}(\text{THETA}) \end{bmatrix}$$

$$\overline{\text{VTS}}_{LV} = \begin{bmatrix} \text{ZCON THETA\_DOT COS}(\text{THETA}) - \text{V\_REL}_3 \text{ SIN}(\text{THETA}) \\ \text{V\_REL}_2 \\ \text{RTS}_{LV_1} \text{ THETA\_DOT} + \text{V\_REL}_3 \text{ COS}(\text{THETA}) \end{bmatrix}$$

- (3) Convert from the LV frame to a target-centered local vertical inertial rectangular frame (LVIR).

$$\overline{\mathbf{R}}_{\text{TS\_LVIR}} = \overline{\mathbf{R}}_{\text{TS\_LV}}$$

$$\overline{\mathbf{V}}_{\text{TS\_LVIR}} = \overline{\mathbf{V}}_{\text{TS\_LV}} + \overline{\boldsymbol{\Omega}}_{\text{LV\_PROX}} \times \overline{\mathbf{R}}_{\text{TS\_LVIR}}$$

- (4) Convert from LVIR coordinates to an inertial frame relative to the target.

$$\overline{\mathbf{R}}_{\text{TS\_M50}} = [\mathbf{M}\hat{\mathbf{A}}_{\text{T\_M50\_LVIR}}]^T \overline{\mathbf{R}}_{\text{TS\_LVIR}}$$

$$\overline{\mathbf{V}}_{\text{TS\_M50}} = [\mathbf{M}\hat{\mathbf{A}}_{\text{T\_M50\_LVIR}}]^T \overline{\mathbf{V}}_{\text{TS\_LVIR}}$$

- (5) Compute the Shuttle inertial M50 coordinate.

$$\overline{\mathbf{R}}_{\text{S\_INER}} = \overline{\mathbf{R}}_{\text{T\_INER}} + \overline{\mathbf{R}}_{\text{TS\_M50}}$$

$$\overline{\mathbf{V}}_{\text{S\_INER}} = \overline{\mathbf{V}}_{\text{T\_INER}} + \overline{\mathbf{V}}_{\text{TS\_M50}}$$

B. Interface Requirements. The input and output parameters for the relative state compute task are given in Tables 4.6.11-1 and 4.6.11-2. A flow diagram of REL\_COMP is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.11-1. Relative State Compute Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
$\dot{I}_{\text{NER\_TO\_LVC}}$	—	Inertial to curvilinear conversion flag	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	D	—
$\bar{R}_{\text{REL}}$	DP	LVLH curvilinear position vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
$\bar{V}_{\text{REL}}$	DP	LVLH curvilinear velocity vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s
$\bar{R}_{\text{S\_INER}}$	DP	Input Shuttle inertial position vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
$\bar{V}_{\text{S\_INER}}$	DP	Input Shuttle inertial velocity vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s
$\bar{R}_{\text{T\_INER}}$	DP	Input target inertial position vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
$\bar{V}_{\text{T\_INER}}$	DP	Input target inertial velocity vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s

Table 4.6.11-2. Relative State Compute Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
$\bar{R}_{REL}$	DP	LVLH curvilinear position vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
$\bar{V}_{REL}$	DP	LVLH curvilinear velocity vector	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s
$\bar{R}_{S_INER}$	DP	Input Shuttle inertial position	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
$\bar{V}_{S_INER}$	DP	Input Shuttle inertial velocity	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s
OMEGA_PROX	DP	Orbital angular rate of target	OFFSET_TGT, OMEGA_DT_COMP	F	rad/s

#### 4.6.12 Proximity Operations Targeting Output Display Load Task (PROX\_DISP\_LOAD)

This task loads the output display buffers with data from the computational buffers once a compute Item 27 or Item 28 is complete.

A. Detailed Requirements. The following steps are required to perform the proximity operations targeting output display load task.

1. Display the maneuver.

MAN\_TGT = PROX\_TGT\_SET\_NO

DISP\_DV = DV\_LVLH

DISP\_DV\_MAG = ABVAL(DV\_LVLH)

2. Convert the T1\_TIG and T2\_TIG times to days, hours, minutes, and seconds using the time conversion task.

- a. TIME\_SEC = T1\_TIG

TIME\_CONVERT\_FLAG = 0

CALL TIME\_CONVRT

Inputs: TIME\_CONVERT\_FLAG, TIME\_SEC

Outputs: DAY, HR, MIN, SEC

DISP\_T1\_DAY = DAY

DISP\_T1\_HR = HR

DISP\_T1\_MIN = MIN

DISP\_T1\_SEC = SEC

- b. TIME\_SEC = T2\_TIG

CALL TIME\_CONVRT

Input: TIME\_CONVERT\_FLAG, TIME\_SEC

Output: DAY, HR, MIN, SEC

DISP\_T2\_DAY = DAY

DISP\_T2\_HR = HR

DISP\_T2\_MIN = MIN

DISP\_T2\_SEC = SEC

3. Display the transfer time.

DISP\_PROX\_DT = COMP\_PROX\_DT

4. Display the maneuver time.

- a. If T\_MAN = T1\_TIG, set:

DISP\_TMAN\_TIME = T1\_TIG

DISP\_TMAN\_DAY = DISP\_T1\_DAY

DISP\_TMAN\_HR = DISP\_T1\_HR

DISP\_TMAN\_MIN = DISP\_T1\_MIN

DISP\_TMAN\_SEC = DISP\_T1\_SEC

- b. If T\_MAN = T2\_TIG, set:

DISP\_TMAN\_TIME = T2\_TIG

DISP\_TMAN\_DAY = DISP\_T2\_DAY

DISP\_TMAN\_HR = DISP\_T2\_HR

DISP\_TMAN\_MIN = DISP\_T2\_MIN

DISP\_TMAN\_SEC = DISP\_T2\_SEC

B. Interface Requirements. The input and output parameters for the proximity operations targeting output display load task are listed in Tables 4.6.12-1 and 4.6.12-2. A flow diagram of PROX\_DISP\_LOAD is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.12-1. Proximity Operations Targeting Output Display Load Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
T_MAN	DP	Time of the computed maneuver (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	ORBIT_TGT_DISP (6.14)	I	—
T1_TIG	DP	T1 maneuver time (MET)	PROX_EXEC, PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_EXEC, PROX_INIT, PROX_TGT_SUP, PROX_TGT_SUP_LAMB, DT_COMP	F	s
DAY	SP	Converted time – day	TIME_CONVRT	I	day
HR	SP	Converted time – hr	TIME_CONVRT	I	hr
MIN	SP	Converted time – min	TIME_CONVRT	I	min
SEC	SP	Converted time – sec	TIME_CONVRT	F	s
$\overline{DV}$ _LVLH	SP	Impulsive maneuver in LVLH reference frame	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft/s



Table 4.6.12-2. Proximity Operations Targeting Output Display Load Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
DISP_PROX_DT	SP	Displayed delta time between T1 and T2	ORBIT_TGT_DISP (6.14)	F	min
DISP_T1_DAY	SP	Displayed T1 time – day	ORBIT_TGT_DISP (6.14)	I	day
DISP_T1_HR	SP	Displayed T1 time – hr	ORBIT_TGT_DISP (6.14)	I	hr
DISP_T1_MIN	SP	Displayed T1 time – min	ORBIT_TGT_DISP (6.14)	I	min
DISP_T1_SEC	SP	Displayed T1 time – sec	ORBIT_TGT_DISP (6.14)	F	s
DISP_T2_DAY	SP	Displayed T2 time – day	ORBIT_TGT_DISP (6.14)	I	day
DISP_T2_HR	SP	Displayed T2 time – hr	ORBIT_TGT_DISP (6.14)	I	hr
DISP_T2_MIN	SP	Displayed T2 time – min	ORBIT_TGT_DISP (6.14)	I	min
DISP_T2_SEC	SP	Displayed T2 time – sec	ORBIT_TGT_DISP (6.14)	F	s
$\overline{\text{DISP}}_{\text{DV}}$	SP	Maneuver LVLH velocity vector	ORBIT_TGT_DISP (6.14)	F(3)	ft/s
DISP_DV_MAG	SP	Maneuver velocity magnitude	ORBIT_TGT_DISP (6.14)	F	ft/s
DISP_TMAN_TIME	DP	Maneuver time (MET)	ORBIT_TGT_DISP (6.14)	F	s
DISP_TMAN_DAY	SP	Displayed maneuver time – day	PROX_TRANS	I	day
DISP_TMAN_HR	SP	Displayed maneuver time – hr	PROX_TRANS	I	hr
DISP_TMAN_MIN	SP	Displayed maneuver time – min	PROX_TRANS	I	min
DISP_TMAN_SEC	SP	Displayed maneuver time – sec	PROX_TRANS	F	s
TIME_CONVERT_FLAG	SP	Time Conversion Flag	TIME_CONVRT	I	—
TIME_SEC	DP	Converted time	TIME_CONVRT	F	s

#### 4.6.13 Time Conversion Task (TIME\_CONVRT)

This task computes total time in seconds given days, hours, minutes, seconds and computes days, hours, minutes, seconds given total time in seconds.

A. Detailed Requirements. The following steps are required to perform the time conversion task.

1. Perform a logical test to determine if the time is to be computed in seconds or days, hours, minutes, seconds.

- a. If total time is to be computed in seconds (TIME\_CONVERT\_FLAG = 1), set

$$\text{TIME\_SEC} = 86400 \text{ DAY} + 3600 \text{ HR} + 60 \text{ MIN} + \text{SEC}$$

- b. If time is to be computed in days, hours, minutes, seconds

(TIME\_CONVERT\_FLAG = 0), set

$$\text{DAY} = \text{TRUNCATE}(\text{TIME\_SEC}/86400)$$

$$\text{HR} = \text{TRUNCATE}((\text{TIME\_SEC} - 86400 \text{ DAY})/3600)$$

$$\text{MIN} = \text{TRUNCATE}((\text{TIME\_SEC} - 86400 \text{ DAY} - 3600 \text{ HR})/60)$$

$$\text{SEC} = \text{TIME\_SEC} - 86400 \text{ DAY} - 3600 \text{ HR} - 60 \text{ MIN}$$

B. Interface Requirements. The input and output parameters for the time conversion task are listed in Tables 4.6.13-1 and 4.6.13-2. A flow diagram of TIME\_CONVRT is given in Appendix A.

C. Processing Requirements. Perform once per call.

D. Initialization Requirements. None.

Table 4.6.13-1. Time Conversion Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
DAY	SP	Converted time (day) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL	I	day
HR	SP	Converted time (hr) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL	I	hr
MIN	SP	Converted time (min) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL	I	min
SEC	SP	Converted time (sec) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL	F	s
TIME_CONVERT_FLAG	SP	Time conversion flag	PROX_EXEC, PROX_TGT_SEL, PROX_INIT, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	I	—
TIME_SEC	DP	Converted time	PROX_EXEC, PROX_TGT_SEL, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	F	s

Table 4.6.13-2. Time Conversion Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
DAY	SP	Converted time (day) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	I	day
HR	SP	Converted time (hr) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	I	hr
MIN	SP	Converted time (min) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	I	min
SEC	SP	Converted time (sec) for TIME_CONVRT	PROX_EXEC, PROX_TGT_SEL, PROX_TGT_SUP_LAMB, PROX_DISP_LOAD	F	s
TIME_SEC	DP	Conversion time	PROX_EXEC, PROX_INIT	F	s

#### 4.6.14 Delta Time Compute Task (DT\_COMP)

The delta time compute task is called to determine the transfer time and/or the maneuver time of the second of two-impulse maneuvers.

A. Detailed Requirements. The following steps are required to perform this task.

1. Set the USE\_OMEGA\_DT flag to off.
2. Check the transfer time (COMP\_PROX\_DT):

$$\text{if COMP\_PROX\_DT} \left\{ \begin{array}{l} > 0, \text{ set } T2\_TIG = T1\_TIG + 60 \text{ COMP\_PROX\_DT} \\ < 0, \text{ set USE\_OMEGA\_DT} = \text{ON} \\ = 0, \text{ set COMP\_PROX\_DT} = (T2\_TIG - T1\_TIG)/60 \end{array} \right.$$

B. Interface Requirements. The input and output parameters for the delta time compute task are given in Tables 4.6.14-1 and 4.6.14-2. A flow diagram of DT\_COMP is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.14-1. Delta Time Compute Task Module Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
COMP_PROX_DT	SP	Delta time computation buffer	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	min

Table 4.6.14-2. Delta Time Compute Task Module Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	s
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	min
USE_OMEGA_DT	—	Use the WT calculation flag	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	D	—

#### 4.6.15 Omega Delta Time Calculation Task (OMEGA\_DT\_COMP)

This task calculates the transfer time needed to go from the T1\_TIG state to the T2\_TIG state such that the T2\_TIG maneuver is perpendicular to the line of sight and intercepts the next target point at the appropriate time.

A. Detailed Requirements. The following steps are required to perform the omega delta time calculation task.

1. If the current target set number, PROX\_TGT\_SET\_NO, is 40, then set COMP\_PROX\_DT equal to the absolute value of COMP\_PROX\_DT and exit this task. Otherwise, proceed to Step 2.
2. Find the velocity required at the displayed T2 time to intercept the next target set.

$$DT\_OFFTGT = ABS(DT\_ILOAD\_ARRAY (PROX\_TGT\_SET\_NO + 1))$$

$$\bar{X}\_OFFTGT = \begin{bmatrix} COMP\_T2\_XOFF \\ COMP\_T2\_YOFF \\ COMP\_T2\_ZOFF \end{bmatrix}$$

$$\bar{X}D\_OFFTGT = (0, 0, 0)$$

$$\bar{X}2\_OFFTGT = \begin{bmatrix} XOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1) \\ YOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1) \\ ZOFF\_ILOAD\_ARRAY(PROX\_TGT\_SET\_NO + 1) \end{bmatrix}$$

DIFF\_DR = 0

CALL OFFSET\_TGT

Inputs:            OMEGA\_PROX, DT\_OFFTGT,  $\bar{X}$ \_OFFTGT,  $\bar{X}$ D\_OFFTGT,  
                      $\bar{X}$ 2\_OFFTGT, DIFF\_DR

Outputs:            $\bar{D}$ V, ALARM\_KILL

3. If the stop computations flag is OFF, (ALARM\_KILL = OFF), then define internal variables. Otherwise, exit this task.

XD1 = DV<sub>1</sub>

YD1 = DV<sub>2</sub>

ZD1 = DV<sub>3</sub>

W = OMEGA\_PROX

X0 = COMP\_X<sub>1</sub>

Y0 = COMP\_X<sub>2</sub>

Z0 = COMP\_X<sub>3</sub>

X1 = COMP\_T2\_XOFF

Y1 = COMP\_T2\_YOFF

Z1 = COMP\_T2\_ZOFF

ALPHA = (X1 XD1 + Y1 YD1 + Z1 ZD1)/W

A = 8 ALPHA - 12 X1 Z1 - 2 X0 Z1 + 2 X1 Z0

B = -A

C = X0 X1 - X1 X1 + 4 Z0 Z1 - 4 Z1 Z1 + 8 Y0 Y1

D = 3(Y1\*\*2 + Z1\*\*2)

E = -3 ALPHA + 6 X1 Z1

F = 8 Y1(Y0 + Y1)

G1 = -8 Y0 Y1

H = -3 Y0 Y1

J = -8 Y1 Y1

L = -3 Z0 Z1

$$M = -8 Y0 Y1$$

4. Set up Newton–Raphson iteration.

$$IC = 0$$

$$DY\_TOL = DEL\_X\_TOL(1)$$

$$X\_IND = - 60 COMP\_PROX\_DT$$

$$FIRST\_JUMP = DEL\_X\_GUESS(1)$$

$$X\_IND\_PRIME = X\_IND + 1$$

5. Do until  $IC \geq IC\_MAX$  or  $ABS(X\_IND - X\_IND\_PRIME) < 0.5$  second:

$$T = W X\_IND$$

$$COS = COS(T)$$

$$SIN = SIN(T)$$

$$TAN = SIN/COS$$

$$X\_DEP = A + B COS + C SIN + D T COS + E T SIN + F COS/TAN + G1 COS \\ COS/TAN + H T + J/TAN + L T + M COS SIN$$

CALL ITERV

Inputs: IC, X\_DEP, X\_IND  
X\_DEP\_PRIME, X\_IND\_PRIME  
FIRST\_JUMP, IC\_MAX, DY\_TOL

Outputs: IC, X\_IND, X\_DEP\_PRIME  
X\_IND\_PRIME, SFAIL

6. If maximum iterations have occurred, ( $IC = IC\_MAX$ ), then set the alarm flags ( $ALARM\_D = ON$ , and  $ALARM\_KILL = ON$ ) to indicate an error in determining the transfer time and exit. Otherwise, compute the transfer time ( $COMP\_PROX\_DT$ )

$$COMP\_PROX\_DT = X\_IND/60$$

B. Interface Requirements. The input and output parameters for the omega delta time calculation task are given in Tables 4.6.15–1 and 4.6.15–2. A flow diagram of OMEGA\_DT\_COMP is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

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E. Supplemental Information. If the constant H is redefined as  $H = -3(Y_0 Y_1 + Z_0 Z_1)$ , then the X\_DEP equation simplifies to:

$$X\_DEP = (A - F/TAN) (1 - COS) + C SIN + (H + D COS + E SIN) T$$

Then the computations listed below can be eliminated from Section A.(3):

$$B = -A$$

$$G1 = -8 Y_0 Y_1$$

$$J = 8 Y_1 Y_1$$

$$L = -3 Z_0 Z_1$$

$$M = -8 Y_0 Y_1$$



Table 4.6.15-1. Omega Delta Time Calculation Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
PROX_TGT_SET_NO	SP	ILOAD set number selected for targeting	ORBIT_TGT_DISP (6.14)	I	—
DT_ILOAD_ARRAY	SP	Delta times from T1 to T2 for target sets	PROX_INIT, ILOAD	F(40)	min
XOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position for target sets	PROX_INIT, ILOAD	F(40)	ft
YOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position for target sets	PROX_INIT, ILOAD	F(40)	ft
ZOFF_ILOAD_ARRAY	DP	ILOAD LVLH offset position for target sets	PROX_INIT, ILOAD	F(40)	ft
COMP_T2_XOFF	DP	Computational desired relative position (X) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	ft
COMP_T2_YOFF	DP	Computational desired relative position (Y) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	ft
COMP_T2_ZOFF	DP	Computational desired relative position (Z) at T2	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	ft
COMP $\bar{X}$	DP	Computation relative position	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F(3)	ft
OMEGA_PROX	DP	Orbital angular rate of target	PROX_EXEC	F	rad/s
$\bar{D}V$	SP	Delta velocity vector	OFFSET_TGT	F(3)	ft/s
DEL_X_TOL	SP	Tolerance in the dependent variable to ensure non-zero slope	ILOAD	F(2)	—
DEL_X_GUESS	SP	Guess at delta-X	ILOAD	F(2)	—
COMP_PROX_DT	SP	Delta time in computational buffer	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	min
ALARM $\dot{M}_D$	—	Alarm flag for transfer time	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	D	—
ALARM $\dot{M}_KILL$	—	Stop computations flag	PROX_EXEC, OFFSET_TGT	D	—

Table 4.6.15-2. Omega Delta Time Calculation Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
COMP_PROX_DT	SP	Delta time in the computation buffer	PROX_TGT_SUP, PROX_TGT_SUP_LAMB	F	min
DT_OFFTGT	SP	Transfer time	OFFSET_TGT	F	s
$\bar{X}$ _OFFTGT	DP	T1 relative position vector	OFFSET_TGT	F(3)	ft
$\bar{X}$ D_OFFTGT	SP	T1 relative velocity vector	OFFSET_TGT	F(3)	ft/s
$\bar{X}$ 2_OFFTGT	DP	T2 relative position vector	OFFSET_TGT	F(3)	ft
DY_TOL	SP	Tolerance in the dependent variable	ITERV	F	—
FIRST_JUMP	SP	Guess at delta-X	ITERV	F	—
DIFF_DR	SP	Differential drag	OFFSET_TGT	F	ft/s <sup>2</sup>
ALARM $\dot{D}$	—	Alarm flag for transfer time	GAX (4.110)	D	—
ALARM $\dot{K}$	—	Stop computations flag	PROX_TGT_SUP, PROX_TGT_SUP_LAMB, PROX_EXEC	D	—

#### 4.6.16 Elevation Angle Search Task (TELEV)

The elevation angle search task determines the time a desired elevation angle exists between the Shuttle and target.

A. Detailed Requirements. The following steps are required in the iteration logic to determine the time a desired elevation angle exists between the Shuttle and target.

1. Set the iteration counter to zero and initialize the previous pass differential altitude indicator to indicate inconsistency:

$$IC = 0$$

$$NN = 0$$

$$DY\_TOL = DEL\_X\_TOL(2)$$

$$FIRST\_JUMP = DEL\_X\_GUESS(2)$$

$$ERR\_DH\_PRIME = 0$$

$$ERR\_EL\_PRIME = 0$$

2. Advance both the Shuttle and target to first guess time where the desired elevation angle should exist. The advancement is performed in two calls to the state vector update task (Subsection 4.6.21), with inputs of vehicle position and velocity vectors, first guess time. The outputs are the vehicle position and velocity vectors and time at the first guess time.

Update Shuttle state:

$$S\_OPTION = 1$$

$$\overline{R\_PRED\_IN} = \overline{RS\_M50\_PROX}$$

$$\overline{V\_PRED\_IN} = \overline{VS\_M50\_PROX}$$

$$T\_PRED\_IN = TIME\_PROX + BASE\_MET$$

$$T\_PRED\_FINAL = T1\_TIG + BASE\_MET$$

$$TTPI = T1\_TIG$$

CALL UPDATVP

$$\text{Inputs: } \overline{R\_PRED\_IN}, \overline{V\_PRED\_IN}, T\_PRED\_IN, T\_PRED\_FINAL$$

$$\text{Outputs: } \overline{R\_PRED\_FINAL}, \overline{V\_PRED\_FINAL}$$

$$\overline{RS\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VS\_OUT} = \overline{V\_PRED\_FINAL}$$

Update target state:

$$S\_OPTION = 2$$

$$\overline{R\_PRED\_IN} = \overline{RT\_M50\_PROX}$$

$$\overline{V\_PRED\_IN} = \overline{VT\_M50\_PROX}$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ , T\_PRED\_IN, T\_PRED\_FINAL

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{RT\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VT\_OUT} = \overline{V\_PRED\_FINAL}$$

3. Perform an iteration to find a time for which the desired elevation angle and the delta-h at that time are consistent ( $-\text{DELTA\_H} (\text{EL\_ANG} - \text{PI}) \geq 0$ ), Execute the following code while the maximum number of iterations has not been reached ( $\text{IC} \leq \text{IC\_MAX}$ ) and while the delta-h and elevation angle are inconsistent ( $\text{NN} = 0$ ). (Note: Initially  $\text{NN} = 0$ , thus the loop will be entered at least once.)

- a. Calculate the differential altitude:  $\text{DELTA\_H} = |\overline{RT\_OUT}| - |\overline{RS\_OUT}|$
- b. Test for consistency between the calculated delta-h and the desired elevation angle.
- (1) If the elevation angle and differential altitude are consistent, set the differential altitude consistency indicator to indicate consistency.

If  $-\text{DELTA\_H} (\text{EL\_ANG} - \text{PI}) \geq 0$ , then

$$\text{NN} = 1$$

If  $\text{NN} = 1$  then go to Step A.4.

- (2) If they are not consistent, compute a dependent variable ( $\text{ERR\_DH}$ ) with the differential altitude and incompatibility tolerance ( $\text{EL\_DH\_TOL}$ ).

If  $-\text{DELTA\_H} (\text{EL\_ANG} - \text{PI}) < 0$ , then

$$\text{ERR\_DH} = \text{DELTA\_H} + \text{EL\_DH\_TOL} \text{SIGN}(\text{DELTA\_H})$$

Calculate the new guess at the time of consistency and advance the Shuttle and target on the time. This is performed in the elevation angle iterator task (Subsection 4.6.19), with inputs of Shuttle position and velocity vectors, iteration counter, error in the DH, current TPI time, previous error, and previous time. The outputs are the Shuttle and target position and velocity vectors, time, iteration counter, the new time, the new values of the previous error and time, and an error flag.

$$ERR = ERR\_DH$$

$$ERR\_PRIME = ERR\_DH\_PRIME$$

Inputs/outputs for the elevation angle iteration (ELITER) task are:

Inputs:  $\bar{R}S\_OUT$ ,  $\bar{V}S\_OUT$ ,  $\bar{R}T\_OUT$ ,  $\bar{V}T\_OUT$ ,  
IC, ERR, TTPI, ERR\\_PRIME,  
TTPI\\_PRIME

Outputs:  $\bar{R}S\_OUT$ ,  $\bar{V}S\_OUT$ ,  $\bar{R}T\_OUT$ ,  $\bar{V}T\_OUT$ ,  
IC, TTPI, ERR\\_PRIME, TTPI\\_PRIME,  $\dot{ALARM\_B}$

$$ERR\_DH\_PRIME = ERR\_PRIME$$

4. Determine the time that the desired elevation angle exists. Test to see if the delta-h iteration has failed (i.e., the consistency flag, NN, is still set to zero).
  - a. If the delta-h iteration has failed (i.e., the consistency flag is set to OFF, NN = 0), then set an alarm and exit the routine, since there will be no time for which the desired elevation angle will exist.

$$\dot{ALARM\_B} = ON$$

- b. If the consistency flag is set to ON (NN = 1), then find the time of elevation angle.
  - (1) If iterations have not occurred (IC = 0) go to Step A.4.b.(3).
  - (2) If iterations have occurred (IC  $\neq$  0), compute a TPI time in the direction of difference between the current and previous TPI time and set iteration counter (IC) to zero. This is done to ensure that the first two iterations are consistent.

$$T\_SAVE = TTPI$$

$$TTPI = TTPI + 10 \text{ SIGN}(TTPI - TTPI\_PRIME)$$

$$IC = 0$$

Advance both the Shuttle and target to the time of TPI. This is performed by two calls to the state vector update task, with inputs of Shuttle and target position and velocity vectors, time, TPI time. The outputs are position and velocity vectors and time.

Update Shuttle state:

$$S\_OPTION = 1$$

$$\overline{R\_PRED\_IN} = \overline{RS\_OUT}$$

$$\overline{V\_PRED\_IN} = \overline{VS\_OUT}$$

$$T\_PRED\_IN = T\_SAVE + BASE\_MET$$

$$T\_PRED\_FINAL = TTPI + BASE\_MET$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ ,  $T\_PRED\_IN$ ,  
 $T\_PRED\_FINAL$

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{RS\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VS\_OUT} = \overline{V\_PRED\_FINAL}$$

Update target state:

$$S\_OPTION = 2$$

$$\overline{R\_PRED\_IN} = \overline{RT\_OUT}$$

$$\overline{V\_PRED\_IN} = \overline{VT\_OUT}$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ ,  $T\_PRED\_IN$ ,  $T\_PRED\_FINAL$

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{RT\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VT\_OUT} = \overline{V\_PRED\_FINAL}$$

- (3) Perform an iteration to find the time of elevation angle. Execute the following code as long as the maximum number of iterations has not been reached and the current error is larger than the tolerance or while the number of iterations is equal to zero. (This condition forces at least one iteration.) The condition for iteration is

$$[|ERR\_EL| \geq EL\_TOL \text{ and } (IC \leq IC\_MAX)] \text{ or } (IC = 0)$$

- (a) Calculate the elevation angle that currently exists between the two vehicles. The calculations are performed in the elevation angle computation task (Subsection 4.6.18), with inputs of the Shuttle position and velocity vectors, and target position vector. The output is the elevation angle.

$$\bar{RS}\_COM = \bar{RS}\_OUT$$

$$\bar{VS}\_COM = \bar{VS}\_OUT$$

$$\bar{RT}\_COM = \bar{RT}\_OUT$$

CALL COMELE

Inputs:  $\bar{RS}\_COM, \bar{VS}\_COM, \bar{RT}\_COM$

Outputs:  $EL\_ANG\_COM$

- (b) Calculate the difference between the desired and computed elevation angles and display the computed angle:

$$ERR\_EL = EL\_ANG - EL\_ANG\_COM$$

$$DISP\_EL\_ANG = EL\_ANG\_COM \cdot 180/PI$$

- (c) If  $|ERR\_EL| < EL\_TOL$  or  $ALARM\_B = ON$ , then exit the routine, otherwise calculate the new guess at the time of TPI and advance the Shuttle and target to the time. This is performed in the elevation angle iterator task (Subsection 4.6.19), with inputs of Shuttle position and velocity vectors, iteration counter, error in the elevation angle, current TPI time, previous error, and TPI time. The outputs are the Shuttle and target positions and velocity vectors, time, iteration counter, new TPI time, new values of the previous error and TPI time, and an error flag.

$$ERR = ERR\_EL$$

$$ERR\_PRIME = ERR\_EL\_PRIME$$

Inputs/outputs for the elevation angle iteration task (ELITER) are:

Inputs:  $\overline{RS\_OUT}$ ,  $\overline{VS\_OUT}$ ,  $\overline{RT\_OUT}$ ,  $\overline{VT\_OUT}$ , IC, ERR,  
TTPI, ERR\_PRIME, TTPI\_PRIME

Outputs:  $\overline{RS\_OUT}$ ,  $\overline{VS\_OUT}$ ,  $\overline{RT\_OUT}$ ,  $\overline{VT\_OUT}$ ,  
IC, TTPI, ERR\_PRIME, TTPI\_PRIME, ALARM\_B

ERR\_EL\_PRIME = ERR\_PRIME

B. Interface Requirements. The input and output parameters for the elevation angle search task are given in Tables 4.6.16-1 and 4.6.16-2. A flow diagram of TELEV is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

E. Supplemental Information. None.



Table 4.6.16-1. Elevation Angle Search Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
EL_TOL	SP	Tolerance between computed and desired elevation angles	ILOAD	F	rad
EL_DH_TOL	SP	Elevation angle–differential altitude incompatibility tolerance	ILOAD	F	—
TIME_PROX	DP	Time tag for M50 state (assumed met)	PROX_TGT_SUP_LAMB	F	s
EL_ANG	SP	Desired elevation angle at TPI	PROX_TGT_SUP_LAMB	F	rad
$\bar{R}_S$ _M50_PROX	DP	Prox ops orbiter M50 position vector	PROX_EXEC	F(3)	ft
$\bar{R}_T$ _M50_PROX	DP	Prox ops target M50 position vector	PROX_EXEC	F(3)	ft
$\bar{V}_S$ _M50_PROX	DP	Prox ops orbiter M50 velocity vector	PROX_EXEC	F(3)	ft/s
$\bar{V}_T$ _M50_PROX	DP	Prox ops target M50 velocity vector	PROX_EXEC	F(3)	ft/s
$\bar{R}$ _PRED_FINAL	DP	Output inertial position vector	UPDATVP	F(3)	ft
$\bar{V}$ _PRED_FINAL	DP	Output inertial velocity vector	UPDATVP	F(3)	ft/s
DEL_X_TOL	SP	Tolerance to ensure non–zero slope	ILOAD	F(2)	—
DEL_X_GUESS	SP	Delta–X guess if none exists	ILOAD	F(2)	—
TTPI	DP	Predicted time of TPI in MET	ELITER	F	s
PI	SP	Mathematical constant	LEVEL A	F	—
EL_ANG_COM	SP	Computed elevation angle	COMELE	F	rad
ERR_PRIME	SP	Previous value of the elevation angle guess	ELITER	F	rad
TTPI_PRIME	DP	Previous value of the TPI time guess	ELITER	F	s
DY_TOL	SP	Tolerance on non–zero slope	ITERV	F	—
FIRST_JUMP	SP	$\Delta X$ guess if none exists	ITERV	F	—
T1_TIG	DP	T1 maneuver time (MET)	PROX_EXEC	F	s
ALARM_B	–	Alarm flag for elevation angle error	ELITER	D	—
IC	SP	Iteration counter	ITERV	I	—
IC_MAX	SP	Maximum no. of iterations	ILOAD	I	—

Table 4.6.16-2. Elevation Angle Search Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
S_OPTION	SP	Spacecraft flag for UPDATVP		I	—
$\bar{R}$ _PRED_IN	DP	Input inertial position vector	UPDATVP	F(3)	ft
$\bar{V}$ _PRED_IN	DP	Input inertial velocity vector	UPDATVP	F(3)	ft/s
T_PRED_IN	DP	Input time in GMT	UPDATVP	F	s
T_PRED_FINAL	DP	Output time in GMT	UPDATVP	F	s
$\bar{R}$ S_OUT	DP	Shuttle position vector	ELITER	F(3)	ft
$\bar{V}$ S_OUT	DP	Shuttle velocity vector	ELITER	F(3)	ft/s
$\bar{R}$ T_OUT	DP	Target position vector	ELITER	F(3)	ft
$\bar{V}$ T_OUT	DP	Target velocity vector	ELITER	F(3)	ft/s
$\bar{R}$ S_COM	DP	Shuttle inertial position	COMELE	F(3)	ft
$\bar{V}$ S_COM	DP	Shuttle inertial velocity	COMELE	F(3)	ft/s
$\bar{R}$ T_COM	DP	Target inertial position	COMELE	F(3)	ft
ERR_PRIME	DP	Previous value of the dependent variable in search of elevation angle	ELITER	F	rad
TTPI_PRIME	DP	Previous value of the independent variable in search of elevation angle	ELITER	F	s
TTPI	DP	Predicted time of TPI (MET)	ELITER PROX_TGT_SUP_LAMB	F	s
FIRST_JUMP	SP	X guess for iterations if no prediction is possible	ELITER	F	—
ALARM_B	—	Alarm flag for elevation angle error	GAX (4.110)	D	—
DISP_EL_ANG	SP	Displayed elevation angle	ORBIT_TGT_DISP (6.14)	F	deg
IC	SP	Iteration counter	ELITER	I	—

#### 4.6.17 Precision Velocity Required Task (PREVR)

The precision velocity required task computes the precision velocity required to satisfy both terminal position and time of flight constraints (Lambert problem).

A. Detailed Requirements. The following steps are required to compute the velocity that satisfies the Lambert problem constraints.

1. Set or initialize variables that are used in the iteration to find the required velocity:

$$\text{DEL\_T\_TRAN} = \text{T2\_TIG} - \text{T1\_TIG}$$

$$\bar{\mathbf{R}}_{\text{OFFSET}} = \bar{\mathbf{R}}_{\text{S\_T2TIG}}$$

$$\text{T\_OFFSET} = \text{T2\_TIG}$$

$$\text{N} = 0$$

$$\bar{\mathbf{V}}_{\text{G}} = 0$$

$$\text{VG\_MAG} = 0$$

$$\text{ALPHA} = 2/|\bar{\mathbf{R}}_{\text{S\_T1TIG}}| - (\bar{\mathbf{V}}_{\text{S\_T1TIG}} \cdot \bar{\mathbf{V}}_{\text{S\_T1TIG}})/\text{EARTH\_MU}$$

$$\text{ORB\_RATE} = \text{ALPHA SQRT}(\text{ALPHA EARTH\_MU})$$

$$\text{S\_ROTATE} = 1$$

$$\bar{\mathbf{U}}_{\text{N\_REF}} = \text{UNIT}(\bar{\mathbf{R}}_{\text{S\_T1TIG}} \times \bar{\mathbf{V}}_{\text{S\_T1TIG}})$$

$$\bar{\mathbf{R}}_{\text{S\_IPO}} = \bar{\mathbf{R}}_{\text{S\_T1TIG}}$$

$$\text{ACC} = \text{THRUST/M}$$

$$\bar{\mathbf{R}}_{\text{MISS}} = 0$$

2. Perform the iteration to compute the required velocity. Continue until the miss distance between the Shuttle position vector at the terminal time is within a tolerance ( $|\bar{\mathbf{R}}_{\text{MISS}}| \leq \text{R\_TOL}$ ) and a minimum number of iterations are achieved ( $\text{N} \geq \text{NMIN}$ ), or until a maximum number of iterations are achieved ( $\text{N} \geq \text{N\_MAX\_ITER}$ ).

- a. Increase the iteration counter by one and initialize the position offset vector for the required velocity computation.

$$\text{N} = \text{N} + 1$$

$$\bar{\mathbf{R}}_{\text{OFFSET}} = \bar{\mathbf{R}}_{\text{OFFSET}} - \bar{\mathbf{R}}_{\text{MISS}}$$

- b. Execute the transfer angle logic.
- (1) Calculate the transfer plane vector and the transfer angle before and after the burn:

$$\bar{U}N = \bar{R}S\_IPO \times \bar{R}\_OFFSET$$

$$S\_ROTATE = \text{SIGN}(\bar{U}N \cdot \bar{U}N\_REF)$$

$$SBETA = S\_ROTATE |\bar{U}N|$$

$$CBETA = \bar{R}S\_IPO \cdot \bar{R}\_OFFSET$$

$$BBEF = \text{PI} + \text{ARCTAN2}(-SBETA, -CBETA)$$

$$BAFT = BBEF - \text{ORB\_RATE} \text{ VG\_MAG/ACC}$$

- (2) Perform a logical test to determine if the transfer angle before and after the burn is not near 180 degrees.
- (a) If the transfer angle is not near 180 degrees ( $BBEF < \text{PI} - \text{CONE}$  or  $BAFT > \text{PI} + \text{CONE}$ ), calculate the transfer plane:

$$\bar{U}N = \bar{U}N/SBETA$$

- (b) If the transfer angle is near 180 degrees ( $BBEF \geq \text{PI} - \text{CONE}$  and  $BAFT \leq \text{PI} + \text{CONE}$ ), set the transfer plane equal to the Shuttle orbital plane, set the projection flag to zero, and project the offset position vector into the transfer plane:

$$S\_ROTATE = 0$$

$$\bar{U}N = \bar{U}N\_REF$$

$$\bar{R}\_OFFSET = \bar{R}\_OFFSET - (\bar{R}\_OFFSET \cdot \bar{U}N) \bar{U}N$$

- c. Calculate the required velocity vector, which with the position vector will pass through the desired target vector at the desired time. The calculations for the required velocity vector are in the Lambert conic-velocity-required task (Subsection 4.6.20), with inputs of the initial position offset vector, the desired target offset vector, the transfer plane vector, and the transfer time. The outputs are the required velocity vector and an alarm or error flag.

Inputs/outputs for the Lambert conic-velocity-required task (LAMBERT) are:

Inputs:  $\bar{R}S\_IPO, \bar{R}\_OFFSET, \bar{U}N, \text{DEL\_T\_TRAN}$

Outputs:  $\bar{V}S\_REQUIRED, \text{ALARM\_KILL}$

- d. If  $\dot{A}LARM\_KILL$  set to OFF, then compute the maneuver and maneuver magnitude. Otherwise, exit this task.

$$\overline{V}G = \overline{V}S\_REQUIRED - \overline{V}S\_T1TIG$$

$$VG\_MAG = ABVAL(\overline{V}G)$$

- e. Advance the Shuttle state vector to the terminal point by a call to the state vector update task (Subsection 4.6.21), with inputs of the state vector time, update option flag, terminal point time. The output is the state vector at terminal point time.

$$S\_OPTION = 1$$

$$\overline{R}\_PRED\_IN = \overline{R}S\_IPO$$

$$\overline{V}\_PRED\_IN = \overline{V}S\_REQUIRED$$

$$T\_PRED\_IN = T1\_TIG + BASE\_MET$$

$$T\_PRED\_FINAL = T2\_TIG + BASE\_MET$$

CALL UPDATVP

Inputs:  $\overline{R}\_PRED\_IN, \overline{V}\_PRED\_IN, T\_PRED\_IN, T\_PRED\_FINAL$

Outputs:  $\overline{R}\_PRED\_FINAL, \overline{V}\_PRED\_FINAL$

$$\overline{R}S\_TERMINAL = \overline{R}\_PRED\_FINAL$$

$$\overline{V}S\_TERMINAL = \overline{V}\_PRED\_FINAL$$

- f. Compute the miss distance vector between the Shuttle position vector and the desired position vector at the terminal point:

$$\overline{R}\_MISS = \overline{R}S\_TERMINAL - \overline{R}S\_T2TIG$$

- g. Perform a logic test to determine if the transfer angle is near 180 degrees. If the transfer angle is near 180 degrees ( $S\_ROTATE = 0$ ), compute the miss as a projection into the actual transfer plane:

$$\overline{R}\_MISS = \overline{R}\_MISS - (\overline{R}\_MISS \cdot \overline{U}N) \overline{U}N$$

- h. Compute the miss distance for the display.

$$DSP\_MISS = ABVAL(\overline{R}\_MISS)$$

- i. Perform a logic test to determine if the maximum number of iterations were exceeded.

If  $N \geq N\_MAX\_ITER$ , set  $\dot{A}LARM\_A = ON$  and then exit the routine.

If  $N < N\_MAX\_ITER$ , then go to Step A.2.

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- B. Interface Requirements. The input and output parameters for the precision velocity required task are given in Tables 4.6.17-1 and 4.6.17-2. A flow diagram of PREVR is given in Appendix A.
- C. Processing Requirements. Perform once on call.
- D. Initialization Requirements. None.

Table 4.6.17-1. Precision Velocity Required Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
PI	DP	Mathematical Constant	CONSTANT	F	
M	SP	Mass of the orbiter	ON-ORBIT GUID	F	slugs
R_TOL	SP	Convergence tolerance in the terminal point offset iteration	ILOAD	F	ft
N_MAX_ITER	SP	Maximum allowed number of iterations	ILOAD	I	—
CONE	SP	Angular tolerance used to determine if the transfer angle 180°	ILOAD	F	rad
NMIN	SP	Minimum allowed number of iterations	ILOAD	I	—
T1_TIG	DP	T1 maneuver time (MET)	PROX_TGT_SUP_LAMB	F	s
T2_TIG	DP	T2 maneuver time (MET)	PROX_TGT_SUP_LAMB	F	s
$\overline{RS}_{T1TIG}$	DP	Inertial position vector of Shuttle at T1_TIG	PROX_TGT_SUP_LAMB	F(3)	ft
$\overline{VS}_{T1TIG}$	DP	Inertial velocity vector of Shuttle at T1_TIG	PROX_TGT_SUP_LAMB	F(3)	ft/s
$\overline{RS}_{T2TIG}$	DP	Inertial position vector of Shuttle at T2_TIG	PROX_TGT_SUP_LAMB	F(3)	ft
$\overline{R}_{PRED\_FINAL}$	DP	Output inertial position vector	UPDATVP	F(3)	ft
$\overline{V}_{PRED\_FINAL}$	DP	Output inertial velocity vector	UPDATVP	F(3)	ft/s
$\overline{VS}_{REQUIRED}$	DP	Velocity required at the maneuver time	LAMBERT	F(3)	ft/s
THRUST	SP	Thrust of the propulsion system	ILOAD	F	lb
ALARM_KILL	—	Stop computations flag	LAMBERT PROX_EXEC	D	—

Table 4.6.17-2. Precision Velocity Required Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
S_ROTATE	SP	Rotation flag for near-180° transfers	PROX_TRANS	I	—
$\bar{R}$ _OFFSET	DP	Offset position vector (inertial)	PROX_TRANS, LAMBERT	F(3)	ft
T_OFFSET	DP	Time of offset position vector in MET	PROX_TRANS	F	s
$\bar{R}$ _PRED_IN	DP	Input inertial position vector	UPDATVP	F(3)	ft
$\bar{V}$ _PRED_IN	DP	Input inertial velocity vector	UPDATVP	F(3)	ft/s
T_PRED_IN	DP	Time of input state in GMT	UPDATVP	F	s
T_PRED_FINAL	DP	Time of output state in GMT	UPDATVP	F	s
ALARM_A	—	Alarm flag indicating error	GAX(4.110)	D	—
$\bar{R}$ S_IPO	DP	Initial position offset in GMT	LAMBERT	F(3)	ft
$\bar{U}$ N	DP	Unit normal along the Shuttle angular momentum vector	LAMBERT	F(3)	—
DEL_T_TRAN	SP	Transfer time	LAMBERT	F	s
$\bar{V}$ S_REQUIRED	DP	Velocity required at the maneuver time	PROX_TGT_SUP_LAMB	F(3)	ft/s
DSP_MISS	SP	Target miss distance	ORBIT_TGT_DISP (6.14)	F	ft
ALARM_KILL	—	Stop computations flag	PROX_TGT_SUP_LAMB, PROX_EXEC	D	—



#### 4.6.18 Elevation Angle Computation Task (COMELE)

The elevation angle computation task computes the elevation angle between one vehicle position vector and another vehicle position vector. The elevation is defined to be the angle measured from the local horizontal plane of the Shuttle to the line of sight of the target.

A. Detailed Requirements. The following steps are required to calculate the elevation angle between one vehicle position vector and another vehicle position vector.

1. Calculate intermediate variables used in the elevation angle computation:

$$A = \overline{RS\_COM} \cdot \overline{RS\_COM}$$

$$B = \overline{RS\_COM} \cdot \overline{RT\_COM}$$

$$D = \overline{RS\_COM} \cdot \overline{VS\_COM}$$

$$E = \overline{RT\_COM} \cdot \overline{VS\_COM}$$

2. Calculate the elevation angle between two position vectors ( $\overline{RS\_COM}$  and  $\overline{RT\_COM}$ ):

$$EL\_ANG\_COM = PI + ARCTAN2[(A - B), SIGN(B - D - A - E) \\ ABVAL(\overline{RS\_COM} \times \overline{RT\_COM})]$$

If  $EL\_ANG\_COM \geq 2 PI$ , set  $EL\_ANG\_COM = 0$ .

B. Interface Requirements. The input and output parameters for the elevation angle computation task are given in Tables 4.6.18-1 and 4.6.18-2. A flow diagram of COMELE is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.18-1. Elevation Angle Computation Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
$\bar{R}_S\_COM$	DP	Shuttle inertial position	TELEV	F(3)	ft
$\bar{V}_S\_COM$	DP	Shuttle inertial velocity	TELEV	F(3)	ft/s
$\bar{R}_T\_COM$	DP	Target inertial position	TELEV	F(3)	ft

Table 4.6.18-2. Elevation Angle Computation Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
EL_ANG_COM	SP	Computed elevation angle	TELEV	F	rad

#### 4.6.19 Elevation Angle Iteration Task (ELITER)

The elevation angle iterator task computes the time of TPI and updates the Shuttle and target to this time.

A. Detailed Requirements. The following steps are required in the computation and the advancement of the Shuttle and target to the time of the TPI maneuver.

1. Calculate the new guess at the time of TPI. This is performed in the Newton–Raphson iteration task (Subsection 4.6.22), with inputs of iteration counter, current error in the elevation angle, current TPI time, previous error, and TPI time. The outputs are the new TPI time, new previous error and TPI time, and an error flag that is set if the maximum number of iterations is exceeded.

X\_DEP = ERR

X\_IND = TTPI

X\_DEP\_PRIME = ERR\_PRIME

X\_IND\_PRIME = TTPI\_PRIME

CALL ITERV

Inputs: IC, X\_DEP, X\_IND, X\_DEP\_PRIME, X\_IND\_PRIME

Outputs: IC, X\_IND, X\_DEP\_PRIME, X\_IND\_PRIME, SFAIL

TTPI = X\_IND

ERR\_PRIME = X\_DEP\_PRIME

TTPI\_PRIME = X\_IND\_PRIME

2. If the iteration maximum has been exceeded ( $SFAIL \neq 0$ ), set an ALARM flag.  
If  $SFAIL \neq 0$ , then  $ALARM\_B = ON$ .
3. Perform a logic test to determine if the current TPI time is greater than some delta time from the previous TPI time. If it is, set the current TPI time to the previous time plus the delta time:

If  $|TTPI - TTPI\_PRIME| > DEL\_T\_MAX$

then  $TTPI = TTPI\_PRIME + DEL\_T\_MAX \text{ SIGN}(TTPI - TTPI\_PRIME)$

4. Advance both Shuttle and target to the current TPI time. The state vector update task performs the advancement with two calls, one for the Shuttle and the other for the target. The inputs are position and velocity vectors, TPI time. The outputs are position and velocity vectors and time of TPI.

Update Shuttle state

S\_OPTION = 1

$$\overline{R\_PRED\_IN} = \overline{RS\_OUT}$$

$$\overline{V\_PRED\_IN} = \overline{VS\_OUT}$$

$$T\_PRED\_IN = TTPI\_PRIME + BASE\_MET$$

$$T\_PRED\_OUT = TTPI + BASE\_MET$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ , T\_PRED\_IN, T\_PRED\_FINAL

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{RS\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VS\_OUT} = \overline{V\_PRED\_FINAL}$$

Update target state

$$S\_OPTION = 2$$

$$\overline{R\_PRED\_IN} = \overline{RT\_OUT}$$

$$\overline{V\_PRED\_IN} = \overline{VT\_OUT}$$

CALL UPDATVP

Inputs:  $\overline{R\_PRED\_IN}$ ,  $\overline{V\_PRED\_IN}$ , T\_PRED\_IN, T\_PRED\_FINAL

Outputs:  $\overline{R\_PRED\_FINAL}$ ,  $\overline{V\_PRED\_FINAL}$

$$\overline{RT\_OUT} = \overline{R\_PRED\_FINAL}$$

$$\overline{VT\_OUT} = \overline{V\_PRED\_FINAL}$$

B. Interface Requirements. The input and output parameters for the elevation angle iteration task are given in Tables 4.6.19–1 and 4.6.19–2. A flow diagram of ELITER is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

E. Supplemental Information. If the ALARM is set (ALARM\_B = ON), the error message corresponding to that ALARM should be displayed. That error message is TGT\_EL\_ANG.

Table 4.6.19-1. ELITER Module Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
BASE_MET	DP	GMT/MET reference time	FCOS	F	s
DEL_T_MAX	SP	Maximum step size used during an iteration	ILOAD	I	s
$\bar{R}_{PRED\_FINAL}$	DP	Output inertial position vector	UPDATVP	F(3)	ft
$\bar{V}_{PRED\_FINAL}$	DP	Output inertial velocity vector	UPDATVP	F(3)	ft/s
TTPI	DP	Predicted time of TPI (MET)	TELEV	F	s
$\bar{R}_S\_OUT$	DP	Shuttle position vector	TELEV	F(3)	ft
$\bar{V}_S\_OUT$	DP	Shuttle velocity vector	TELEV	F(3)	ft/s
$\bar{R}_T\_OUT$	DP	Target position vector	TELEV	F(3)	ft
$\bar{V}_T\_OUT$	DP	Target velocity vector	TELEV	F(3)	ft/s
X_IND	DP	Independent variable	ITERV	F	—
X_DEP_PRIME	DP	Previous value of the dependent variable	ITERV	F	—
X_IND_PRIME	DP	Previous value of the independent variable	ITERV	F	—
ERR	DP	Guess of the elevation angle	TELEV	F	rad
ERR_PRIME	DP	Previous guess of the elevation angle	TELEV	F	rad
TTPI_PRIME	DP	Previous guess of the TPI time	TELEV	F	s
IC	SP	Iteration counter	TELEV, ITERV	I	—
SFAIL	SP	Flag set if maximum number of iterations occurred	ITERV	I	—

Table 4.6.19-2. ELITER Module Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
S_OPTION	SP	Spacecraft flag for UPDATVP	UPDATVP	I	—
$\overline{R}_{PRED\_IN}$	DP	Input inertial position vector for UPDATVP	UPDATVP	F(3)	ft
$\overline{V}_{PRED\_IN}$	DP	Input inertial velocity vector for UPDATVP	UPDATVP	F(3)	ft/s
TTPI	DP	Predicted time of TPI (MET)	TELEV	F	s
T_PRED_IN	DP	Time of input state to UPDATVP in GMT	UPDATVP	F	s
T_PRED_FINAL	DP	Time of output state to UPDATVP in GMT	UPDATVP	F	s
$\overline{RS\_OUT}$	DP	Shuttle position vector	PROX_TGT_SUP_LAMB	F(3)	ft
$\overline{VS\_OUT}$	DP	Shuttle velocity vector	PROX_TGT_SUP_LAMB	F(3)	ft/s
$\overline{RT\_OUT}$	DP	Target position vector	PROX_TGT_SUP_LAMB	F(3)	ft
$\overline{VT\_OUT}$	DP	Target velocity vector	PROX_TGT_SUP_LAMB	F(3)	ft/s
IC	SP	Iteration counter to ITERV		I	—
X_DEP	DP	Dependent variable to ITERV	ITERV	F	—
X_IND	DP	Independent variable to ITERV	ITERV	F	—
X_DEP_PRIME	DP	Previous value of the dependent variable to ITERV	ITERV	F	—
X_IND_PRIME	DP	Previous value of the independent variable to ITERV	ITERV	F	—
ERR_PRIME	DP	Previous guess of the elevation angle	TELEV	F	rad
TTPI_PRIME	DP	Previous guess of TPI in MET	TELEV	F	s
ALARM_B	—	Alarm flag	GAX (4.110), TELEV	D	—

#### 4.6.20 Lambert Conic-Velocity-Required Task (LAMBERT)

The Lambert conic-velocity-required task calculates the required orbital velocity vector that satisfies the following Lambert problem: given an initial position vector, a terminal position vector, and a specified transfer time between the initial and final vectors, determine the initial velocity required to transfer from the initial vector to the final vector with the required transfer time, assuming two-body conic orbital motion. The equations hold only for the elliptical case, and the task does not have multirevolution capability. This task is used in targeting and in the execution of a Lambert-guided maneuver.

A. Detailed Requirements. The following steps are required to calculate the initial velocity vector to transfer from an initial position vector to a final position vector with a specified transfer time.

1. Calculate the magnitude of the initial vector and the final vector:

$$\bar{R}_0 = \bar{R}_{S\_IPO}$$

$$\bar{R}_1 = \bar{R}_{OFFSET}$$

$$R0\_MAG = ABVAL(\bar{R}_0)$$

$$R1\_MAG = ABVAL(\bar{R}_1)$$

2. Calculate the semiperimeter of the transfer triangle to be used as a normalizing constant:

$$R\_PARABOLA = (R0\_MAG + R1\_MAG + ABVAL(\bar{R}_1 - \bar{R}_0))/2$$

3. Calculate the parabolic velocity at perigee for R\_PARABOLA for use as a normalizing factor.

$$V\_PARABOLA = \sqrt{2 \text{ EARTH\_MU} / R\_PARABOLA}$$

4. Calculate the parameter Z, where  $Z = R0\_MAG R1\_MAG - \bar{R}_0 \cdot \bar{R}_1$ . Z is equal to  $R0\_MAG R1\_MAG(1 - \cos\theta)$ , where  $\theta$  is the transfer angle. Test to determine if  $\theta$  is close to 0 or 360 degrees. If  $Z \leq EP\_TRANSFER R0\_MAG R1\_MAG$ , set the alarm flags and exit:

$$ALARM\_D = ON$$

$$ALARM\_KILL = ON$$

5. Calculate the cotangent of  $\theta/2$  (also to be designated by the parameter Z).  $\bar{R}_0$  and  $\bar{R}_1$  are assumed to be in the plane defined by UN:

$$Z = (\bar{R}_0 \times \bar{R}_1) \cdot \bar{UN}/Z$$

6. Calculate the parameter VH:

$$VH = \sqrt{R0\_MAG R1\_MAG / (1 + Z^2)}$$

7. Set the initial value on the counter to count the number of iterations:

$$N = 0$$



8. Set the upper and lower limits of the independent variable:

$$U\_MAX = 1 - DU/2$$

$$U\_MIN = -1.0$$

DU is an I-load parameter to prevent the orbit from becoming close to parabolic.

9. Calculate the constant parameter, LAMBDA:

$$LAMBDA = (VH/R\_PARABOLA) Z$$

10. Calculate the first guess for the independent variable. This first guess assumes a circular orbit:

$$U = LAMBDA/(1 + LAMBDA^2)^{1/2}$$

11. Calculate the normalized transfer time:

$$T\_TILDA\_DESIRED = (V\_PARABOLA/R\_PARABOLA) DEL\_T\_TRAN$$

12. Determine a transfer time that is slightly greater than the parabolic transfer time:

$$T\_MIN = (2/3) (1 - LAMBDA^3) + (0.4) (1 - LAMBDA^5) DU$$

If the normalized transfer time is less than or equal to T\_MIN (T\_TILDA\_DESIRED ≤ T\_MIN), set the alarm flags and exit:

$$ALARM\_D = ON$$

$$ALARM\_KILL = ON$$

13. The initialization procedure has been completed. A Newton-Raphson iteration is performed to determine the value of U which yields the desired transfer time from Kepler's equation. This iteration is performed until the dependent variable error T\_TILDA\_ERROR is less than the desired value of the dependent variable T\_TILDA\_DESIRED times EPS\_U (abs(T\_TILDA\_ERROR) < T\_TILDA\_DESIRED EPS\_U), or until the number of iterations performed, N, is equal to the maximum number of iterations allowed, N\_MAX\_ITER. The iteration steps are as follows:

- a. Increase the counter on the number of iterations by one:

$$N = N + 1$$

- b. The following parameters are calculated to obtain the transfer time corresponding to the current value of U:

$$W = \sqrt{1 - U^2}$$

$$X1 = \text{LAMBDA } W$$

$$Y = \sqrt{1 - X1^2}$$

$$F = W Y - U X1$$

$$G1 = U Y + W X1$$

- c. The current value of the transfer time is given by

$$T\_TILDA = [\text{ARCTAN2}(F, G1) - (U W - X1 Y)]/W^3$$

The ARCTAN2 function should produce angles between 0 and  $2 \pi$  radians.

- d. Determine the slope of T\_TILDA with respect to the independent variable U for use with the Newton–Raphson iteration:

$$S\_TILDA = (3 U T\_TILDA - 2(1 - (U/Y)\text{LAMBDA}^3))/W^2$$

- e. Determine the error in the current value of T\_TILDA and the desired value T\_TILDA\_DESIRED:

$$T\_TILDA\_ERROR = T\_TILDA\_DESIRED - T\_TILDA$$

- f. Determine if the error in T\_TILDA\_DESIRED is small enough to consider the current value of U as the correct answer. If the absolute value of T\_TILDA\_ERROR is less than T\_TILDA\_DESIRED times EPS\_U, then the Newton–Raphson iteration is considered converged and the required initial velocity can be determined in Step 14. Otherwise, continue calculations.

- g. Calculate a change in the current value of U:

$$U\_STEP = T\_TILDA\_ERROR/S\_TILDA.$$

- h. Determine if the maximum number of iterations have been performed. If N is equal to the maximum number of iterations allowed, N\_MAX\_ITER, then set ALARM\_A = ON, set ALARM\_KILL = ON, and exit the Lambert task. Otherwise continue the calculations.

- i. If U\_STEP is positive, then perform the following:

$$U\_MIN = U$$

$$U = U + U\_STEP$$

$$\text{If } U > U\_MAX, \text{ then set } U = (U\_MIN + U\_MAX)/2$$

Otherwise, i.e. if U\_STEP is negative perform the following:

$$U\_MAX = U$$

$$U = U + U\_STEP$$

$$\text{If } U < U\_MIN, \text{ then set } U = (U\_MIN + U\_MAX)/2$$

j. Go to Step A.13a.

14. The required initial velocity can now be obtained by the following relationships:

$$VH = VH/R0\_MAG$$

$$VR = (R\_PARABOLA/R0\_MAG) LAMBDA - G1$$

$$COEF = V\_PARABOLA/(Y - LAMBDA U)$$

$$\overline{VS\_REQUIRED} = (COEF/R0\_MAG)(VR \overline{R0} + VH (\overline{UN} \times \overline{R0}))$$

where  $\overline{UN}$  is a unit vector in the direction of the angular momentum vector.

B. Interface Requirements. The input and output parameters for the Lambert conic-velocity-required task are given in Tables 4.6.20-1 and 4.6.20-2. A flow diagram of LAMBERT is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

E. Supplemental Information. If the transfer angle is near 180 degrees, the parameter LAMBDA will be near zero. When this occurs, raising LAMBDA to a power in the code may result in an underflow. This situation must be covered in the code.

If the ALARM is set ( $\dot{ALARM\_A} = ON$ ), the error message corresponding to that ALARM should be displayed. The alarm message is "TGT ITER".

If  $\dot{ALARM\_D} = ON$ , the error message is "TGT DELTA T".

Since U, U\_MIN, and U\_MAX are all declared to be DOUBLE precision, the requirements specified in paragraph A.13j yield the same result as the following formulation:

If  $U\_STEP > 0$ , then set  $U\_MIN = U$ . Otherwise set  $U\_MAX = U$ .

Set  $U = U + U\_STEP$ .

If this new value of U is not the middle value of U, U\_MIN, and U\_MAX, then set  $U = (U\_MIN + U\_MAX)/2$ .

Table 4.6.20-1. LAMBERT Module Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
N_MAX_ITER	SP	Maximum allowed number of iterations	ILOAD	I	—
DU	SP	Small deviation to prevent orbit from being almost parabolic	ILOAD	F	—
EP_TRANSFER	SP	Parameter to test if transfer angle is close to 0°	ILOAD	F	—
EPS_U	SP	Parameter to test convergence of the Newton–Raphson iteration	ILOAD	F	—
$\bar{R}$ _OFFSET	DP	Offset position vector	PREVR	F(3)	ft
$\bar{R}$ S_IPO	DP	Initial position offset of Shuttle	PREVR	F(3)	ft
$\bar{U}$ N	DP	Unit normal along the Shuttle angular momentum vector	PREVR	F(3)	—
DEL_T_TRAN	DP	Transfer time	PREVR	F	s
ALARM_D	—	Alarm flag	PROX_TGT_SUPT_LAMB	D	—
ALARM_KILL	—	Stop computations flag	PREVR, VGO CORR TSK, PROX_EXEC	D	—

Table 4.6.20-2. LAMBERT Module Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
ALARM_A	—	Alarm flag indicating error	GAX(4.110)	D	—
$\bar{V}$ S_REQUIRED	DP	Velocity required at the maneuver time	PROX_TGT_SUP_LAMB, PREVR	F(3)	ft/s
ALARM_D	—	Alarm flag – timing error	GAX(4.110)	D	—
ALARM_KILL	—	Stop computations flag	PREVR, VGO CORR TSK, PROX_TGT_SUP_LAMB, PROX_EXEC	D	—

#### 4.6.21 State Vector Update Task (UPDATVP)

The state vector update task calls for the precision on-orbit predictor to update a state vector to a time.

A. Detailed Requirements. The following steps are required to update a state vector to a specific point of interest.

1. Determine if the Shuttle state or target state is to be updated. (S\_OPTION = 1, 2, respectively). Also, set the on-orbit predictor parameters: gravity model degree and order flags, drag model, vent model, attitude mode flag, and minimum integration step size.

set GMD\_PRED = GMD\_I

GMO\_PRED = GMO\_I

ATM = ATM\_I(S\_OPTION)

PRED\_STEP = DTMIN\_I

set DMP = DMP\_I(S\_OPTION)

VMP = VMP\_I(S\_OPTION)

if S\_OPTION = 1, then

PRED\_ORB\_MASS = M

PRED\_ORB\_CD = PRED\_ORB\_CD\_I

PRED\_ORB\_AREA = PRED\_ORB\_AREA\_I

2. Call the on-orbit predictor to update the state vector to the final time.

CALL ON\_ORB\_PRED

Inputs: GMD\_PRED, GMO\_PRED, DMP, VMP, ATM, PRED\_STEP

PRED\_ORB\_MASS, PRED\_ORB\_CD, PRED\_ORB\_AREA,

$\bar{R}$ \_PRED\_IN,  $\bar{V}$ \_PRED\_IN, T\_PRED\_IN, T\_PRED\_FINAL

Outputs:  $\bar{R}$ \_PRED\_FINAL,  $\bar{V}$ \_PRED\_FINAL

B. Interface Requirements. The input and output parameters for the state vector update task are given in Tables 4.6.21-1 and 4.6.21-2. A flow diagram of UPDATVP is given in Appendix A.

C. Processing Requirements. Perform once per call.

D. Initialization Requirements. None.

Table 4.6.21-1. State Vector Update Task Input Parameters

Symbol	Precision	Definition	Source	Type	Units
GMD_I	SP	Gravity model degree flag	ILOAD	I	—
GMO_I	SP	Gravity model order flag	ILOAD	I	—
ATM_I	SP	Attitude mode flag	ILOAD	I(2)	—
DMP_I	SP	Drag model flag	ILOAD	I(2)	—
VMP_I	SP	Vent model flag	ILOAD	I(2)	—
PRED_ORB_CD_I	SP	On-Orbit predictor flag	ILOAD	F	—
PRED_ORB_AREA_I	SP	On-Orbit predictor area	ILOAD	F	ft <sup>2</sup>
S_OPTION	SP	Spacecraft flag for UPDATVP	PROX_TGT_SUP, PROX_TGT_SUP_ LAMB, PREVR, TELEV, ELITER	I	—
$\overline{R}$ _PRED_IN	DP	Input inertial position for vector for UPDATVP	PROX_TGT_SUP, PROX_TGT_SUP_ LAMB, PREVR, TELEV, ELITER	F(3)	ft
$\overline{V}$ _PRED_IN	DP	Input inertial velocity	PROX_TGT_SUP, PROX_TGT_SUP_ LAMB, PREVR, TELEV, ELITER	F(3)	ft/s
T_PRED_IN	DP	Time of the input state to UPDATVP in GMT	PROX_TGT_SUP, PROX_TGT_SUP_ LAMB, PREVR, TELEV, ELITER	F	s
T_PRED_FINAL	DP	Time of the output state to UPDATVP in GMT	PROX_TGT_SUP, PROX_TGT_SUP_ LAMB, PREVR, TELEV, ELITER	F	s
M	SP	Mass of the orbiter	ON-ORBIT GUID	F	slugs
DTMIN_I	SP	Integration step size	ILOAD	F	s

Table 4.6.21-2. State Vector Update Task Output Parameters

Symbol	Precision	Definition	Destination	Type	Units
$\overline{R\_PRED\_FINAL}$	DP	Output inertial position vector	PROX_TGT_SUP_LAMB, TELEV, PREVR, ELITER, PROX_TGT_SUP	F(3)	ft
$\overline{V\_PRED\_FINAL}$	DP	Output inertial velocity vector	PROX_TGT_SUP_LAMB, TELEV, PREVR, ELITER, PROX_TGT_SUP	F(3)	ft/s

#### 4.6.22 Newton-Raphson Iteration Task (ITERV)

The Newton-Raphson task performs an iteration with a secant numerical derivative to drive the differences between two successive values of a dependent variable to zero.

A. Detailed Requirements. The following are the steps required to drive the successive difference of the dependent variable to zero.

1. Perform a logic test to determine if it is the first pass through the function.
  - a. If it is the first pass ( $IC = 0$ ), set the delta independent variable to a constant first guess:

$$DEL\_X\_IND = - FIRST\_JUMP; \text{ then go to Step A.2.}$$

- b. If it is not the first pass ( $IC \neq 0$ ), calculate the delta-dependent variable from the current and previous values of the dependent variable.

$$DEL\_X\_DEP = X\_DEP - X\_DEP\_PRIME$$

Perform a logic test of  $DEL\_X\_DEP$  to see if it is less than a small tolerance:

If  $|DEL\_X\_DEP|$  is less than a small tolerance ( $DY\_TOL$ ), then

$$DEL\_X\_IND = - FIRST\_JUMP$$

If  $|DEL\_X\_DEP|$  is not less than  $DY\_TOL$ , then

$$SLOPE = \frac{DEL\_X\_DEP}{(X\_IND - X\_IND\_PRIME)}$$

$$DEL\_X\_IND = \frac{X\_DEP}{SLOPE}$$

2. Set the previous values of the dependent and independent variable to the current values. Calculate the new current values of the independent variable. Add one to the iteration counter and set an iteration failure flag to zero:

$$SFAIL = 0$$

$$IC = IC + 1$$

$$X\_DEP\_PRIME = X\_DEP$$

$$X\_IND\_PRIME = X\_IND$$

$$X\_IND = X\_IND - DEL\_X\_IND$$

3. Perform a logic test to determine if the maximum number of iterations has been exceeded. If the iteration exceeds the maximum ( $IC > IC\_MAX$ ),

$$SFAIL = 1$$



- B. Interface Requirements. The input and output parameters for the Newton Raphson iteration task are given in Tables 4.6.22–1 and 4.6.22–2. A flow diagram of ITERV is given in Appendix A.
- C. Processing Requirements. Perform once on call.
- D. Initialization Requirements. None.

Table 4.6.22-1. Newton-Raphson Iteration Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
FIRST_JUMP	SP	$\Delta X$ guess for iterator if no prediction is possible	OMEGA_DT_COMP, ELITER	F	—
IC_MAX	SP	Maximum allowed number of iterations	ILOAD	I	—
DY_TOL	SP	Tolerance of dependent variable to ensure that a slope exists	OMEGA_DT_COMP, TELEV	F	—
IC	SP	Iteration counter in ITERV	OMEGA_DT_COMP, ELITER	I	—
X_DEP	DP	Dependent variable to ITERV	ITERV	F	—
X_IND	DP	Independent variable to ITERV	ITERV	F	—
X_DEP_PRIME	DP	Previous value of the dependent variable to ITERV	ITERV	F	—
X_IND_PRIME	DP	Previous value of the independent variable to ITERV	ITERV	F	—

Table 4.6.22-2. Newton-Raphson Iteration Task Output Parameters					
Symbol	Precision	Definition	Destination	Type	Units
X_IND	DP	Independent variable to ITERV	ELITER	F	—
X_DEP_PRIME	DP	Previous value of the dependent variable	ELITER	F	—
X_IND_PRIME	DP	Previous value of the independent variable	ELITER	F	—
SFAIL	SP	Flag set if maximum number of iterations occurred	ELITER, OMEGA_DT_COMP	I	—
IC	SP	Iteration counter in ITERV	OMEGA_DT_COMP, ELITER		

#### 4.6.23 Orbiter LVLH Transformation Task (ORBLV)

The orbiter LVLH transformation task determines the maneuver as seen from an orbiter-centered LVLH frame.

A. Detailed Requirements. The following steps are required to perform this task.

1. Compute the transformation matrix from M50 inertial frame to the local vertical inertial Shuttle-centered rectangular coordinate frame:

$$\mathbf{M\ddot{A}T\_M50\_LVIR} = \begin{bmatrix} \text{UNIT}((\overline{\mathbf{RS}} \times \overline{\mathbf{VS}}) \times \overline{\mathbf{RS}})^T \\ -\text{UNIT}(\overline{\mathbf{RS}} \times \overline{\mathbf{VS}})^T \\ -\text{UNIT}(\overline{\mathbf{RS}})^T \end{bmatrix}$$

2. Convert to a Shuttle-centered LVLH frame.

$$\overline{\mathbf{DV}}\_LVLH = [\mathbf{M\ddot{A}T\_M50\_LVIR}] \overline{\mathbf{DV}}\_INER$$

B. Interface Requirements. The input and output parameters for the Orbiter LVLH transformation task are given in Tables 4.6.23-1 and 4.6.23-2. A flow diagram of ORBLV is given in Appendix A.

C. Processing Requirements. Perform once on call.

D. Initialization Requirements. None.

Table 4.6.23-1. Orbiter LVLH Transformation Task Input Parameters					
Symbol	Precision	Definition	Source	Type	Units
$\overline{\mathbf{RS}}$	DP	Input inertial position of Shuttle	PROX_TGT_SUP_LAMB	F(3)	ft
$\overline{\mathbf{VS}}$	DP	Input inertial velocity of Shuttle	PROX_TGT_SUP_LAMB	F(3)	ft/s
DV_INER	SP	Inertial maneuver	PROX_TGT_SUP_LAMB	F(3)	ft/s

Table 4.6.23-2. Orbiter LVLH Transformation Task Output Parameters					
Symbol	Precision	Definition	Source	Type	Units
$\overline{\mathbf{DV}}\_LVLH$	SP	Shuttle-centered LVLH maneuver	PROX_TGT_SUP_LAMB	F(3)	ft/s

**4.6.24 Parameter Tables for Orbit Targeting (G5.10)**

The IDD inputs and outputs are listed in Tables 4.6.24-1 and 4.6.24-2. Values for the I-loads are contained in the I-load requirements document (JSC-19350); however, I-load definitions applicable to this principal function are listed in Table 4.6.24-3. K-loads are listed in Table 4.6.24-4. Constants are listed in Table 4.6.24.5. The cross-reference listing is given in the table listed below.

Orbit Targeting (G5.10) Cross-Reference Listing		
Local Name	Source Name	MSID
BASE_MET	T_MET_REF	V91W1996C
$\bar{D}$ _DRAG	D_SAVE(1)	V95A0804C
	D_SAVE(2)	V95A0805C
	D_SAVE(3)	V95A0806C
CRT_TIME	CRT_TIMER_START	V94X4063XC
T_PRED_IN	T_PRED_INIT	V94W3970CB
PROX_ITEM_2TO20_STATUS	PROX_ITEM_2_TO_20_STATUS	V93X6557X
PROX_ITEM_21TO24_STATUS	PROX_ITEM_21_TO_24_STATUS	V93X6558X
PROX_T_CURRENT	T_STATE	V95W0200CF

TABLE 4.6.24-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALARM_A	V95X7330XA	ALARM(A) REQUESTING "TGT ITER"	ORB GUID					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
DISP_EL_ANG	V93H6530CA	T1 ELEVATION ANGLE	ORB TGTING DISP	DEG				
DISP_PROX_DT	V93W6510CA	T2 DELTA T	ORB TGTING DISP	MIN				
DISP_T1_DAY	V93W6501CA	T1 TIG (DAYS)	ORB TGTING DISP	DAY				
DISP_T1_HR	V93W6502CA	T1 TIG (HRS)	ORB TGTING DISP	HR				
DISP_T1_MIN	V93W6503CA	T1 TIG (MIN)	ORB TGTING DISP	MIN				
DISP_T1_SEC	V93W6504CA	T1 TIG (SEC)	ORB TGTING DISP	S				
DISP_T1_X(1)	V93L6543CA	T1 DELTA X/DN RNG	ORB TGTING DISP	FT				
DISP_T1_X(2)	V93L6545CA	T1 DELTA Y	ORB TGTING DISP	FT				
DISP_T1_X(3)	V93L6547CA	T1 DELTA Z/DELTA H	ORB TGTING DISP	FT				
DISP_T1_XD(1)	V93U6550CA	T1 DELTA X DOT	ORB TGTING DISP	FT/S				
DISP_T1_XD(2)	V93U6531CA	T1 DELTA Y DOT	ORB TGTING DISP	FT/S				
DISP_T1_XD(3)	V93U6559CA	T1 DELTA Z DOT	ORB TGTING DISP	FT/S				
DISP_T2_DAY	V93W6516CA	T2 TIG (DAYS)	ORB TGTING DISP	DAY				
DISP_T2_HR	V93W6517CA	T2 TIG (HRS)	ORB TGTING DISP	HR				
DISP_T2_MIN	V93W6518CA	T2 TIG (MIN)	ORB TGTING DISP	MIN				
DISP_T2_SEC	V93W6519CA	T2 TIG (SEC)	ORB TGTING DISP	S				
DISP_T2_XOFF	V93H6511CA	T2 DELTA X	ORB TGTING DISP	FT				
DISP_T2_YOFF	V93H6514CA	T2 DELTA Y	ORB TGTING DISP	FT				
DISP_T2_ZOFF	V93H6520CA	T2 DELTA Z	ORB TGTING DISP	FT				
D_SAVE(1)	V95A0804C	ORB OR TGT DRAG ACCEL (1)	ORB PRED	FT/S2			89648A	
D_SAVE(2)	V95A0805C	ORB OR TGT DRAG ACCEL (2)	ORB PRED	FT/S2			89648A	
D_SAVE(3)	V95A0806C	ORB OR TGT DRAG ACCEL (3)	ORB PRED	FT/S2			89648A	
LOAD_FLASH	V94X3814XB	LOAD FLASH FLAG	ORB MNVR DIP				93017G	*
M	V90U1961CD	CURRENT VEHICLE MASS	ORB GUID	SLUGS			89648A	
PROX_BASE_DAY	V93W6524CA	BASE TIME (DAYS)	ORB TGTING DISP	DAY				
PROX_BASE_HR	V93W6525CA	BASE TIME (HRS)	ORB TGTING DISP	HR				
PROX_BASE_MIN	V93W6526CA	BASE TIME (MIN)	ORB TGTING DISP	MIN				
PROX_BASE_SEC	V93W6527CA	BASE TIME (SEC)	ORB TGTING DISP	S				
PROX_ITEM_1_STATUS	V93X6556X	ITEM ENTRY 1 DATA CHANGED	ORB TGTING DISP					
PROX_ITEM_21_TO_24_STATUS	V93X6558X	ITEM ENTRY 21-24 DATA CHANGED	ORB TGTING DISP					
PROX_ITEM_25_STATUS	V93X6528X	T2 TO T1 XFER CMD	ORB TGTING DISP		BD			
PROX_ITEM_26_STATUS	V93X6535X	LOAD CMD	ORB TGTING DISP		BD			
PROX_ITEM_28_STATUS	V93X6537X	COMPUTE T1 CMD	ORB TGTING DISP		BD		89692B	
PROX_ITEM_29_STATUS	V93X6538X	COMPUTE T2 CMD	ORB TGTING DISP		BD		89692B	
PROX_ITEM_2_TO_20_STATUS	V93X6557X	ITEM ENTRY 2 THRU 20 DATA CHANGED	ORB TGTING DISP					
PROX_TGT_SET_NO	V93J6540C	TGT NO. SELECTED	ORB TGTING DISP		VAR			
R_AVGG(1)	V95H0185CF	X-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CF	Y-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CF	Z-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_PRED_FINAL(1)	V95H0811C	X-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
R_PRED_FINAL(2)	V95H0812C	Y-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
R_PRED_FINAL(3)	V95H0813C	Z-COMP PRED SHUTTLE POS VECTOR	ORB PRED	FT	DPL		93017G	*
R_TARGET(1)	V95H0862C	X-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*
R_TARGET(2)	V95H0863C	Y-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*

TABLE 4.6.24-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
R_TARGET(3)	V95H0864C	Z-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*
T_MET_REF	V91M1996P	MET REFERENCE	SYS S/W	S			93017G	*
T_STATE	V95W0200CF	TIME TAG ASSOC WITH CURRENT STATE	ORB UPP	S			93017G	*
V_AVGG(1)	V95L0190CF	X-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CF	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CF	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ORB UPP	FT/S	SPL		93017G	*
V_PRED_FINAL(1)	V95L0814C	X-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
V_PRED_FINAL(2)	V95L0815C	Y-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
V_PRED_FINAL(3)	V95L0816C	Z-COMP PRED SHUTTLE VEL VECTOR	ORB PRED	FT/S	DPL		93017G	*
V_TARGET(1)	V95L0867C	X-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
V_TARGET(2)	V95L0868C	Y-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
V_TARGET(3)	V95L0869C	Z-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
	V90X8646X	MM 202 FROM MM 201 FLAG	MSC				92355B	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.6.24-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALARM_A	V95X7330XB	ALARM(A) REQUESTING "TGT ITER"	GAX					
ALARM_B	V95X7331X	ALARM(B) REQUESTING "TGT EL ANG"	GAX					
ALARM_C	V95X7332X	ALARM(C) REQUESTING "TGT ITER"	GAX					
ALARM_D	V95X7339X	ALARM(D) REQUESTING "TGT DELTA T"	GAX					
ATM	V94J3999CB	ATTITUDE MODE FLAG	ORB PRED					
BACKGROUND_CALC	V95X7329X	BACKGROUND CALC IN PROGRESS FLAG	XXXXX MNVR DISP					
CRT_COUNTDOWN	V94X4064XC	CRT TIMER COUNTDOWN FLAG	FCOS					
CRT_SEC	V94W4053CC	SECONDS TO IGNITION	FCOS	S				
CRT_TIMER_START	V94X4063XC	CRT TIMER START FLAG	FCOS					
DISP_DV(1)	V95L7407C	LVLH X-COMP OF TGT DELTA V	ORB TGTING DISP	FT/S	VAR			
DISP_DV(2)	V95L7408C	LVLH Y-COMP OF TGT DELTA V	ORB TGTING DISP	FT/S	VAR			
DISP_DV(3)	V95L7409C	LVLH Z-COMP OF TGT DELTA V	ORB TGTING DISP	FT/S	VAR			
DISP_DV_MAG	V95L7405C	TGT DELTA V TOTAL	ORB TGTING DISP	FT/S	VAR			
DISP_EL_ANG	V93H6530CB	T1 ELEVATION ANGLE	ORB TGTING DISP	DEG				
DISP_PROX_DT	V93W6510CB	T2 DELTA T	ORB TGTING DISP	MIN				
DISP_T1_DAY	V93W6501CB	T1 TIG (DAYS)	ORB TGTING DISP	DAY				
DISP_T1_HR	V93W6502CB	T1 TIG (HRS)	ORB TGTING DISP	HR				
DISP_T1_MIN	V93W6503CB	T1 TIG (MIN)	ORB TGTING DISP	MIN				
DISP_T1_SEC	V93W6504CB	T1 TIG (SEC)	ORB TGTING DISP	S				
DISP_T1_X(1)	V93L6543CB	T1 DELTA X/DN RNG	ORB TGTING DISP	FT				
DISP_T1_X(2)	V93L6545CB	T1 DELTA Y	ORB TGTING DISP	FT				
DISP_T1_X(3)	V93L6547CB	T1 DELTA Z/DELTA H	ORB TGTING DISP	FT				
DISP_T1_XD(1)	V93U6550CB	T1 DELTA X DOT	ORB TGTING DISP	FT/S				
DISP_T1_XD(2)	V93U6531CB	T1 DELTA Y DOT	ORB TGTING DISP	FT/S				
DISP_T1_XD(3)	V93U6559CB	T1 DELTA Z DOT	ORB TGTING DISP	FT/S				
DISP_T2_DAY	V93W6516CB	T2 TIG (DAYS)	ORB TGTING DISP	DAY				
DISP_T2_HR	V93W6517CB	T2 TIG (HRS)	ORB TGTING DISP	HR				
DISP_T2_MIN	V93W6518CB	T2 TIG (MIN)	ORB TGTING DISP	MIN				
DISP_T2_SEC	V93W6519CB	T2 TIG (SEC)	ORB TGTING DISP	S				
DISP_T2_XOFF	V93H6511CB	T2 DELTA X	ORB TGTING DISP	FT				
DISP_T2_YOFF	V93H6514CB	T2 DELTA Y	ORB TGTING DISP	FT				
DISP_T2_ZOFF	V93H6520CB	T2 DELTA Z	ORB TGTING DISP	FT				
DISP_TMAN_TIME	V95W7410C	IMPULSIVE IGNITION TIME(SEC)	ORB TGTING DISP	S	VAR			
DMP	V94X3969XB	PROPER DRAG MODEL FLAG	ORB PRED					
DSP_MISS	V95H7431C	TARGET MISS DISTANCE	ORB TGTING DISP	FT	VAR			
EXT_DV_LVLH(1)	V93L6950CB	EXT DELTA V X-COMP	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(2)	V93L6951CB	EXT DELTA V Y-COMP	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CB	EXT DELTA V Z-COMP	DL FMT 22/A XXXXX MNVR DISP	FT/S			93017G	*
GMD_PRED	V94J3975CB	GRAVITY MODEL DEGREE FLAG	ORB PRED					
GMO_PRED	V94J3963CB	GRAVITY MODEL ORDER FLAG	ORB PRED					
GUID_FLAG	V94X4029X	GUIDANCE OPTION FLAG	DL FMT 22/1 ORB MNVR DIP XXXXX MNVR DISP		BD		93017G	*

TABLE 4.6.24-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
MAN_TGT	V95J7466C	MNVR TGT NO COMPUTED	DL FMT 22/A ORB TGTING DISP	ND	HXS		93017G	*
PRED_ORB_AREA	V93U6955CB	ORBITER REF AREA USED IN PRED	ORB PRED	FT2			89648A	
PRED_ORB_CD	V93U6954CB	ORBITER DRAG COEFF USED IN PRED	ORB PRED					
PRED_ORB_MASS	V93U6953CB	ORBITER MASS USED IN PREDICTION	ORB PRED	SLUGS			89648A	
PRED_STEP	V90W3964CB	INTEGRATION STEP SIZE	ORB PRED	S				
PROX_BASE_DAY	V93W6524CB	BASE TIME (DAYS)	ORB TGTING DISP	DAY				
PROX_BASE_HR	V93W6525CB	BASE TIME (HRS)	ORB TGTING DISP	HR				
PROX_BASE_MIN	V93W6526CB	BASE TIME (MIN)	ORB TGTING DISP	MIN				
PROX_BASE_SEC	V93W6527CB	BASE TIME (SEC)	ORB TGTING DISP	S				
PROX_LOAD_FLASH	V95X7411X	LOAD FLASH FLAG	ORB TGTING DISP		BD			
PROX_PAST_STATUS	V95X7457X	MNVR PAST FLAG	ORB TGTING DISP		BD			
PROX_T1_STAR_STATUS	V95X7386X	T1 COMPUTATION IN PROGRESS	ORB TGTING DISP		BD			
PROX_T2_STAR_STATUS	V95X7392X	T2 COMPUTATION IN PROGRESS	ORB TGTING DISP		BD			
RS_IPO(1)	V94H4034C	RS IPO (1) INITIAL X OFFSET POSN	DL FMT 22/1	FT	DPL		93017G	*
RS_IPO(2)	V94H4035C	RS IPO (2) INITIAL Y OFFSET POSN	DL FMT 22/1	FT	DPL		93017G	*
RS_IPO(3)	V94H4036C	RS IPO (3) INITIAL Z OFFSET POSN	DL FMT 22/1	FT	DPL		93017G	*
R_OFFSET_GUID(1)	V94H4016CA	LAMBERT TGT OFFSET VECTOR X-COMP	DL FMT 22/1 ORB MNVR DIP	FT			93017G	*
R_OFFSET_GUID(2)	V94H4017CA	LAMBERT TGT OFFSET VECTOR Y-COMP	DL FMT 22/1 ORB MNVR DIP	FT			93017G	*
R_OFFSET_GUID(3)	V94H4018CA	LAMBERT TGT OFFSET VECTOR Z-COMP	DL FMT 22/1 ORB MNVR DIP	FT			93017G	*
R_PRED_INIT(1)	V94H4002CB	X-COMP POS VEC AT INITIAL TIME	ORB PRED	FT			89493B	
R_PRED_INIT(2)	V94H4003CB	Y-COMP POS VEC AT INITIAL TIME	ORB PRED	FT			89493B	
R_PRED_INIT(3)	V94H4004CB	Z-COMP POS VEC AT INITIAL TIME	ORB PRED	FT			89493B	
START_BACKGROUND	V95X7328X	BEGIN TARGETING CALCULATION FLAG	ORB MNVR DIP					
S_ROTATE_GUID	V94J4025CA	NEAR 180 DEG MNVR PROJ FLAG	DL FMT 22/1 ORB MNVR DIP				93017G	*
TIG_GUID_DAY	V93W6947CB	TIG(DAYS)	XXXXX MNVR DISP	DAY				
TIG_GUID_HR	V93W6944CB	TIG(HOURS)	XXXXX MNVR DISP	HR				
TIG_GUID_MIN	V93W6945CB	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_GUID_SEC	V93W6946CB	TIG(SEC)	XXXXX MNVR DISP	S				
T_OFFSET_GUID	V94W4015CA	TIME OF LAMB TGT POSN VECTOR	DL FMT 22/1 ORB MNVR DIP	S			93017G	*
T_PRED_FINAL	V94W3979CB	TIME AT WHICH STATE IS DESIRED	ORB PRED	S			89493B	
T_PRED_INIT	V94W3970CB	TIME AT BEGINNING OF PRED	ORB PRED	S			89493B	
UN(1)	V94H4037C	UN (1) X-VECTOR NORMAL TO TGT PL	DL FMT 22/1	FT	DPL		93017G	*
UN(2)	V94H4038C	UN (2) Y-VECTOR NORMAL TO TGT PL	DL FMT 22/1	FT	DPL		93017G	*
UN(3)	V94H4039C	UN (3) Z-VECTOR NORMAL TO TGT PL	DL FMT 22/1	FT	DPL		93017G	*
VMP	V94X3971XB	PROPER VENT MODEL FLAG	ORB PRED					
V_PRED_INIT(1)	V94L4006CB	X-COMP VEL VEC AT INITIAL TIME	ORB PRED	FT/S			89493B	
V_PRED_INIT(2)	V94L4007CB	Y-COMP VEL VEC AT INITIAL TIME	ORB PRED	FT/S			89493B	
V_PRED_INIT(3)	V94L4008CB	Z-COMP VEL VEC AT INITIAL TIME	ORB PRED	FT/S			89493B	
	V94M3045P	CGZB_DISP_TGT_FLAG_WORDS(16:)	DL FMT 22/1				93017G	*



TABLE 4.6.24-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
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**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

**Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
 (HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec**

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ATM_I(1)	V96U7770C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
ATM_I(2)	V96U7771C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
BASE_START_DAY	V96U7778C	DAYS	I	S	M	P	G5.10	00	OT1	DC0599	
BASE_START_HR	V96U7779C	HRS	I	S	M	P	G5.10	00	OT1	DC0599	
BASE_START_MIN	V96U7780C	MIN	I	S	M	P	G5.10	00	OT1	DC0599	
BASE_START_SEC	V96U7781C	SEC	F	S	M	P	G5.10	00	OT1	DC0599	
CONE	V96U7791C	RAD	F	S	D	P	G5.10	00	ZFW	DC0599	
DEL_T_MAX	V96U7512C	SEC	F	S	D	P	G5.10	00	ZFW	DC0599	
DEL_X_GUESS(1)	V96U7766C	SEC	F	S	M	P	G5.10	00	ZFW	DC0599	
DEL_X_GUESS(2)	V96U7767C	SEC	F	S	M	P	G5.10	00	ZFW	DC0599	
DEL_X_TOL(1)	V96U7768C	ND	F	S	M	P	G5.10	00	ZFW	DC0599	
DEL_X_TOL(2)	V96U7769C	ND	F	S	M	P	G5.10	00	ZFW	DC0599	
DMP_I(1)	V96U7521C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
DMP_I(2)	V96U8332C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
DTMIN_I	V96U7520C	SEC	F	S	D	P	G5.10	00	ZFW	DC0599	
DT_ILOAD_ARRAY(01)	V96U7566C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(02)	V96U7567C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(03)	V96U7568C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(04)	V96U7569C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(05)	V96U7570C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(06)	V96U7571C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(07)	V96U7572C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(08)	V96U7573C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(09)	V96U7574C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(10)	V96U7575C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(11)	V96U7576C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(12)	V96U7577C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(13)	V96U7578C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(14)	V96U7579C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(15)	V96U7580C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(16)	V96U7581C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(17)	V96U7582C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(18)	V96U7583C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(19)	V96U7584C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
DT_ILOAD_ARRAY(20)	V96U7585C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(21)	V96U7586C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(22)	V96U7587C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(23)	V96U7588C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(24)	V96U7589C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(25)	V96U7590C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(26)	V96U7591C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(27)	V96U7592C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(28)	V96U7593C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(29)	V96U7594C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(30)	V96U7595C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(31)	V96U7596C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(32)	V96U7597C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
DT_ILOAD_ARRAY(33)	V96U7598C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(34)	V96U7599C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(35)	V96U7600C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(36)	V96U7601C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(37)	V96U7602C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(38)	V96U7603C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(39)	V96U7604C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DT_ILOAD_ARRAY(40)	V96U7605C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
DU	V96U7513C	ND	F	S	D	P	G5.10	00	ZFW	DC0599	
EL_DH_TOL	V96U7788C	FT	F	S	D	P	G5.10	00	ZFW	DC0599	
EL_ILOAD_ARRAY(01)	V96U7606C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(02)	V96U7607C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(03)	V96U7608C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(04)	V96U7609C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(05)	V96U7610C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(06)	V96U7611C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(07)	V96U7612C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(08)	V96U7613C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(09)	V96U7614C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(10)	V96U7615C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(11)	V96U7616C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(12)	V96U7617C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(13)	V96U7618C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(14)	V96U7619C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(15)	V96U7620C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(16)	V96U7621C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(17)	V96U7622C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(18)	V96U7623C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(19)	V96U7624C	RAD	F	S	M	P	G5.10	00	OT1	DC0599	
EL_ILOAD_ARRAY(20)	V96U7625C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(21)	V96U7626C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(22)	V96U7627C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(23)	V96U7628C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(24)	V96U7629C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(25)	V96U7630C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(26)	V96U7631C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(27)	V96U7632C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(28)	V96U7633C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(29)	V96U7634C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(30)	V96U7635C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(31)	V96U7636C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(32)	V96U7637C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(33)	V96U7638C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(34)	V96U7639C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(35)	V96U7640C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(36)	V96U7641C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(37)	V96U7642C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
EL_ILOAD_ARRAY(38)	V96U7643C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(39)	V96U7644C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_ILOAD_ARRAY(40)	V96U7645C	RAD	F	S	M	P	G5.10	00	OT2	DC0599	
EL_TOL	V96U7787C	RAD	F	S	D	P	G5.10	00	ZFW	DC0599	
EPS_U	V96U7515C	ND	F	S	D	P	G5.10	00	ZFW	DC0599	
EP_TRANSFER	V96U7514C	ND	F	S	D	P	G4.209 G4.3 G5.10	00	ZFW	93182B	*
GMD_I	V96U7518C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
GMO_I	V96U7519C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
IC_MAX	V96U7517C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
LAMB_ILOAD(01)	V99U7447C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(02)	V99U7448C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(03)	V99U7449C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(04)	V99U7450C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(05)	V99U7451C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(06)	V99U7452C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(07)	V99U7453C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(08)	V99U7454C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(09)	V99U7455C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(10)	V99U7456C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(11)	V99U7457C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(12)	V99U7458C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(13)	V99U7459C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(14)	V99U7460C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(15)	V99U7461C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(16)	V99U7462C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(17)	V99U7463C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(18)	V99U7464C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(19)	V99U7465C	NO UNITS	D	M	P	P	G5.10	00	OT1	DC0599	
LAMB_ILOAD(20)	V99U7466C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(21)	V99U7467C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(22)	V99U7468C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(23)	V99U7469C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(24)	V99U7470C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(25)	V99U7471C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(26)	V99U7472C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(27)	V99U7473C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(28)	V99U7474C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(29)	V99U7475C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(30)	V99U7476C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(31)	V99U7477C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(32)	V99U7478C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(33)	V99U7479C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(34)	V99U7480C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(35)	V99U7481C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(36)	V99U7482C	NO UNITS	D	M	P	P	G5.10	00	OT2	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
LAMB_ILOAD(37)	V99U7483C	NO UNITS	D		M	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(38)	V99U7484C	NO UNITS	D		M	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(39)	V99U7485C	NO UNITS	D		M	P	G5.10	00	OT2	DC0599	
LAMB_ILOAD(40)	V99U7486C	NO UNITS	D		M	P	G5.10	00	OT2	DC0599	
NMIN	V96U7516C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
N_MAX_ITER	V96U7790C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
PRED_ORB_AREA_I	V96U7774C	FT**2	F	S	M	P	G5.10	00	OT1	DC0599	
PRED_ORB_CD_I	V96U7772C	ND	F	S	M	P	G5.10	00	OT1	DC0599	
PROX_DTMIN	V96U7776C	SEC	F	D	D	P	G5.10	00	ZFW	DC0599	
PROX_DTMIN_LAMB	V96U7777C	SEC	F	S	D	P	G5.10	00	ZFW	DC0599	
R_TOL	V96U7789C	FT	F	S	D	P	G5.10	00	ZFW	DC0599	
R_TOL_CW	V99U7446C	ND	F	S	D	P	G5.10	00	ZFW	DC0599	
T1_ILOAD_ARRAY(01)	V96U7526C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(02)	V96U7527C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(03)	V96U7528C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(04)	V96U7529C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(05)	V96U7530C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(06)	V96U7531C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(07)	V96U7532C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(08)	V96U7533C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(09)	V96U7534C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(10)	V96U7535C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(11)	V96U7536C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(12)	V96U7537C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(13)	V96U7538C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(14)	V96U7539C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(15)	V96U7540C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(16)	V96U7541C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(17)	V96U7542C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(18)	V96U7543C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(19)	V96U7544C	MIN	F	S	M	P	G5.10	00	OT1	DC0599	
T1_ILOAD_ARRAY(20)	V96U7545C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(21)	V96U7546C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(22)	V96U7547C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(23)	V96U7548C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(24)	V96U7549C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(25)	V96U7550C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(26)	V96U7551C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(27)	V96U7552C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(28)	V96U7553C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(29)	V96U7554C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(30)	V96U7555C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(31)	V96U7556C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(32)	V96U7557C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(33)	V96U7558C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(34)	V96U7559C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(35)	V96U7560C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
T1_ILOAD_ARRAY(36)	V96U7561C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(37)	V96U7562C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(38)	V96U7563C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(39)	V96U7564C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
T1_ILOAD_ARRAY(40)	V96U7565C	MIN	F	S	M	P	G5.10	00	OT2	DC0599	
THRUST	V96U7524C	LBS	F	S	M	P	G5.10	00	OT1	DC0599	
VMP_I(1)	V96U7522C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
VMP_I(2)	V96U8333C	ND	I	S	D	P	G5.10	00	ZFW	DC0599	
X_OFF_ILOAD_ARRAY(01)	V96U7646C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(02)	V96U7647C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(03)	V96U7648C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(04)	V96U7649C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(05)	V96U7650C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(06)	V96U7651C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(07)	V96U7652C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(08)	V96U7653C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(09)	V96U7654C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(10)	V96U7655C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(11)	V96U7656C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(12)	V96U7657C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(13)	V96U7658C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(14)	V96U7659C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(15)	V96U7660C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(16)	V96U7661C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(17)	V96U7662C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(18)	V96U7663C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(19)	V96U7664C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
X_OFF_ILOAD_ARRAY(20)	V96U7665C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(21)	V96U7666C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(22)	V96U7667C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(23)	V96U7668C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(24)	V96U7669C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(25)	V96U7670C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(26)	V96U7671C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(27)	V96U7672C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(28)	V96U7673C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(29)	V96U7674C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(30)	V96U7675C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(31)	V96U7676C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(32)	V96U7677C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(33)	V96U7678C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(34)	V96U7679C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(35)	V96U7680C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(36)	V96U7681C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(37)	V96U7682C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(38)	V96U7683C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
X_OFF_ILOAD_ARRAY(39)	V96U7684C	FT	F	D	M	P	G5.10	00	OT2	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
X_OFF_ILOAD_ARRAY(40)	V96U7685C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(01)	V96U7686C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(02)	V96U7687C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(03)	V96U7688C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(04)	V96U7689C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(05)	V96U7690C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(06)	V96U7691C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(07)	V96U7692C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(08)	V96U7693C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(09)	V96U7694C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(10)	V96U7695C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(11)	V96U7696C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(12)	V96U7697C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(13)	V96U7698C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(14)	V96U7699C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(15)	V96U7700C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(16)	V96U7701C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(17)	V96U7702C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(18)	V96U7703C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(19)	V96U7704C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Y_OFF_ILOAD_ARRAY(20)	V96U7705C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(21)	V96U7706C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(22)	V96U7707C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(23)	V96U7708C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(24)	V96U7709C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(25)	V96U7710C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(26)	V96U7711C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(27)	V96U7712C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(28)	V96U7713C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(29)	V96U7714C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(30)	V96U7715C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(31)	V96U7716C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(32)	V96U7717C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(33)	V96U7718C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(34)	V96U7719C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(35)	V96U7720C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(36)	V96U7721C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(37)	V96U7722C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(38)	V96U7723C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(39)	V96U7724C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Y_OFF_ILOAD_ARRAY(40)	V96U7725C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY(01)	V96U7726C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY(02)	V96U7727C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY(03)	V96U7728C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY(04)	V96U7729C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY(05)	V96U7730C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY(06)	V96U7731C	FT	F	D	M	P	G5.10	00	OT1	DC0599	

TABLE 4.6.24-3. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
Z_OFF_ILOAD_ARRAY (07)	V96U7732C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (08)	V96U7733C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (09)	V96U7734C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (10)	V96U7735C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (11)	V96U7736C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (12)	V96U7737C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (13)	V96U7738C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (14)	V96U7739C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (15)	V96U7740C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (16)	V96U7741C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (17)	V96U7742C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (18)	V96U7743C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (19)	V96U7744C	FT	F	D	M	P	G5.10	00	OT1	DC0599	
Z_OFF_ILOAD_ARRAY (20)	V96U7745C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (21)	V96U7746C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (22)	V96U7747C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (23)	V96U7748C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (24)	V96U7749C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (25)	V96U7750C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (26)	V96U7751C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (27)	V96U7752C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (28)	V96U7753C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (29)	V96U7754C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (30)	V96U7755C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (31)	V96U7756C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (32)	V96U7757C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (33)	V96U7758C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (34)	V96U7759C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (35)	V96U7760C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (36)	V96U7761C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (37)	V96U7762C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (38)	V96U7763C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (39)	V96U7764C	FT	F	D	M	P	G5.10	00	OT2	DC0599	
Z_OFF_ILOAD_ARRAY (40)	V96U7765C	FT	F	D	M	P	G5.10	00	OT2	DC0599	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.



TABLE 4.6.24-4. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
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NO REQUIREMENTS

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.6.24-5. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_MU EARTH GRAVITATIONAL CONSTANT	V97U4378C	00	+1.40764487566E+16	FT**3/SEC**2	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.2 G4.205 G4.209 G4.210 G4.211 G4.224 G4.236 G4.3 G4.4 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.6.24-5. ORBIT TARGETING SPEC FUNCTION (REF DISP 6.14) (G5.10) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PI RATIO OF CIRCUMFERENCE TO DIAMETER	V98U8725C	00	+3.14159265358E+00	ND	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.144 G4.15 G4.158 G4.16 G4.19 G4.2 G4.20 G4.205 G4.209 G4.210 G4.213 G4.220 G4.236 G4.237 G4.3 G4.4 G4.5 G4.97 G5.10 G5.24 G5.26 G5.27	93090E	

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

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## 4.7 RELATIVE NAVIGATION SPECIALIST FUNCTION

The Relative Navigation Specialist Function computes data for the relative navigation display that provides the crew with information concerning the relative motion between the orbiter and a target. It is used primarily during rendezvous and station keeping.

The specification for the Relative Navigation Specialist Function is modularly presented as a set of several computational tasks. These tasks are listed below with the corresponding section numbers of this document that describe the detailed requirements.

Subsection	Title
4.7.1	Relative Navigation Specialist Function Executive Task (REL_EXEC)
4.7.2	Relative Motion Parameter Task (REL_MO_PAR)

These tasks are arranged in a simple line organization as shown in Figure 4.7-1.

A general functional flow of the Relative Navigation Specialist Function is presented in Figure 4.7-2. The data flow for the Relative Navigation Specialist Function is shown in Figure 4.7-3.

A REL NAV sample display is presented in Figure 4.7-4. The item entries for the Relative Navigation Specialist Function are listed in Table 4.7-1. The outputs to the REL NAV display are given below (see Figure 4.7-4).

- A. The following current navigated relative state information will be computed and displayed by the REL NAV Spec function if REND NAV is enabled or blank if REND NAV is inhibited.
  1. Line-of-sight range (kft) between vehicles (RNG).
  2. Range rate (ft/s) – sign convention is negative for a closing rate and positive for an opening rate (RDOT).
  3. The angle between the projection of the orbiter tracking body vector into the Shuttle orbital plane and the Shuttle local horizontal ( $\theta$ ).
  4. Out-of-plane position – the current perpendicular distance between the orbiter and the orbital plane of the target vehicle (kft); positive along the negative angular momentum vector of the target (Y).
  5. Out-of-plane velocity – the current rate at which the orbiter is moving relative to the target orbital plane (ft/s); positive along the negative angular momentum vector of the target (YDOT).
  6. Time of the next orbiter/target orbital node crossing (NODE) (MET – hr:min:sec).
- B. STATUS INDICATOR - the status indicator for the GPS LRU's based on GPS commfault, GPS selection filter candidate status and GPS Quality Assessment 4 status.

There are additional dynamic parameters appearing on the REL NAV display that are discussed here; these parameters and how they are updated are not a part of the Book 3 FSW requirements.

- C. SV UPDATE POSITION AND VELOCITY – the magnitude of the change to the filtered state vector (usually the orbiter filtered SV) in the last computation cycle (source ORB/REND NAV).
- D. RR data and status words (source RR SOP):
  - 1. RNG – line-of-sight range (kft) between the vehicles
  - 2.  $\dot{R}$  – range rate (ft/s), sign convention negative for closing
  - 3. EL – pitch position (elevation) of the radar antenna gimbal relative to its null position ( $\pm 90^\circ$ ); positive sense antenna motion toward the +X orbiter axis
  - 4. AZ – roll position (azimuth) of the radar antenna gimbal relative to its null position ( $\pm 180^\circ$ ); positive sense, antenna motion toward the –Y axis.
  - 5.  $\omega_P$  – pitch inertial angle rate ( $\pm$  mr/sec); positive sense, antenna motion toward the +X orbiter axis (mr = milliradian)
  - 6.  $\omega_R$  – roll inertial angle rate ( $\pm$  mr/sec); positive sense – antenna motion toward the –Y orbiter axis
- E. SV TRANSFER, FLTR MINUS PROP (POS AND VEL) – Indicates the difference between the propagated and the filtered state vectors. These parameters can be used to determine when to update the propagated state with the filtered state (source ORB/REND NAV).
- F. RESID – The residuals formed in NAV by subtracting the NAV estimate of measurement from the observed measurement are displayed for RR range and range rate and S TRK, RR or COAS angle parameters for the instrument selected (source ORB/REND NAV).

RATIO – The residual ratio is computed by the on-orbit rendezvous navigation software and is displayed and used for editing bad data. Please see the Book 20 FSSR, Section 4.2.23, for further information concerning this parameter (source ORB/REND NAV).
- G. MARK HISTORY – ACPT AND REJ: These data reflect the number of NAV marks that have been accepted or rejected for a data type by the NAV filter (source ORB/REND NAV).
- H. Star tracker status and –Z COAS offset angles (deg) of the target when using the –Z star tracker (source star tracker SOP). The six possible star tracker status words and their meanings are listed below.
  - 1) STST – self-test in progress
  - 2) COMM – MODE switch is in the COMM position indicating that the KU band antenna is being used for communications:

Any of the following status indicators will be overridden by the self test.

- 3) GPC – The antenna steering switch is in the GPC position. Antenna pointing and search are under GPC control and the manual slew switches are inhibited.
- 4) GDSG – The antenna steering switch is in the GPC DESIG position. Antenna pointing and inertial stabilization are under GPC control. The manual stew switches, programmed search function and RF angle tracking are inhibited.
- 5) ATRK – The antenna steering switch is in the AUTO position. Antenna pointing is done via the manual slew switches which are disabled when RF angle track is achieved.
- 6) MSLW – The antenna steering switch is in the MAN SLEW position. Antenna pointing is done via the manual slew switches. RF Angle track and inertial stabilization are inhibited.

Table 4.7-1. Relative Navigation Specialist Function Item Entries

Item	Name	Description
1	RNDZ NAV ENA	Enable/inhibit Rendezvous Navigation
2	KU ANT ENA	The KU antenna enable/inhibit command and set the Demand Update flag for the display. (This item entry enables the KU antenna (RR) to be used as a NAV sensor during rendezvous.)
3	MEAS ENA	Enable/inhibit navigation to incorporate sensor measurements in MM202. (If REND NAV is inactive or MM201 is active then this item entry results in an illegal entry message.)
4	SV SEL	Change the source of the navigation relative state data from the propagated state vector to the filtered state vector or vice-versa.
5	AVG G ON	SET/RESET the powered Flight Average G Command flag. (When the Powered Flight flag is off, the IMU-sensed delta-velocities are not incorporated in the NAV state. This capability is provided for when the IMU performance is suspect.)
6	Deleted	
7	Deleted	
8*	FLTR TO PROP	Filtered to propagated state vector transfer. (This item entry will cause an illegal entry message if REND NAV is inhibited or if another state vector transfer is in progress.)
9*	PROP TO FLTR	Propagated to filtered state vector transfer. (This item entry will cause an illegal entry message if REND NAV is inhibited or if another state vector transfer is in progress.)
10*	ORB TO TGT	Orbiter to target state vector transfer
11*	TGT TO ORB	Target to orbiter state vector transfer
12	S TRK	Select the Star Tracker as the source of angle information for state vector navigation.
13	RR	Select the Rendezvous Radar as the source of angle information for state vector navigation.

Table 4.7-1. Relative Navigation Specialist Function Item Entries

Item	Name	Description
14	COAS	Select the COAS as the source of angle information for state vector navigation.
15	FLTR UPDATE	Set the bit to indicate which vehicle state is to be filtered. (REND NAV must be disabled for this item entry to be valid. This is a flip-flop item entry and text of either "ORB" or "TGT" is displayed. Initial value based on I-Load SHUTTLE_FILTER_FLAG, MSID V90X4952X).
16	COVAR REINIT	Covariance matrix reinitialization can be performed to relax the criterion used to evaluate each successive NAV mark before it can be incorporated in the NAV.
17*	RNG AUT	Set the range edit override to auto.
18*	RNG INH	Set the range edit override to inhibit.
19*	RNG FOR	Set the range edit override to force.
20*	RDOT AUT	Set the range rate edit override to auto.
21*	RDOT INH	Set the range rate edit override to inhibit.
22*	RDOT FOR	Set the range rate edit override to force.
23*	ANG AUT	Set the angle edit override to auto.
24*	ANG INH	Set the angle edit override to inhibit.
25*	ANG FOR	Set the angle edit override to force.
31	GPS 1 DES	Select or Deselect (Toggle) GPS receiver 1 for use by the GPS selection filter. (Item entry legal only if GPS 1 receiver is installed).
32	GPS 2 DES	Select or Deselect (Toggle) GPS receiver 2 for use by the GPS selection filter. (Item entry legal only if GPS 2 receiver is installed).
33	GPS 3 DES	Select or Deselect (Toggle) GPS receiver 3 for use by the GPS selection filter. (Item entry legal only if GPS 3 receiver is installed).
42	GPS TO NAV AUTO	Select GPS to Navigation Auto/Inhibit Command to be Auto Selected. (Mutually exclusive with item entry 43. Legal only if at least one GPS receiver is installed and GPS_LOCKOUT I-Load greater than or equal to 2).
43	GPS TO NAV INHIBIT	Select GPS to Navigation Auto/Inhibit Command to be Inhibit Selected. (Mutually exclusive with item entry 42. Legal only if at least one GPS receiver is installed and GPS_LOCKOUT I-Load greater than or equal to 2).



Table 4.7-1. Relative Navigation Specialist Function Item Entries		
Item	Name	Description
44	GPS TO NAV FORCE	Select GPS to Navigation Force Command to be FORCE. The “force” state of the GPS Navigation Force Command is reset to inactive state after one NAV cycle. (Overrides item entries 42 and 43. Legal only if at least one GPS receiver is installed and GPS_LOCKOUT I-Load greater than or equal to 2).
<p>*Items 8 and 9</p> <p>Either of these two item entries is performed when it is believed that one state vector is more accurate than the other. Both item entries transfer into and overwrite the other state vector data slot. A FLTR TO PROP would be done after several NAV marks have been incorporated into the filtered relative state, and an accurate backup state vector (propagated state) is required. The propagated state cannot be corrupted by NAV marks, therefore it provides the state vector redundancy required for a successful rendezvous. A PROP TO FLTR would be performed when the filtered state has been corrupted.</p>		
<p>*Items 10 and 11</p> <p>If REND NAV is enabled and no state vector transfer is in progress, then allow the state vector transfer to proceed, otherwise set the illegal entry flag equal to on. State vector transfers are done when either the orbiter or the target state vector is inaccurate. Item 10 (ORB TO TGT) or Item 11 (TGT TO ORB) is usually done during station-keeping, where the relative position and velocity are small and one of the states is very inaccurate. These item entries cause the transfer and overwriting of the first state vector into the second state vector data slot.</p>		
<p>*Items 17 through 25</p> <p>The AUTO function allows for automatic processing of data in the NAV filter.</p> <p>The INHIBIT function causes data to be presented to the filter for processing in order to generate residual and ratio data for display, but it shall not be used to update the state vector nor shall the reject counter be incremented.</p> <p>The FORCE function will relax the edit test criterion based upon the value of the residual ratio from the last data point. Data will be processed if the current residual passes the new edit test criteria. The FORCE function, when executed, stays in effect only for the next data point. Then control reverts to the previously executed function (either auto or inhibit).</p>		

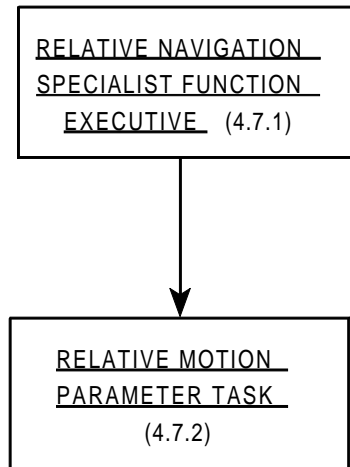


FIGURE 4.7-1. Relative Navigation Specialist Function Task Organization

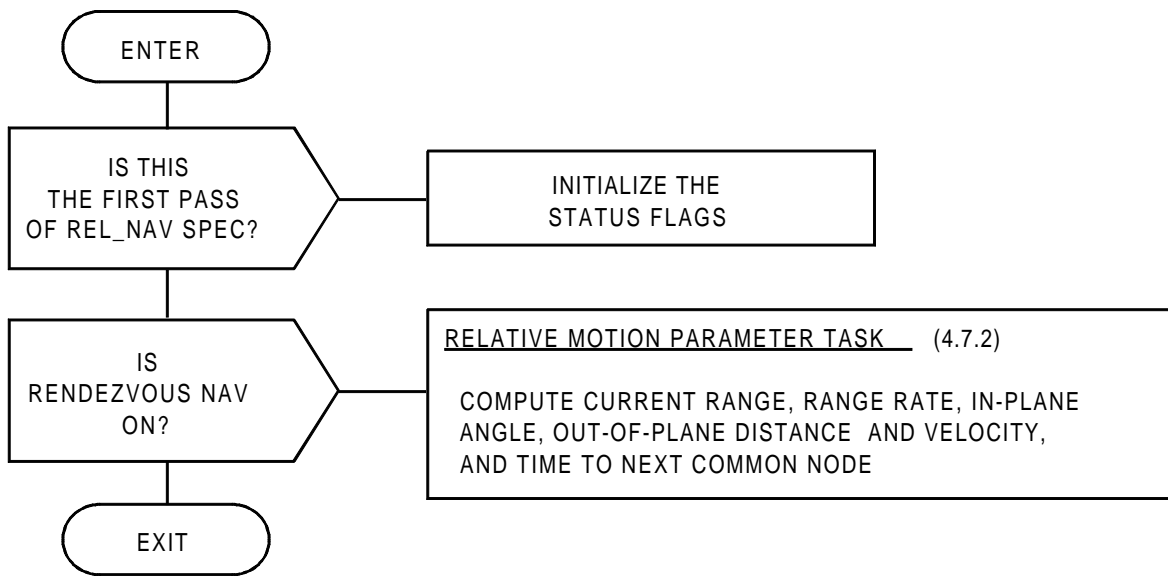


FIGURE 4.7-2. Relative Navigation Specialist Function Functional Flow

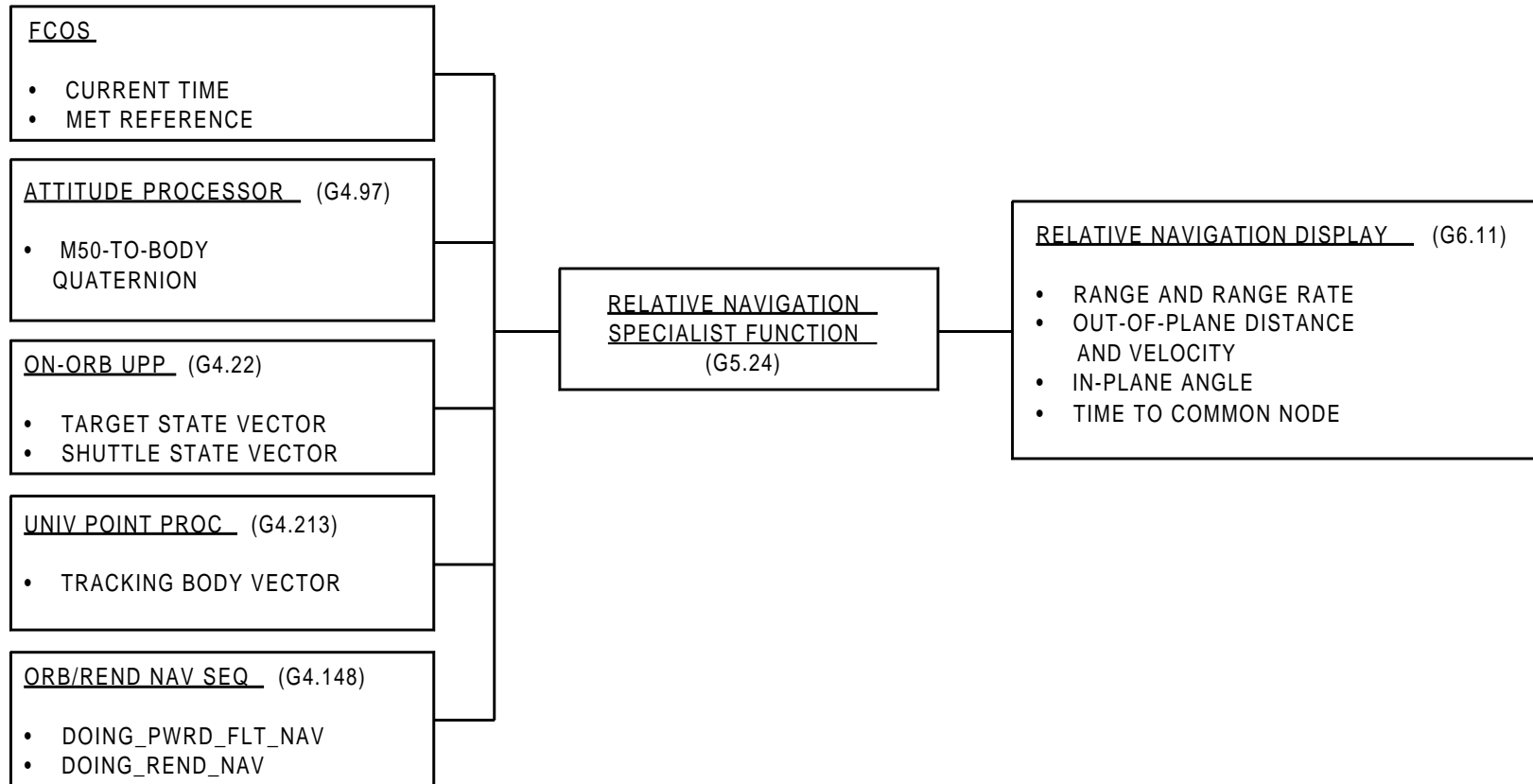


FIGURE 4.7-3. Relative Navigation Specialist Function Data Flow

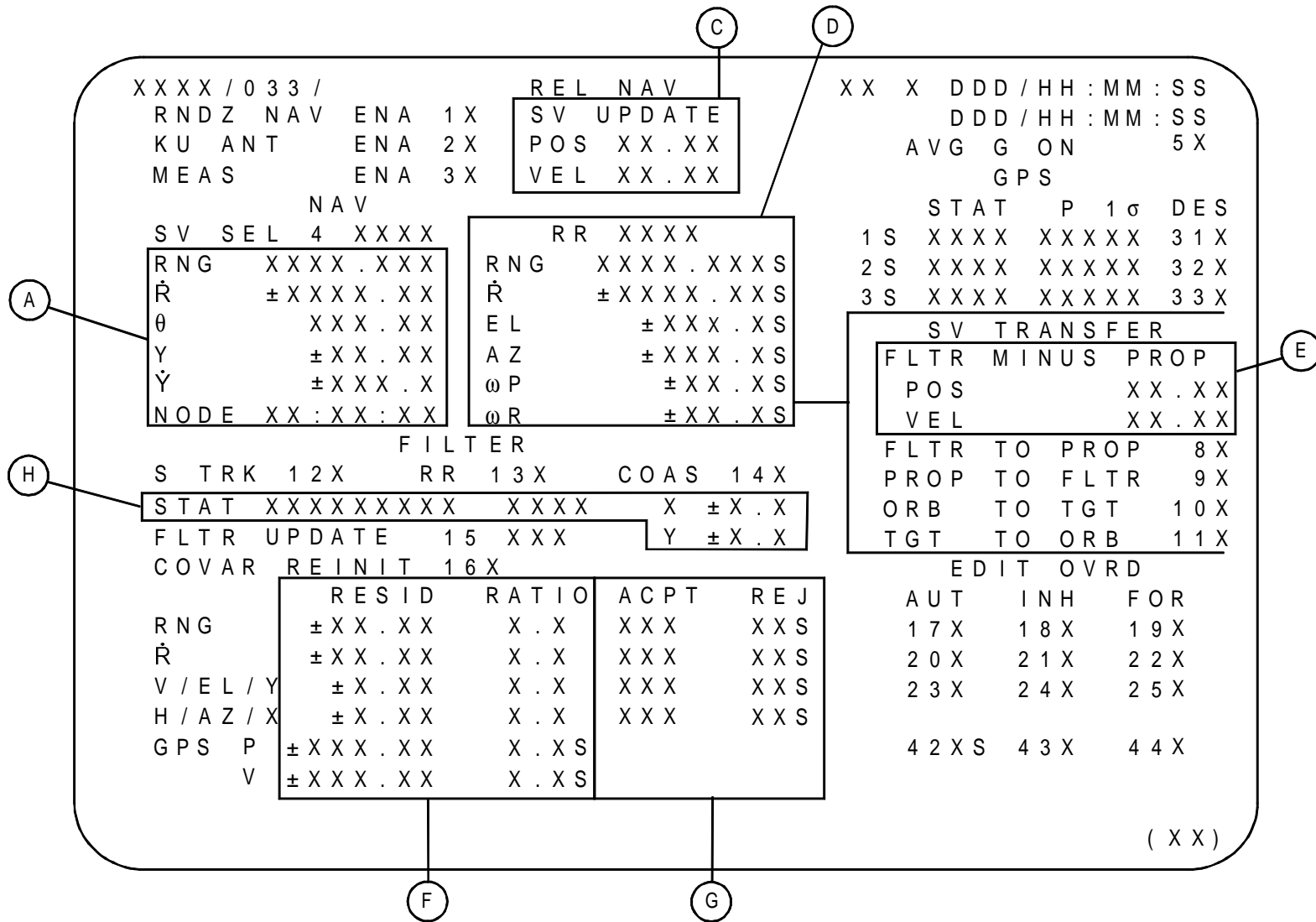


FIGURE 4.7-4. Relative Navigation Sample Display (PFS)

**4.7.1 Relative Navigation Specialist Function Executive Task (REL EXEC)**

The Relative Navigation Specialist Function executive task calculates the relative parameters between the Shuttle and the target at the current time.

A. Detailed Requirements. The following steps are required in the calculation of the relative navigation parameters.

1. The status indicator for the GPS LRU's Parameters shall be determined as shown in the following logic:

O U T P U T	GPS "x" Display Status Indicator	M	↓	?	(blank)
I N P U T S	GPS_ COMMFAULT(x)	Fault -----	Good ----- and -----	Good ----- and -----	Good ----- and -----
	SEL_CMD(x)	----	Fail (off) ----- and -----	Fail (off) ----- and -----	Good (on) -----
	GPS_DISP_ DILEMMA(x)	----	<u>Good</u> (off)	<u>Dilemma</u> (on)	----

where "x" = 1, 2, 3

2. If REL NAV SPEC function is active and DOING\_REND\_NAV is on, then calculate the current relative motion parameters. The calculation is performed in the Relative Motion Parameter Task (Subsection 4.7.2), with inputs of Shuttle and target state vectors, current time, inertial-to-body quaternion, tracking body vector, previous value of time, the previous out-of-plane distance, and the reference time. The outputs are the relative motion parameters at current time.

Inputs/outputs of the Relative Motion Parameter Task (REL MO PAR) are:

Inputs:  $\bar{R}_{AVGG}$ ,  $\bar{V}_{AVGG\_DP}$ ,  $\bar{R}_{TARGET}$ ,  $\bar{V}_{TARGET}$ ,  $\bar{G}_{TARGET}$ ,  
T\_GMT, Q\_B\_I\_S, Q\_B\_I\_V, BODY\_TRACK\_V, BASE\_MET

Outputs: RNG\_CUR\_DISP, RD\_CUR, THETA\_CUR, Y\_CUR\_DISP,  
YD\_CUR, T\_NODE\_SEC

B. Interface Requirements. None.

C. Processing Requirements. The relative motion task should be cycled at the same rate as the on-orbit UPP so that the Shuttle and target states will be current.

D. Initialization Requirements. None.

#### 4.7.2 Relative Motion Parameter Task (REL\_MO\_PAR)

If Rendezvous Navigation is enabled (DOING\_RÉND\_NAV) and there is a current target state vector, then the Relative Motion Parameter Task (REL MO PAR) is automatically processed at the same rate as the UPP. The inputs to this task are Shuttle and target state vectors including target acceleration, current time, inertial-to-body quaternion, tracking body vector, and the reference time. The outputs are the relative motion parameters at the current time.

Inputs/outputs of the Relative Motion Parameter Task are:

Inputs:  $\bar{R}_{AVGG}$ ,  $\bar{V}_{AVGG\_DP}$ ,  $\bar{R}_{TARGET}$ ,  $\bar{V}_{TARGET}$ ,  $\bar{G}_{TARGET}$ ,  
 $Q\_B\_I\_S$ ,  $Q\_B\_I\_V$ ,  $BODY\_TRACK\_V$ ,  $T\_GMT$ ,  $BASE\_MET$

Outputs:  $RNG\_CUR\_DISP$ ,  $RD\_CUR$ ,  $THETA\_CUR$ ,  $Y\_CUR\_DISP$ ,  $YD\_CUR$ ,  
 $T\_NODE\_SEC$

A. Detailed Requirements. The following steps are required in the calculation of the relative motion parameters.

1. Calculate the line-of-sight range, range rate, out-of-plane distance, and velocity:

$$\bar{R}_{REL} = \bar{R}_{TARGET} - \bar{R}_{AVGG}$$

$$\bar{V}_{REL} = \bar{V}_{TARGET} - \bar{V}_{AVGG\_DP}$$

$$\bar{HT} = \bar{V}_{TARGET} \times \bar{R}_{TARGET}$$

$$MAG = ABVAL(\bar{HT})$$

$$\bar{HT} = \frac{\bar{HT}}{MAG}$$

$$RNG\_CUR = |\bar{R}_{REL}|$$

$$RD\_CUR = \frac{(\bar{V}_{REL} \cdot \bar{R}_{REL})}{RNG\_CUR}$$

$$Y\_CUR = \bar{R}_{AVGG} \cdot \bar{HT}$$

$$YD\_CUR = (\bar{V}_{AVGG\_DP} \cdot \bar{HT}) + \frac{1}{MAG}(\bar{R}_{AVGG} - Y\_CUR \bar{HT}) \cdot (\bar{G}_{TARGET} \times \bar{R}_{TARGET})$$

2. Calculate the inertial tracking vector and the local vertical, local horizontal coordinate system using the calculated vector components as the columns of the resulting transformation matrix:

CALL QUAT\_XFORM

Inputs:  $Q\_B\_I\_S, -Q\_B\_I\_V, \overline{BODY\_TRACK\_V}$

Output:  $\overline{V\_PT}$

$\overline{Z\_LVLH} = -UNIT(\overline{R\_AVGG})$

$\overline{Y\_LVLH} = UNIT(\overline{V\_AVGG\_DP} \times \overline{R\_AVGG})$

$\overline{X\_LVLH} = UNIT(\overline{Y\_LVLH} \times \overline{Z\_LVLH})$

$\overline{MATRIX\_LVLH} = [\overline{X\_LVLH}, \overline{Y\_LVLH}, \overline{Z\_LVLH}]$

3. Calculate the pointing vector in the local vertical, local horizontal system:

$\overline{V\_LVLH} = UNIT(\overline{MATRIX\_LVLH}^T \overline{V\_PT})$

4. Perform a logical test to determine if the X- and Z-components of the local vertical, local horizontal pointing vector are equal to zero.

If  $V\_LVLH_1 = 0$  and  $V\_LVLH_3 = 0$ , then

$THETA\_CUR = 0$

Otherwise (i.e.,  $V\_LVLH_1 \neq 0$  or  $V\_LVLH_3 \neq 0$ ), calculate the pitch angle in the range zero to  $2\pi$ .

$THETA\_CUR = ARCTAN2(V\_LVLH_3, -V\_LVLH_1) + \pi$

5. Calculate the reciprocal of the semimajor axis and the Shuttle orbital rate:

$ALPHA = 2/|\overline{R\_AVGG}| - \overline{V\_AVGG\_DP} \cdot \overline{V\_AVGG\_DP}/EARTH\_MU$

$OMEGA = ALPHA \sqrt{ALPHA \ EARTH\_MU}$

6. Calculate the variables, TOP and BOTTOM, used in the time to node computation:

$TOP = OMEGA \ Y\_CUR$

$BOTTOM = YD\_CUR$

7. Perform a logical test to determine if TOP and BOTTOM are equal to zero:

If  $TOP = 0$  and  $BOTTOM = 0$ , then

$DT\_NODE = 0$

Otherwise, calculate the time to the common node.



$$DT\_NODE = -ARCTAN2(TOP, BOTTOM)/OMEGA$$

8. Perform a logical test to determine if the node is in front of or behind the Shuttle. If the node is behind the Shuttle ( $DT\_NODE < 0$ ), add one half of the Shuttle period so that the time will be to the upcoming node:

$$DT\_NODE = DT\_NODE + Pi/OMEGA$$

9. Calculate the time of the upcoming node in seconds of the current MET day:

$$T\_NODE\_SEC = T\_GMT + DT\_NODE - BASE\_MET$$

$$T\_NODE\_SEC = MOD(T\_NODE\_SEC, 86400)$$

10. Calculate for display the out-of-plane distance and line-of-sight range in kilo-feet:

$$RNG\_CUR\_DISP = RNG\_CUR 0.001$$

$$Y\_CUR\_DISP = Y\_CUR 0.001$$

B. Interface Requirements. The input and output parameters for the Relative Motion Parameter Task are given in Tables 4.7.2-1 and 4.7.2-2. A flow diagram of REL\_MO\_PAR is given in Appendix A.

C. Processing Requirements. This task is active only if Rendezvous Navigation is active.

D. Initialization Requirements. None.

Table 4.7.2-1. Relative Motion Parameter Task Input Parameters

MSID No.	Name	Definition	Source	Precision	Units	Data Type
V95H0185CF thru V95H0187CF	$\bar{R}_{AVGG}$	Shuttle position vector	ORB UPP (G4.22)	DP	ft	V(3)
V95L0142CF thru V95L0144CF	$\bar{V}_{AVGG\_DP}$	Shuttle velocity vector	ORB UPP (G4.22)	DP	ft/s	V(3)
V95H0862C thru V95H0864C	$\bar{R}_{TARGET}$	Target position vector	ORB UPP (G4.22)	DP	ft	V(3)
V95L0867C thru V95L0869C	$\bar{V}_{TARGET}$	Target velocity vector	ORB UPP (G4.22)	DP	ft/s	V(3)
V91W5000C	T_GMT	Current time	FCOS	DP	s	F
V91W1996C	BASE_MET	MET reference time	FCOS	DP	s	F
V90U2240CB thru V90U2243CB	Q_B_I_S, Q_B_I_V	Inertial to body quaternion	ORB ATT PROC (G4.97)	SP	N/A	V(4)
V95U2225C thru V95U2227C	$\bar{B}ODY\_TRACK\_V$	Tracking body vector	UNIV PTG PROC	SP	N/A	V(3)
V98U8725C	Pi	Pi	CONSTANT	DP	N/A	F
V95A0073C thru V95A0075C	$\bar{G}_{TARGET}$	Target acceleration vector	ORB UPP (G4.22)	DP	ft/s <sup>2</sup>	V(3)

Table 4.7.2-2. Relative Motion Parameter Task Output Parameters

MSID No.	Name	Definition	Destination	Precision	Units	Data Type
V94H3322C	RNG_CUR_DISP	Current LOS range between Shuttle and target	REL NAV DISP (G6.11)	SP	kft	F
V94H3323C	RD_CUR	Current rate of change of LOS range	REL NAV DISP (G6.11)	SP	ft/s	F
V94U3338C	THETA_CUR	Angle between Shuttle horizontal plane and tracking body vector	REL NAV DISP (G6.11)	SP	rad	F
V94H3326C	Y_CUR_DISP	Current out-of-plane distance	REL NAV DISP (G6.11)	SP	kft	F
V94L3325C	YD_CUR	Current out-of-plane velocity	REL NAV DISP (G6.11)	SP	ft/s	F
V94W3336C	T_NODE_SEC	Time Shuttle will arrive at common node	REL NAV DISP (G6.11)	DP	s	F

#### 4.7.3 Deleted

#### 4.7.4 Parameter Tables for Relative NAV SPEC (G5.24)

The IDD inputs and outputs are listed in Tables 4.7.4-1 and 4.7.4-2 respectively. Values for the I-loads are contained in the I-load requirements document (JSC-19350); however, I-load definitions applicable to this principal function are listed in Table 4.7.4-3. K-loads are listed in Table 4.7.4-4. Constants are listed in Table 4.7.4-5. The cross-reference listing is given in table listed below.

Local Name	SourceName	MSID
Q_B_I_S	Q_BOD_M50(1)	V90U2240CB
$\bar{Q}_B_I_V$	Q_BOD_M50(2)	V90U2241CB
	Q_BOD_M50(3)	V90U2242CB
	Q_BOD_M50(4)	V90U2243CB
$\bar{B}ODY\_TRACK\_V$	PLOS_C(1)	V95U2225C
	PLOS_C(2)	V95U2226C
	PLOS_C(3)	V95U2227C
T_GMT	CLOCK	V91W5000C
BASE_MET	T_MET_REF	V91W1996C

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TABLE 4.7.4-1. INPUT FUNCTIONAL PARAMETERS FOR RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
DOING_PWRD_FLT_NAV	V90X1289X	PWR FLT NAV AVG G ON/OFF IND	ORB/RND NAV SEQ		BD		93017G	*
DOING_REND_NAV	V90X4765X	RENDZ NAV ACTIVE FLAG	ORB/RND NAV SEQ		BD		93017G	*
GPS_COMMFAULT(1)	V91X0015X	FF1 GPS1 COMMFAULT	FCOS		BD		92067D	
GPS_COMMFAULT(2)	V91X0016X	FF2 GPS2 COMMFAULT	FCOS		BD		92067D	
GPS_COMMFAULT(3)	V91X0017X	FF3 GPS3 COMMFAULT	FCOS		BD		92067D	
GPS_DISP_DILEMMA(1)	V94X0022X	GPS 1 DISPLAY DILEMMA FLAG	GPS RCVR STATE PROC		BD		92208C	
GPS_DISP_DILEMMA(2)	V94X0023X	GPS 2 DISPLAY DILEMMA FLAG	GPS RCVR STATE PROC		BD		92208C	
GPS_DISP_DILEMMA(3)	V94X0024X	GPS 3 DISPLAY DILEMMA FLAG	GPS RCVR STATE PROC		BD		92208C	
G_TARGET(1)	V95A0073C	X-COMP OF CURRENT TARGET ACC VCTR	ORB UPP	FT/S2	DPL		92688B	
G_TARGET(2)	V95A0074C	Y-COMP OF CURRENT TARGET ACC VCTR	ORB UPP	FT/S2	DPL		92688B	
G_TARGET(3)	V95A0075C	Z-COMP OF CURRENT TARGET ACC VCTR	ORB UPP	FT/S2	DPL		92688B	
PLOS_C(1)	V95U2225C	X-COMP OF CURRENT BODY VECTOR	UNIV POINT PROC					
PLOS_C(2)	V95U2226C	Y-COMP OF CURRENT BODY VECTOR	UNIV POINT PROC					
PLOS_C(3)	V95U2227C	Z-COMP OF CURRENT BODY VECTOR	UNIV POINT PROC					
PWRD_FLT_NAV	V93X5408XC	PWR FLT NAV AVG G ON/OFF CMD	REL NAV DISP					
Q_BOD_M50(1)/Q_B_M50(1)	V90U2240CB	M50 TO BODY QUAT MEASURED ELEM 1	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(2)/Q_B_M50(2)	V90U2241CB	M50 TO BODY QUAT MEASURED ELEM 2	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(3)/Q_B_M50(3)	V90U2242CB	M50 TO BODY QUAT MEASURED ELEM 3	ORB ATT PROC		SPL		93017G	*
Q_BOD_M50(4)/Q_B_M50(4)	V90U2243CB	M50 TO BODY QUAT MEASURED ELEM 4	ORB ATT PROC		SPL		93017G	*
R_AVGG(1)	V95H0185CF	X-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CF	Y-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CF	Z-COMP OF CUR SHUTTLE POS VCTR M50	ORB UPP	FT	DPL		93017G	*
R_TARGET(1)	V95H0862C	X-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*
R_TARGET(2)	V95H0863C	Y-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*
R_TARGET(3)	V95H0864C	Z-COMP OF CURRENT TARGET POS VCTR	ORB UPP	FT	DPL		93017G	*
SEL_CMD(1)	V94X1034X	GPS 1 SEL FILTER CANDIDATE	GPS RCVR STATE PROC		BD		92067D	
SEL_CMD(2)	V94X1035X	GPS 2 SEL FILTER CANDIDATE	GPS RCVR STATE PROC		BD		92067D	
SEL_CMD(3)	V94X1036X	GPS 3 SEL FILTER CANDIDATE	GPS RCVR STATE PROC		BD		92067D	
T_MET_REF	V91M1996P	MET REFERENCE	SYS S/W	S			93017G	*
V_AVGG_DP(1)	V95L0142CF	X-COMP CUR SHUT VEL VCT M50 (DP)	ORB UPP	FT/S	DPL		92748B	
V_AVGG_DP(2)	V95L0143CF	Y-COMP CUR SHUT VEL VCT M50 (DP)	ORB UPP	FT/S	DPL		92748B	
V_AVGG_DP(3)	V95L0144CF	Z-COMP CUR SHUT VEL VCT M50 (DP)	ORB UPP	FT/S	DPL		92748B	
V_TARGET(1)	V95L0867C	X-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
V_TARGET(2)	V95L0868C	Y-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
V_TARGET(3)	V95L0869C	Z-COMP OF CURRENT TARGET VEL VCTR	ORB UPP	FT/S	DPL		93017G	*
	V93X5410X	THR MON DEL V RES COMP	REL NAV DISP		BD			
	V93X5413X	THR MON DEL V RES TOT	REL NAV DISP		BD			

NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.7.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
GPS_DISP_FAIL_DIL(1)	V94J6090CB	GPS 1 DISPLAY STATUS	REL NAV DISP		VAR		92067D	
GPS_DISP_FAIL_DIL(2)	V94J6091CB	GPS 2 DISPLAY STATUS	REL NAV DISP		VAR		92067D	
GPS_DISP_FAIL_DIL(3)	V94J6092CB	GPS 3 DISPLAY STATUS	REL NAV DISP		VAR		92067D	
RD_CUR	V94H3323C	RANGE RATE CURRENT	REL NAV DISP	FT/S	SPL		89662B	
RNG_CUR_DISP	V94H3322C	LOS RANGE CURRENT	REL NAV DISP	KFT	SPL		89662B	
THETA_CUR	V94U3338C	PTG VECTOR ELEV ANGLE	REL NAV DISP	RAD	SPL		89662B	
T_NODE_SEC	V94W3336C	ORBITER/TARGET NODE TIME(SEC)	REL NAV DISP	S	SPL		89662B	
YD_CUR	V94L3325C	OUT-OF-PLANE VEL CURRENT	REL NAV DISP	FT/S	SPL		89662B	
Y_CUR_DISP	V94H3326C	OUT-OF-PLANE POS CURRENT	REL NAV DISP	KFT	SPL		89662B	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

**Rate Codes: (HDR Only) 1 = 1 sample/sec 2 = 5 samples/sec 3 = 12.5 samples/sec 4 = 25 samples/sec 5 = 100 samples/sec  
(HDR and LDR) A = 1 sample/sec B = 5 samples/sec C = 12.5 samples/sec D = 25 samples/sec E = 100 samples/sec**

TABLE 4.7.4-3. RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
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NO REQUIREMENTS

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

TABLE 4.7.4-4. RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
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NO REQUIREMENTS

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**



TABLE 4.7.4-5. RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EARTH_MU EARTH GRAVITATIONAL CONSTANT	V97U4378C	00	+1.40764487566E+16	FT**3/SEC**2	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.139 G4.144 G4.148 G4.15 G4.158 G4.2 G4.205 G4.209 G4.210 G4.211 G4.224 G4.236 G4.3 G4.4 G5.10 G5.24 G5.26 G5.27	93090E	

TABLE 4.7.4-5. RELATIVE NAVIGATION SPEC FUNCTION (REF DISP 6.11) (G5.24) CONSTANTS

FSSR NAME DESCRIPTION	MSID	MC	CONSTANT VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PI RATIO OF CIRCUMFERENCE TO DIAMETER	V98U8725C	00	+3.14159265358E+00	ND	F	D	C	A6.9 G4.126 G4.127 G4.13 G4.144 G4.15 G4.158 G4.16 G4.19 G4.2 G4.20 G4.205 G4.209 G4.210 G4.213 G4.220 G4.236 G4.237 G4.3 G4.4 G4.5 G4.97 G5.10 G5.24 G5.26 G5.27	93090E	

**NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.**

## 5.0 SUPPLEMENTAL MATERIAL

### 5.1 COORDINATE SYSTEMS

The terms used within the coordinate system definitions are defined as follows.

Inertial coordinate system. A system whose coordinate axes are fixed, relative to the stars, at infinite distances. That is, the rotation rates about all axes, relative to the stars, are zero.

Rotating systems. A reference frame that varies with time from an inertial system and whose rates of rotation about axes are included in transformations of velocity vectors to derive relative velocity.

Quasi-inertial system. A system that rotates with time from an inertial system and whose instantaneous rates of rotation and translational velocity between respective origins are, by definition, equal to zero. Thus, a velocity-vector transformation between quasi-inertial systems does not include the rotation rates of axes; hence, velocity magnitudes are invariant under such a transformation.

Nonrotating systems. An inertial or quasi-inertial system. That is, any system whose rate of rotation about all axes, relative to any inertial system, is zero.

Cartesian system. A system whose reference frame consists of a triad of mutually perpendicular directed lines originating from a common point, in which a vector is expressed by components that are scalar magnitude projections along each axis.

Perigee and apogee. The unique points in an elliptic orbit about the earth, wherein the object achieves minimum and maximum distance, respectively, from the center of the earth.

Osculating conic. A two-body approximation to non-two-body motion that is derived from conditions existing at some instant of time but that is exact only for that instant. An osculating-conic trajectory is one that is tangent to the true trajectory at the defining instant.

Geodetic local vertical. A reference ellipsoid of revolution that approximates the figure of the earth is presumed. Then the local vertical at any point is along the unique line that is normal to the ellipsoid surface and that contains the point of interest.

Mean versus true systems. The line of intersection of the ecliptic plane (the instantaneous plane of motion of the earth and sun) and the celestial equator (mean earth equator) precesses among the fixed stars with a rate of one revolution in 26,000 years. Additionally, the earth wobbles slightly on its axis, relative to its mean position, with periods of oscillations of only a few years. The former phenomenon is called precession; the latter is called nutation. A mean system conveys the concept that precession is included when relating that system to another system at a different time, but the nutation phenomenon is not included. A true system, however, conveys the concept that a mean system at any specific instant of time is converted to a true system at the same instant of time by including terms associated with the nutation phenomenon.

## 5.2 HAL PROGRAMMING LANGUAGE SYNTAX DEFINITIONS

$A B$ or $(A) (B)$	scalar multiplication
$A_K$	Kth element of Array A
$A \cdot B$	vector dot product
$A \times B$	vector cross product
$ABS(A)$	absolute value of A
$ABVAL(A)$	magnitude of Vector A
$ARCCOS(A)$	arc cosine of A
$ARCSIN(A)$	arc sine of A
$ARCTAN(A)$	arc tangent of A
$ARCTAN2(A,B)$	arc tangent of A/B in the proper quadrant
$COS(A)$	cosine of A
$EXP(A)$	$e^A$
$INTEGER(A_1, A_2, \dots, A_N)$	array of integers formed from elements of A where A may be any type; e.g., integers, scalar, Boolean, etc.
$LOG(A)$	natural log of A
$MATRIX(A_1, A_2, \dots, A_q)$	matrix formed by elements of A where A may be integer, scalar, vector, or matrix type only
$MAX(A_1, A_2, \dots, A_N)$	maximum of all elements of A
$MIDVAL(A,B,C)$	value of the argument which is between the other two
$MIN(A_1, A_2, \dots, A_N)$	minimum of all elements of A
$MOD(A,B)$	smallest positive value that can be obtained by successive subtractions of absolute value of B from absolute value of A
$ROUND(A)$	nearest integral value of A

SCALAR( $A_1, A_2, \dots, A_N$ )	array of scalars formed from elements of A where A may be any type; e.g., integers, scalar, Boolean, etc.
SIGN(A)	sign (+ or -) of A
SIN(A)	sine of A
SQRT(A)	square root of A
SUM( $A_1, A_2, \dots, A_N$ )	sum of all elements of A
TAN(A)	tangent of A
UNIT(A)	unit vector of Vector A
VECTOR( $A_1, A_2, A_3$ )	vector formed by elements of A where A may be integer, scalar, vector, or matrix type only

### 5.3 LIST OF ACRONYMS AND ABBREVIATIONS

ACT	Active
ADI	Attitude director indicator
A/E PREC PRED	Ascent/Entry Precision State Prediction principal function
AM	Antenna management
AOA/ATO TGT	Abort–once–around/abort–to–orbit targeting principal function
ATT PROC	Attitude processing principal function
AUTO	Auto mode of flight control system
BOD	Body coordinates
BODY VECTOR TABLE	I–load table containing pitch–yaw body vector components
CNTL	Control
CPDS	Computer Program Development Specification
CRT	Cathode ray tube
DAP	Digital autopilot
DEORB DAP	Deorbit Digital Autopilot principal function
DEORB GUID	Deorbit Guidance principal function
DEORB MNVR DIP	Deorbit XXXXX Maneuver YYYYYY Display Processing principal function
DIP	Display interface processing
DISP	Display
DP	Double precision
EF	Earth–fixed Greenwich–true–of–date
EPHEM	Ephemeris
EXEC	Execute
FC	Flight control
FCOS	Flight computer operating system
FCS	Flight control system
FSSR	Functional Subsystem Software Requirements document
FUT	Future
GAX	Guidance, navigation, and control/annunciation interface principal function
G/C STEER	Guidance/Control Steering Interface principal function
GMT	Greenwich mean time
GN&C	Guidance, navigation, and control

GNC	Guidance, navigation, and control
HAL	Higher-order assembly language
Hz	Hertz
ID	Identifier
I-load	Initial load
IMU	Inertial measurement unit
LTVC	Linear terminal velocity constraint
LVLH	Local vertical, local horizontal
LOMS	Left orbital maneuvering system
MET	Mission elapsed time
MM	Major mode
MNVR	Maneuver
MNVR DISP	XXXXXX maneuver YYYYYY display
MSC	Moding, sequencing, and control
M50	Aries-mean-of-1950 coordinate system
N/A	Not applicable
OFT	Orbital flight test
OMS	Orbital maneuvering system
OMS FDI	Orbital Maneuvering System Fault Detection and Identification principal function
OMS FIRE SEQ	Orbital Maneuvering System Firing Sequencer principal function
OMS/TVC FB SOP	Orbital Maneuvering System Thrust Vector Control Feedback Subsystem Operating Program principal function
ON-ORB GUID	On-Orbit Guidance principal function
ON-ORB PRED	On-Orbit Precision State Prediction principal function
ON-ORB UPP	On-Orbit User Parameter Processing principal function
ON-ORBIT DAP	On-Orbit Digital Autopilot principal function
ORBIT MNVR DIP	On-Orbit XXXXXX Maneuver YYYYYY Display Processing principal function
OPS	Operational sequence
OPT	Option
PEG	Powered explicit guidance
PF	Principal function
PFG	Powered flight guidance

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PL	Payload
PROC	Processor
RBOD	Required body coordinates
RCS	Reaction control system
RHC	Rotational hand controller
RNDZ TGTING	Rendezvous Targeting Specialist function
ROMS	Right orbital maneuvering system
SEL	Select
SM	Systems management
SOP	Subsystem operating program
SP	Single precision
SPEC	Specialist
SYS S/W	System software
STAR TABLE	I-load table containing celestial target unit vectors
TB	Time base
TBD	To be determined
TBS	To be supplied
TB5	Time base five
TB7	Time base seven
THC	Translational hand controller
TIG	Time-of-ignition
TRK	Target or tracking vector
TVC	Thrust vector control
UNIV POINT DISP	Universal pointing display function
UNIV POINT PROC	Universal Pointing Processor principal function
UNIV POINT SPEC	Universal Pointing Specialist function
UPP	User parameter processor
VU	Vehicle utility
XFR	Transfer
XXXXX MNVR YYYYY	XXXXX maneuver YYYYY display
$\Delta V$	Change-in-velocity



## 5.4 SOFTWARE SINGULARITY PREVENTIVE MEASURES

### General Requirements

The following functions in the On-orbit I Guidance FSSR are identified as possible sources of program failure if the arguments submitted are not within the range for which the functions are defined.

1. Arithmetic division – divisor must not be zero.
2. Square root – argument must not be negative.
3. Logarithm – argument must be positive.
4. Special functions, such as UNIT and H\_ELLIPSOID – argument must not be a zero vector.

The requirements are to avoid or cope with the singular cases wherever they occur.

### General Responses to Requirements

1. Care must be taken to see that functional arguments submitted are within the required range.
2. I-load constants are assumed to be bona fide, valid, and unchanged throughout the program. Therefore, no additional checks will be made on operations, such as SQRT(EARTH\_MU), to ensure nonnegativeness of the gravitational constant.
3. When argument is outside of the functional range, proper interpretation of the program must be made and appropriate recourse is to be taken. For example, the reference thrust vector is computed by  $L\bar{A}M\bar{C} = \bar{V}GO/VGOMAG$ . However, if  $VGOMAG = 0$ , then no thrust vector and no guidance is needed. The computation is not done and a logic is implemented to exit guidance.
4. Avoid loading I-load values used primarily as denominators.

### Specific Identification of Equations

In the On-orbit I Deorbit Guidance and Deorbit Maneuver DIP principal functions, the following equations are identified when trouble can theoretically develop. A preponderant number of cases are of zero divisor nature. Most of these can be dismissed on the basis of the I-load bona fide assumption. Others are flagged, analyzed, and/or coped with.

### Deorbit Guidance

1.  $G\bar{C}B = -EARTH\_MU \bar{R}GD / (ABVAL(\bar{R}GD)^3)$
2.  $M = M \text{ EXP}(-ABVAL(\bar{D}\bar{V}S)/VEX_{PROP\_FLAG})$
3.  $ATR = FT_{PROP\_FLAG}/M$
4.  $TGO = (VEX_{PROP\_FLAG}/ATR) (1 - \text{EXP}(-VGOMAG/VEX_{PROP\_FLAG}))$
5.  $L\bar{A}M\bar{C} = \bar{V}GO/VGOMAG$

PEG

1.  $LAMDZX = \text{SQRT}[(\text{EARTH\_MU})/(\text{RMAG}^3)] (\text{K\_LAMDZX})$
2.  $JOL = \text{TAU} - \text{VEX}_{\text{PROP\_FLAG}} (\text{TGO}/\text{VGOMAG})$
3.  $\overline{VC1} = \overline{VGD} + (6/5)(\overline{RGO}/\text{TGO}) - (\overline{VGO}/10)$
4.  $\text{DTAVG} = \text{MIDVAL} (\text{DTMAX}, \text{TGO}/\text{NSEG}, \text{DTMIN})$
5.  $\text{DTCOAST} = \text{THETA} \text{K\_LAMDZX}/\text{LAMDZX}$
6.  $\text{VGOD} = (\text{VEX}_{\text{PROP\_FLAG}})\text{LOG}(\text{M}/\text{MBO})$
7.  $\overline{VGO} = \overline{VGIP} - (\text{SFUELD})\text{SQRT}(\text{VGOYS}) \overline{IY}$
8.  $\overline{RT} = (\text{RTMAG} - \text{H\_ELLIPSOID} (\overline{RT}) + \text{HEI}) \overline{RT}/\text{RTMAG}$

LTVC

1.  $\text{K} = (\text{R1\_MAG} - \text{R0\_MAG})/\text{R0\_MAG}$
2.  $\text{W} = (\overline{RT} \times \overline{RP}) \cdot (\overline{IY})/\text{R0\_MAG} \text{R1\_MAG} - (\overline{RP} \cdot \overline{RT})$
3.  $\text{THETA} = \text{PI} + \text{ARCTAN2}(-2 \text{W}, 1 - \text{W}^2)$
4.  $\text{C} = 2 \text{EARTH\_MU}/\text{R1\_MAG}$
5.  $\text{VH1} = \text{C}/[\text{SQRT}(\text{D}) - \text{B}]$
6.  $\overline{VD} = \frac{(\text{K} \text{W} \text{VH1} - \text{VR1}) \overline{RP} - (1 + \text{K}) \text{VH1} (\overline{RP} \times \overline{IY})}{\text{R0\_MAG}}$

Deorbit Maneuver DIP

1.  $\text{M} = \text{WT\_DISP}/\text{G\_TO\_FPS}$
2.  $\text{YMP} = \frac{\text{ALPH} \text{CBETA} + \text{THRUST\_BODY}_1 \text{SQRT}(\text{ALPH}^2 + \text{THRUST\_BODY}_1^2 - \text{CBETA}^2)}{\text{ALPH}^2 + \text{THRUST\_BODY}_1^2}$
3.  $\text{T2} = \text{T1} - \text{H\_MISS}/\text{V\_VERT}$
4.  $\text{AM} = \text{EARTH\_MU} \text{RMAG}/[2 \text{EARTH\_MU} - \text{RMAG} (\overline{V} \cdot \overline{V})]$
5.  $\text{P} = \text{RMAG}[2 - (\text{RMAG}/\text{AM}) - \text{RMAG} \text{RDOT}^2/\text{EARTH\_MU}]$
6.  $\text{R\_UNIT} = \overline{R}/\text{RMAG}$
7.  $\text{NN} = \text{UNIT}(\overline{V} - \text{RDOT} \text{R\_UNIT}) \cdot \text{EARTH\_POLE}$

8.  $RDOT = RDOT + 4 K MM NN/NU$
9.  $M = RMAG RDOT/SQRT(EARTH\_MU AM)$
10.  $M = SQRT(1-E^2) M/[E(1-N)]$

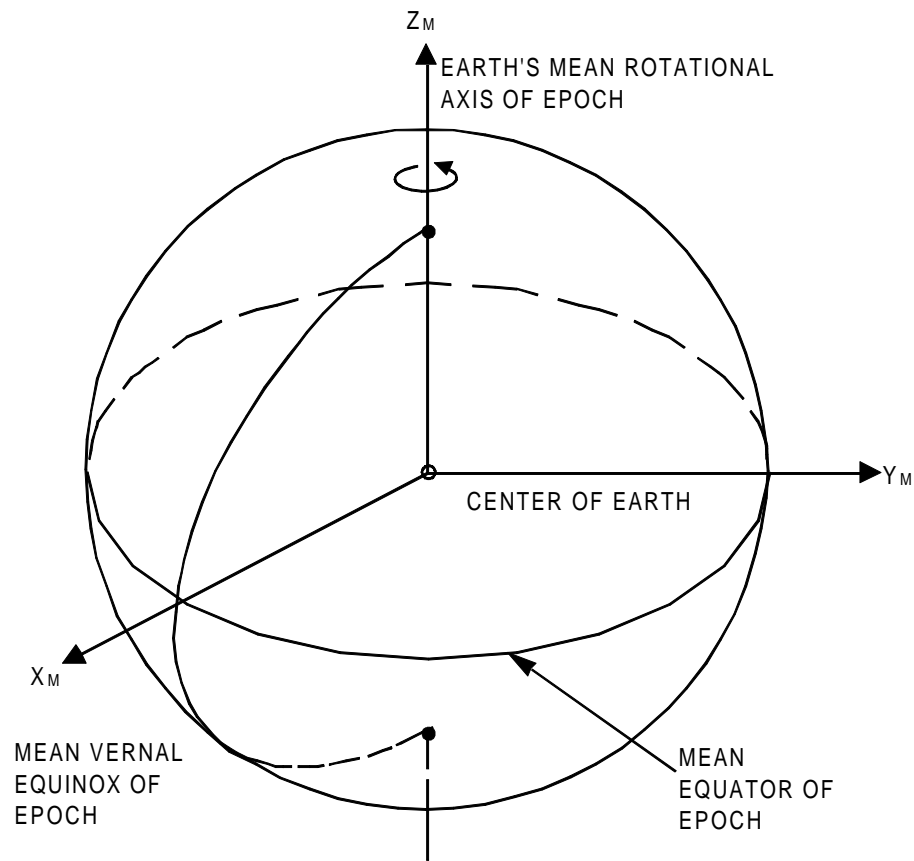
Specific Responses

DG1	$\overline{RGD}$ is obtained from ENTRY UPP and it is updated with a simplified gravitational coast algorithm. $ABVAL(\overline{RGD}) = 0$ is ruled out.
DG2	VEX is a nonzero I-load parameter, thus division is no problem.
DG3	M cannot be zero as observed from DG2 and DIPL.
DG4	FT is a nonzero I-load value, thus ATR is not zero. Again, VEX is a nonzero I-load parameter, so there is no zero divisor here.
DG5	VGOMAG is tested for zero value prior to this step. If so, this calculation is not done.
PEG1	Same as DG1. Note $LAMDZX \neq 0$ as $K\_LAMDZX$ and $EARTH\_MU$ are I-load positive values.
PEG2	This equation is not computed if $VGOMAG = 0$ .
PEG3	DG4 is computed only if $VGOMAG \neq 0$ . From DG4 it is seen that $VGOMAG \neq 0$ , implying $TGO \neq 0$ . When $VGOMAG = 0$ , this equation is not computed.
PEG4	NSEG is a nonzero I-load parameter.
PEG5	From PEG1 it was noted that $LAMDZX \neq 0$ .
PEG6	If $M/MBO \leq 1$ , propellant waste cannot be afforded, and VGOD is forced to zero.
PEG7	If $VGOYS < 0$ , no out-of-plane burn is required and $\overline{VGO}$ is set equal to $\overline{VGIP}$ (in-plane only).
PEG8	$\overline{RT}$ is the in-plane component of the target vector. $RTMAG = ABVAL(RT) \neq 0$ . Hence, division by $RTMAG$ and evaluation of $H\_ELLIPSOID$ function pose no singular problems.
LTVC1	The burnout position vector $\overline{RP}$ as input to the LTVC task cannot be zero. Hence, $RO\_MAG \neq 0$ .
LTVC2	The denominator is zero only if $\overline{RP}$ and $\overline{RT}$ are colinear and in the same sense. This singularity occurs for a 360-degree coast from burnout to entry interface. This case is under study.

- LTVC3 No problem can arise unless W is large. As in LTVC2, this case is under investigation.
- LTVC4  $R1\_MAG = ABVAL(\overline{RT}) \neq 0$ , similar to LTVC1.
- LTVC5 This case is under study.
- LTVC6 No division problem, similar to LTVC1.
- DIP1  $G\_TO\_FPS$  is an I-load item. As far as guidance is concerned, it can be replaced by its reciprocal. Other considerations will be checked.
- DIP2 If  $ALPH^2 + THRUST\_BODY_1^2 - CBETA^2 < 0$ , then unacceptable crew roll input value was made. At present, the response is to skip the computation.
- DIP3 Problem arises if for any entry interface there is no vertical velocity component. This would be a negation of definition.
- DIP4 AM is positive and it will blow up only if  $\overline{V}$  is escape velocity corresponding to the given RMAG.
- DIP5 From DIP4,  $AM \neq 0$  and  $EARTH\_MU$  is a nonzero I-load value.
- DIP6  $RMAG = ABVAL(\overline{R}) \neq 0$  implies no division singularity.
- DIP7 The argument of the function UNIT can be zero only if the velocity vector V is colinear and in the same sense with the position vector R. No OFT situation permits this occurrence.
- DIP8 AM, the adjusted semimajor axis, can be written as  

$$AM = AM (1 - J2\_GRAV RE^2 AM (1 - 3 MM^2)/RMAG^3)$$

$$AM (1 - O(J2\_GRAV))$$
 where  $O(J2\_GRAV)$  is in the order of  $10^{-3}$  in magnitude. As AM is initially given by DIP4, AM will remain positive.  
 NU is given by  $NU = AM \text{ SQRT}(AM/EARTH\_MU)$ . Thus NU is nonzero and DIP8 is well defined.
- DIP9 AM is positive from the above argument, and  $EARTH\_MU$  is an I-load positive parameter. Hence, no negative square root or zero division singularity exists.
- DIP10  $1 - N = RMAG/AM \neq 0$   
 If  $E = 0$ , software logic bypasses this equation. Thus no zero division problem exists.  
 If  $E > 1$ , a hyperbolic orbit is present, contrary to the OFT mission scenario. Thus no negative square root argument exists and DIP10 is defined.



NAME: ARIES-MEAN-OF-1950, CARTESIAN, COORDINATE SYSTEM

ORIGIN: THE CENTER OF THE EARTH

ORIENTATION: THE EPOCH IS THE BEGINNING OF BESSELIAN YEAR 1950 OR JULIAN EPHEMERIS DATE 2433282.423357.

THE  $X_M$  - $Y_M$  PLANE IS THE MEAN EARTH'S EQUATOR OF EPOCH.

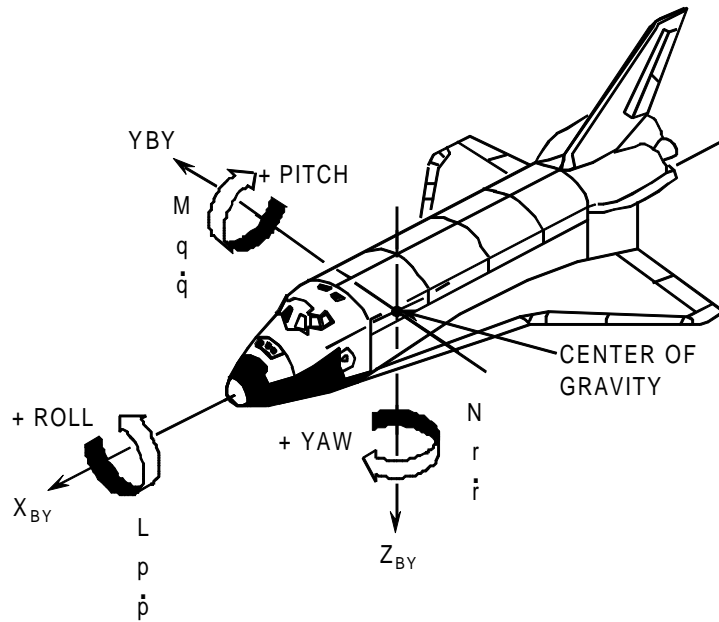
THE  $X_M$  -AXIS IS DIRECTED TOWARD THE MEAN VERNAL EQUINOX OF EPOCH.

THE  $Z_M$  -AXIS IS DIRECTED ALONG THE EARTH'S MEAN ROTATIONAL AXIS OF EPOCH AND IS POSITIVE NORTH.

THE  $Y_M$  -AXIS COMPLETES A RIGHT-HANDED SYSTEM.

CHARACTERISTICS: INERTIAL, RIGHT-HANDED, CARTESIAN SYSTEM.

FIGURE 5.1-1. Aries-Mean-of-1950



NAME BODY AXIS COORDINATE SYSTEM.

ORIGIN: CENTER OF MASS.

ORIENTATION:  $X_{BY}$  -AXIS IS PARALLEL TO THE ORBITER STRUCTURAL BODY  $X_o$  -AXIS;  
POSITIVE TOWARD THE NOSE.

$Z_{BY}$  -AXIS IS PARALLEL TO THE ORBITER PLANE OF SYMMETRY AND IS  
PERPENDICULAR TO  $X_{BY}$  ; POSITIVE DOWN WITH RESPECT TO THE ORBITER  
FUSELAGE.

$Y_{BY}$  -AXIS COMPLETES THE RIGHT-HANDED ORTHOGONAL SYSTEM.

CHARACTERISTICS: ROTATING, RIGHT-HANDED, CARTESIAN SYSTEM.

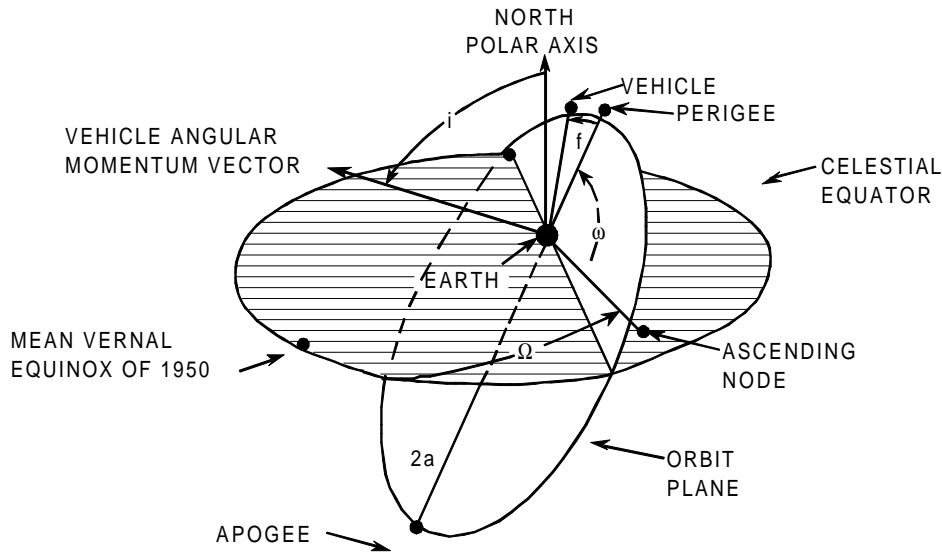
L, M, N: MOMENTS ABOUT  $X_{BY}$ ,  $Y_{BY}$ , AND  $Z_{BY}$  AXES, RESPECTIVELY.

$p$ ,  $q$ ,  $r$ : BODY RATES ABOUT  $X_{BY}$ ,  $Y_{BY}$ , AND  $Z_{BY}$  AXES, RESPECTIVELY.

$\dot{p}$ ,  $\dot{q}$ ,  $\dot{r}$ : ANGULAR BODY ACCELERATION ABOUT  $X_{BY}$ ,  $Y_{BY}$ , AND  $Z_{BY}$  AXES,  
RESPECTIVELY.

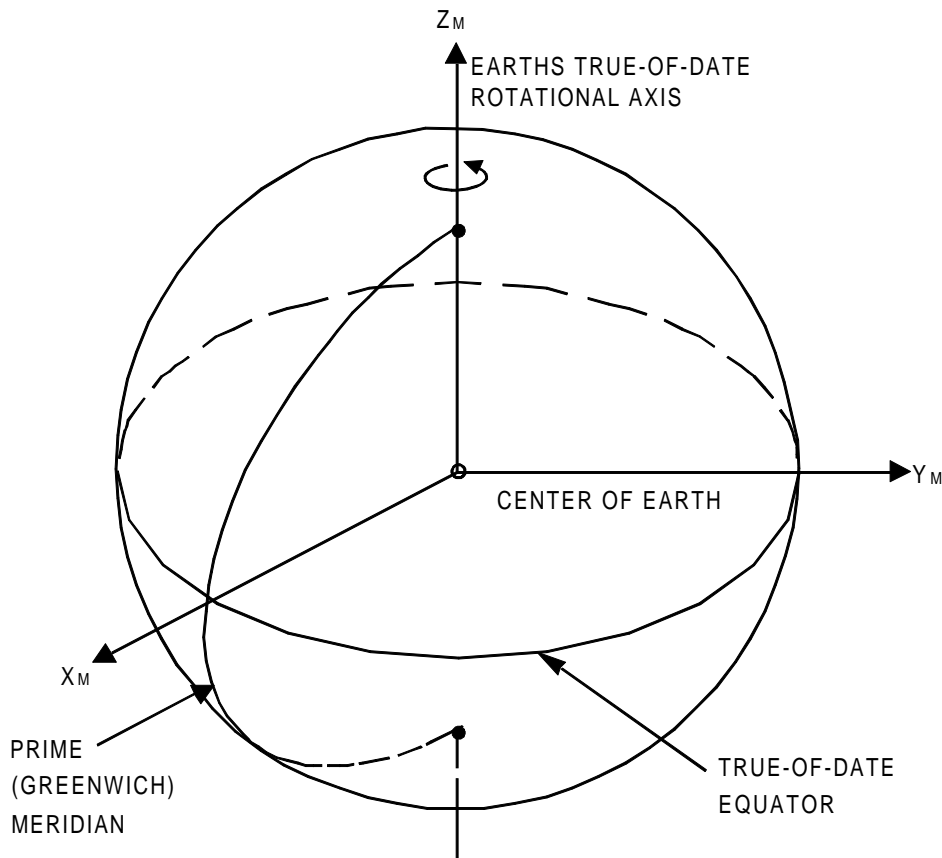
THE EULER SEQUENCE THAT IS COMMONLY ASSOCIATED WITH THIS SYSTEM  
IS A YAW, PITCH, AND ROLL SEQUENCE, WHERE  $\psi$  = YAW,  $\theta$  = PITCH, AND  $\phi$  = ROLL  
OR BANK. THIS ATTITUDE SEQUENCE IS YAW, PITCH, AND ROLL AROUND THE  
 $Z_{BY}$ ,  $Y_{BY}$ , AND  $X_{BY}$  AXES, RESPECTIVELY.

FIGURE 5.1-2. Body Axis



- NAME: ORBITAL ELEMENT COORDINATE SYSTEM.
- ORIGIN: THE CENTER OF THE EARTH.
- ORIENTATION AND DEFINITIONS: THE REFERENCE FOR COMPUTING OSCILLATING ORBITAL ELEMENTS IS THE ARIES-MEAN-OF-1950 COORDINATE SYSTEM.
- "a" IS THE SEMIMAJOR AXIS OF THE ORBIT.
- "e" IS THE ECCENTRICITY OF THE ORBIT.
- "i", THE INCLINATION OF THE ORBITAL PLANE, IS THE ANGLE BETWEEN THE NORTH POLAR AXIS AND THE ORBITAL ANGULAR MOMENTUM VECTOR.
- " $\Omega$ ", THE RIGHT ASCENSION OF THE ASCENDING NODE, IS THE ANGLE MEASURED EASTWARD FROM THE VERNAL EQUINOX ALONG THE EQUATOR TO THAT INTERSECTION WITH THE ORBIT PLANE WHERE THE VEHICLE PASSES FROM SOUTH TO NORTH. IN THE CASE WHERE INCLINATION EQUALS ZERO, THE ASCENDING NODE IS DEFINED TO BE THE X-AXIS OF THE REFERENCE SYSTEM.
- " $\omega$ ", THE ARGUMENT OF PERIGEE, IS THE ANGLE MEASURED IN THE ORBIT PLANE BETWEEN THE ASCENDING NODE AND PERIGEE, POSITIVE IN THE DIRECTION OF TRAVEL IN THE ORBIT. IN THE CASE WHERE ECCENTRICITY EQUALS ZERO, PERIGEE IS DEFINED TO BE AT THE ASCENDING NODE.
- "f", THE TRUE ANOMALY, IS THE GEOCENTRIC ANGULAR DISPLACEMENT OF THE VEHICLE MEASURED FROM PERIGEE IN THE ORBIT PLANE, AND POSITIVE IN THE DIRECTION OF TRAVEL IN THE ORBIT.
- CHARACTERISTICS: QUASI-INERTIAL.

FIGURE 5.1-3. Orbital Elements



EARTH FIXED (GREENWICH TRUE-OF-DATE) COORDINATE SYSTEM

NAME: GREENWICH TRUE-OF-DATE (GEOGRAPHIC) COORDINATE SYSTEM

ORIGIN: THE CENTER OF THE EARTH

ORIENTATION: THE  $X_G$  -  $Y_G$  PLANE IS THE EARTH'S TRUE-OF-DATE EQUATOR.

THE  $Z_G$  -AXIS IS DIRECTED ALONG THE EARTH'S TRUE-OF-DATE ROTATIONAL AXIS AND IS POSITIVE NORTH.

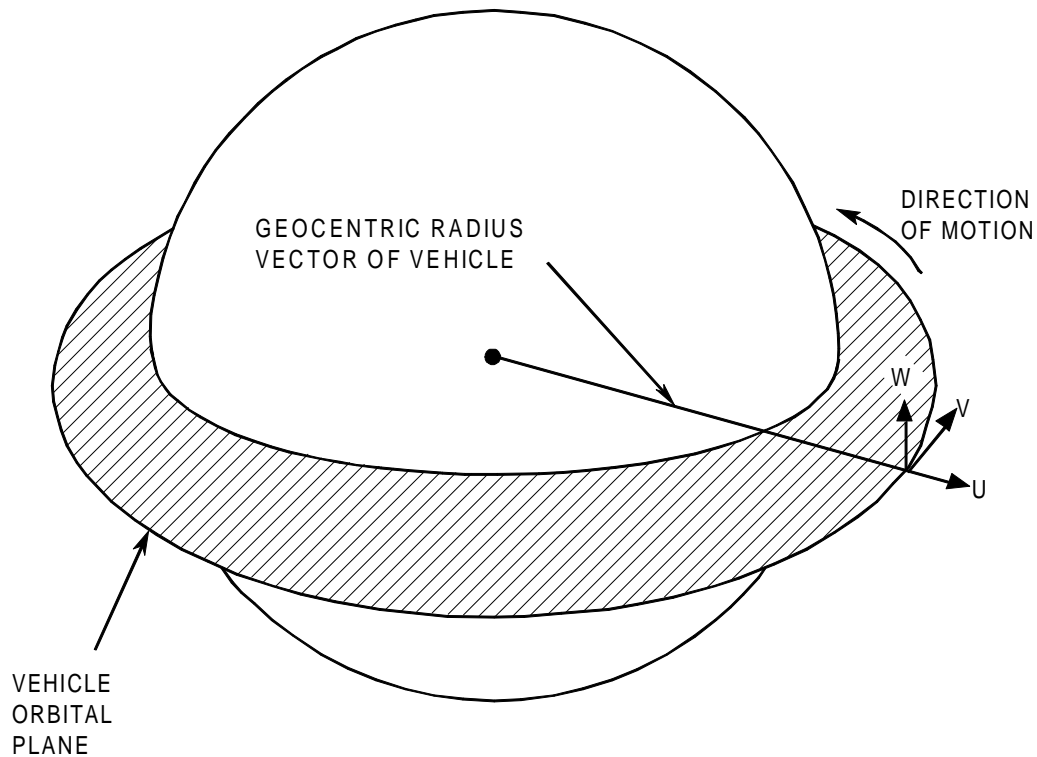
THE  $+X_G$  -AXIS IS DIRECTED TOWARD THE PRIME MERIDIAN.

THE  $Y_G$  -AXIS COMPLETES A RIGHT-HANDED SYSTEM.

CHARACTERISTICS: ROTATING, RIGHT-HANDED, CARTESIAN. VELOCITY VECTORS EXPRESSED IN THIS SYSTEM ARE RELATIVE TO A ROTATING REFERENCE FRAME FIXED TO THE EARTH, WHOSE ROTATION RATES ARE EXPRESSED RELATIVE TO THE ARIES MEAN OF 1950 SYSTEM.

FIGURE 5.1-4. Earth Fixed - Greenwich True-of-Date





NAME: U, V, W COORDINATE SYSTEM.

ORIGIN: POINT OF INTEREST.

ORIENTATION: THE U-V PLANE IS THE INSTANTANEOUS ORBIT PLANE AT EPOCH.

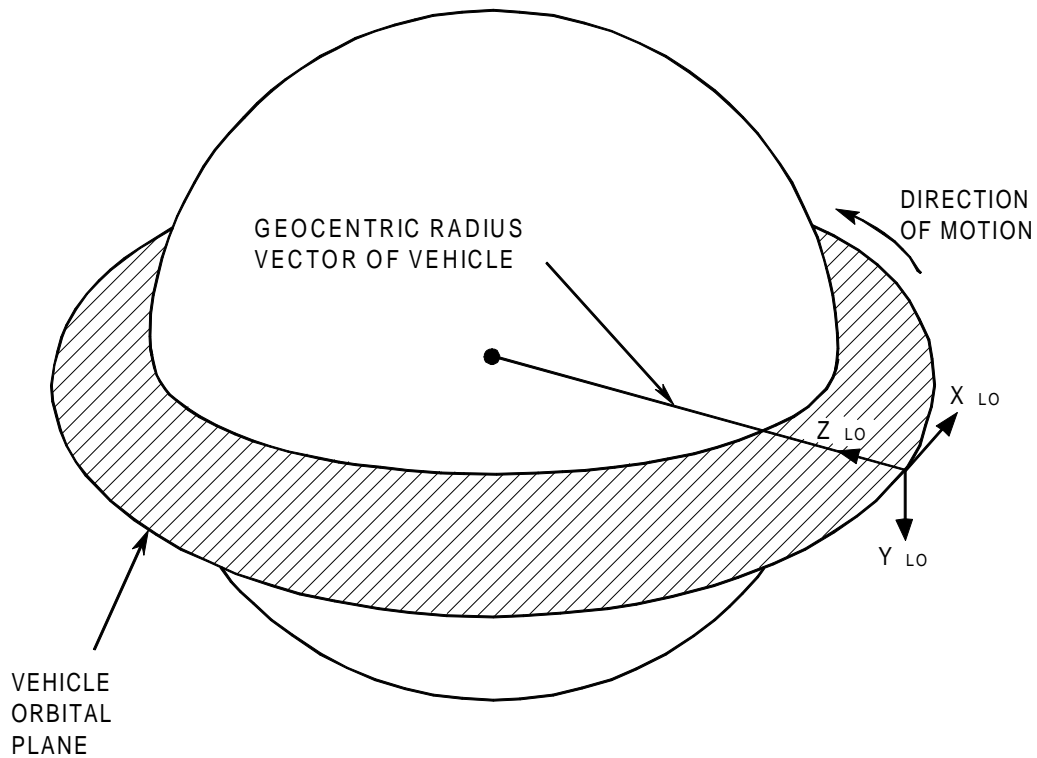
THE U AXIS LIES ALONG THE GEOCENTRIC RADIUS VECTOR TO THE VEHICLE AND IS POSITIVE RADIALLY OUTWARD.

THE W AXIS LIES ALONG THE INSTANTANEOUS ORBITAL ANGULAR MOMENTUM VECTOR AT EPOCH AND IS POSITIVE IN THE DIRECTION OF THE ANGULAR MOMENTUM VECTOR.

THE V AXIS COMPLETES A RIGHT-HANDED SYSTEM.

CHARACTERISTIC: QUASI-INERTIAL, RIGHT-HANDED, CARTESIAN COORDINATE SYSTEM. THIS SYSTEM IS QUASI-INERTIAL IN THE SENSE THAT IT IS TREATED AS AN INERTIAL COORDINATE SYSTEM, BUT IT IS REDEFINED AT EACH POINT OF INTEREST.

FIGURE 5.1-5. U, V, W



NAME: LOCAL VERTICAL, LOCAL HORIZONTAL COORDINATE SYSTEM.

ORIGIN: VEHICLE CENTER OF MASS.

ORIENTATION: THE  $X_{Lo}$  -  $Z_{Lo}$  PLANE IS THE INSTANTANEOUS ORBIT PLANE AT THE TIME OF INTEREST. THE  $Z_{Lo}$  AXIS LIES ALONG THE GEOCENTRIC RADIUS VECTOR TO THE VEHICLE AND IS POSITIVE TOWARD THE CENTER OF THE EARTH.

THE  $X_{Lo}$  AXIS LIES IN THE VEHICLE ORBITAL PLANE, PERPENDICULAR TO THE  $Z_{Lo}$  AXIS, AND POSITIVE IN THE DIRECTION OF VEHICLE MOTION.

THE  $Y_{Lo}$  AXIS IS NORMAL TO THE ORBIT PLANE AND COMPLETES THE RIGHT-HANDED ORTHOGONAL SYSTEM.

CHARACTERISTICS: RIGHT-HANDED, CARTESIAN COORDINATE SYSTEM.

FIGURE 5.1-6. Local Vertical, Local Horizontal

## APPENDIX A      DETAILED REQUIREMENTS FLOWCHARTS

This material presented in this appendix is suggested flowcharts corresponding to the detailed requirements specified in Section 4.0. This appendix is divided into the following sections

- A 4.1      Orbit Maneuver Display Processing
- A 4.2      On-Orbit Guidance
- A 4.3      Universal Pointing
- A 4.4      Deorbit Maneuver Display Processing
- A 4.5      Deorbit Guidance
- A 4.6      Orbit Targeting
- A 4.7      Relative Navigation

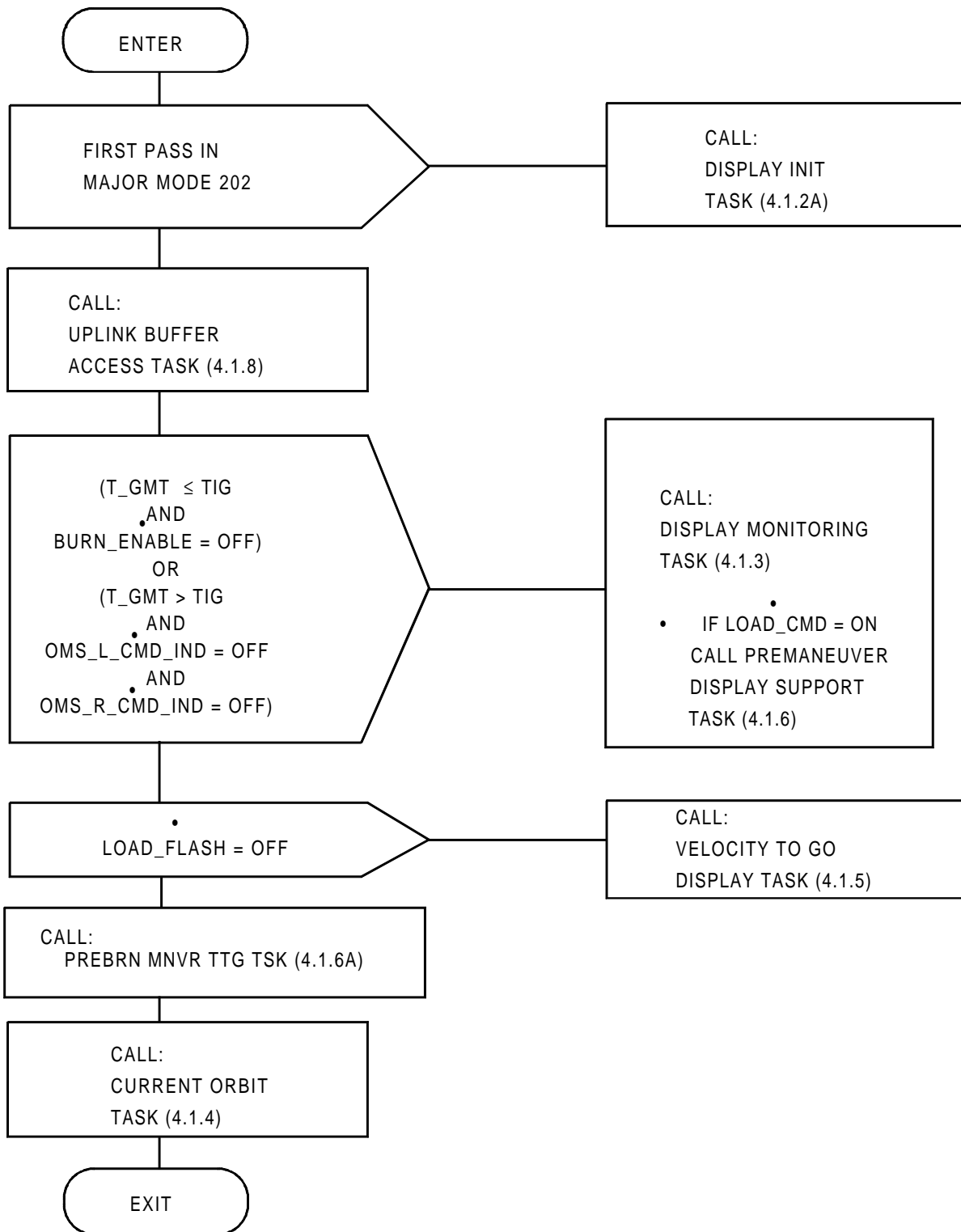


FIGURE A4.1.2. Orbit Maneuver Display Sequencing Flowchart

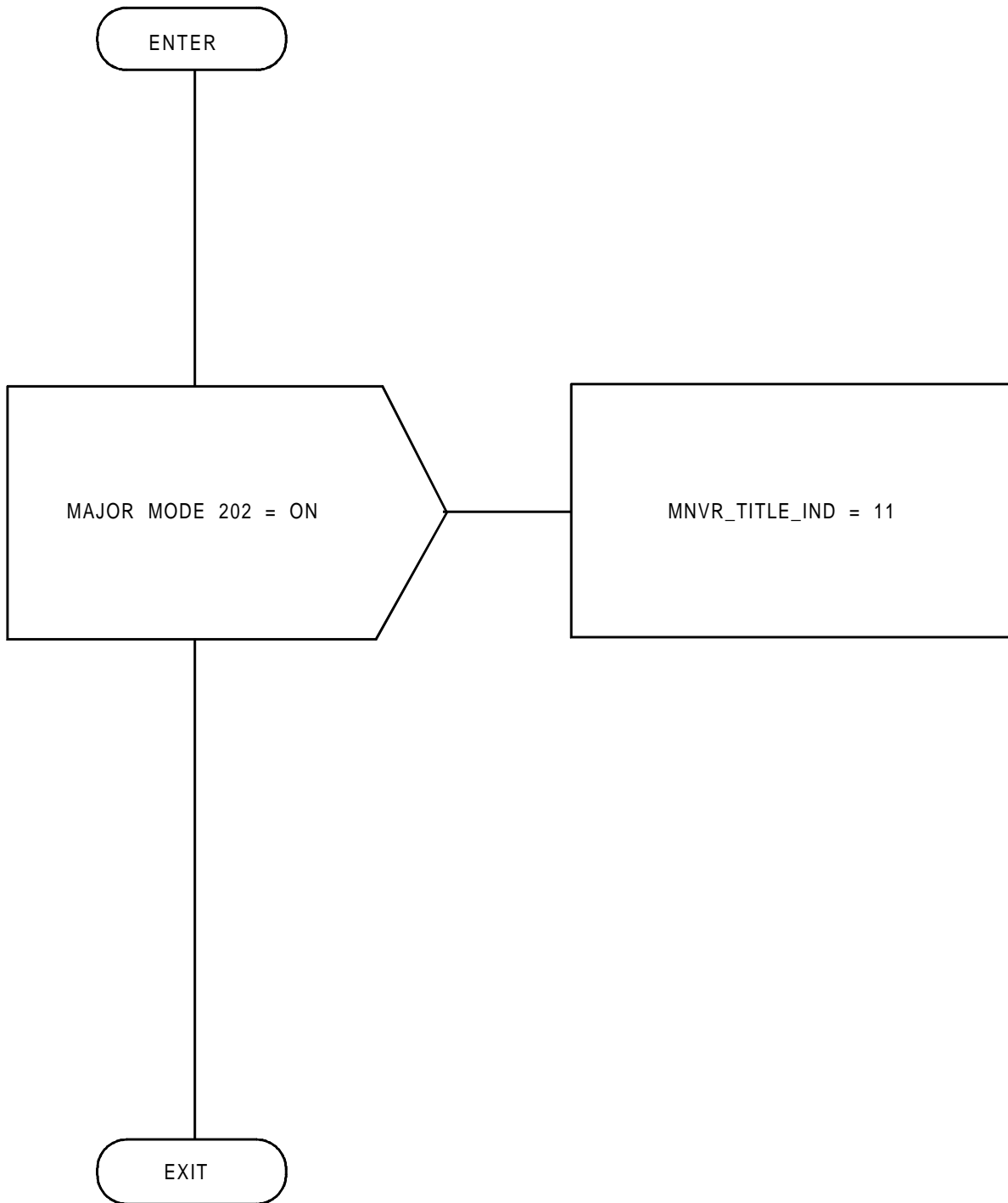


FIGURE A4.1.2A. DISP INIT TSK

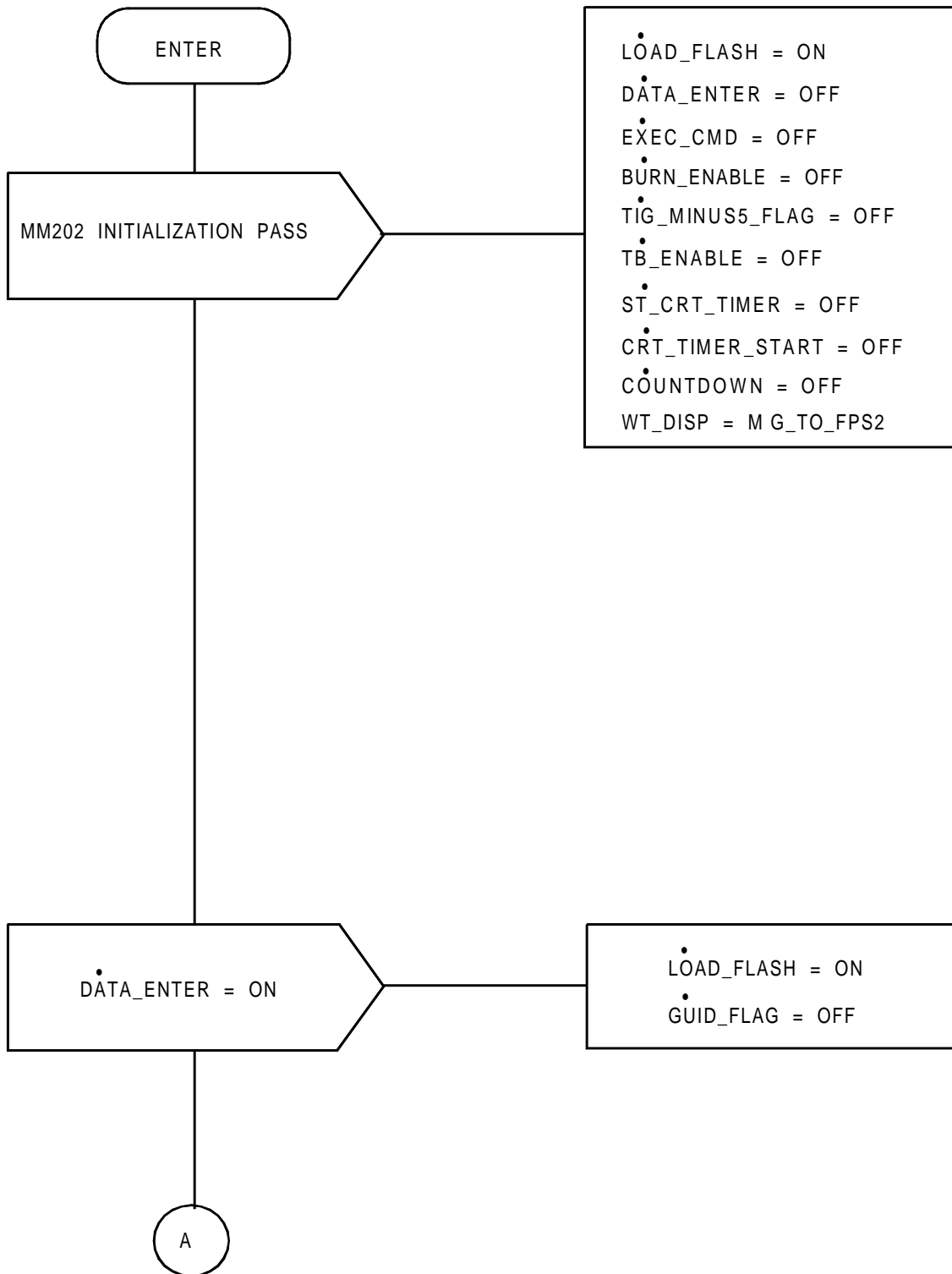


FIGURE A4.1.3.(1) DISP MONIT TSK (Sheet 1 of 2)



FIGURE A4.1.3.(2) DISP MONIT TSK (Sheet 2 of 2)

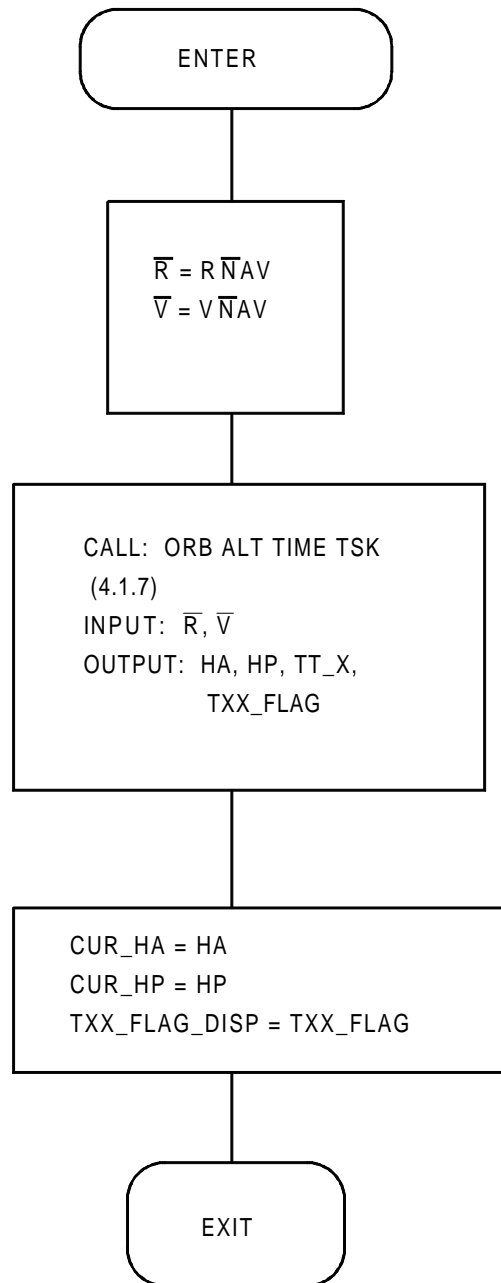


FIGURE A4.1.4. CUR ORBIT TSK



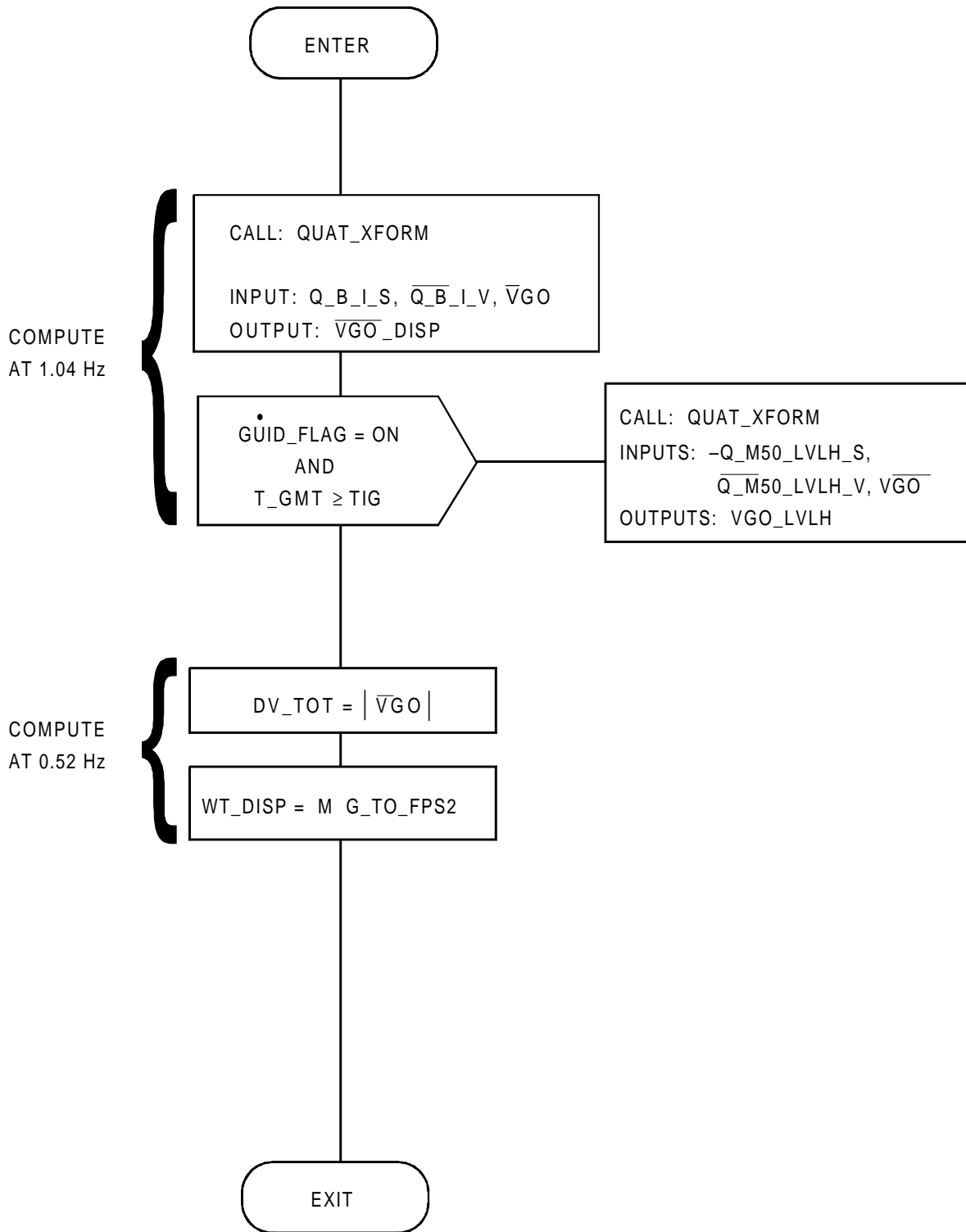


FIGURE A4.1.5. VGO DISP TSK

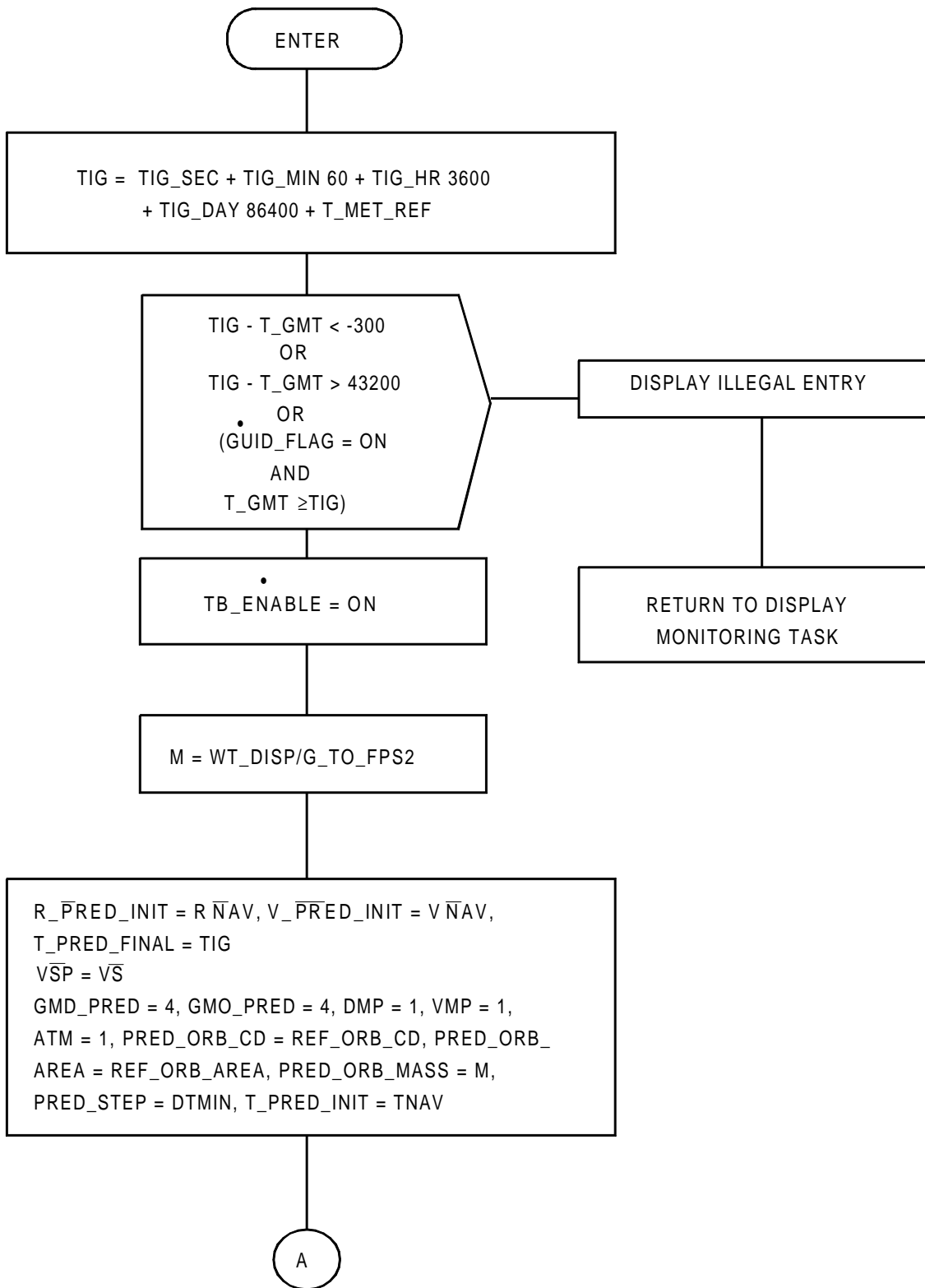


FIGURE A4.1.6.(1) PRE-MAN DISP SUPT TSK (Sheet 1 of 4)

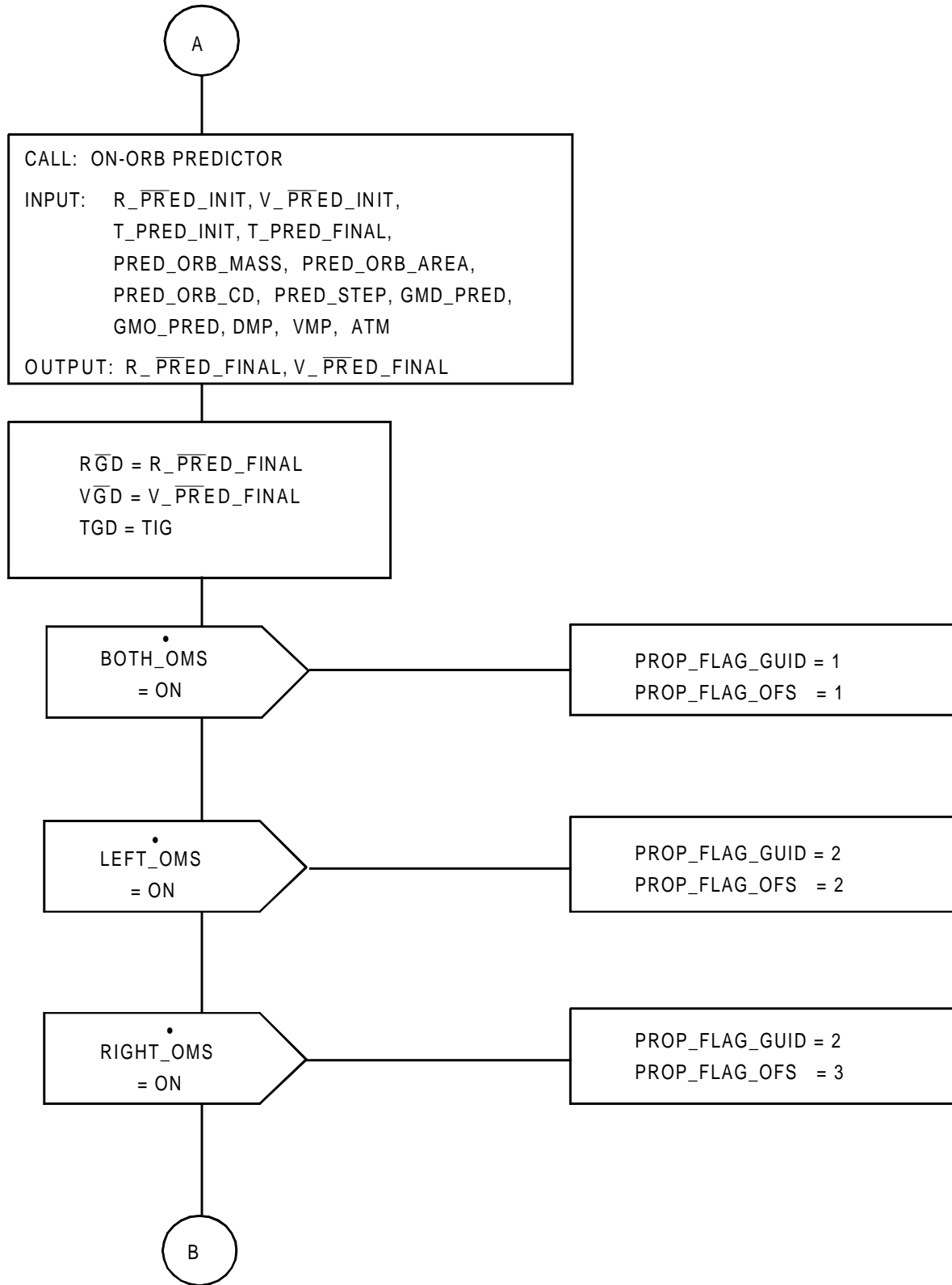


FIGURE A4.1.6.(2) PRE-MAN DISP SUPT TSK (Sheet 2 of 4)

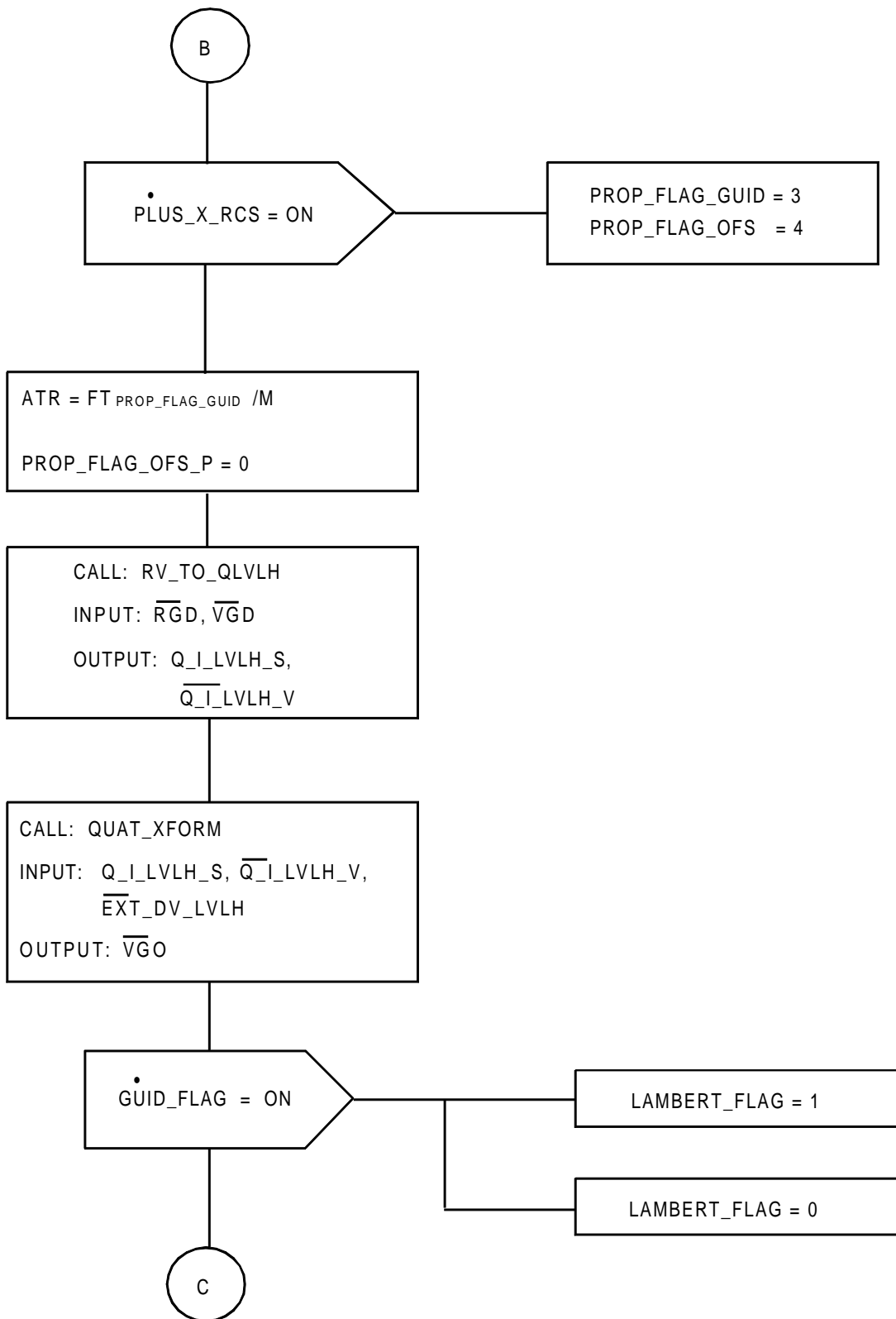


FIGURE A4.1.6.(3) PRE-MAN DISP SUPT TSK (Sheet 3 of 4)

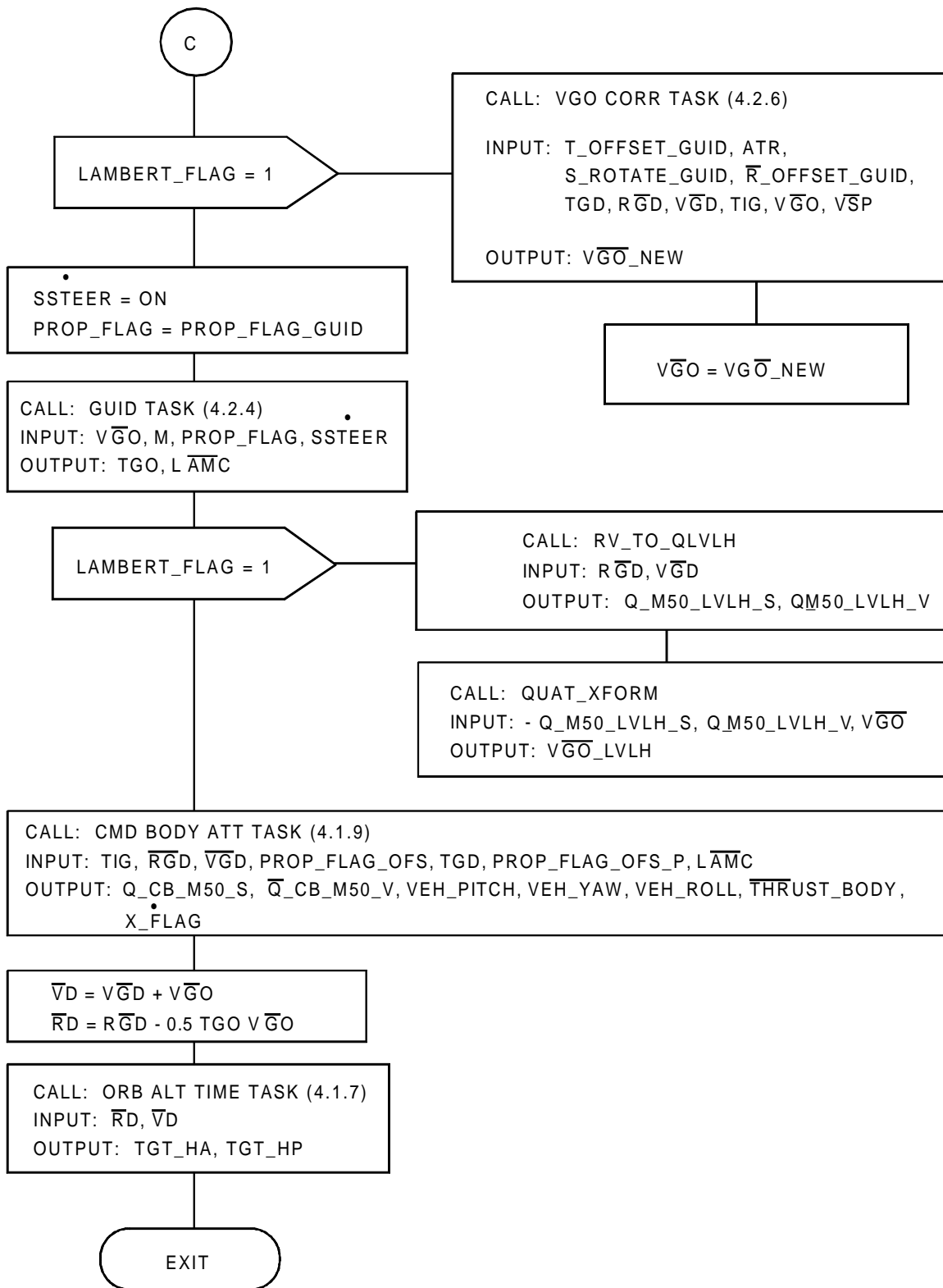


FIGURE A4.1.6.(4) PRE-MAN DISP SUPT TSK (Sheet 4 of 4)

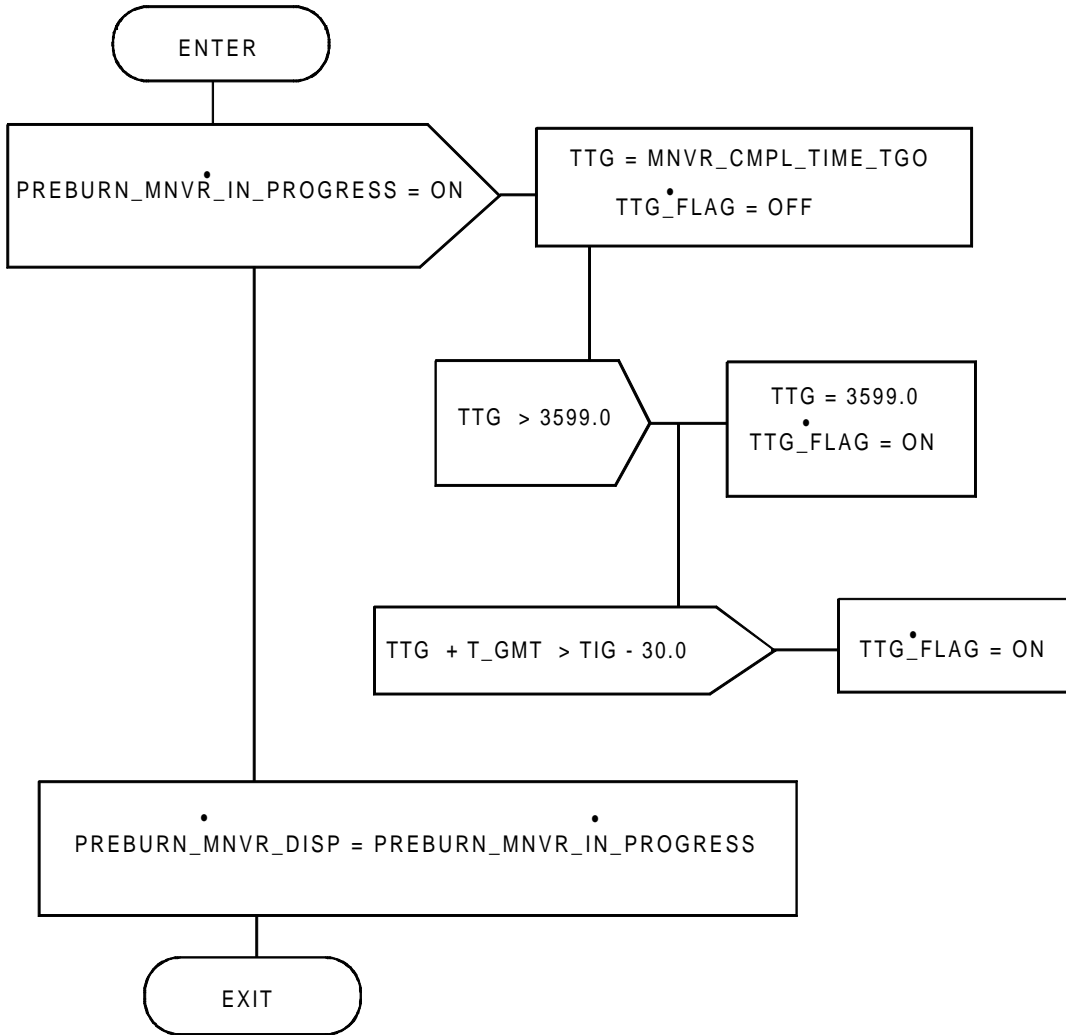


FIGURE A4.1.6A. PREBRN MNVR TTG TSK

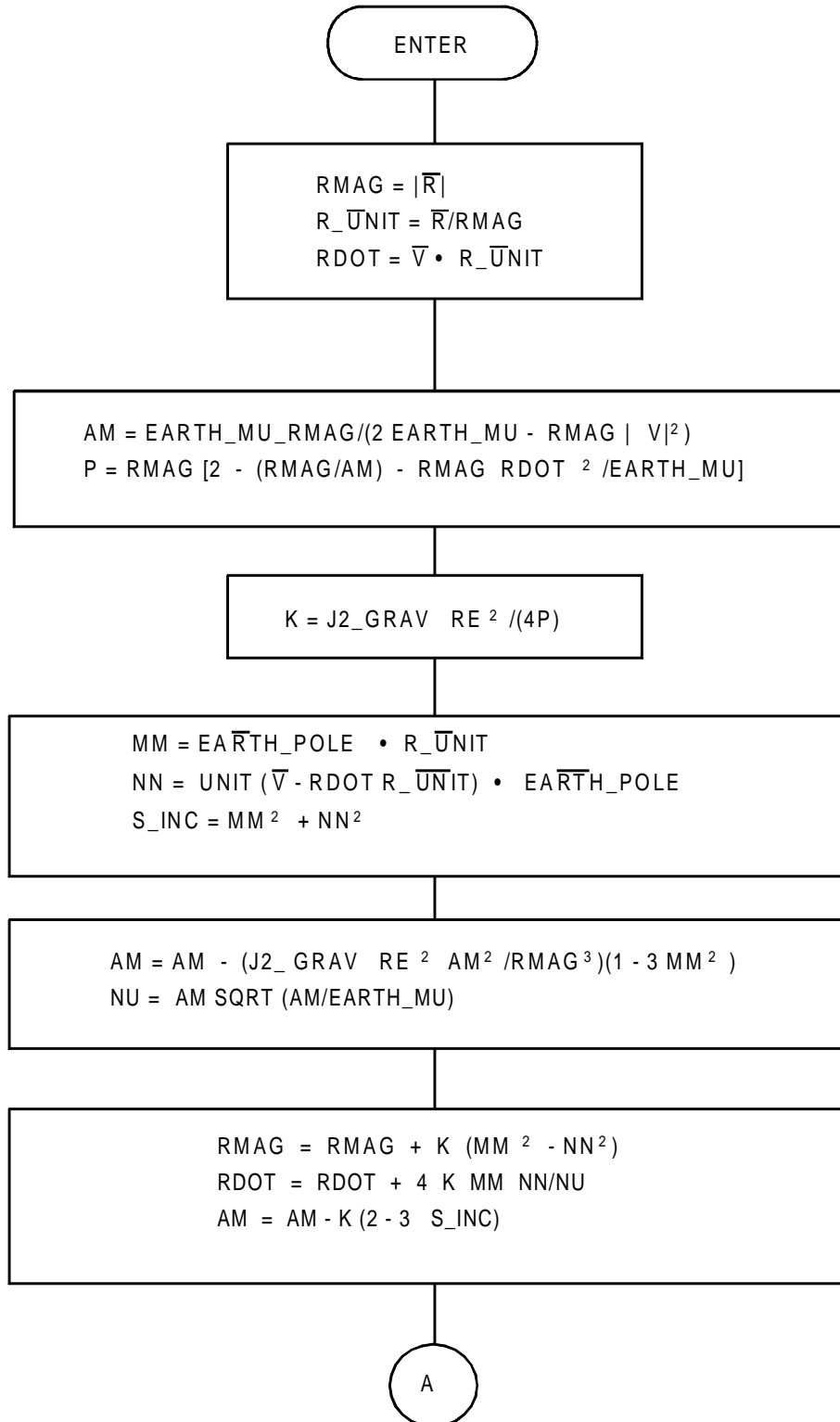


FIGURE A4.1.7.(1) ORB ALT TIME TSK (Sheet 1 of 3)

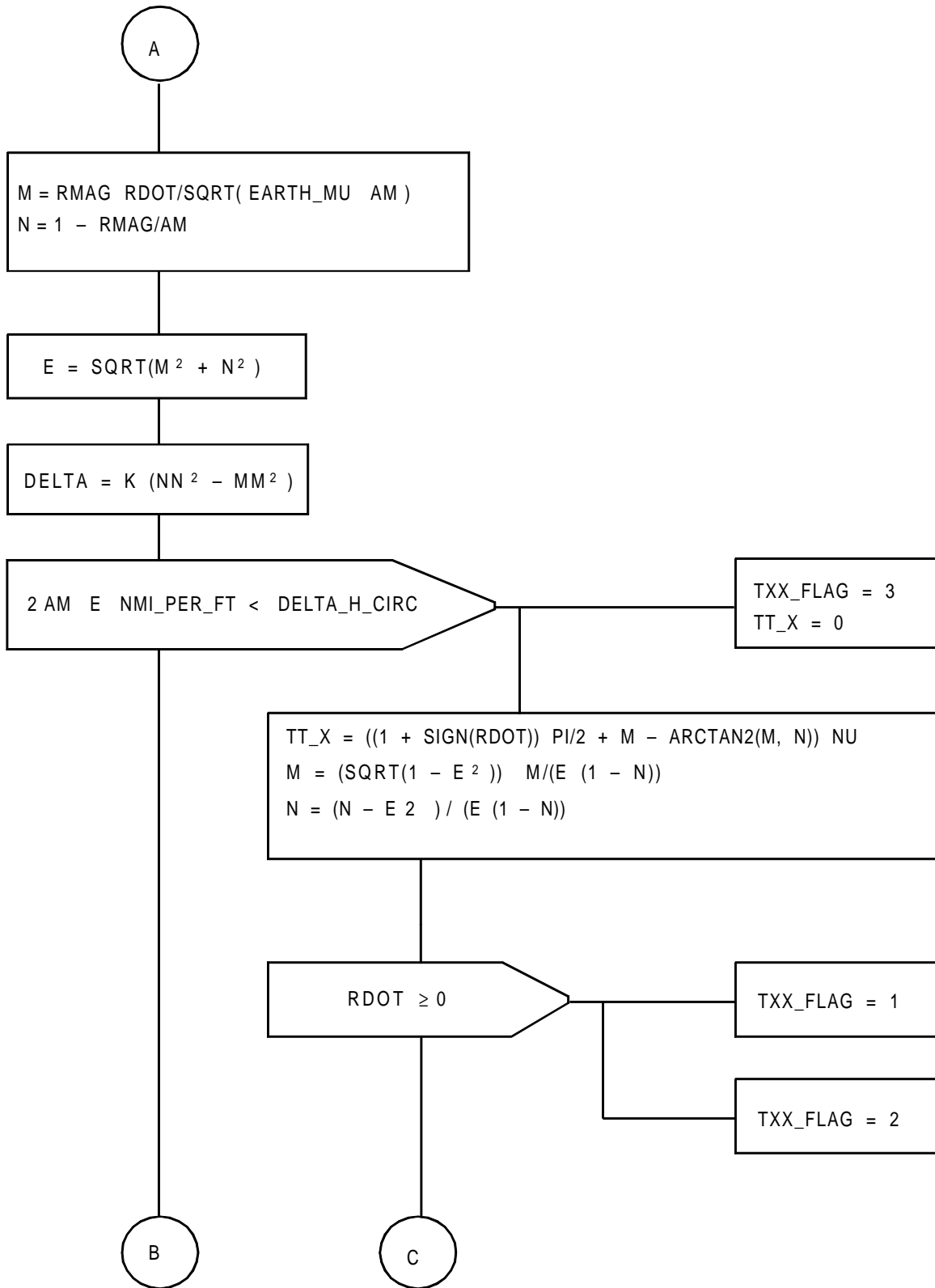


FIGURE A4.1.7.(2) ORB ALT TIME TSK (Sheet 2 of 3)



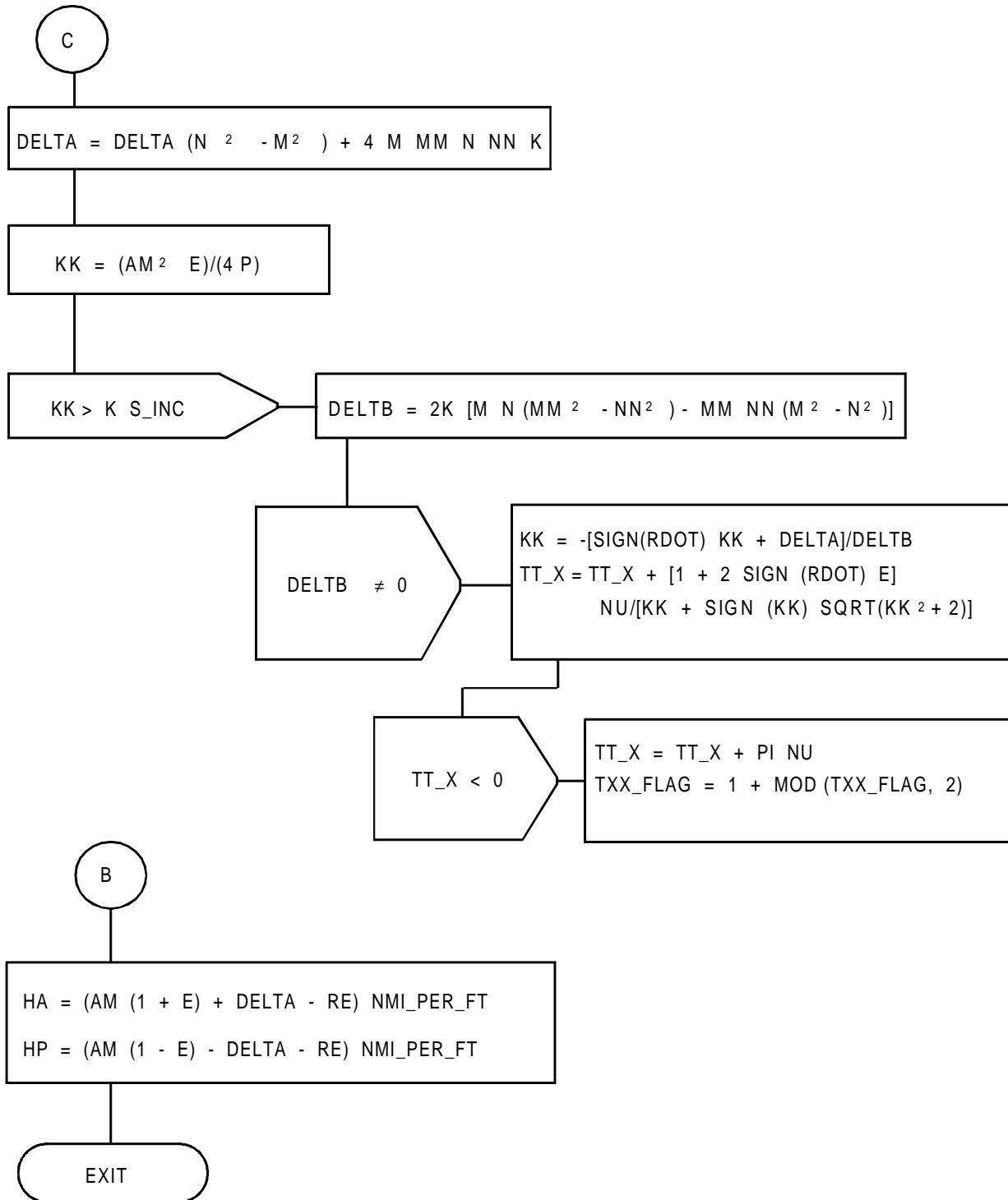


FIGURE A4.1.7.(3) ORB ALT TIME TSK (Sheet 3 of 3)

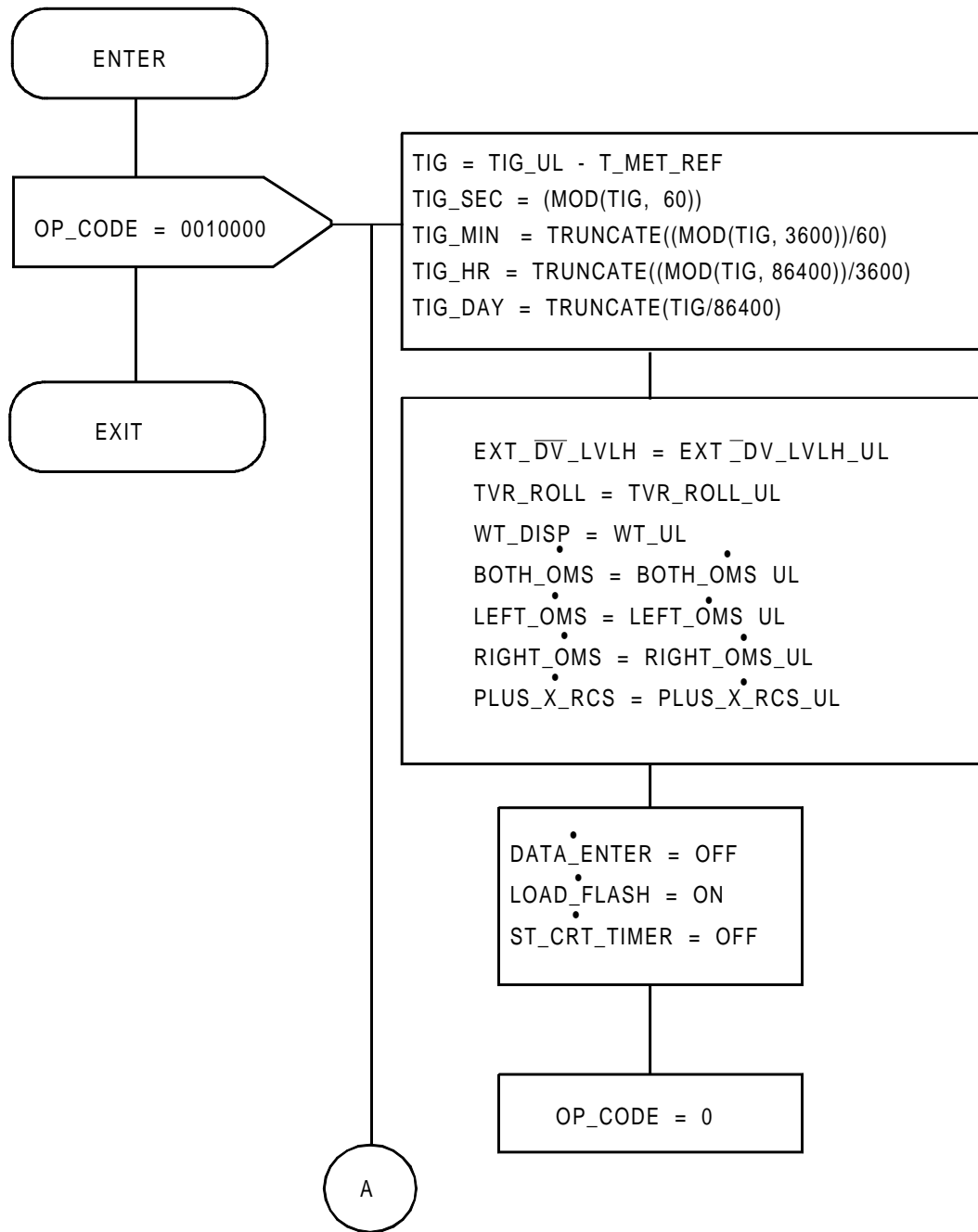


FIGURE A4.1.8.(1) UL ACCSS TSK (Sheet 1 of 2)

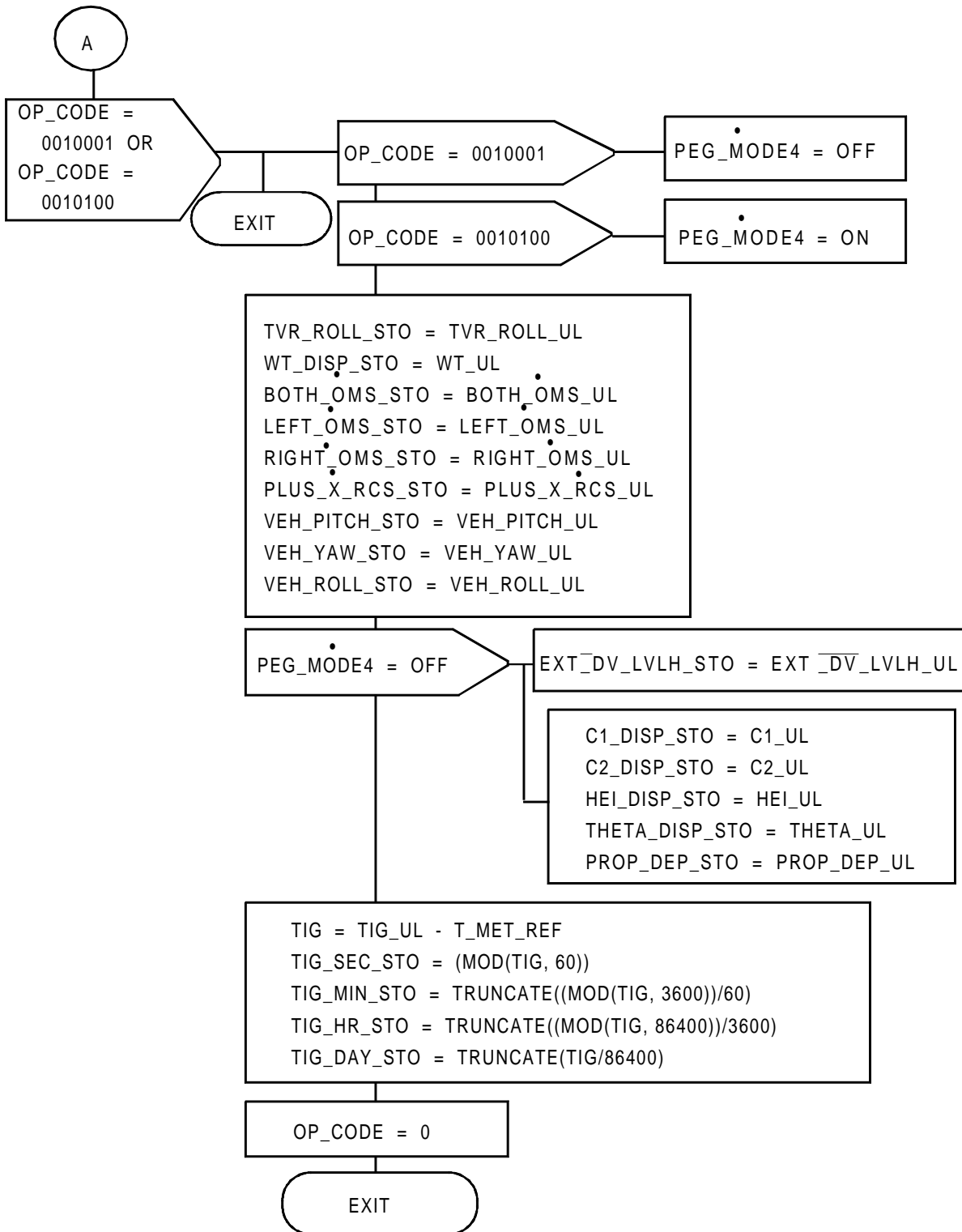


FIGURE A4.1.8.(2) UL ACCSS TSK (Sheet 2 of 2)

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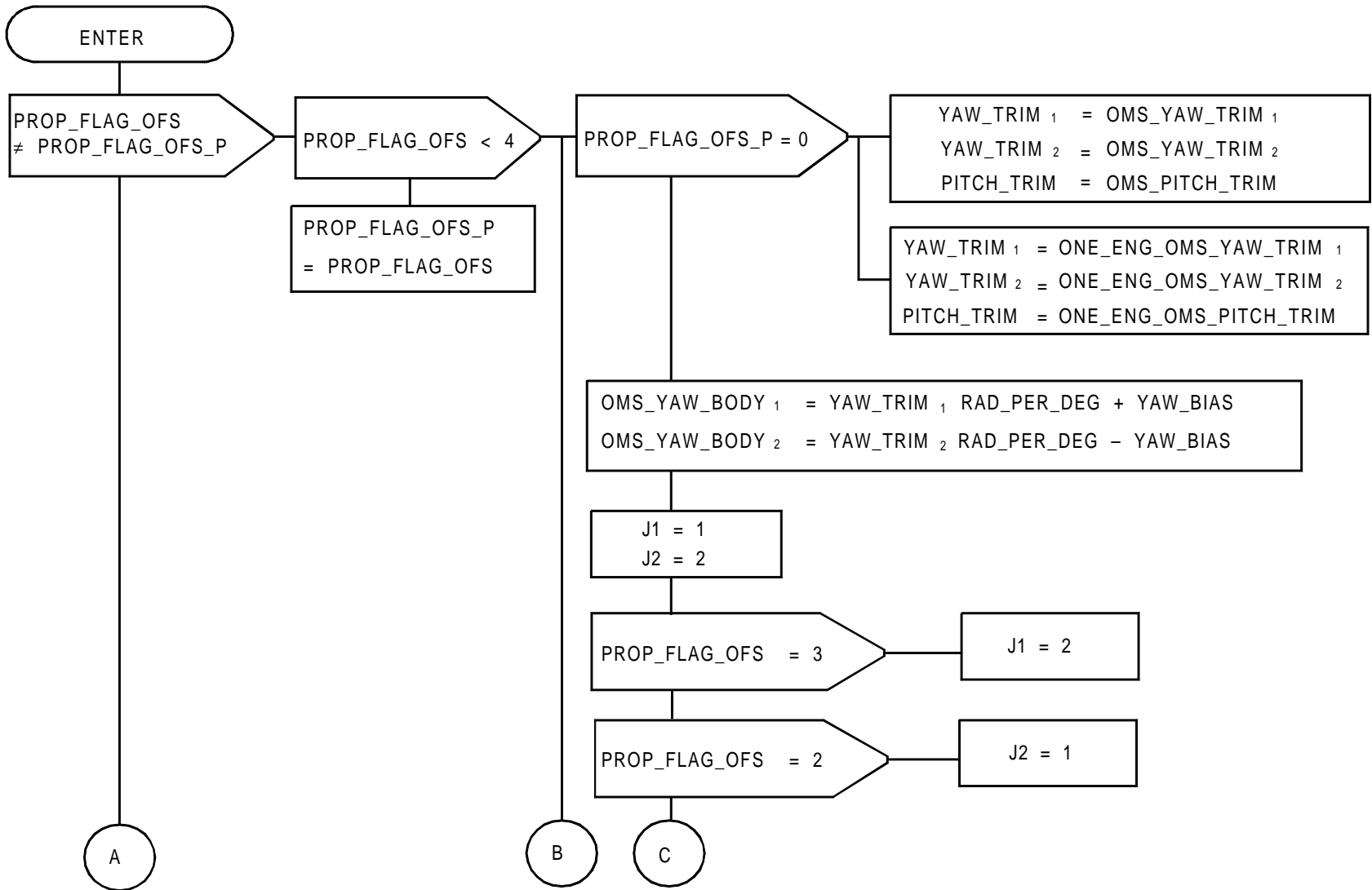


FIGURE A4.1.9.(1) CMD BDY ATT TSK (Sheet 1 of 5)

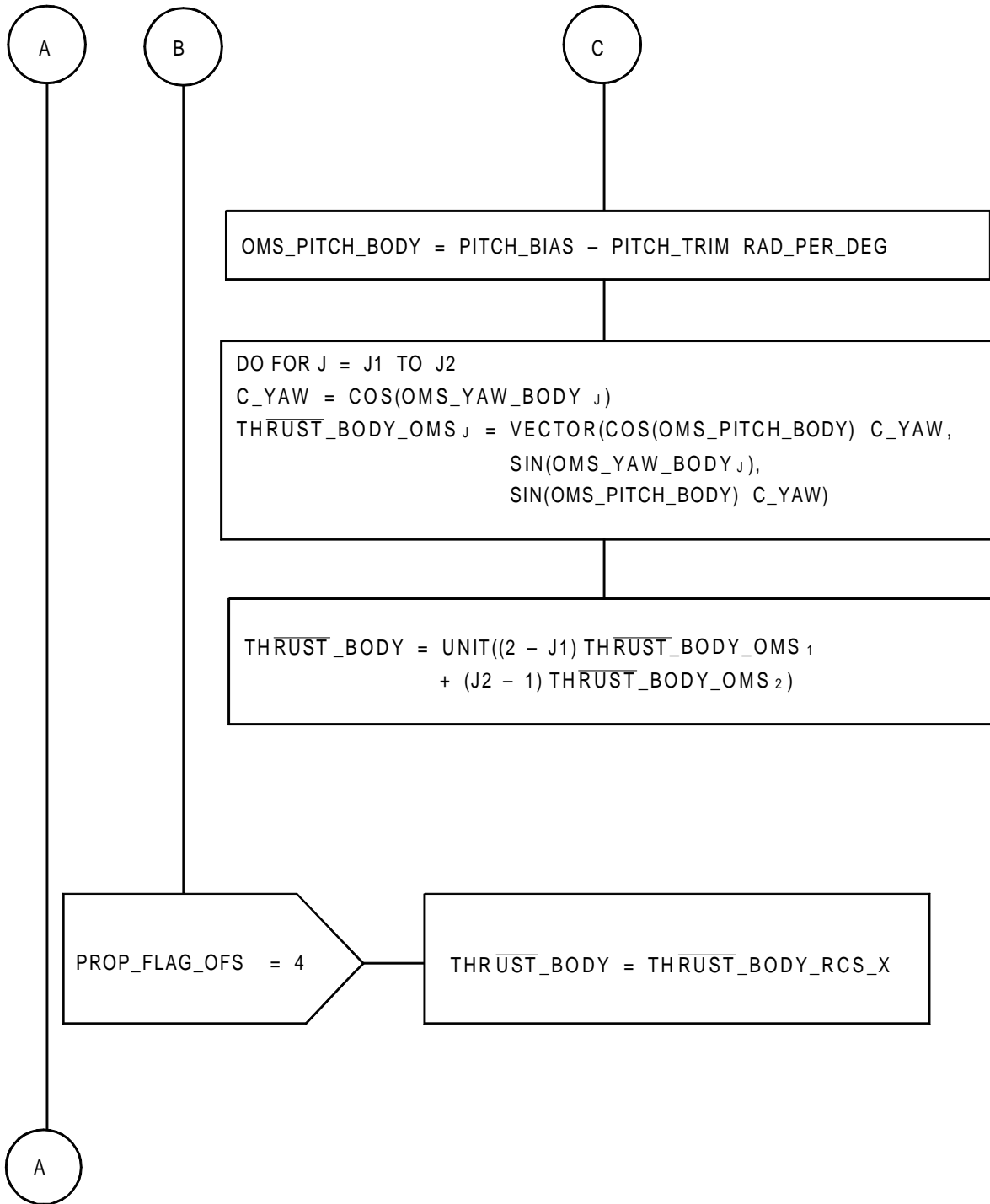


FIGURE A4.1.9.(2) CMD BDY ATT TSK (Sheet 2 of 5)

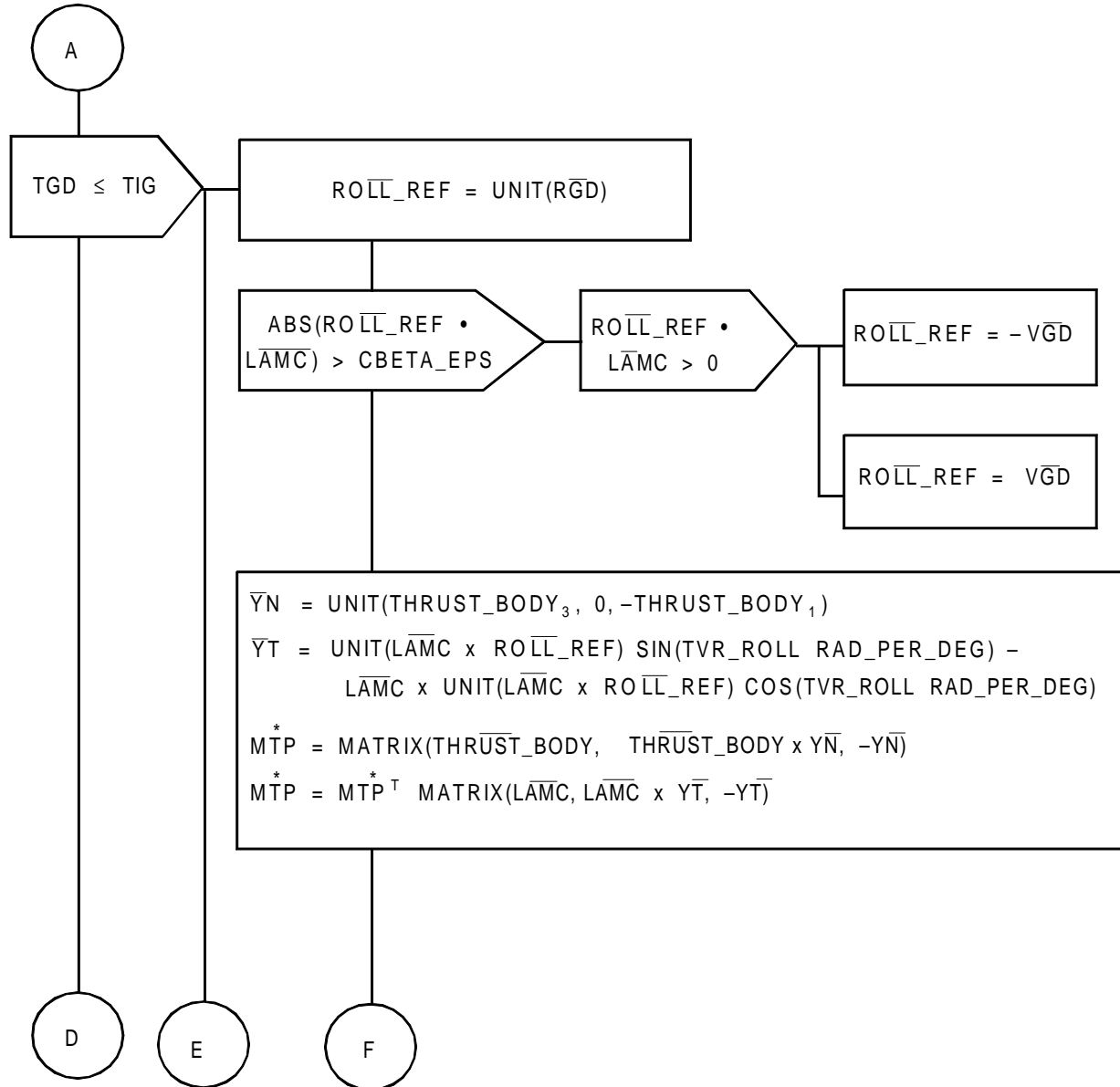


FIGURE A4.1.9.(3) CMD BDY ATT TSK (Sheet 3 of 5)

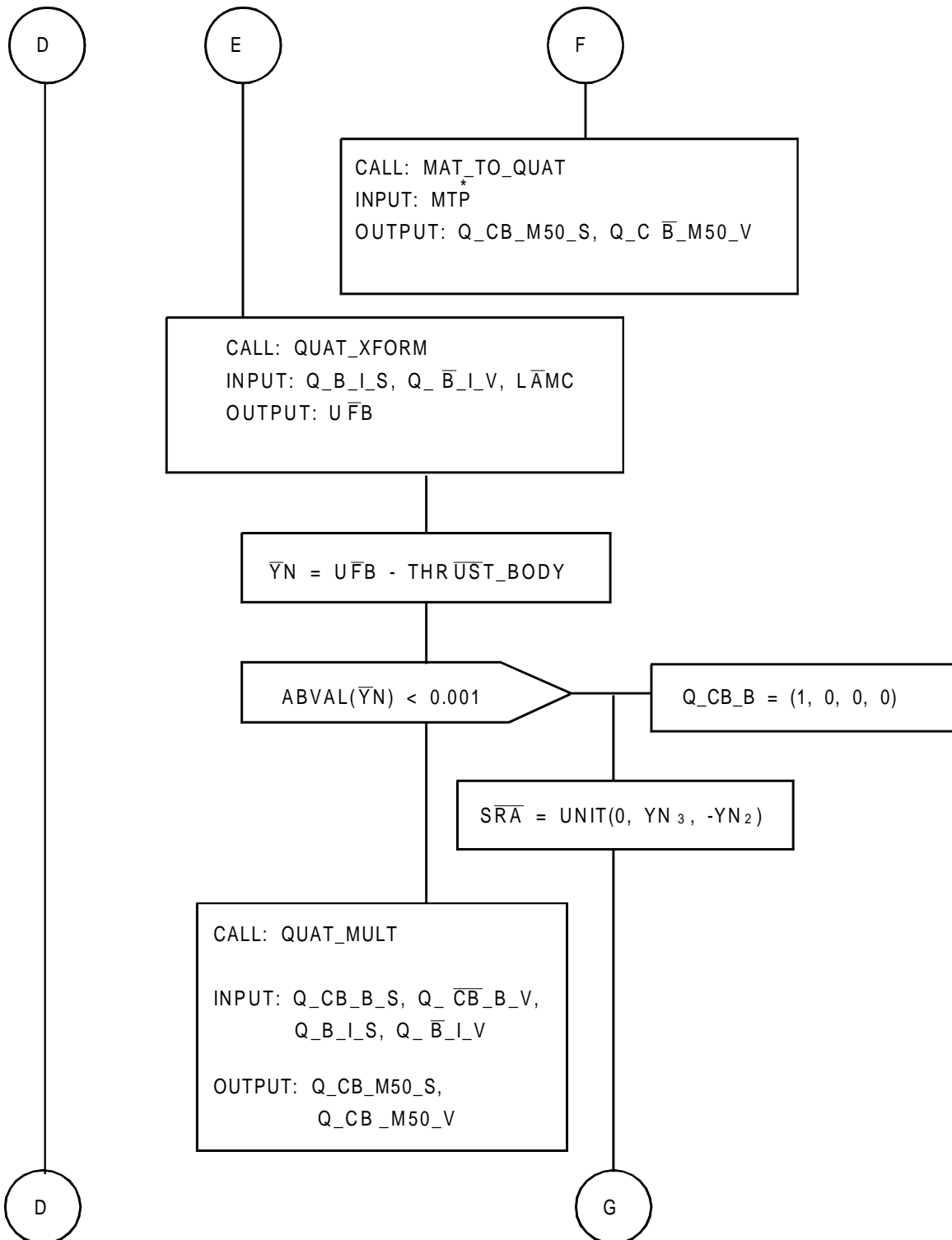


FIGURE A4.1.9.(4) CMD BDY ATT TSK (Sheet 4 of 5)



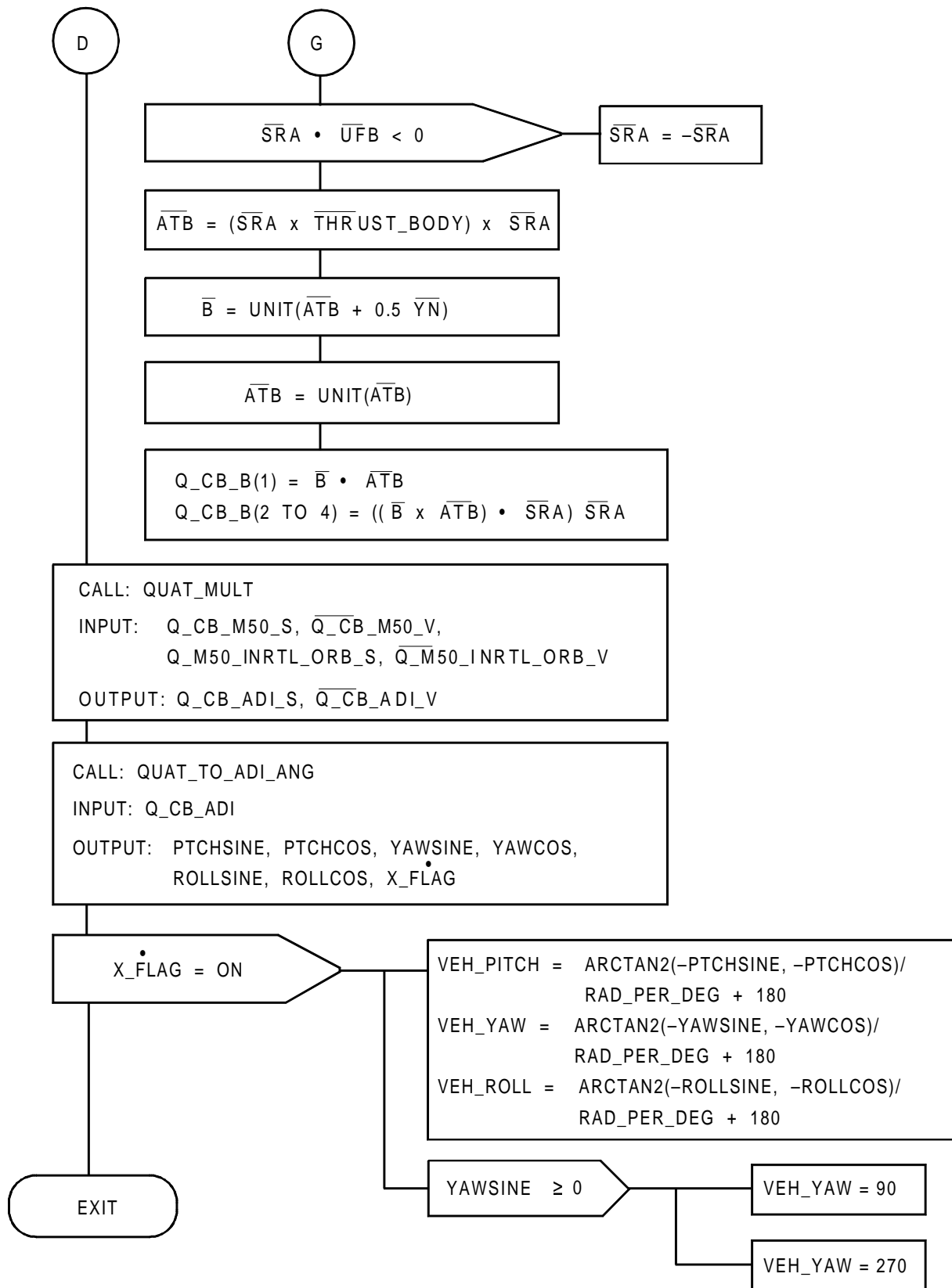


FIGURE A4.1.9.(5) CMD BDY ATT TSK (Sheet 5 of 5)

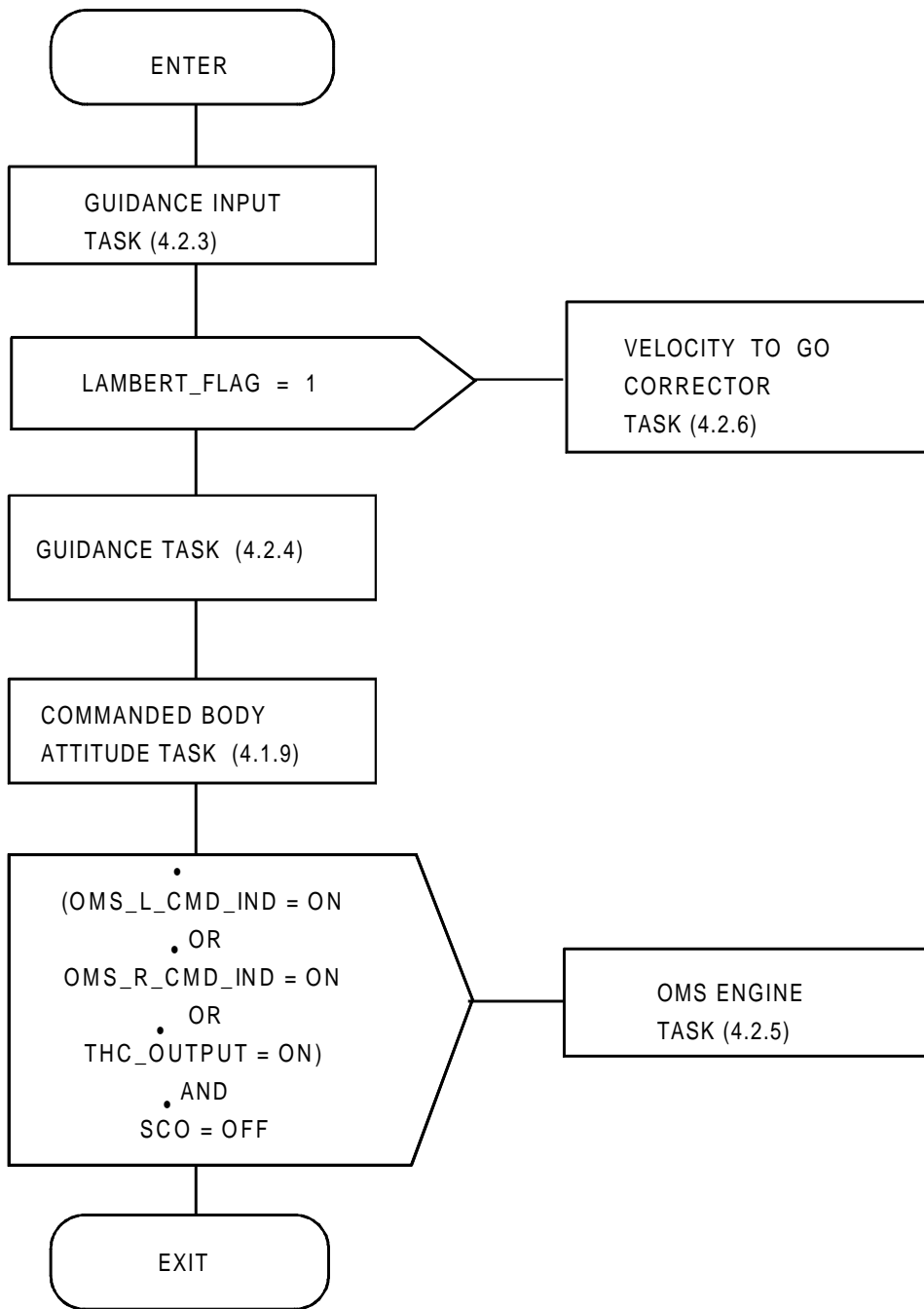


FIGURE A4.2.2. On-Orbit Guidance Sequencing Flowchart

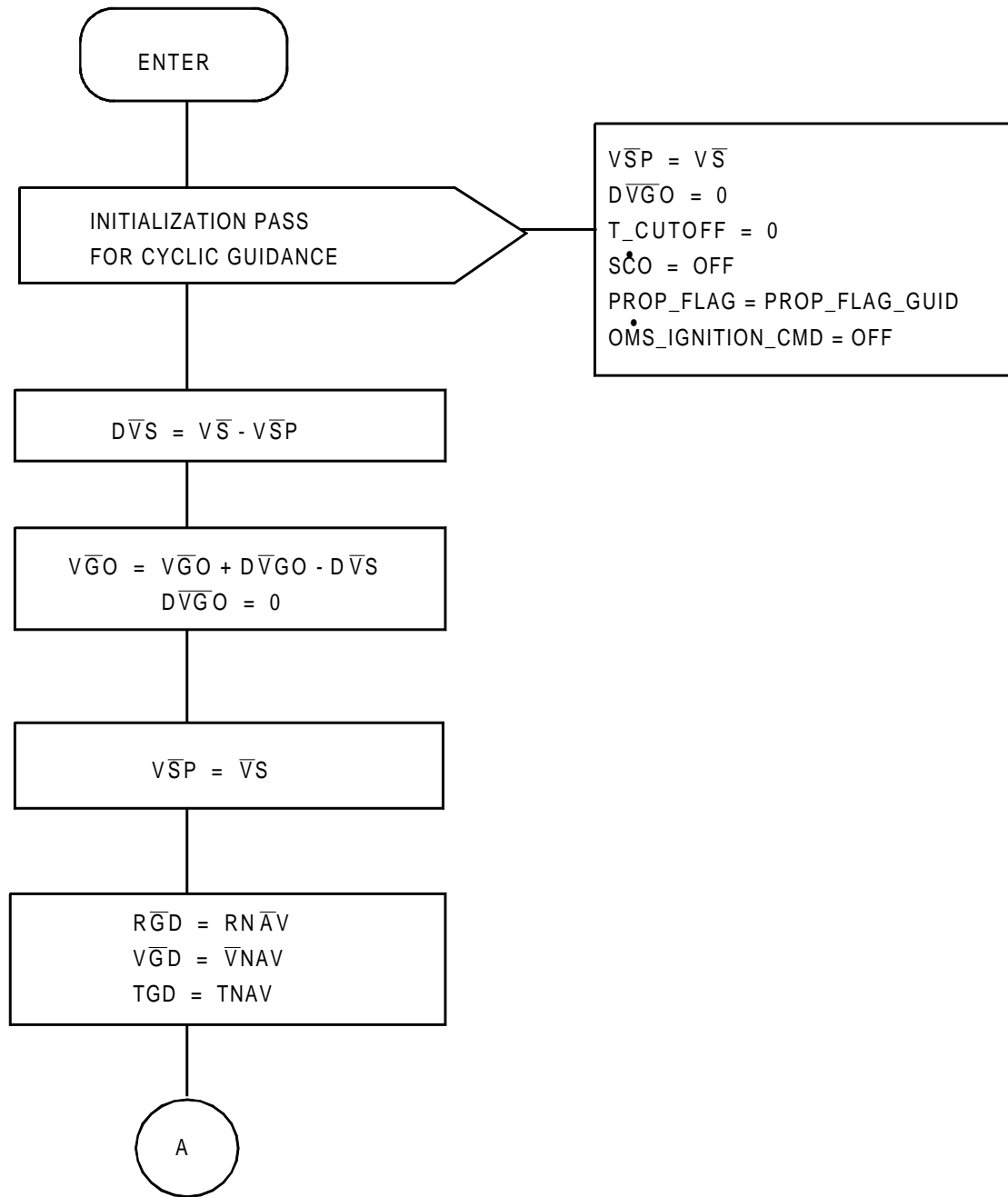


FIGURE A4.2.3.(1) GUID INP TSK (Sheet 1 of 2)

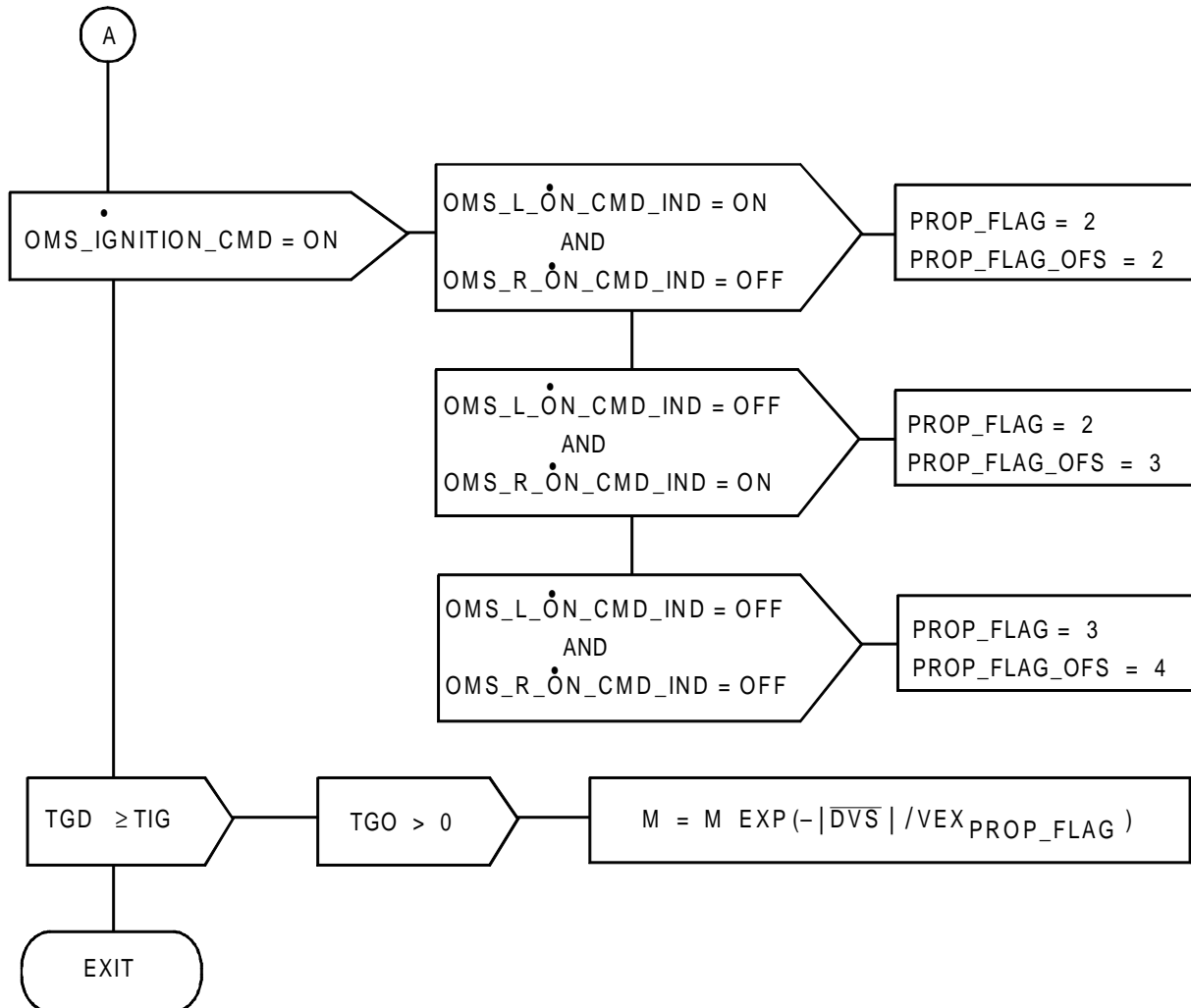


FIGURE A4.2.3.(2) GUID INP TSK (Sheet 2 of 2)

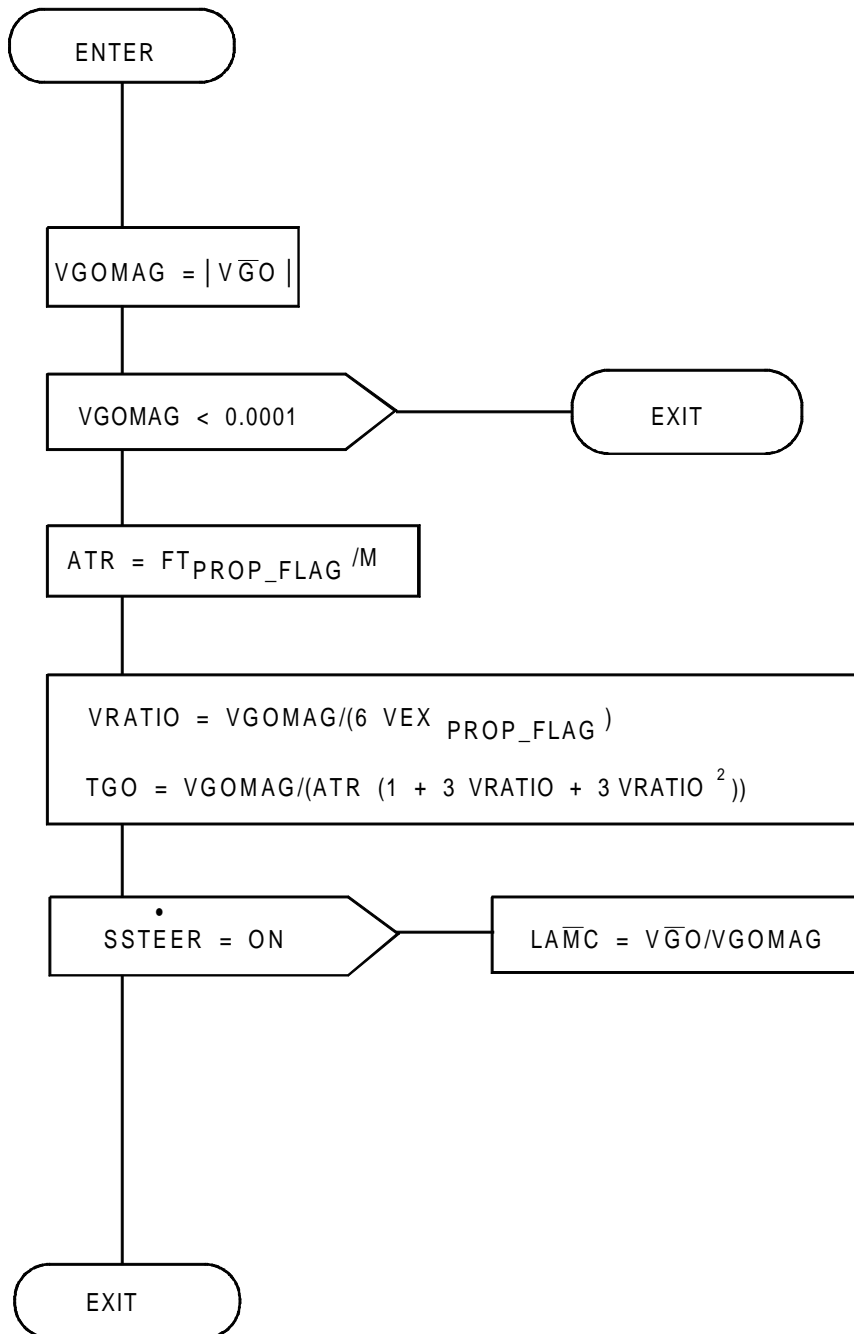


FIGURE A4.2.4. GUID TSK

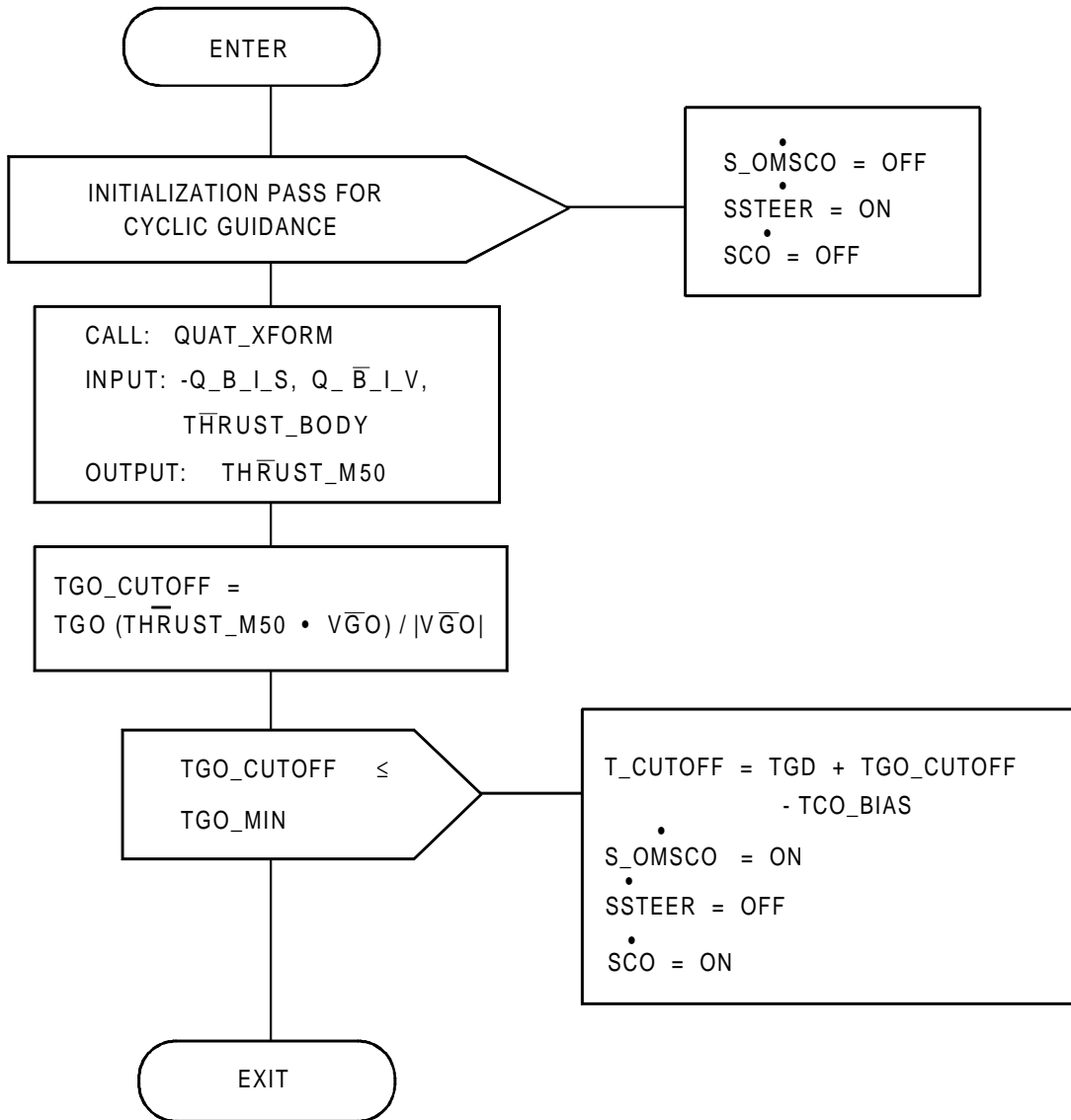


FIGURE A4.2.5. OMS TSK

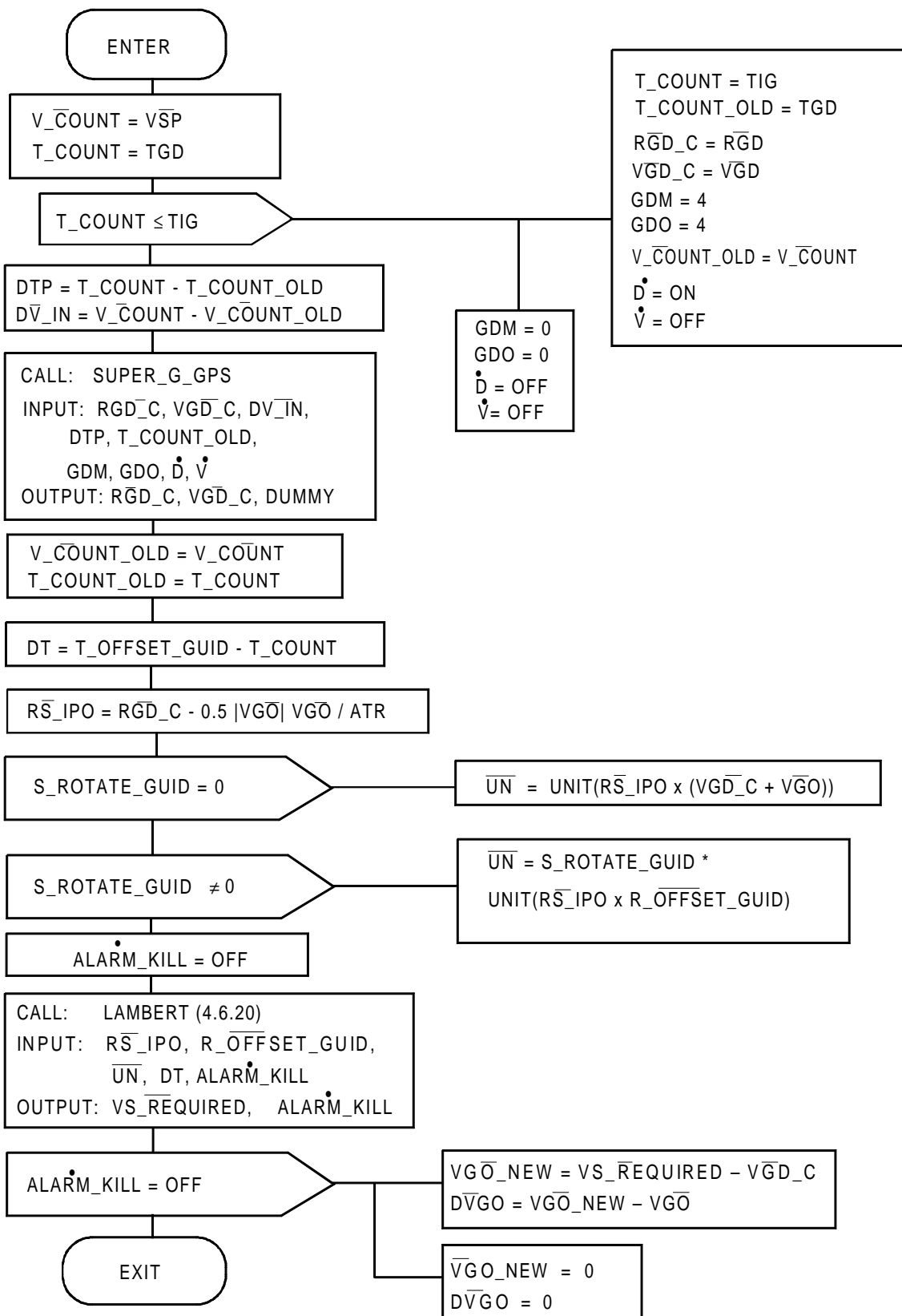


FIGURE A4.2.6. VGO CORR TSK

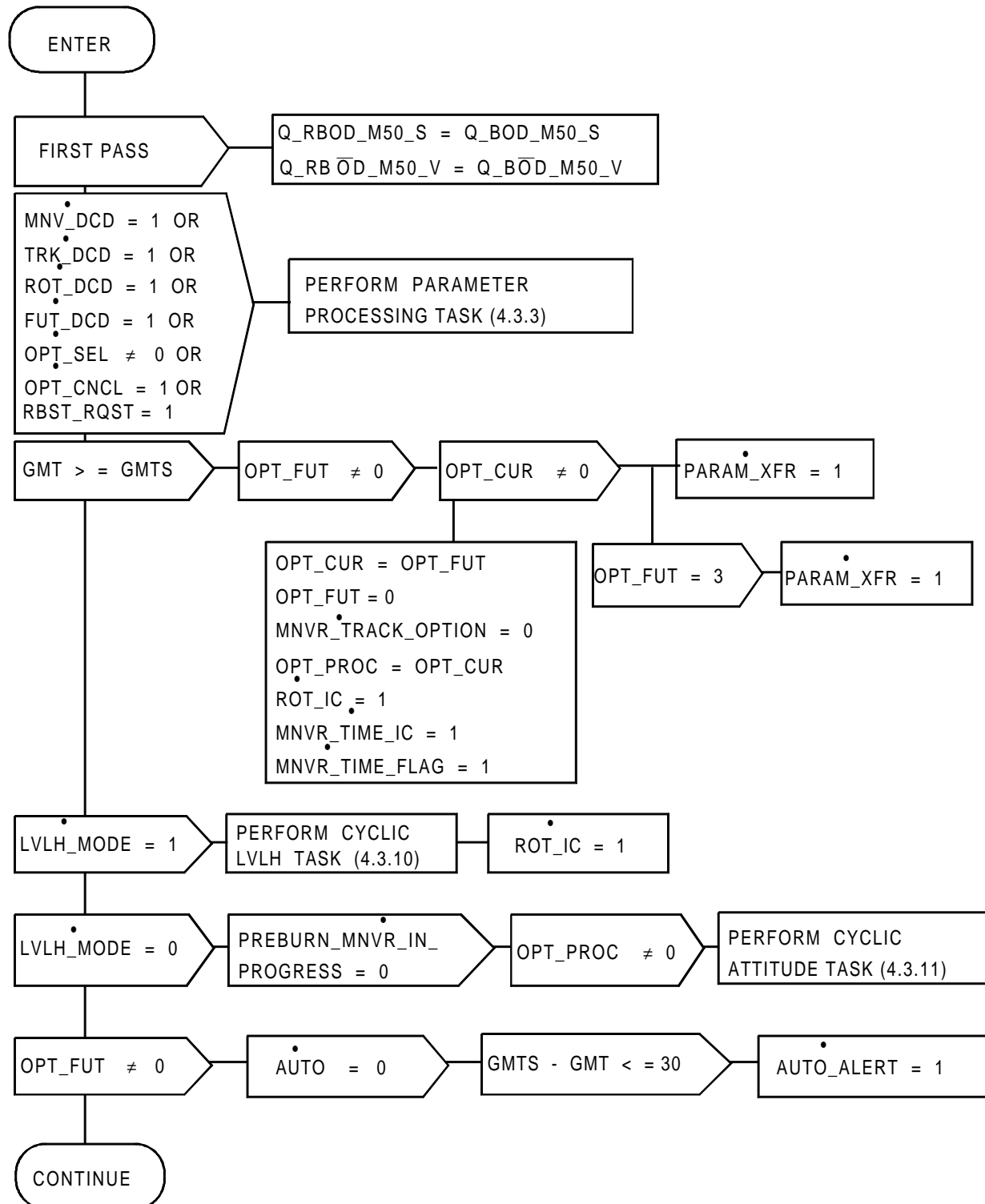


FIGURE A4.3.2.(1) Universal Pointing Processor Sequencing Task (Sheet 1 of 3)



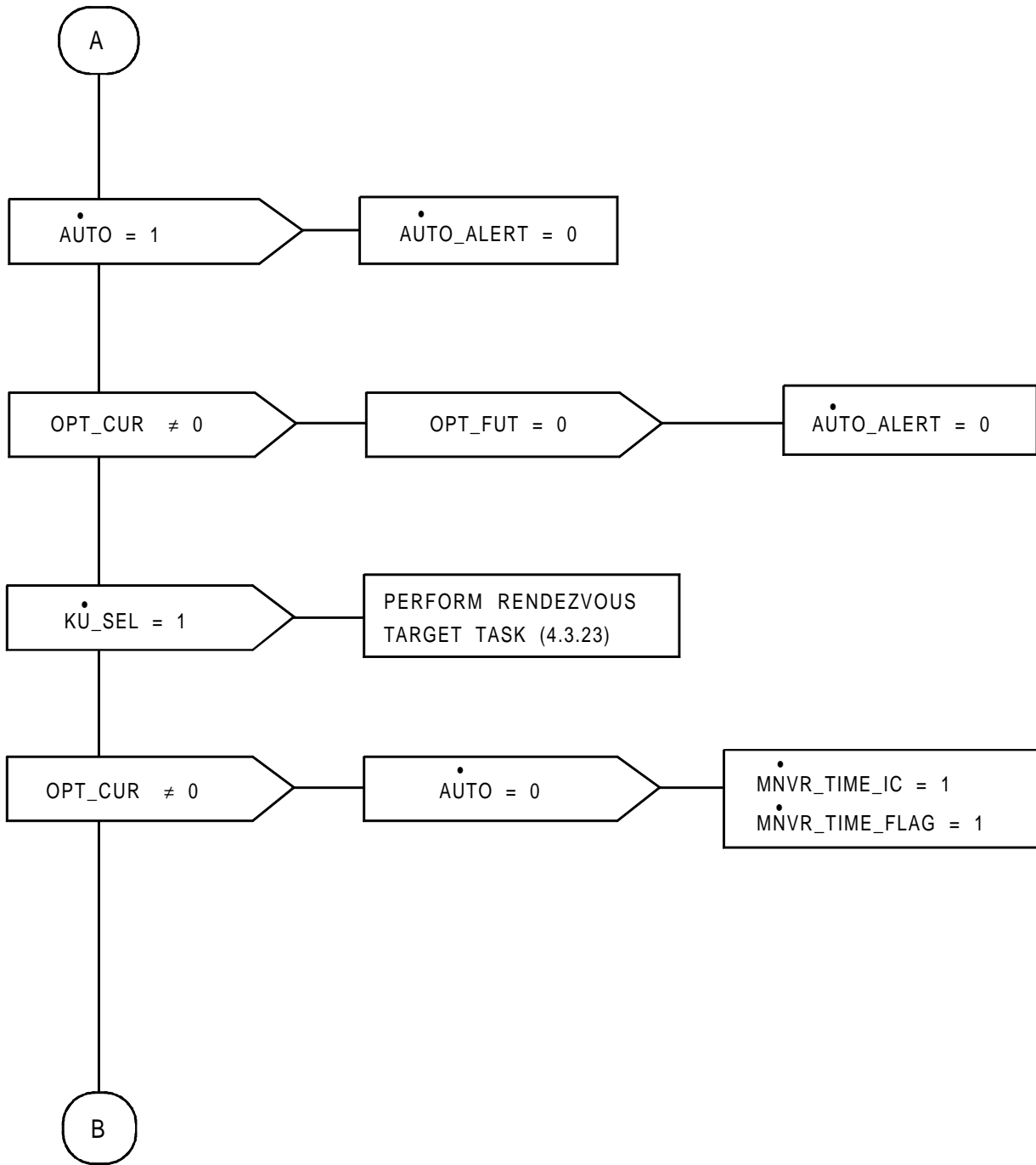


FIGURE A4.3.2.(2) Universal Pointing Processor Sequencing Task (Sheet 2 of 3)

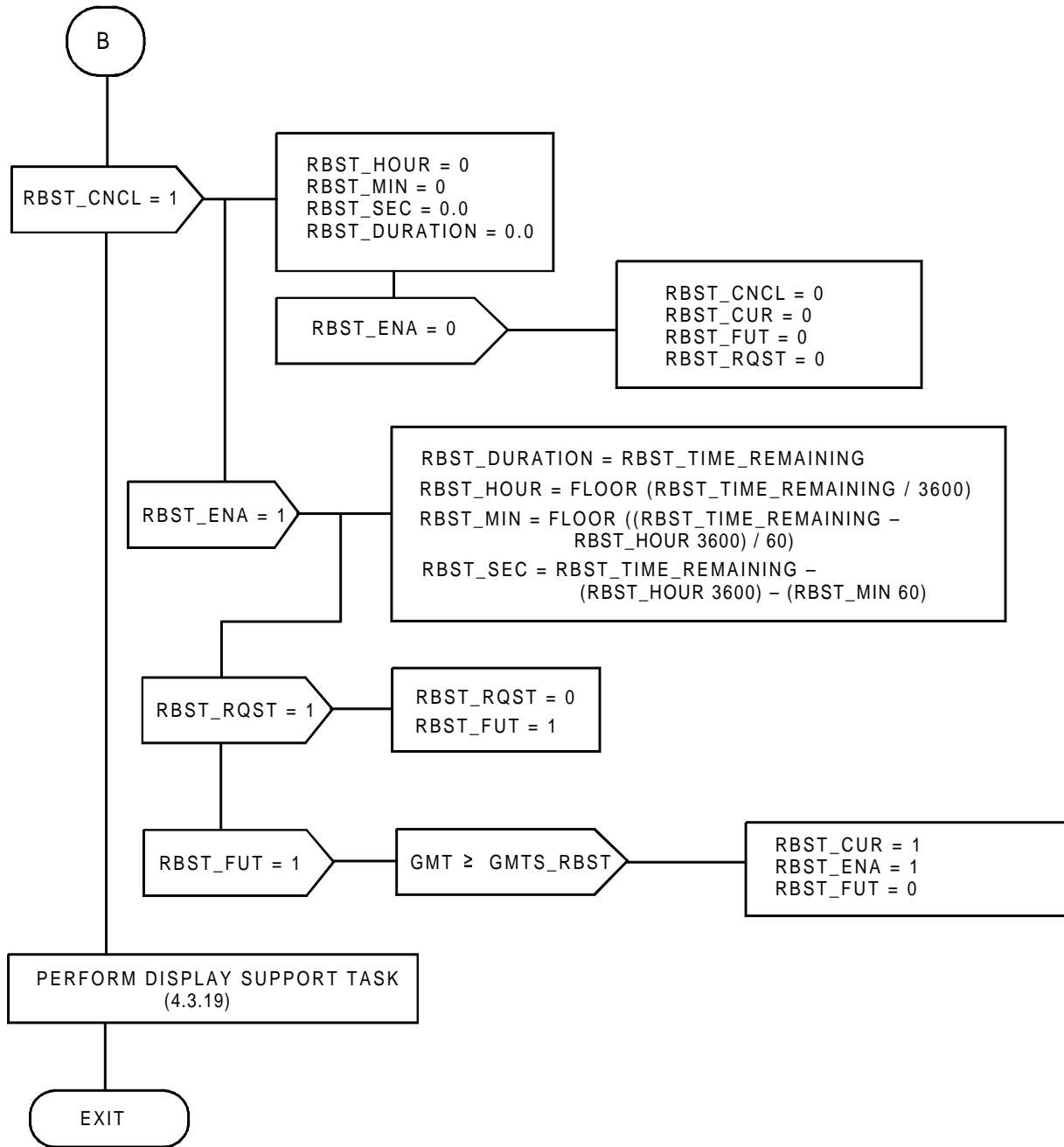


FIGURE A4.3.2.(3) Universal Pointing Processor Sequencing Task (Sheet 3 of 3)

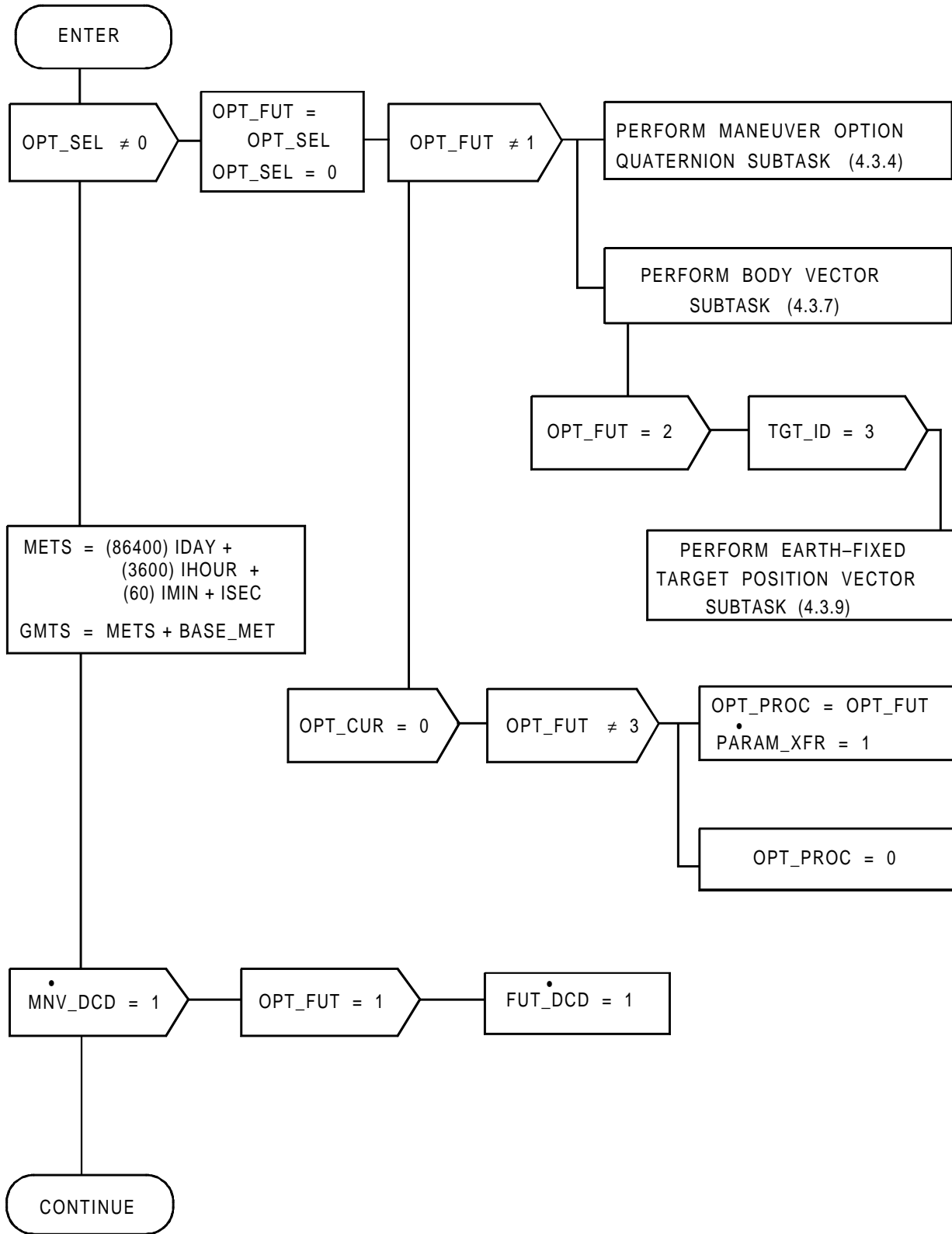


FIGURE A4.3.3.(1) Parameter Processing Task (Sheet 1 of 2)

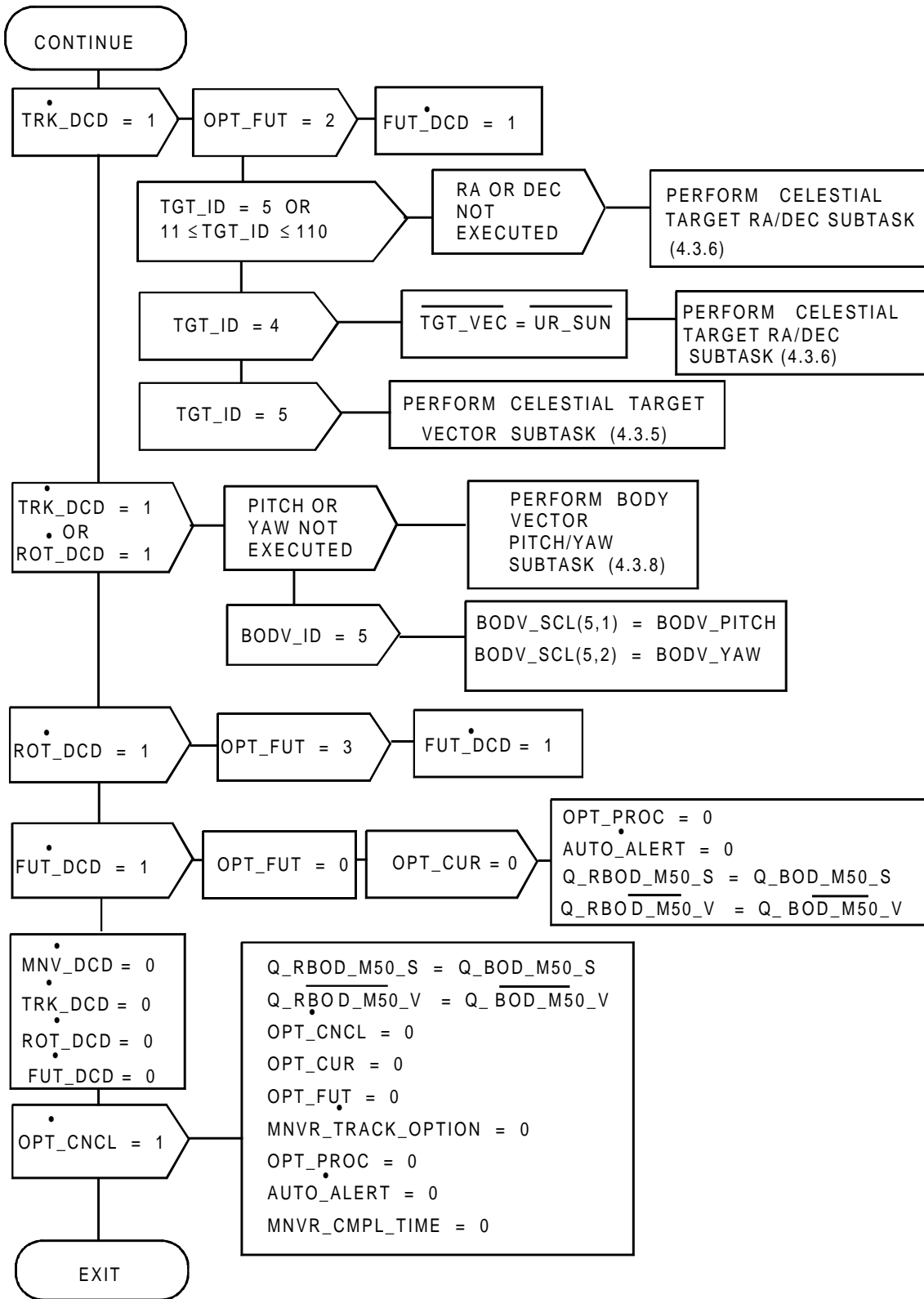


FIGURE A4.3.3.(2) Parameter Processing Task (Sheet 2 of 2)

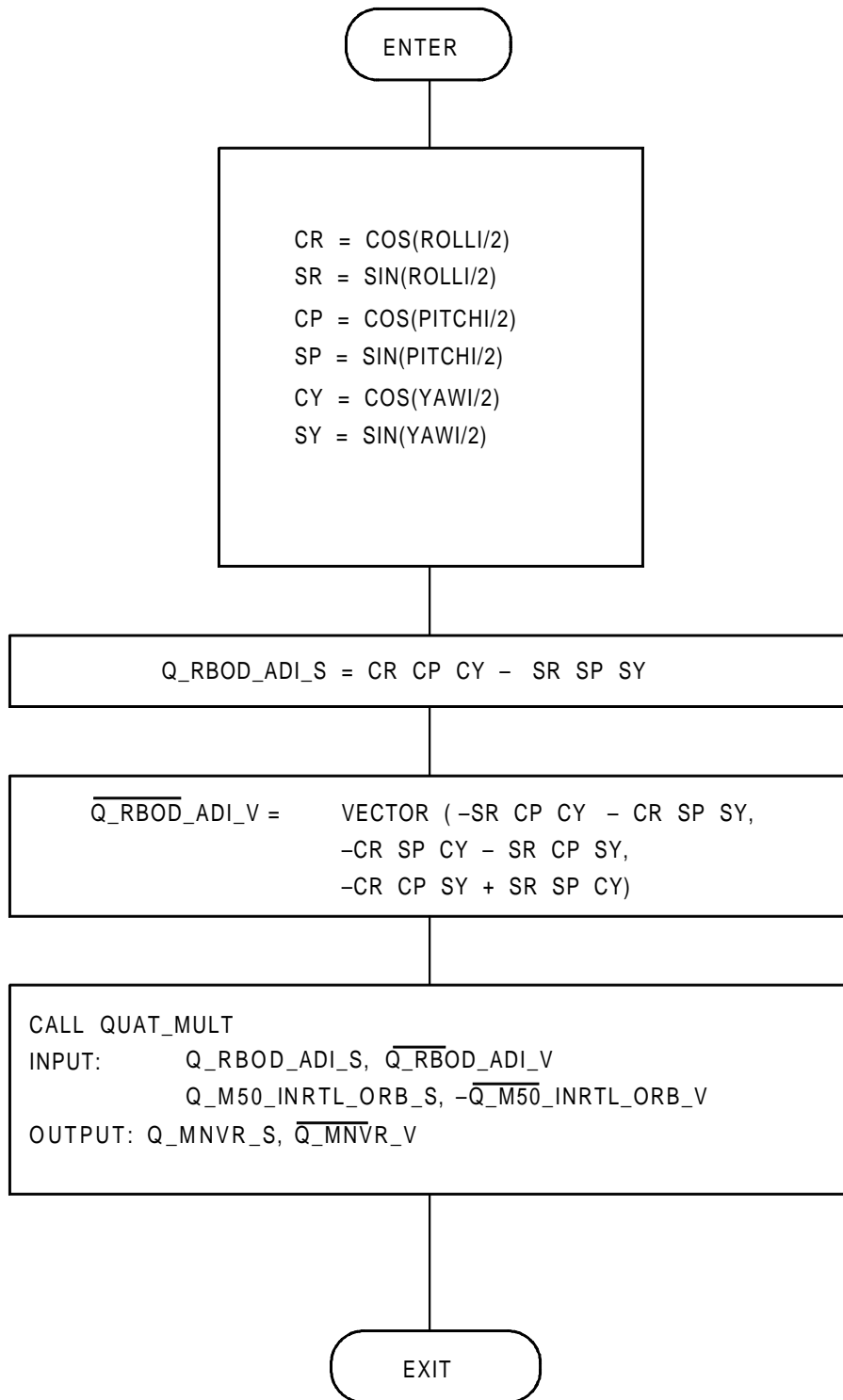


FIGURE A4.3.4. MNVR QUAT

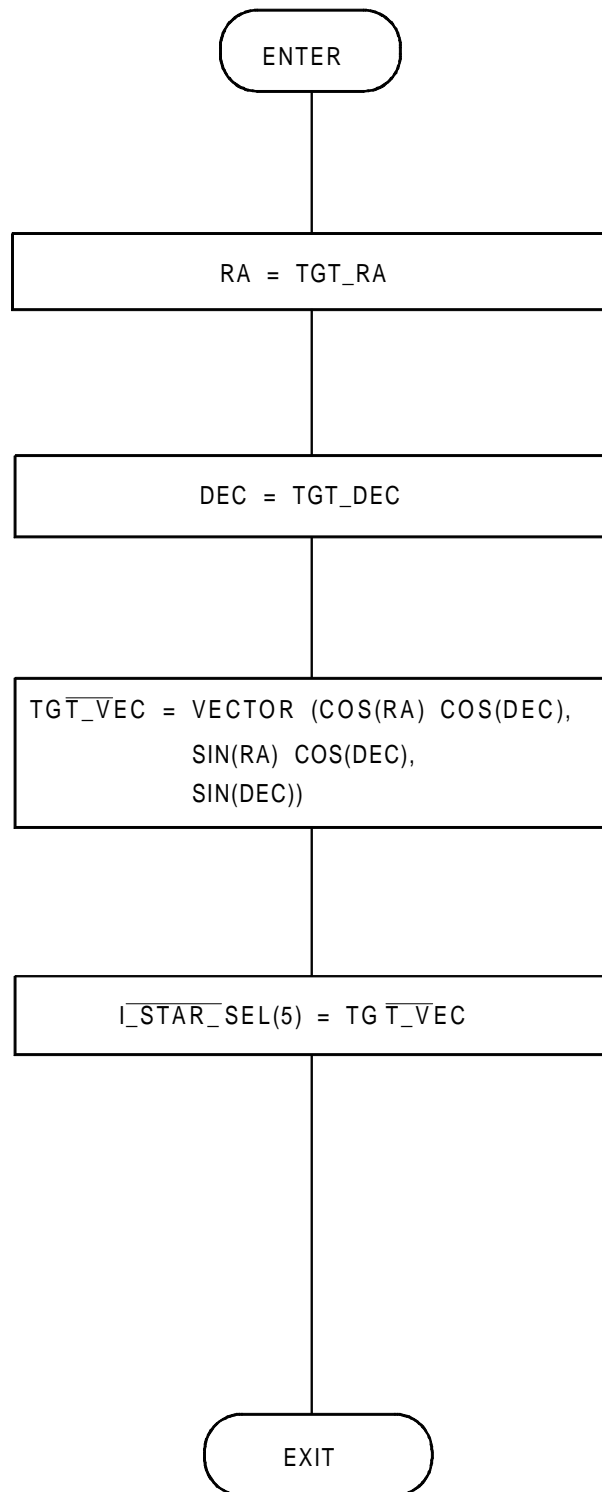


FIGURE A4.3.5. STAR

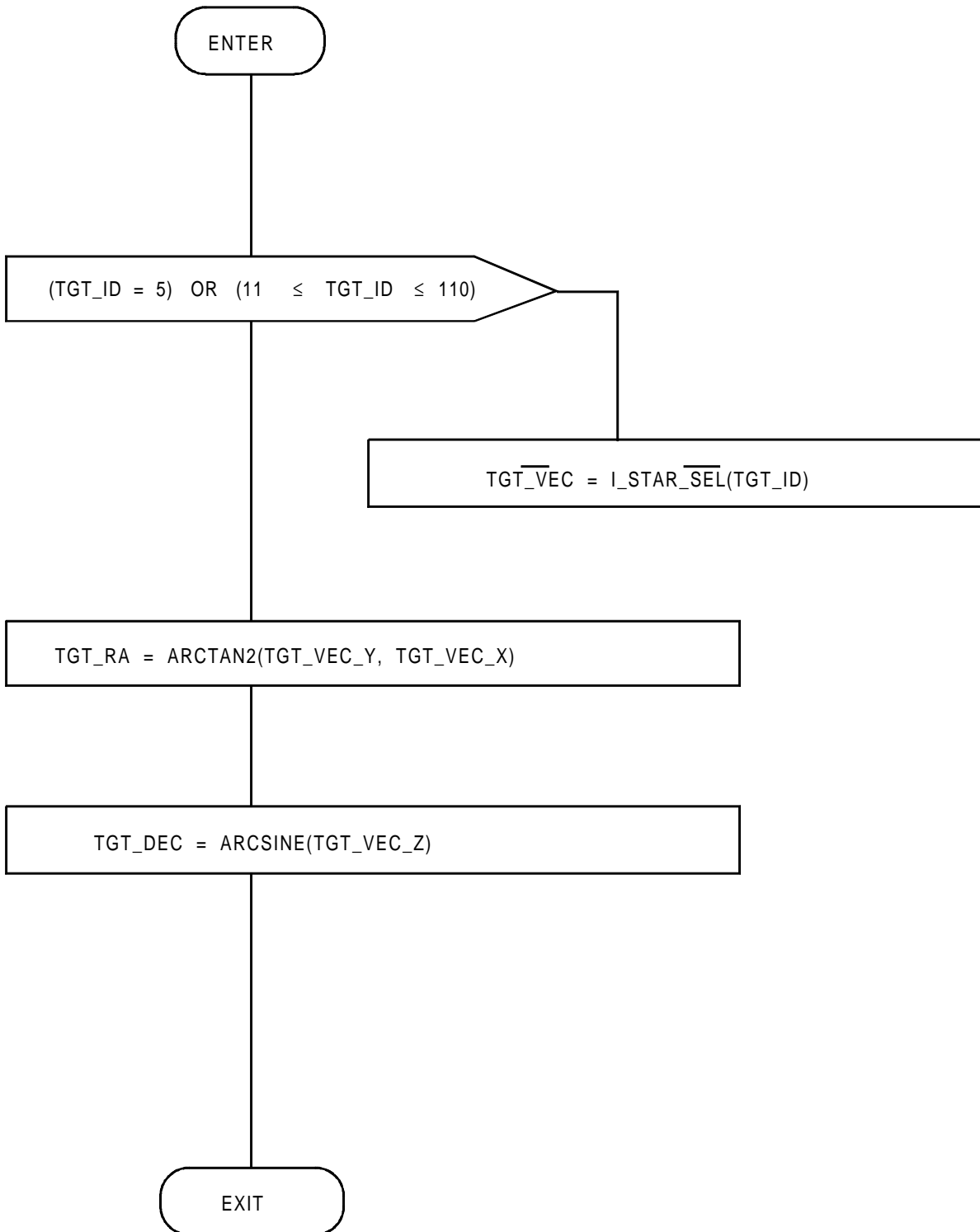


FIGURE A4.3.6. RA DEC

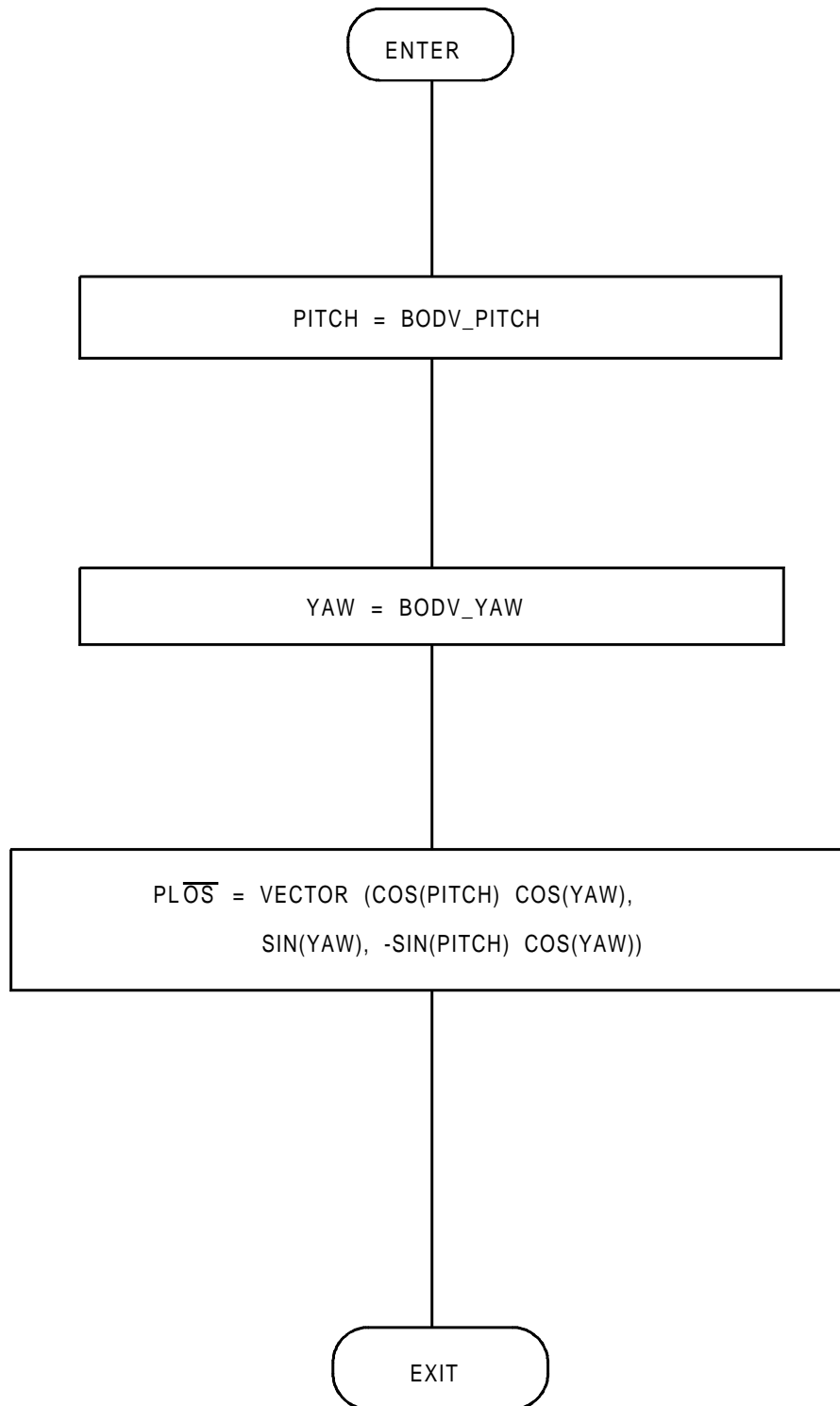


FIGURE A4.3.7. BODY VEC



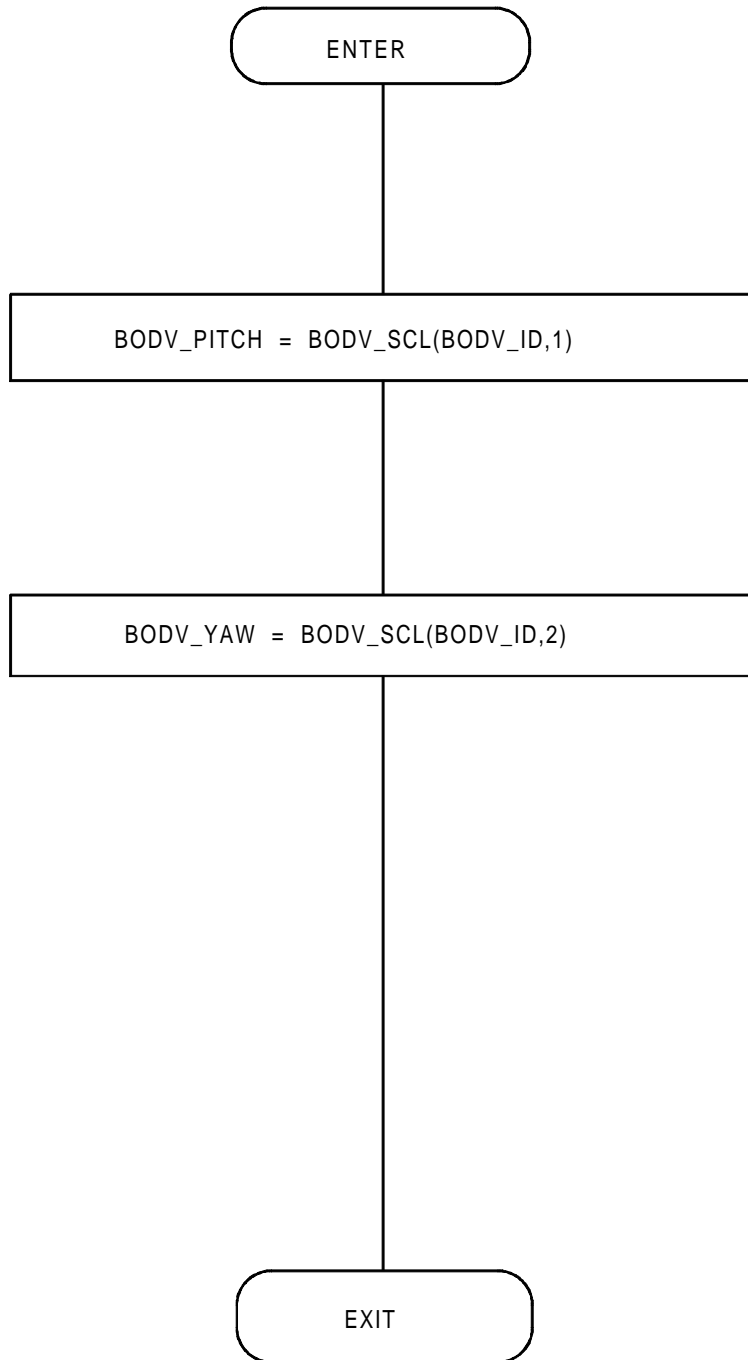


FIGURE A4.3.8. PY

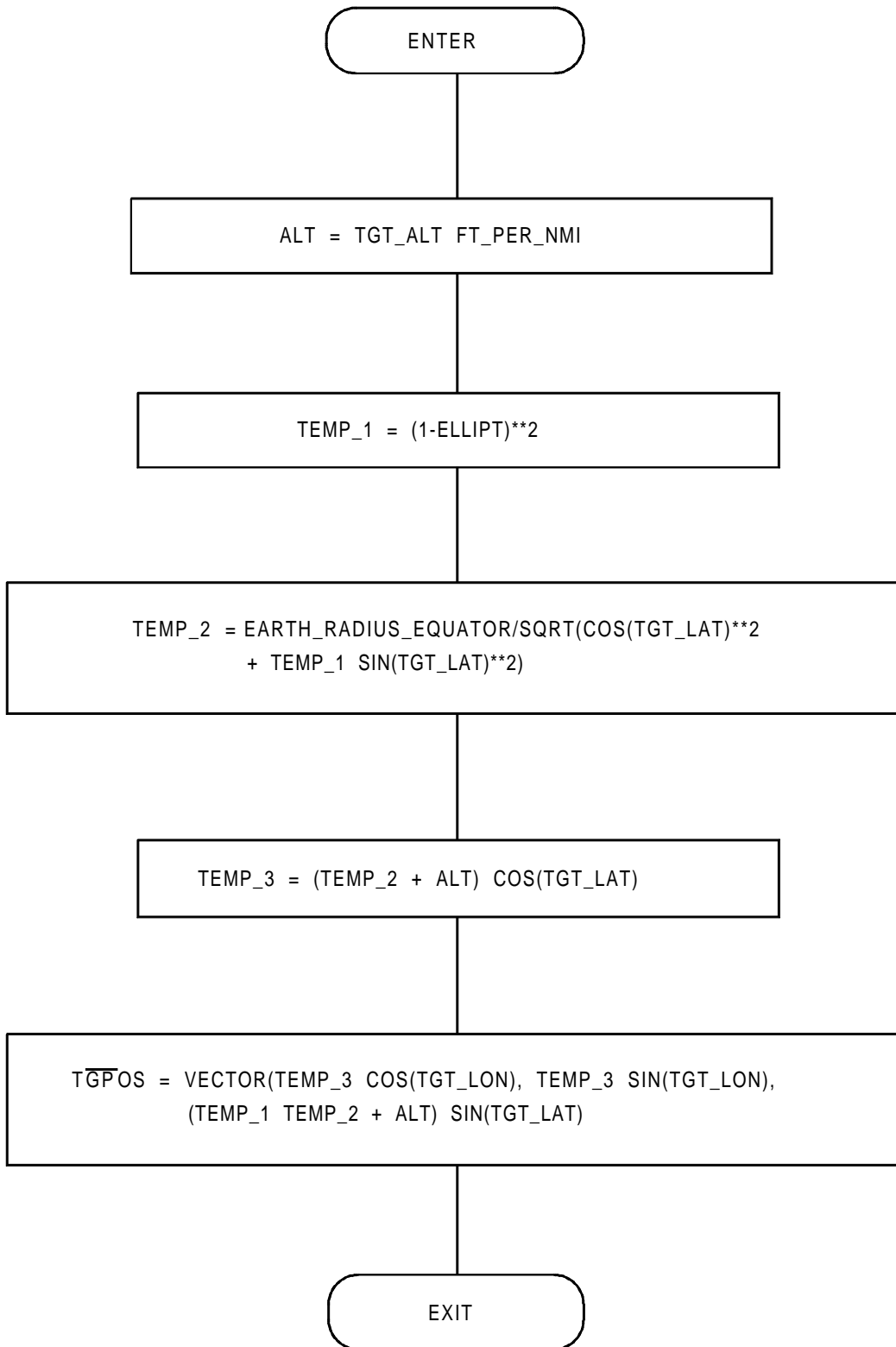


FIGURE A4.3.9. ETGT POS

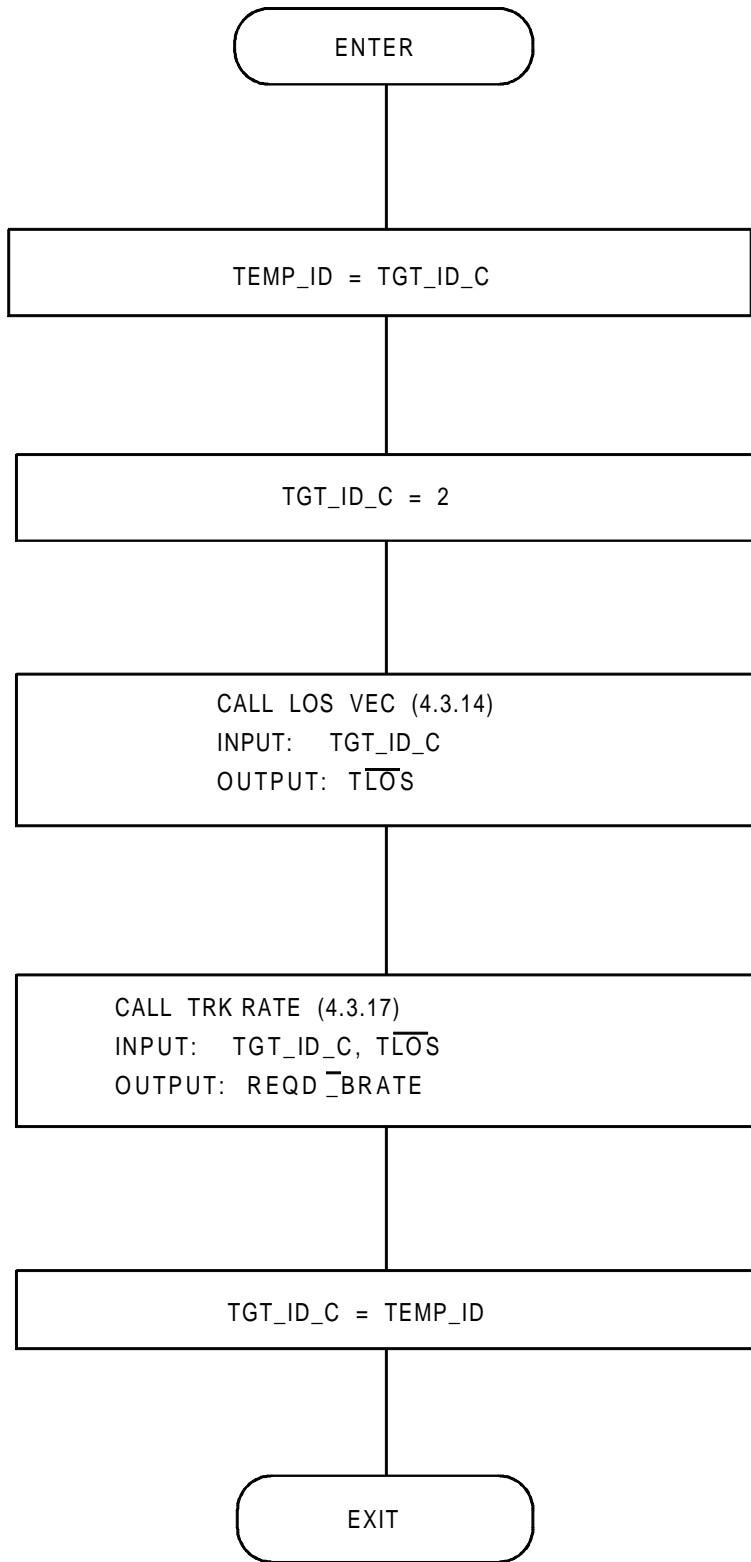


FIGURE A4.3.10. CYC LVLH

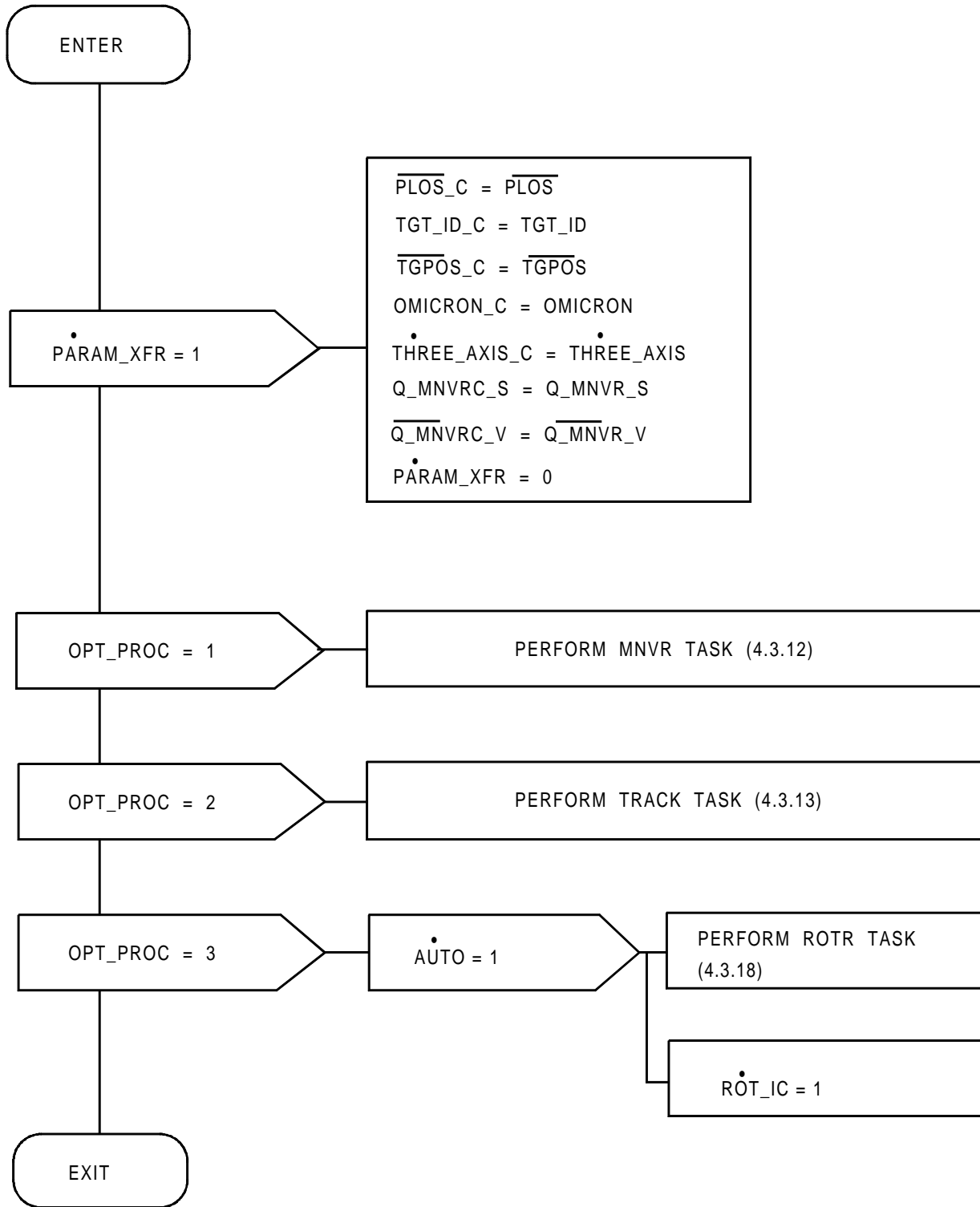


FIGURE A4.3.11. Cyclic Attitude Option Task

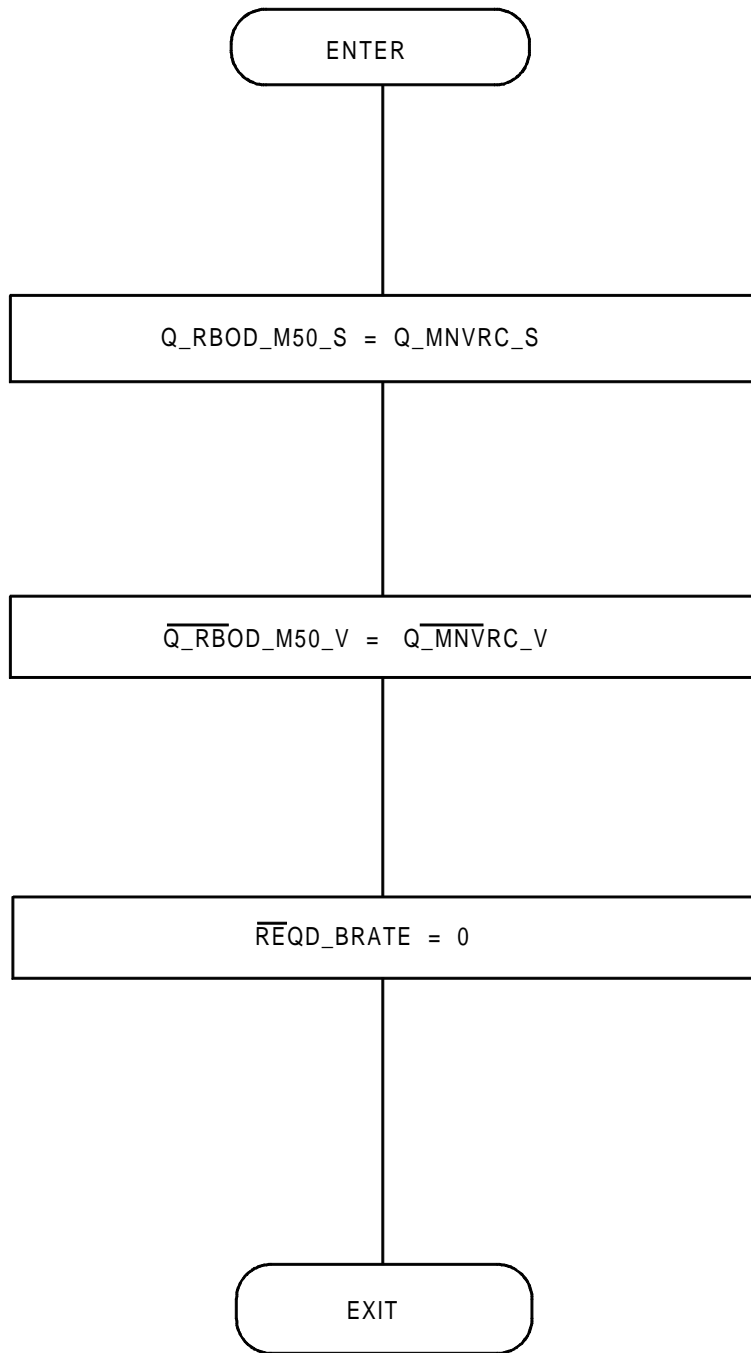


FIGURE A4.3.12. MNVR

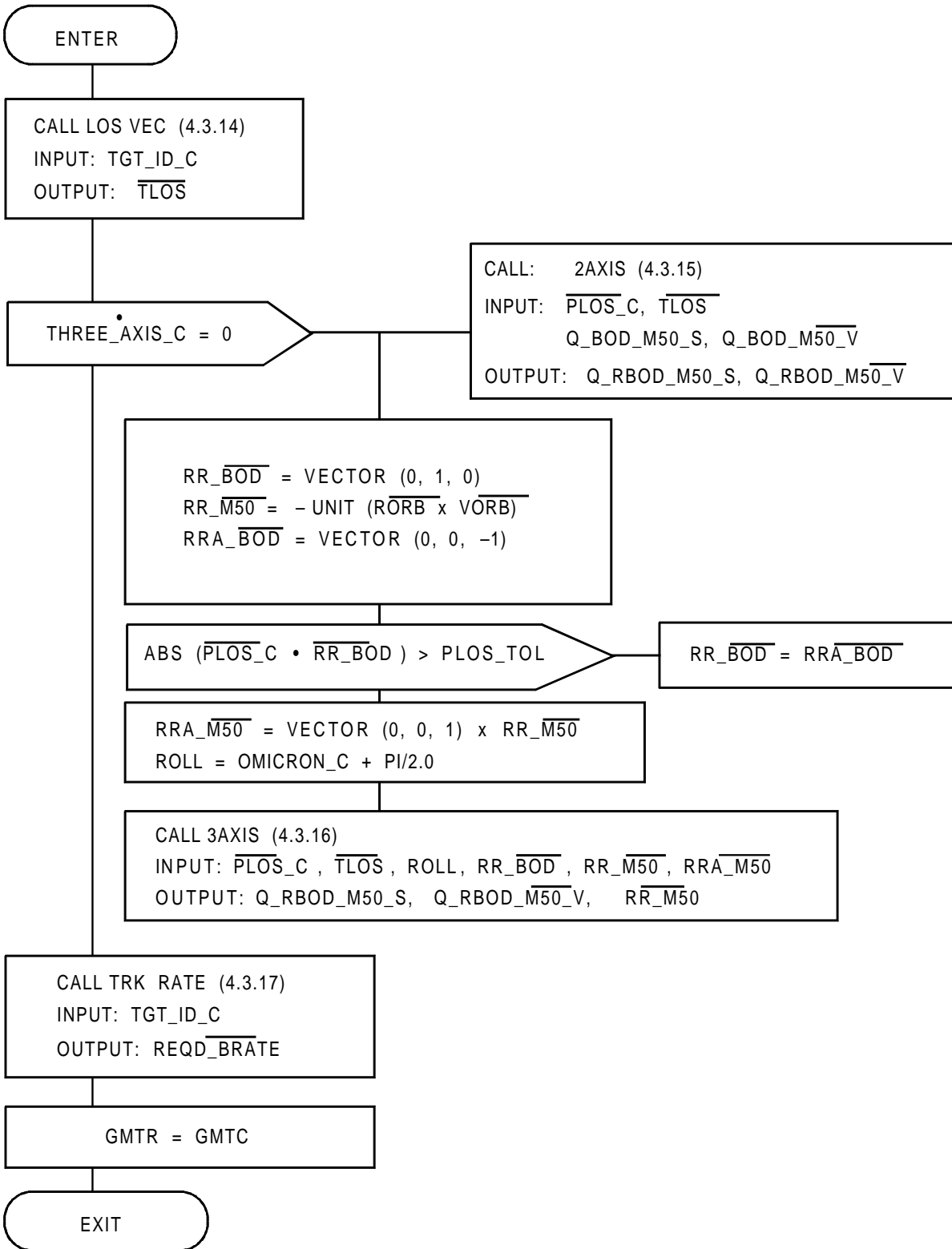


FIGURE A4.3.13. Universal Pointing Processor Tracking Task

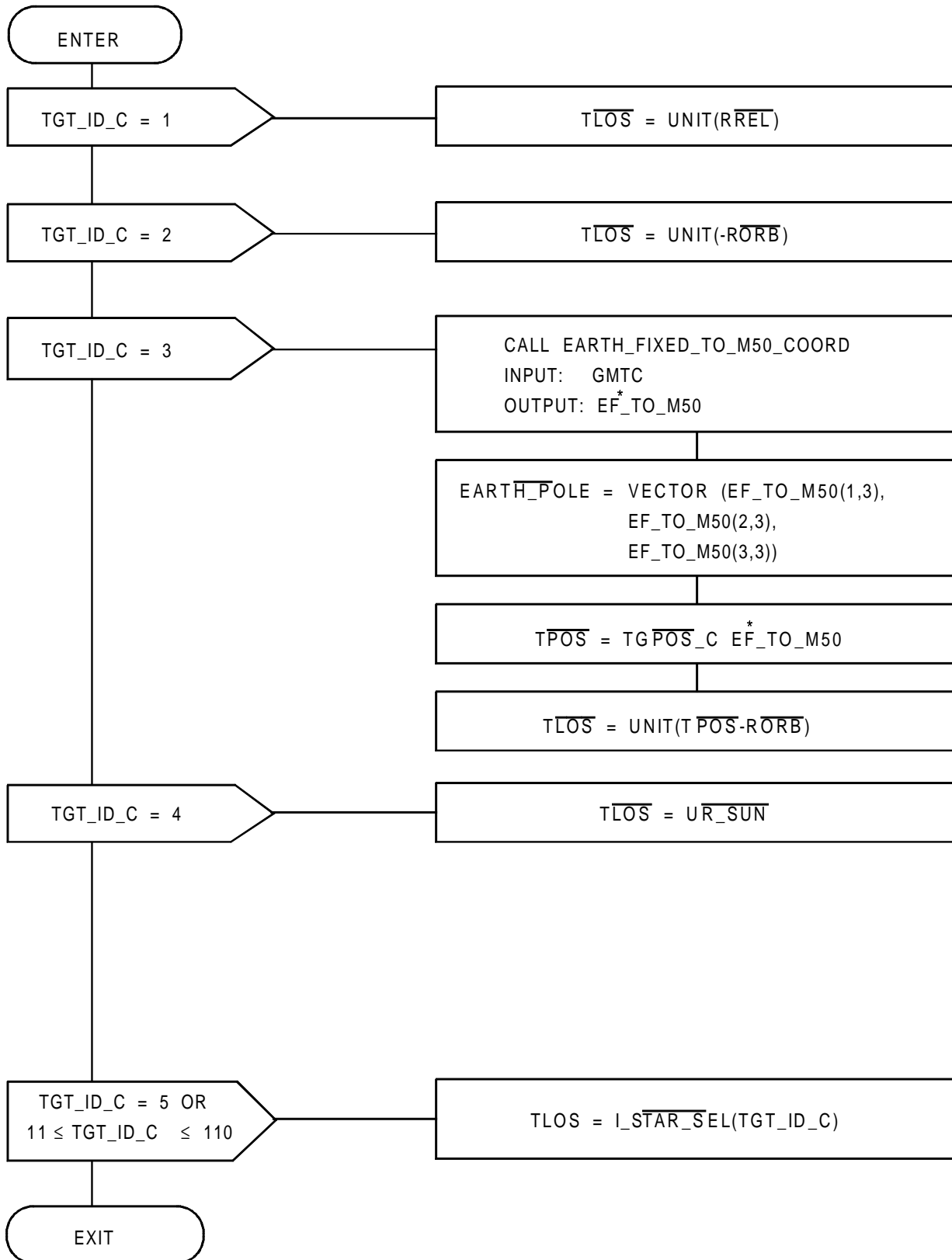


FIGURE A4.3.14. LOS VEC

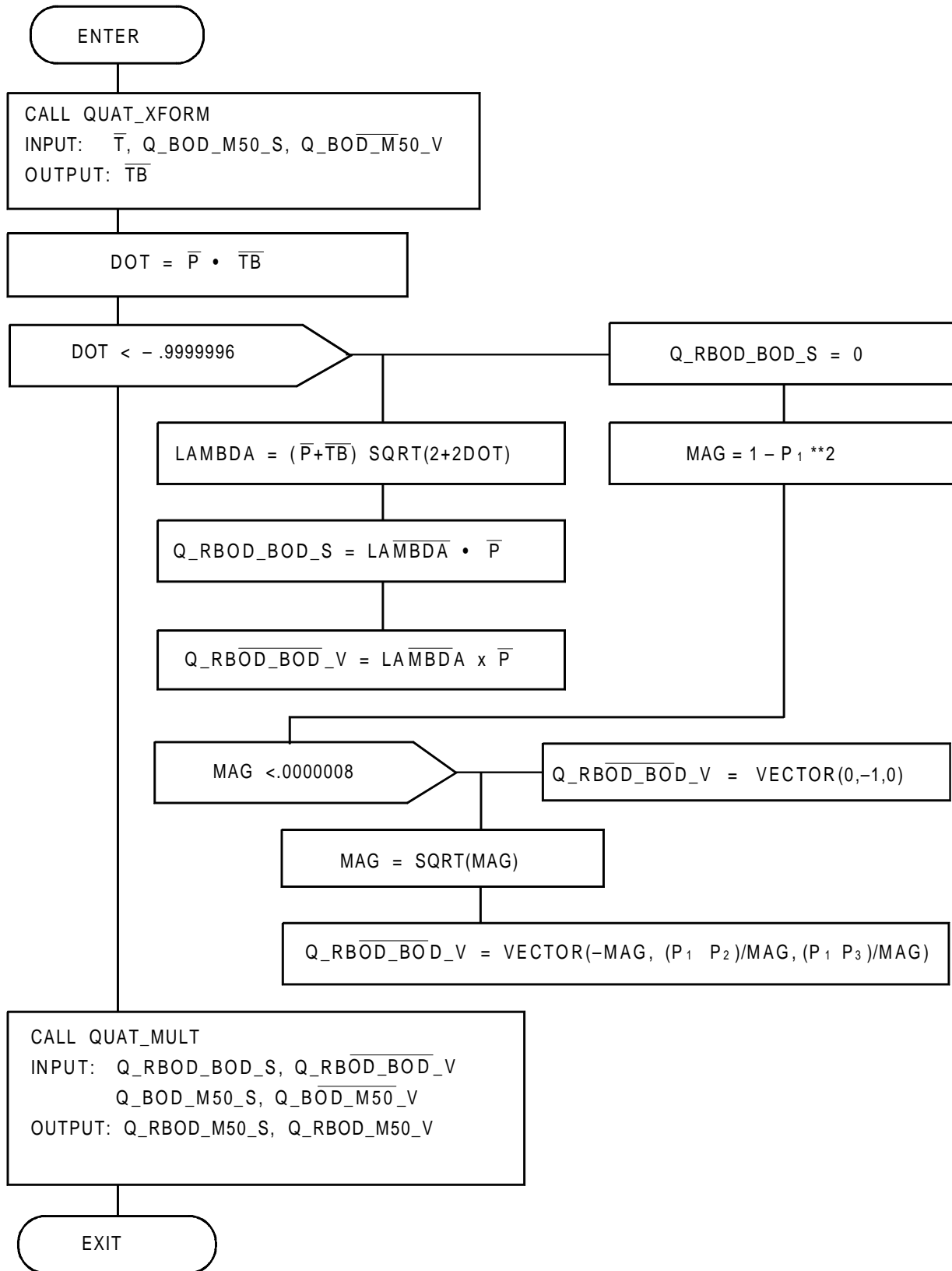


FIGURE A4.3.15. 2AXIS



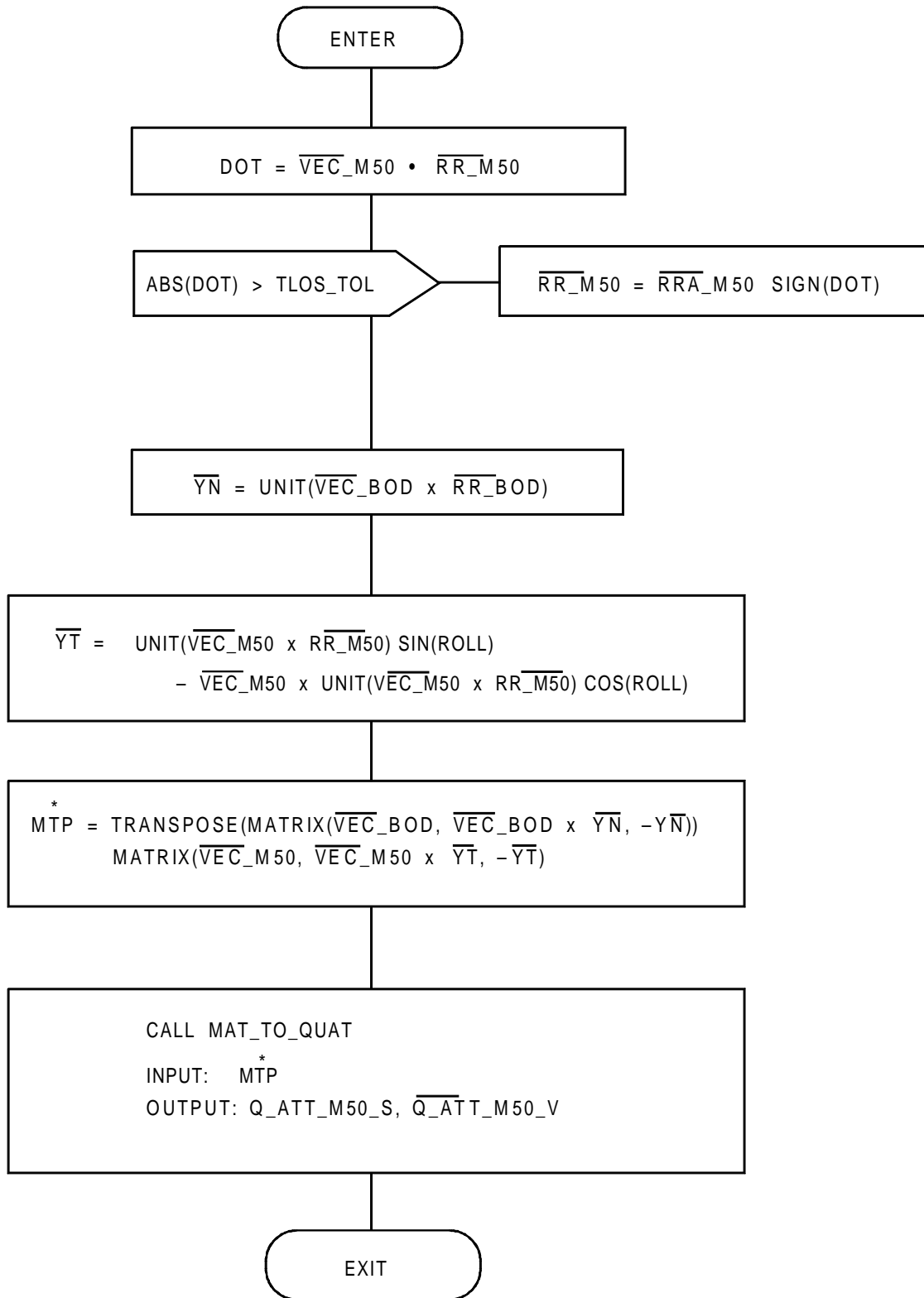


FIGURE A4.3.16. 3AXIS

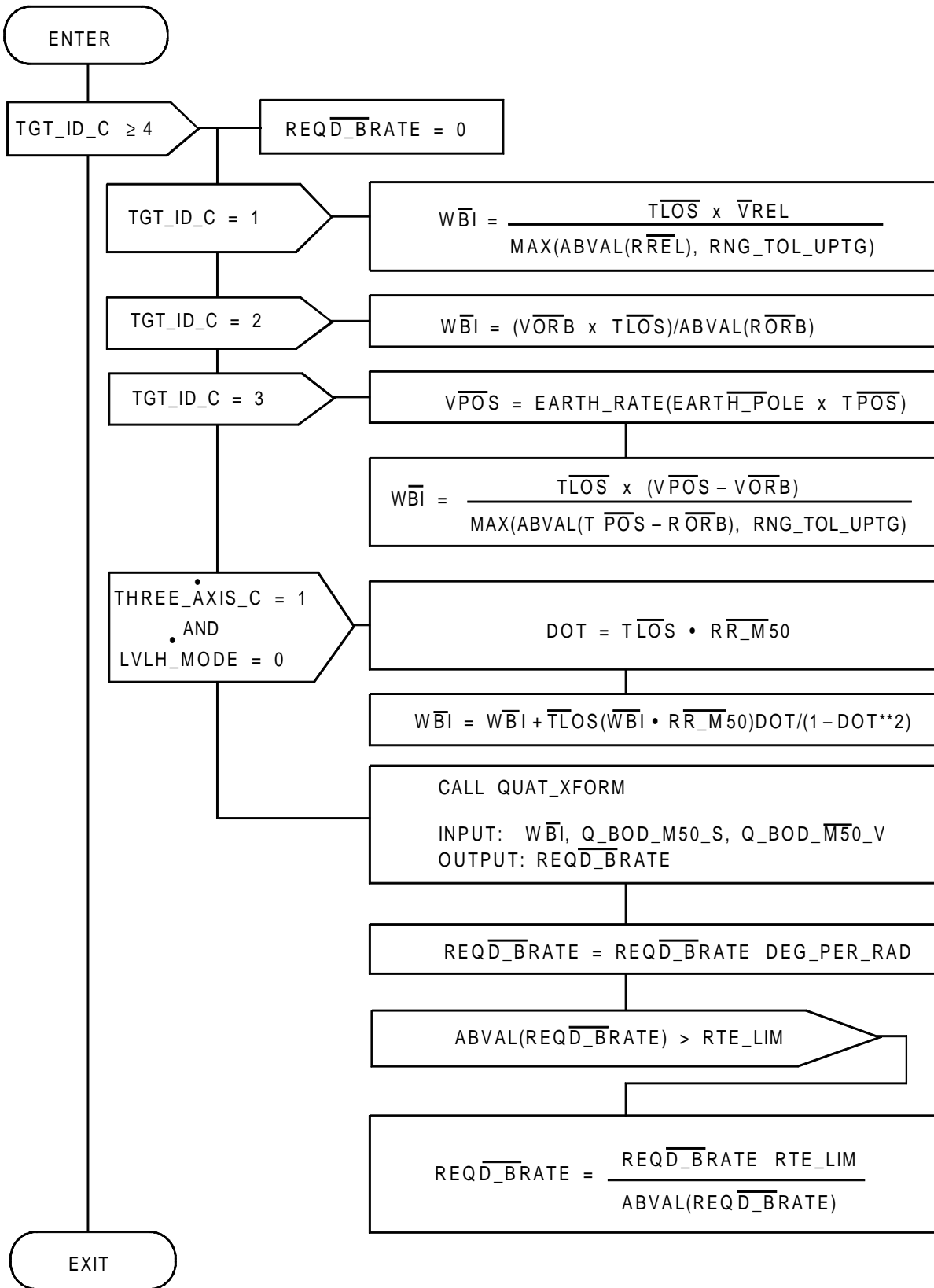


FIGURE A4.3.17. TRK RATE

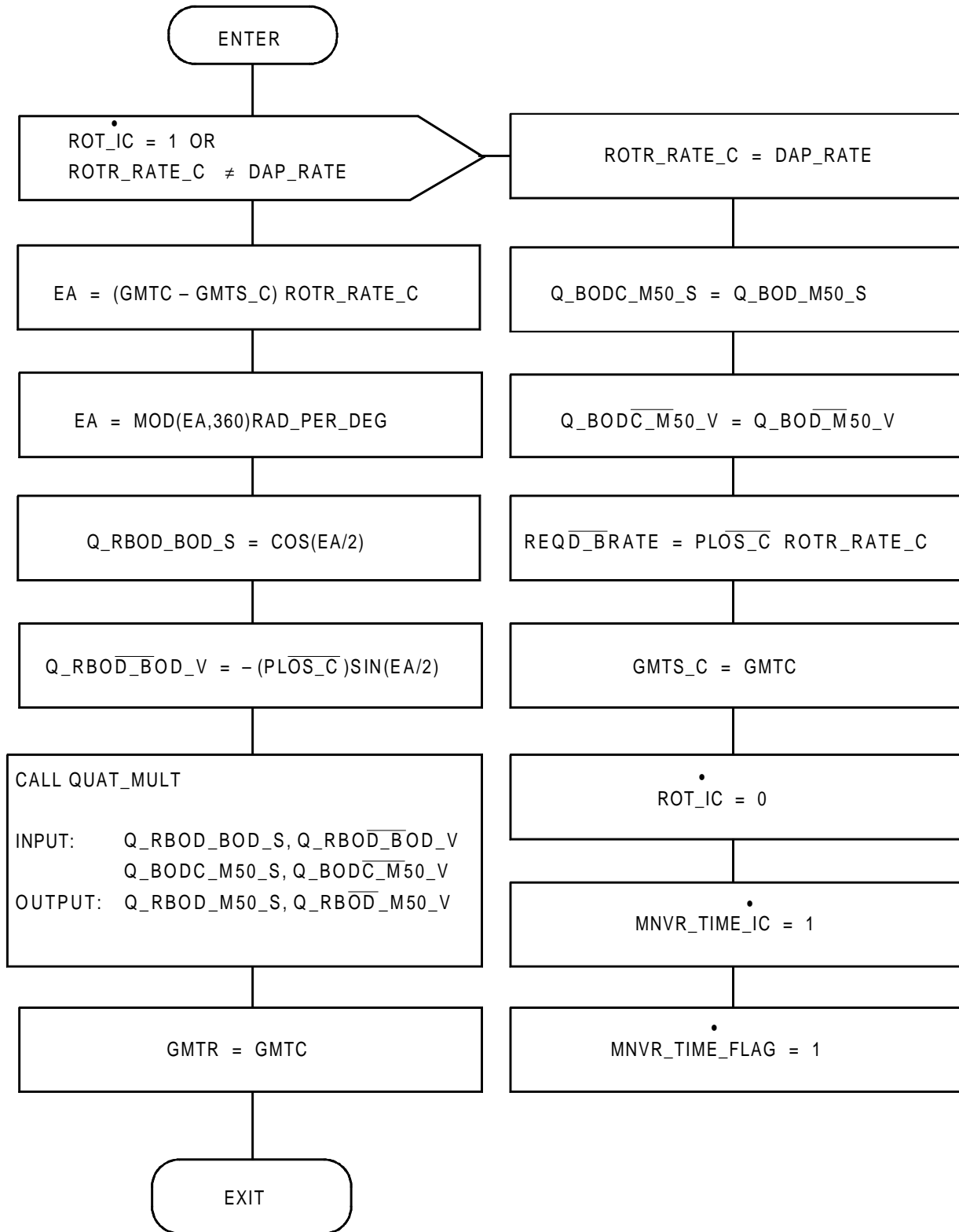


FIGURE A4.3.18. ROTR

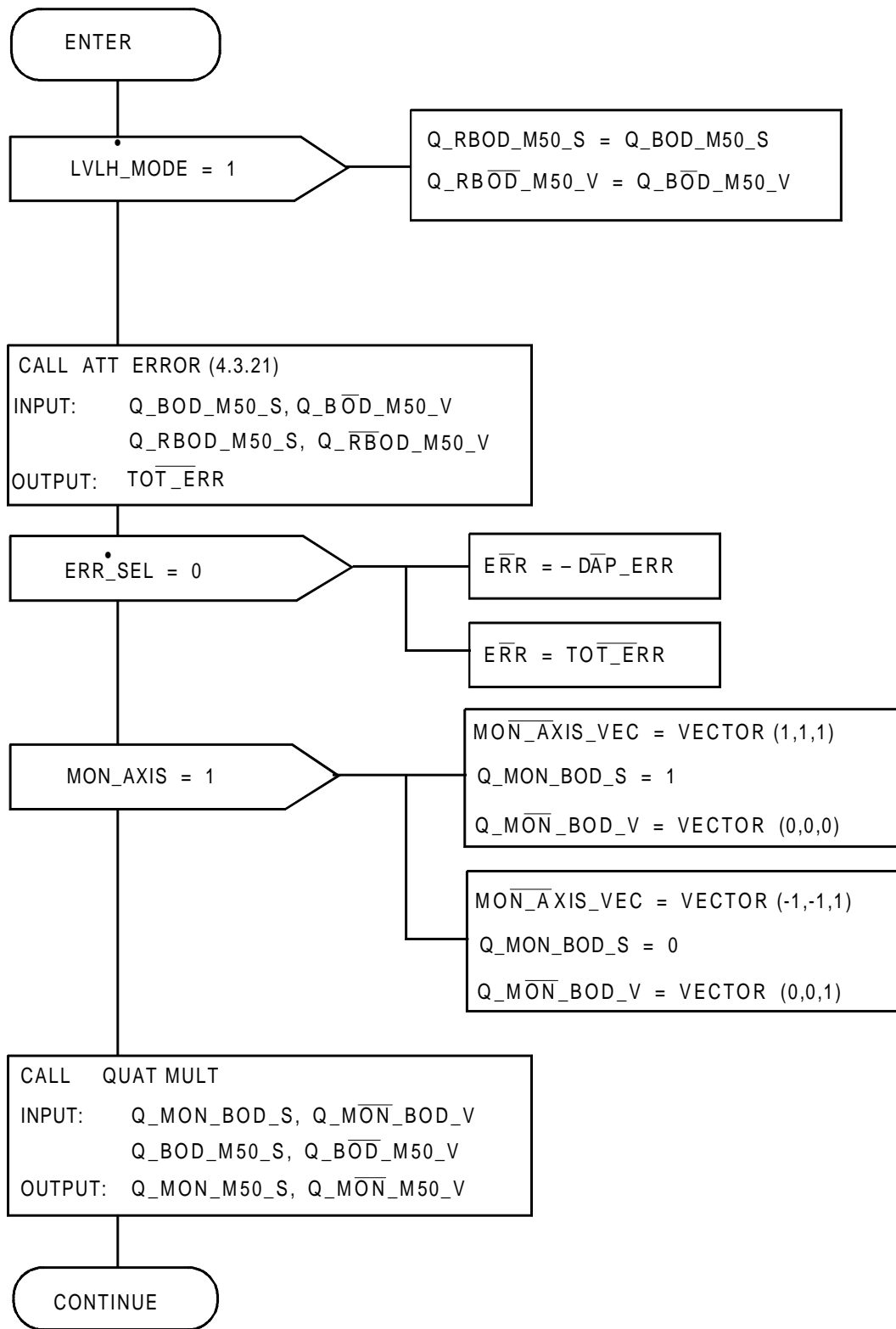


FIGURE A4.3.19.(1) Display Support Task (Sheet 1 of 2)

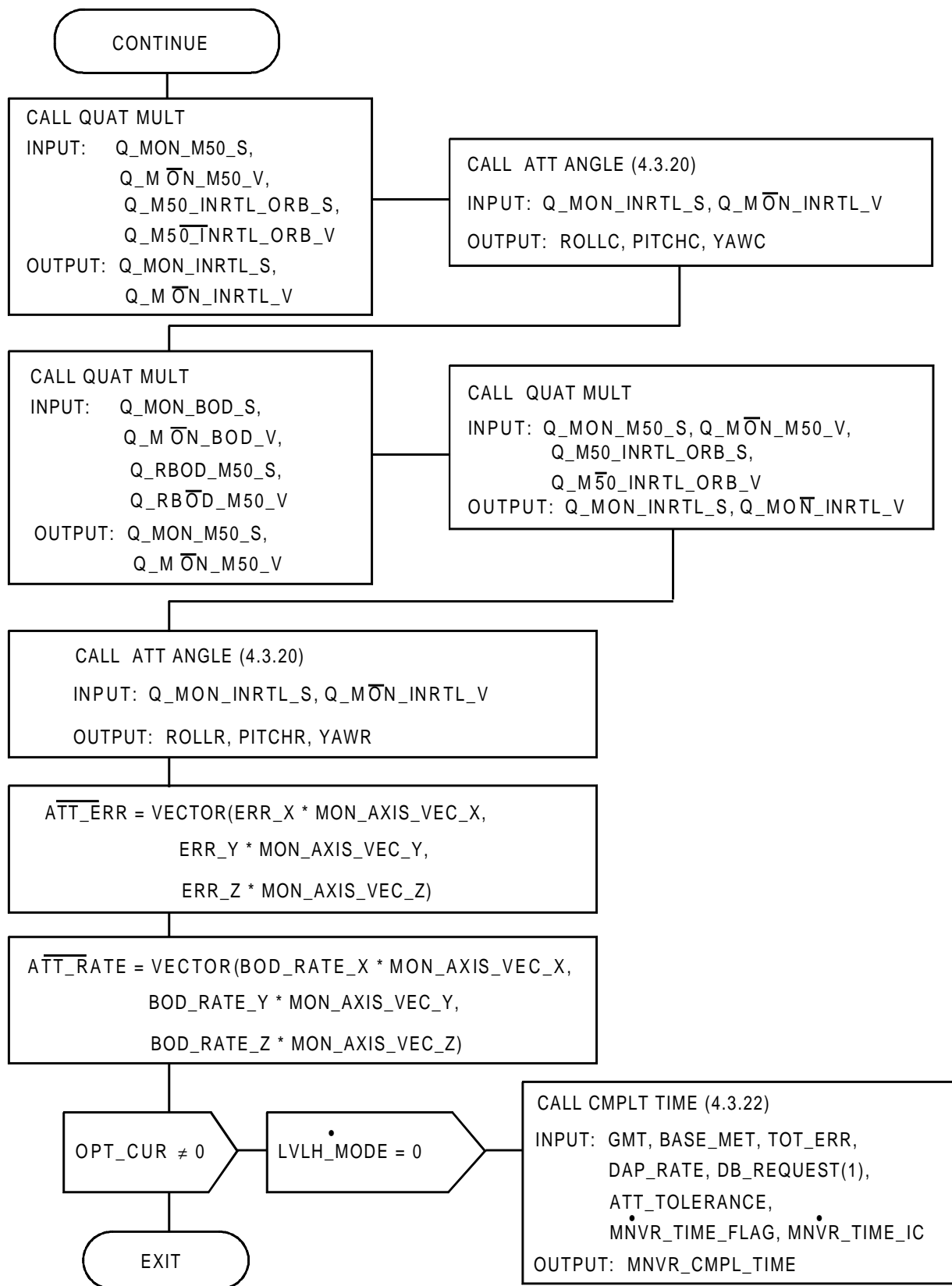


FIGURE A4.3.19.(2) Display Support Task (Sheet 2 of 2)

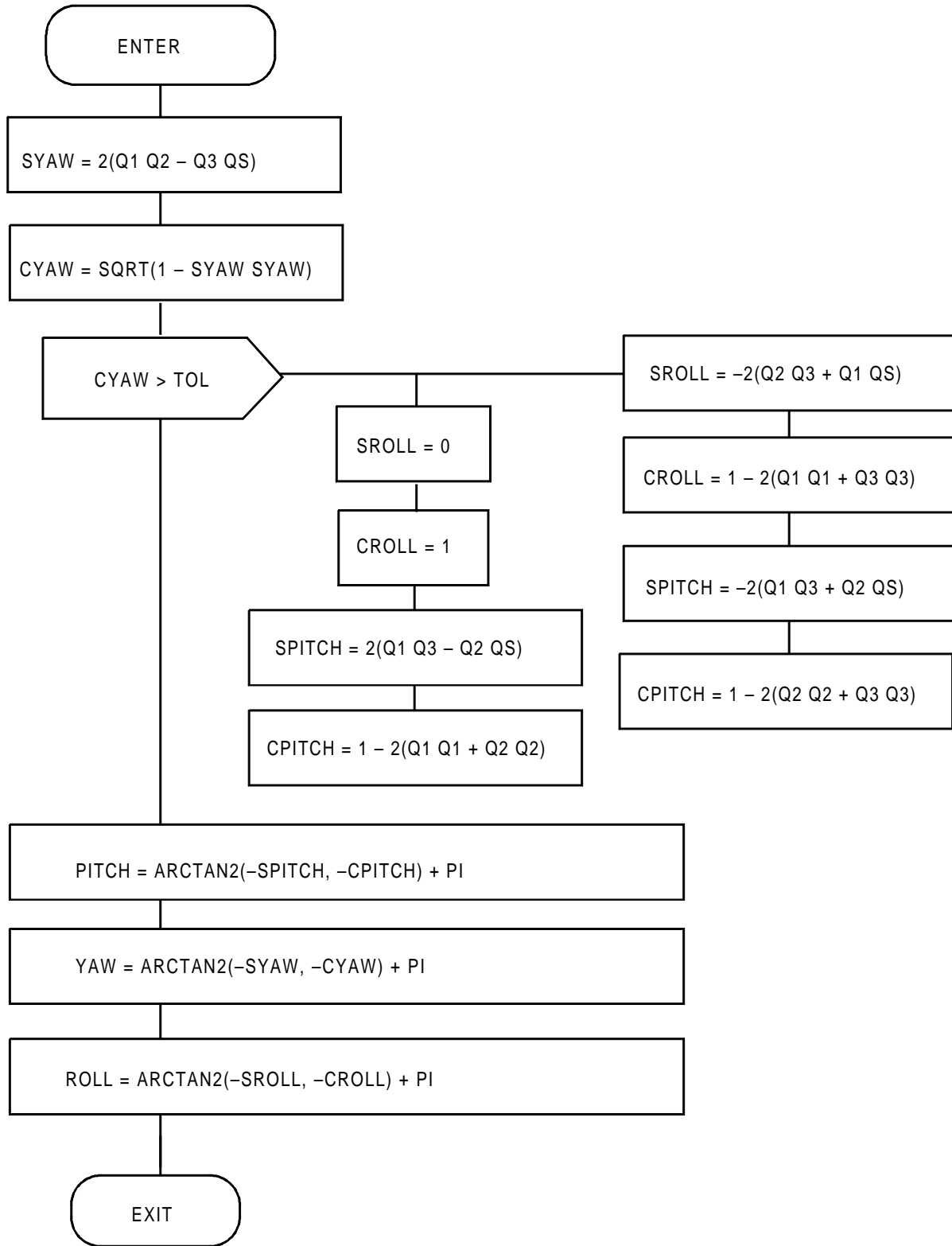


FIGURE A4.3.20. ATT ANG

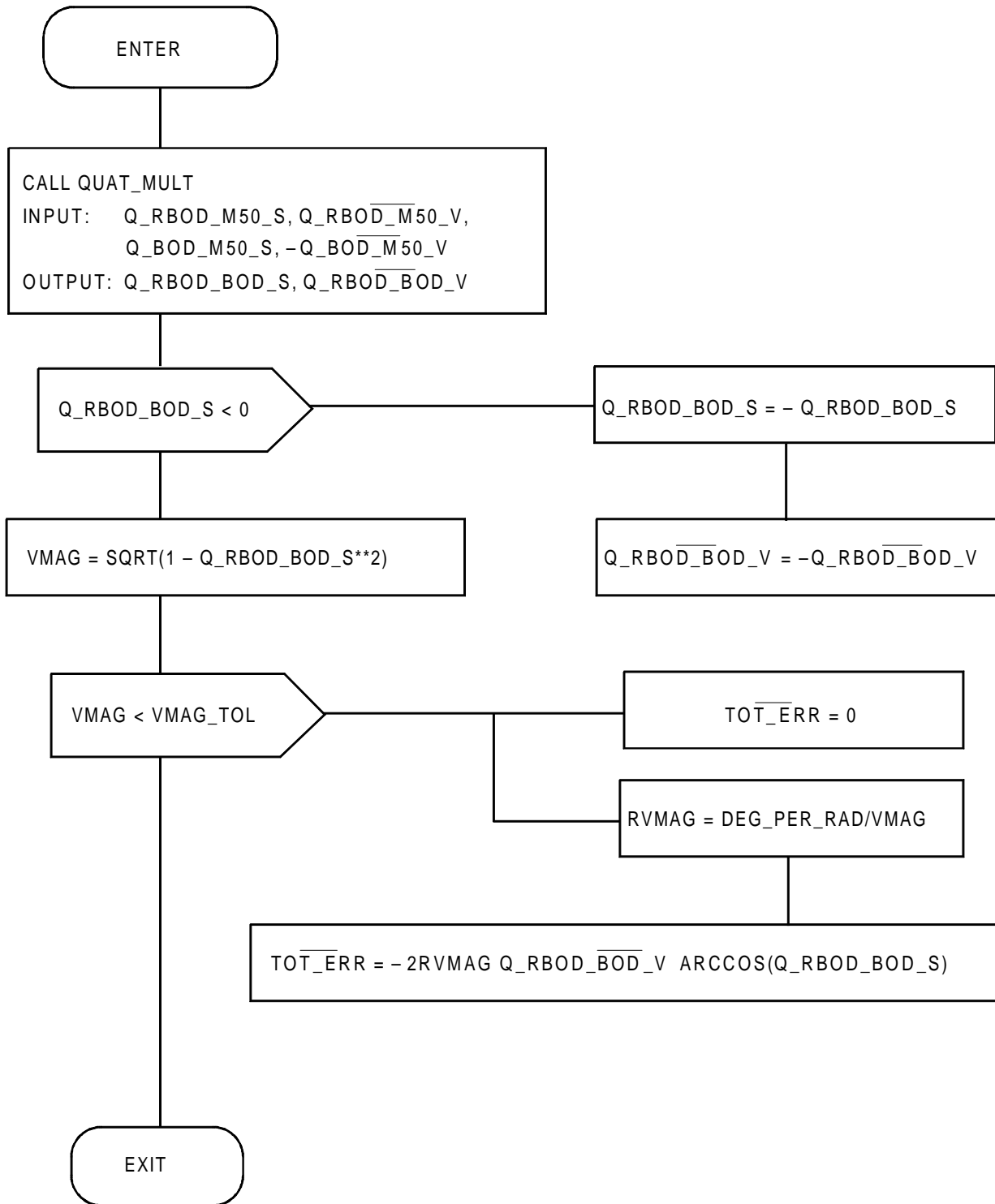


FIGURE A4.3.21. ATT ERROR

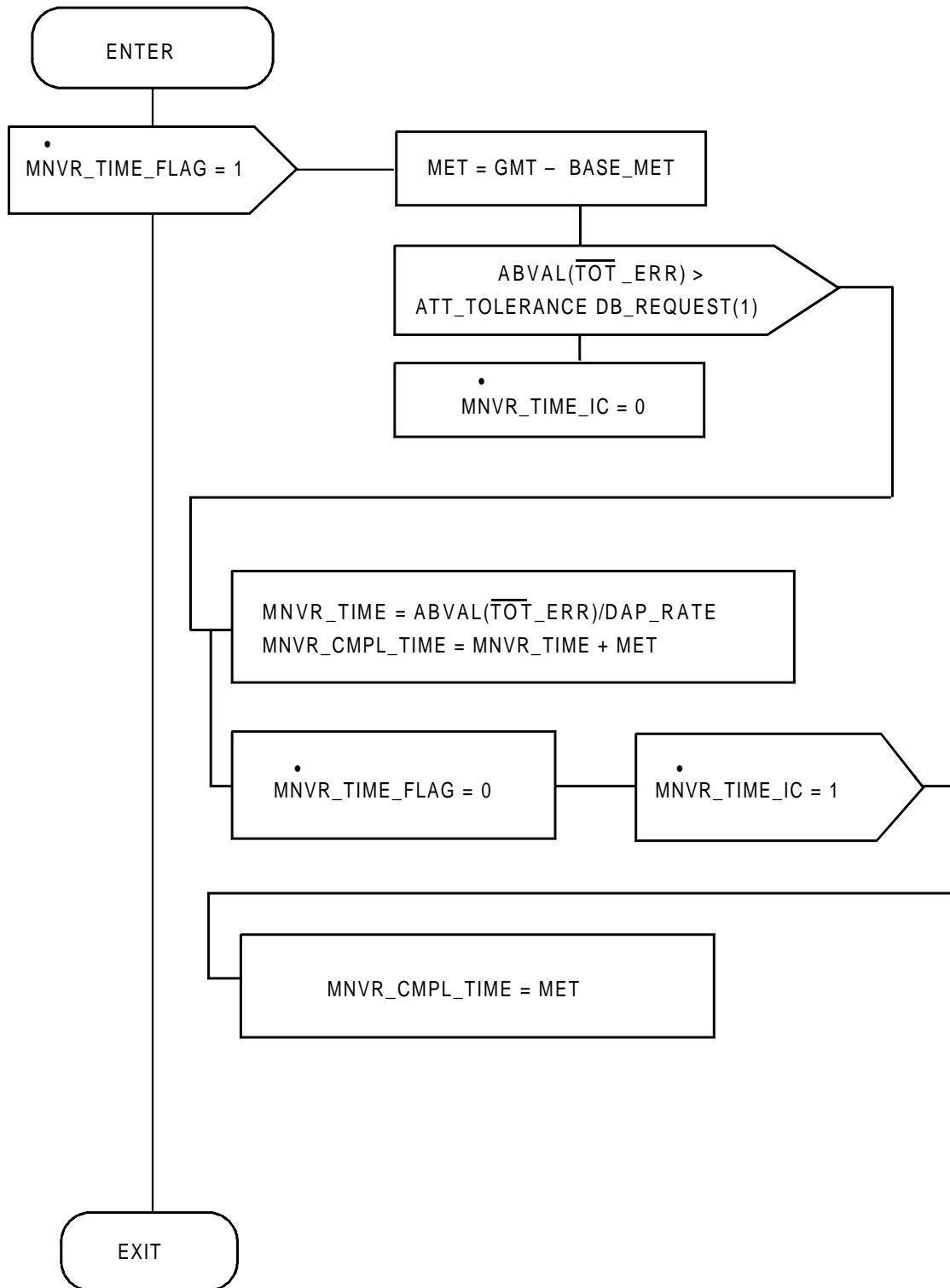


FIGURE A4.3.22. Maneuver Completion Time Subtask



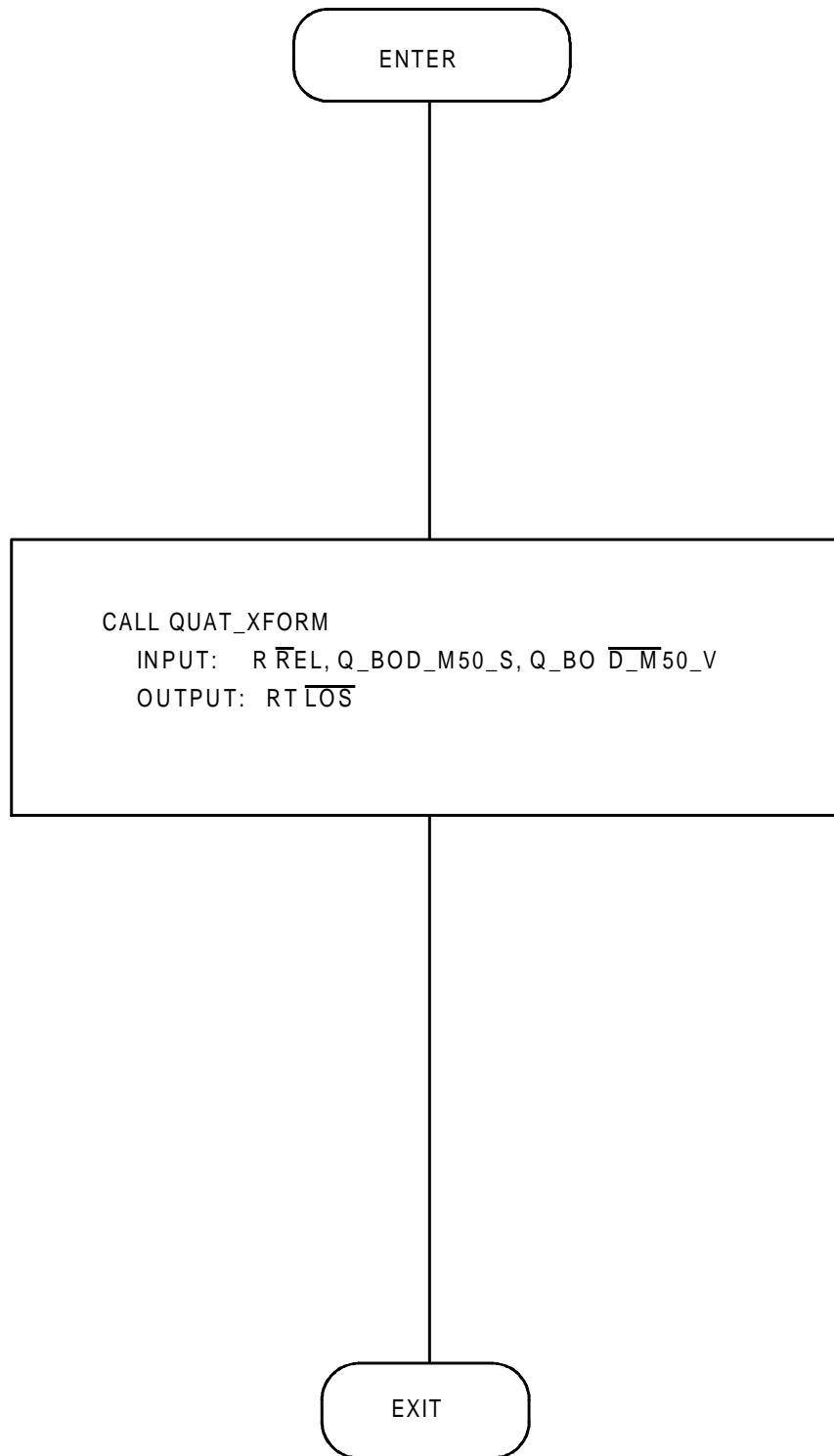


FIGURE A4.3.23. RNDZTGT

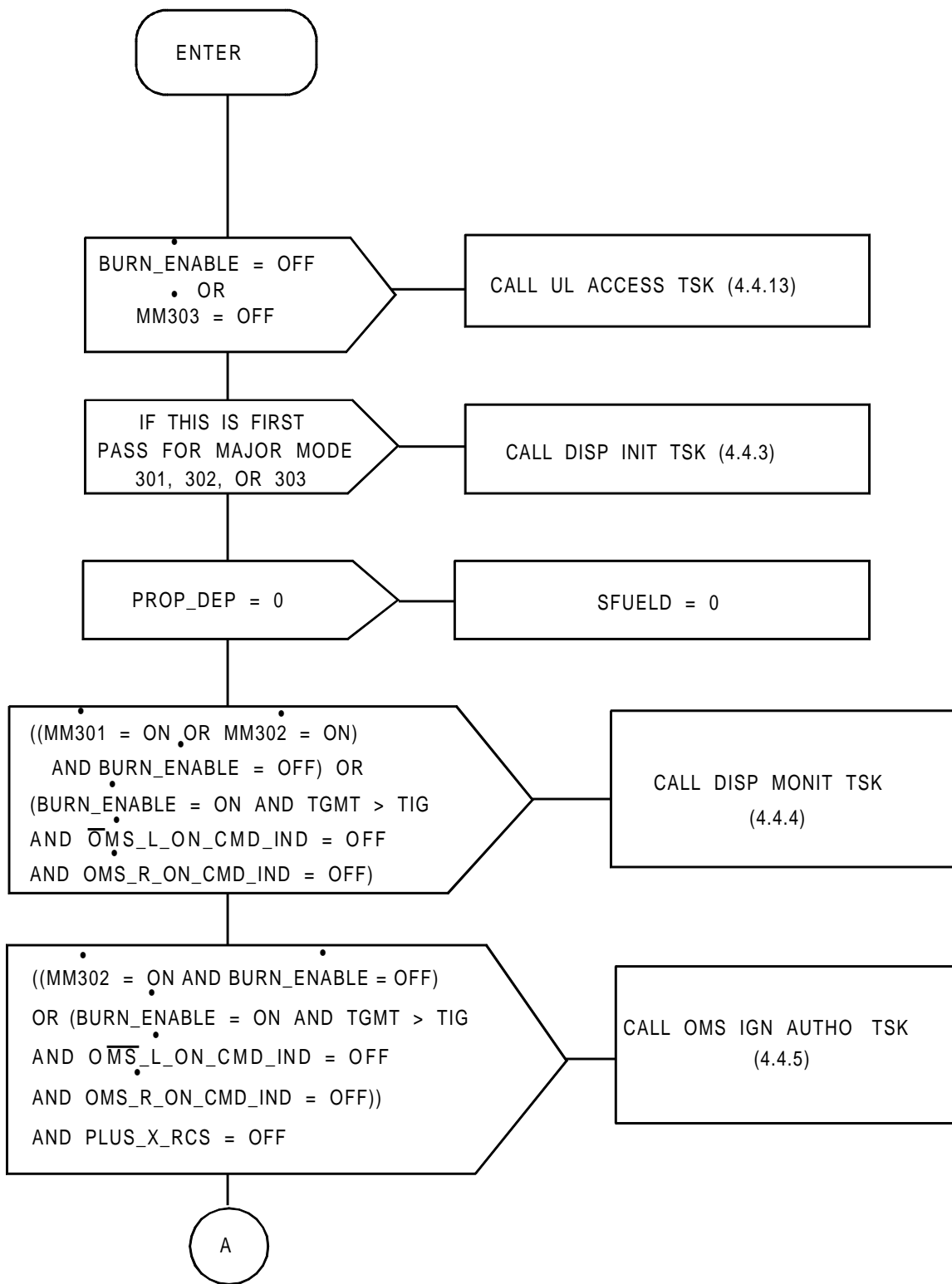


FIGURE A4.4.2.(1) DEORB MNVR DIP SEQ (Sheet 1 of 2)

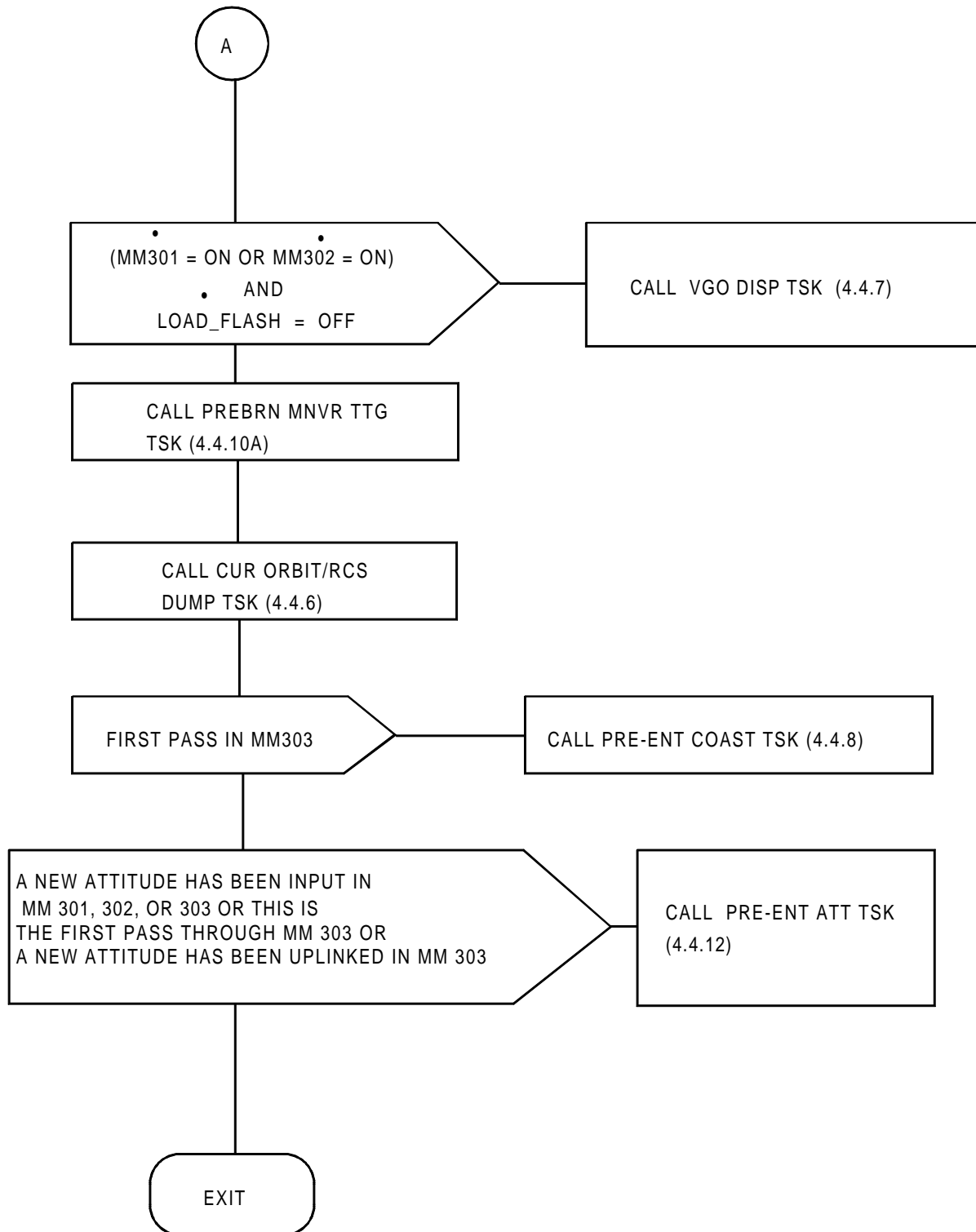


FIGURE A4.4.2.(2) DEORB MNVR DIP SEQ (Sheet 2 of 2)

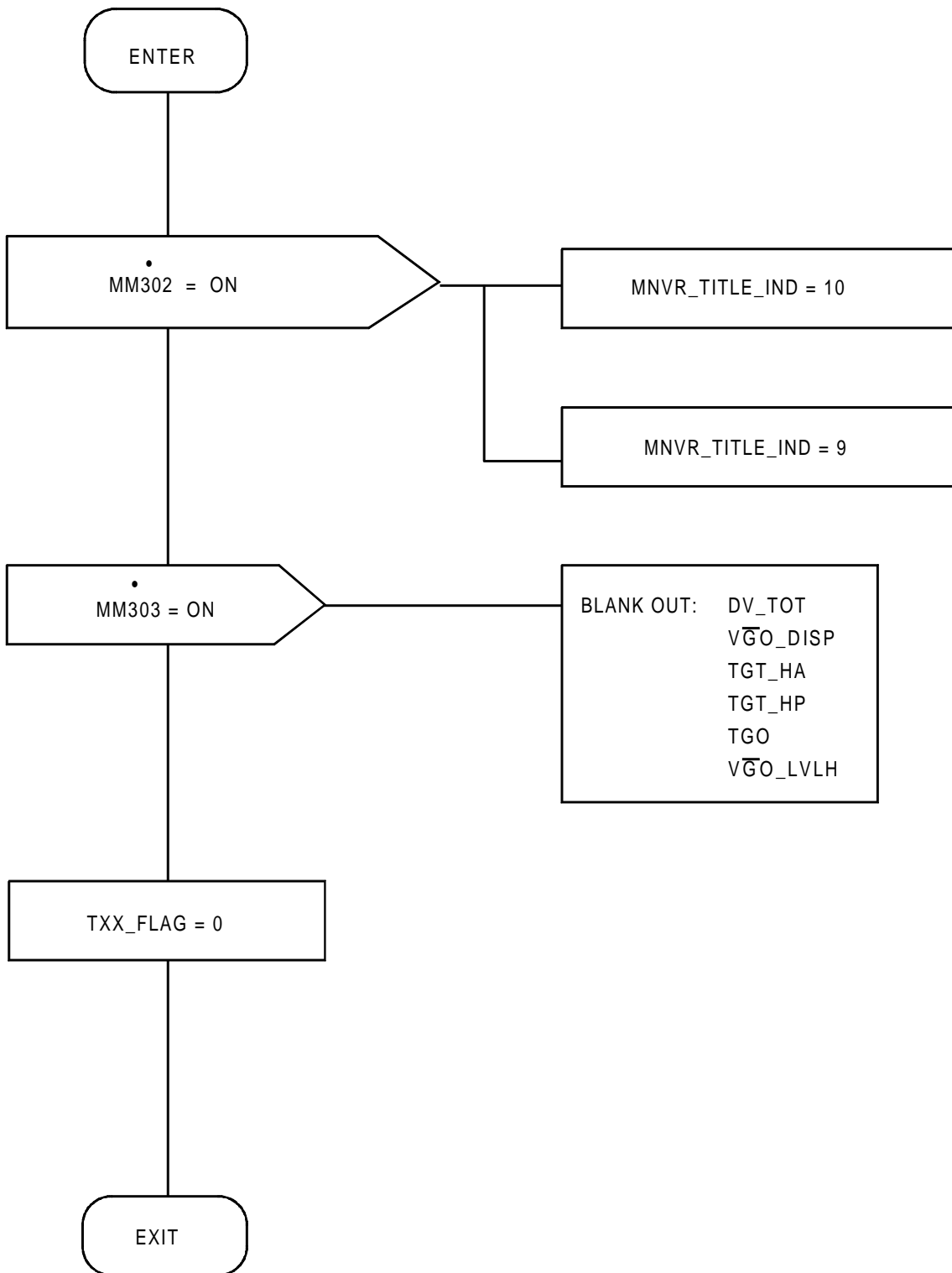


FIGURE A4.4.3. DISP\_INIT\_TSK

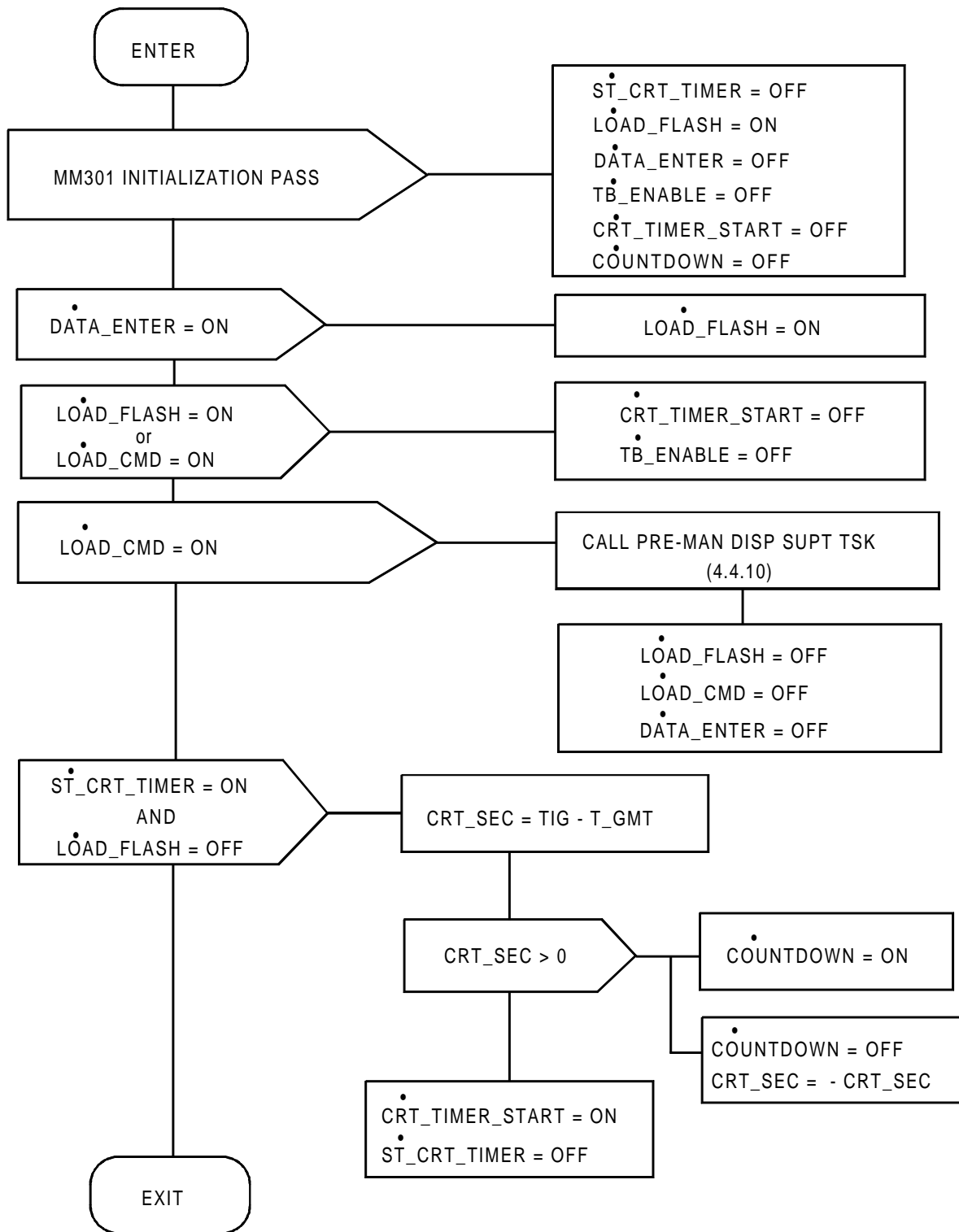


FIGURE A4.4.4. DISP MONIT TSK

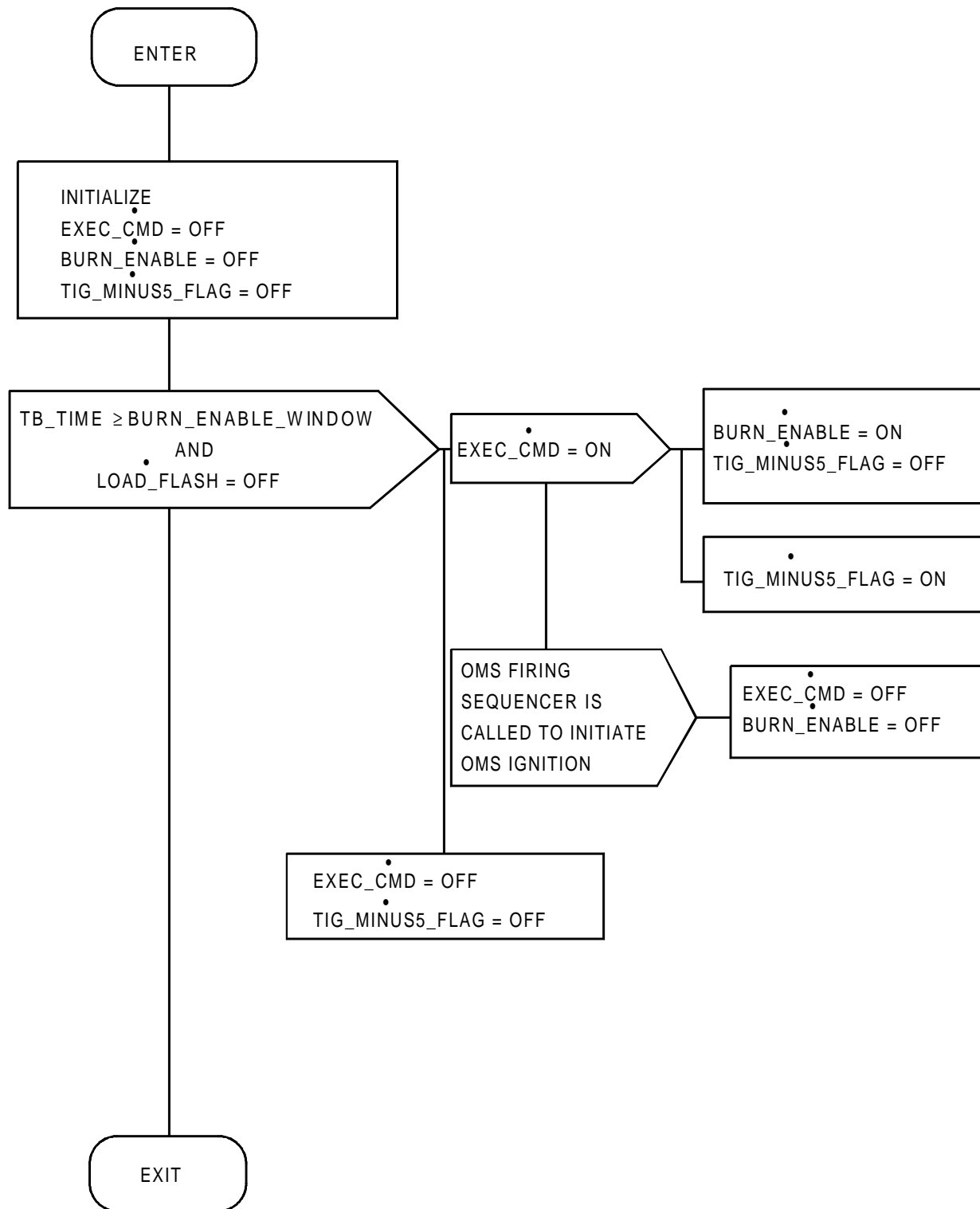


FIGURE A4.4.5. OMS IGN AUTHO TSK

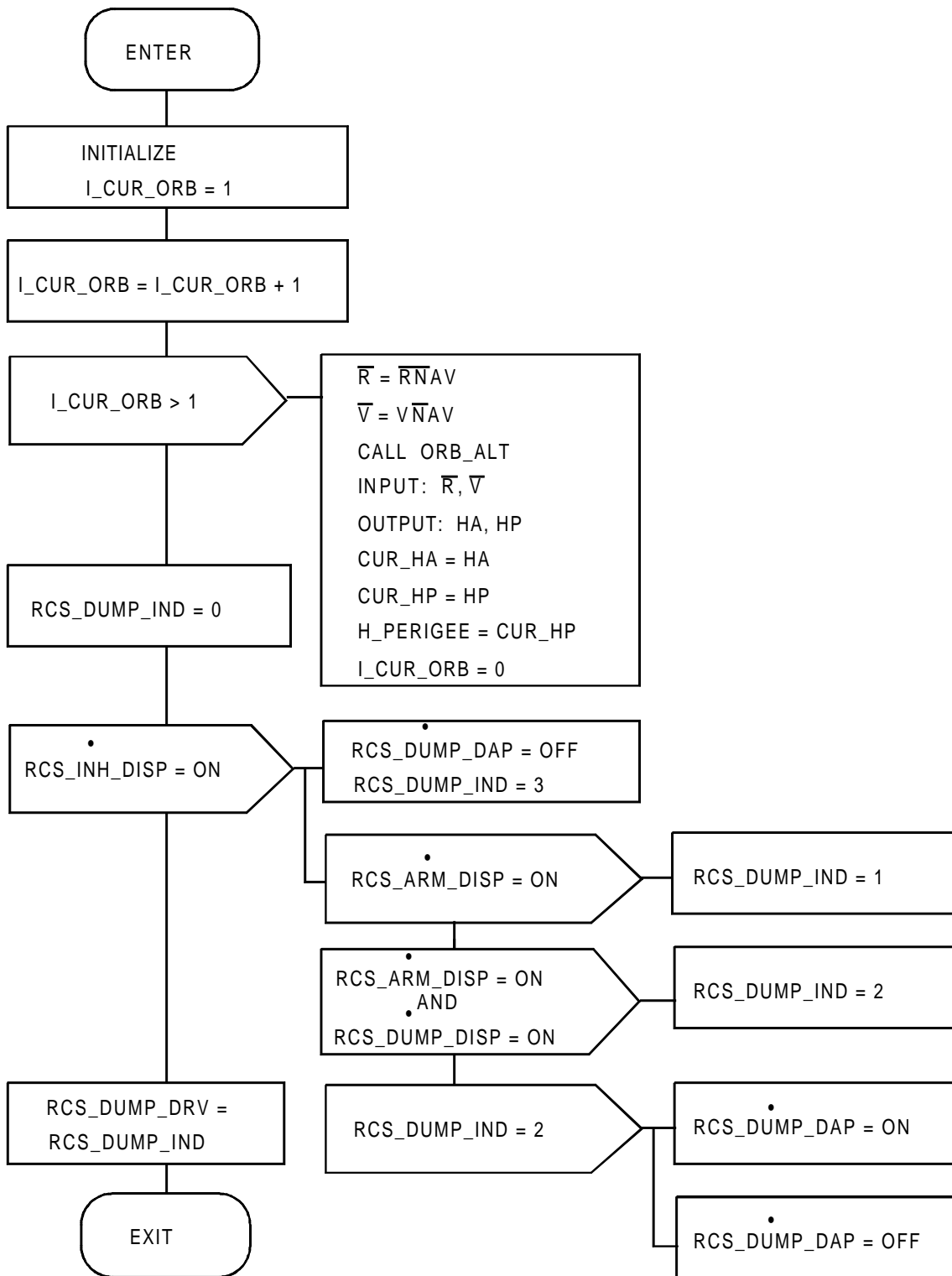


FIGURE A4.4.6. CUR ORBIT/RCS DUMP TSK

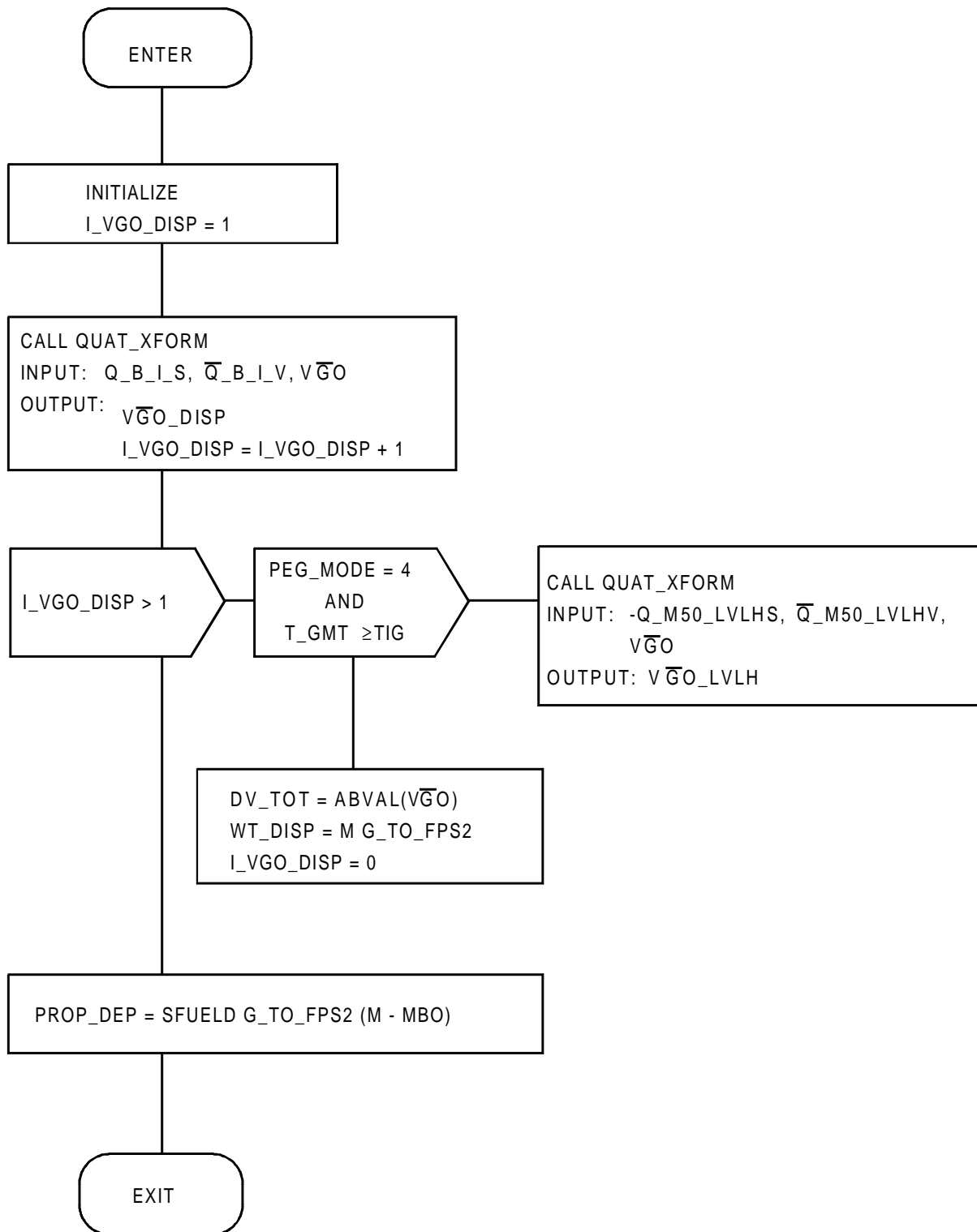


FIGURE A4.4.7. VGO DISP TSK



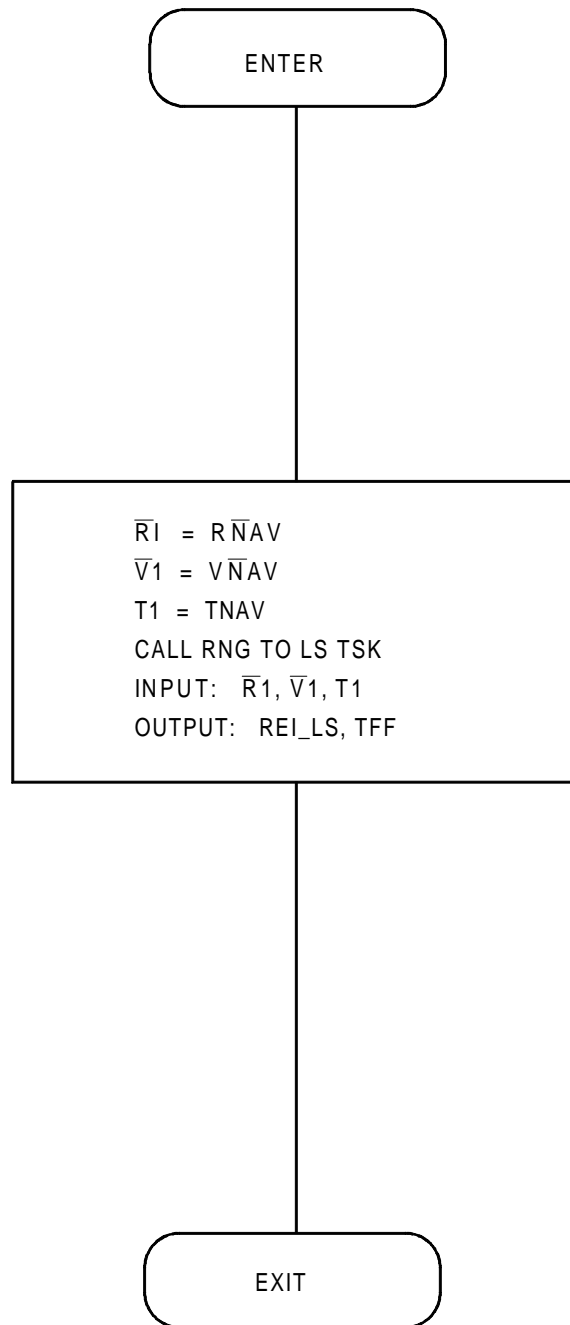


FIGURE A4.4.8. PRE-ENT COAST TSK

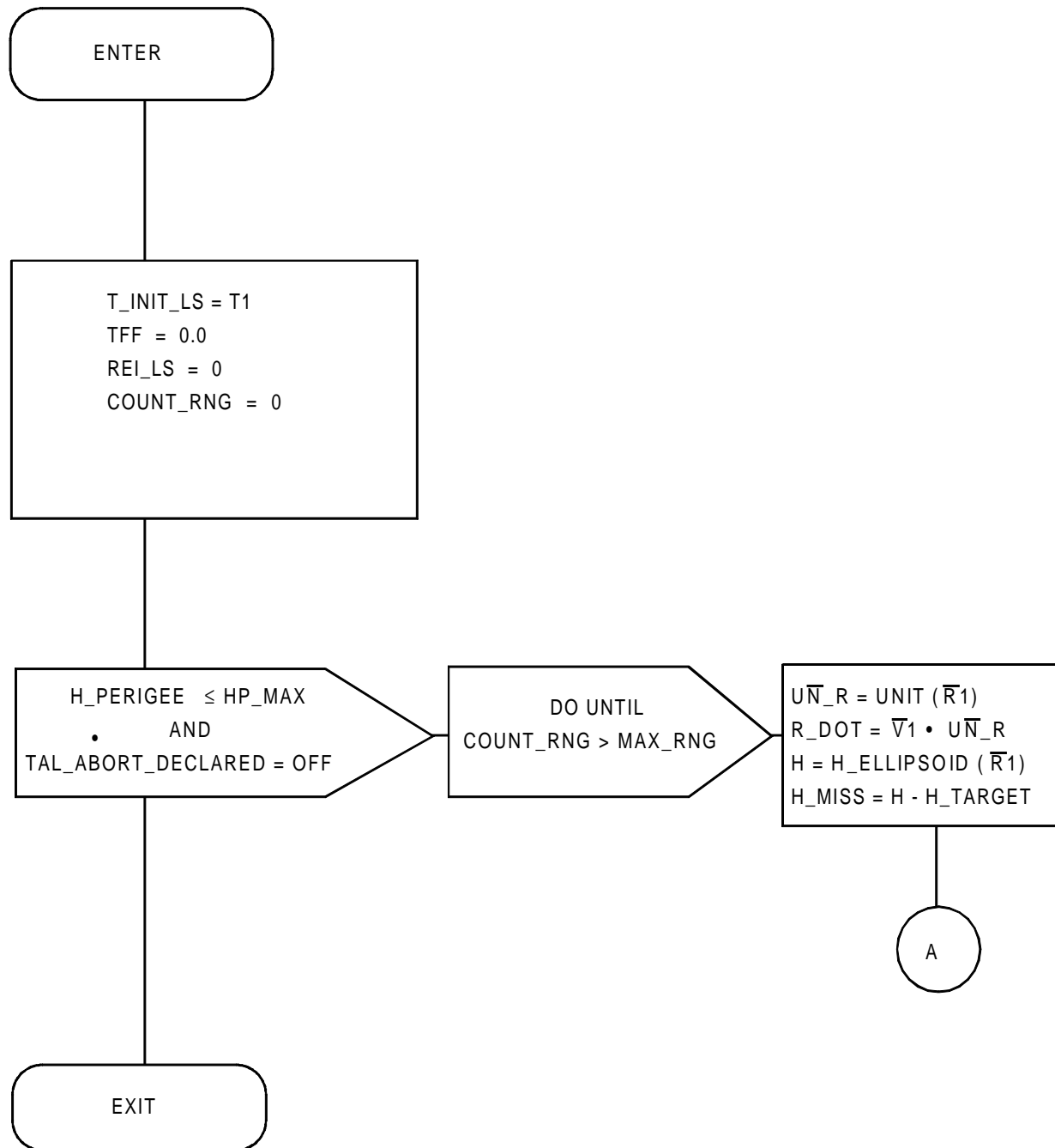


FIGURE A4.4.9.(1) RNG TO LS TSK (Sheet 1 of 3)

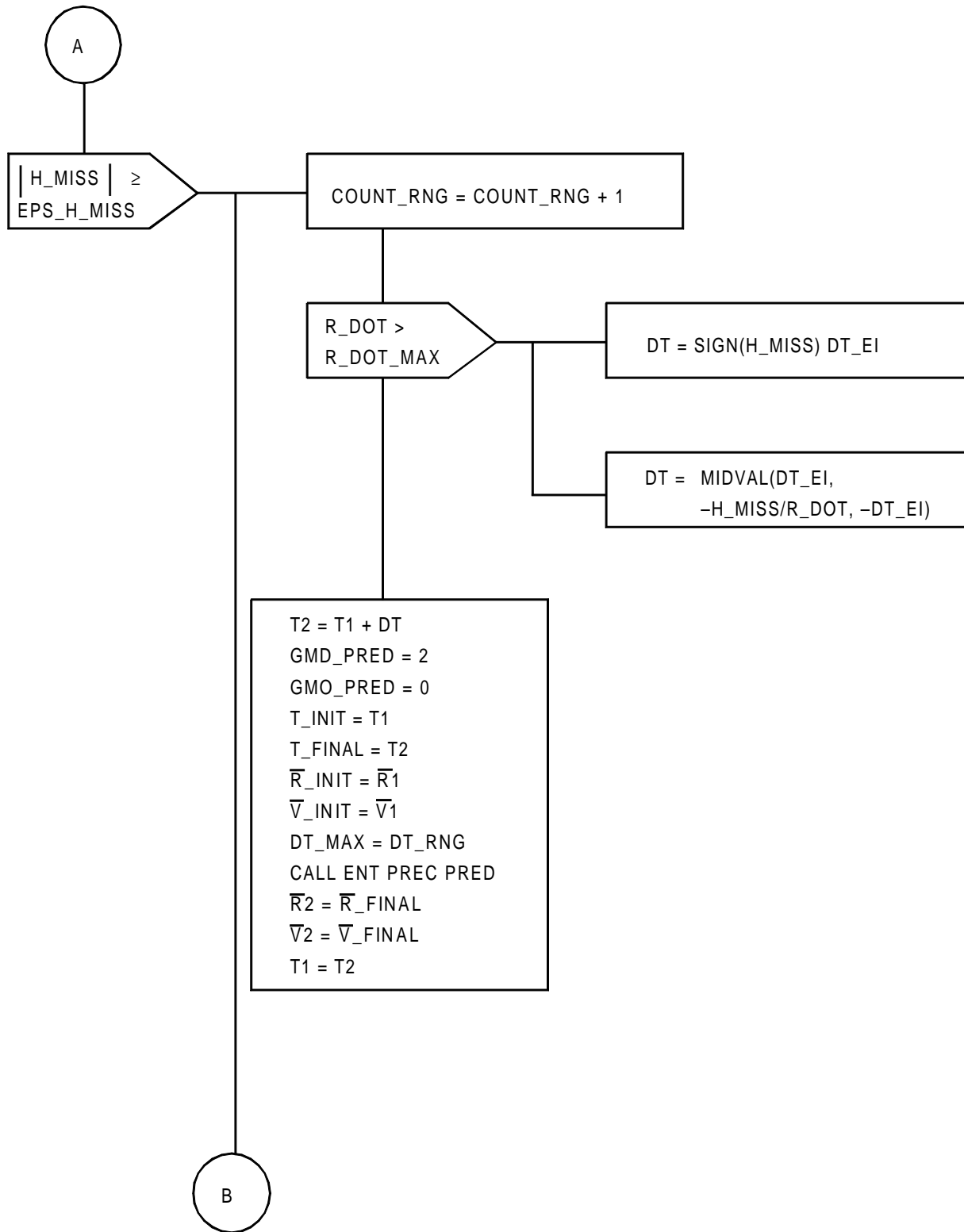


FIGURE A4.4.9.(2) RNG TO LS TSK (Sheet 2 of 3)

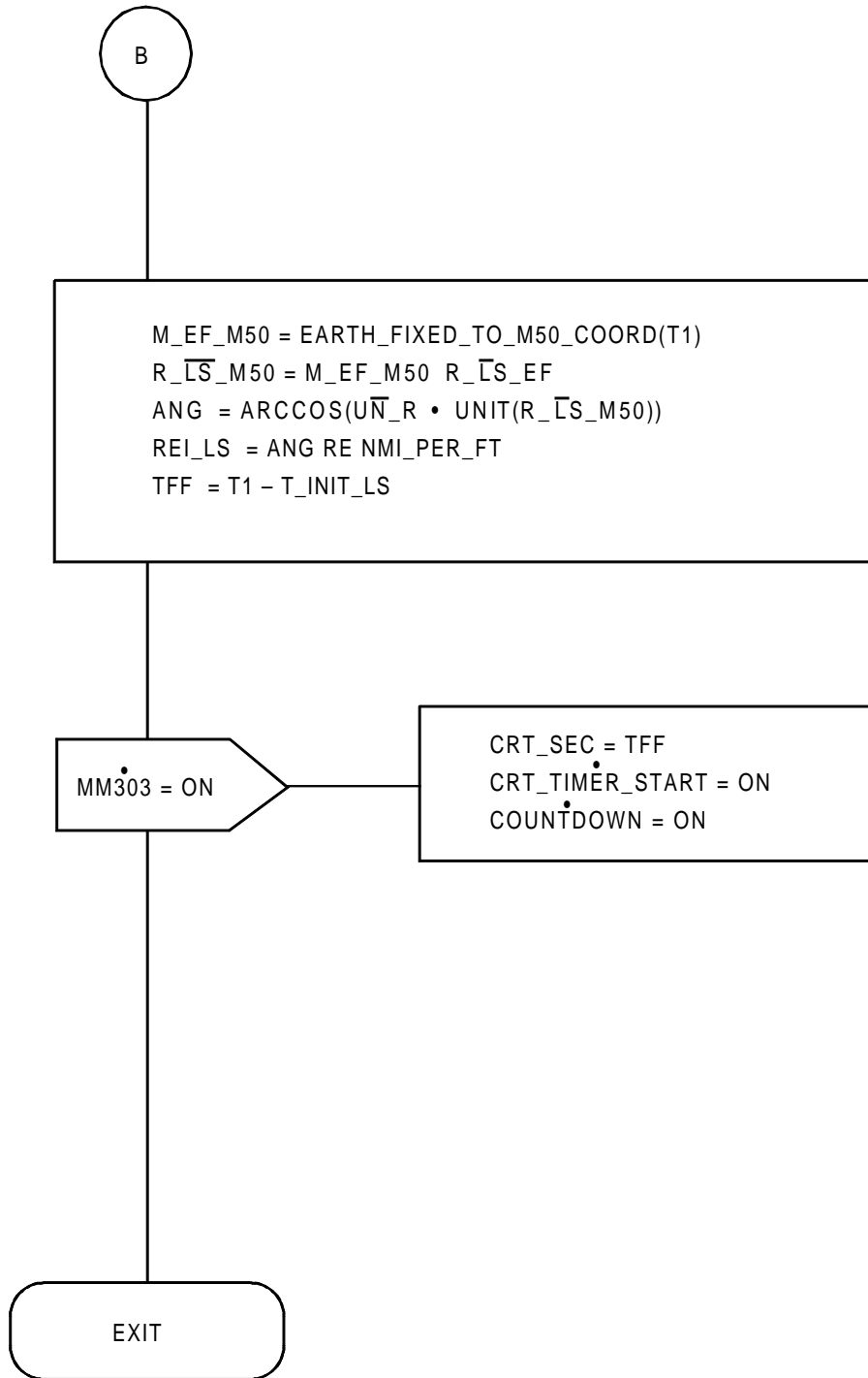


FIGURE A4.4.9.(3) RNG TO LS TSK (Sheet 3 of 3)

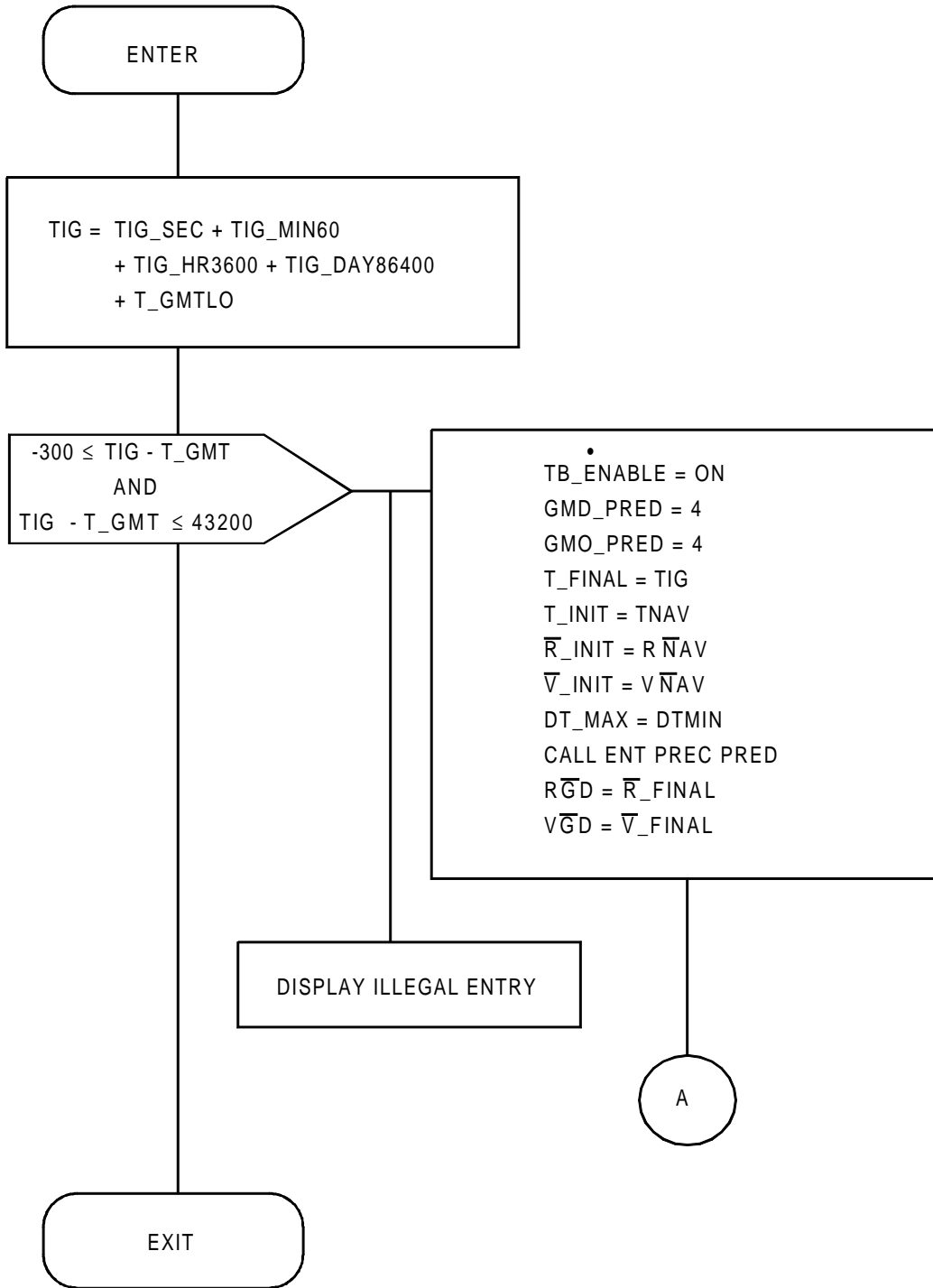


FIGURE A4.4.10.(1) PRE-MAN DISP SUPT TSK (Sheet 1 of 4)

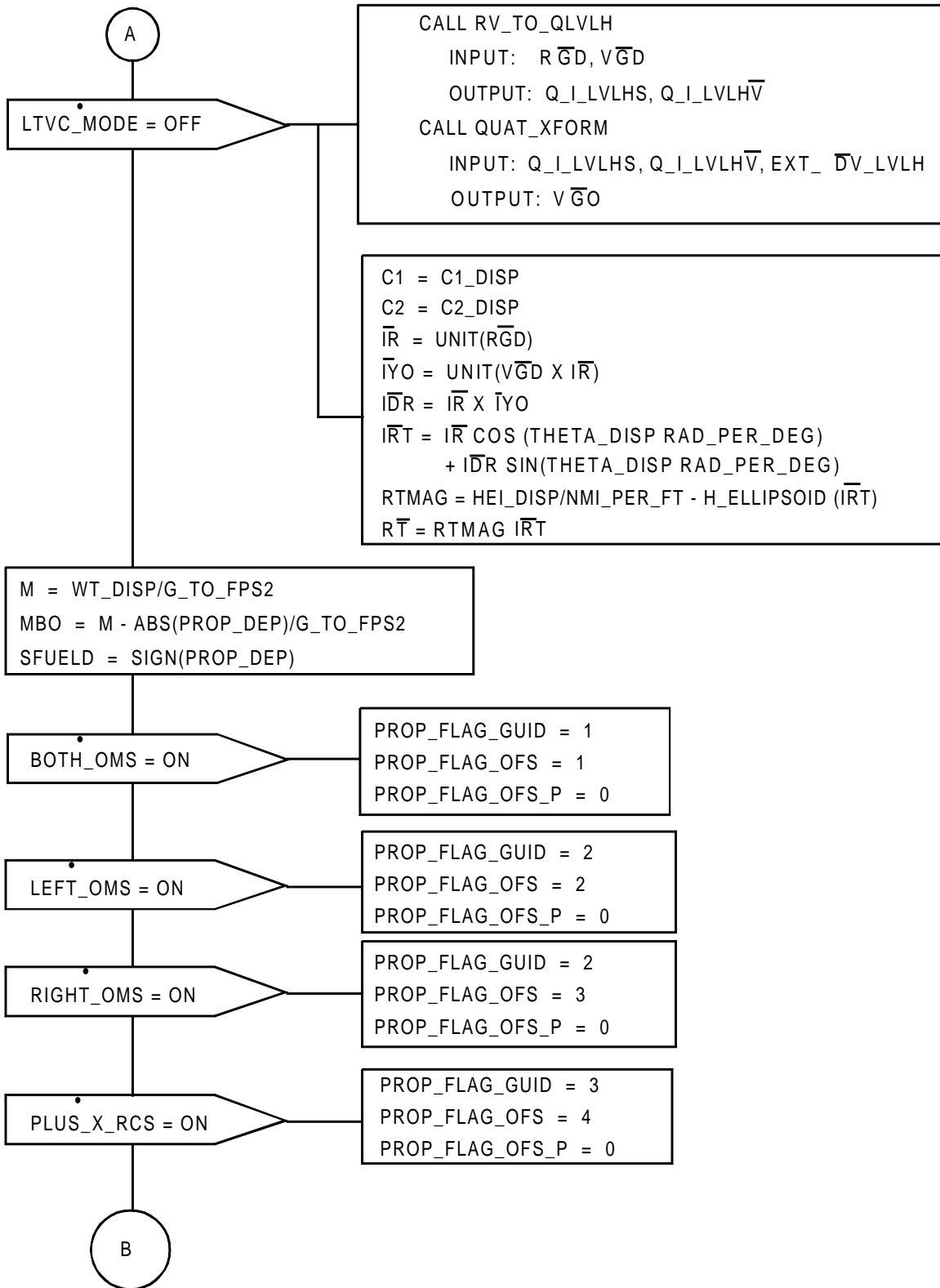


FIGURE A4.4.10.(2) PRE-MAN DISP SUPT TSK (Sheet 2 of 4)

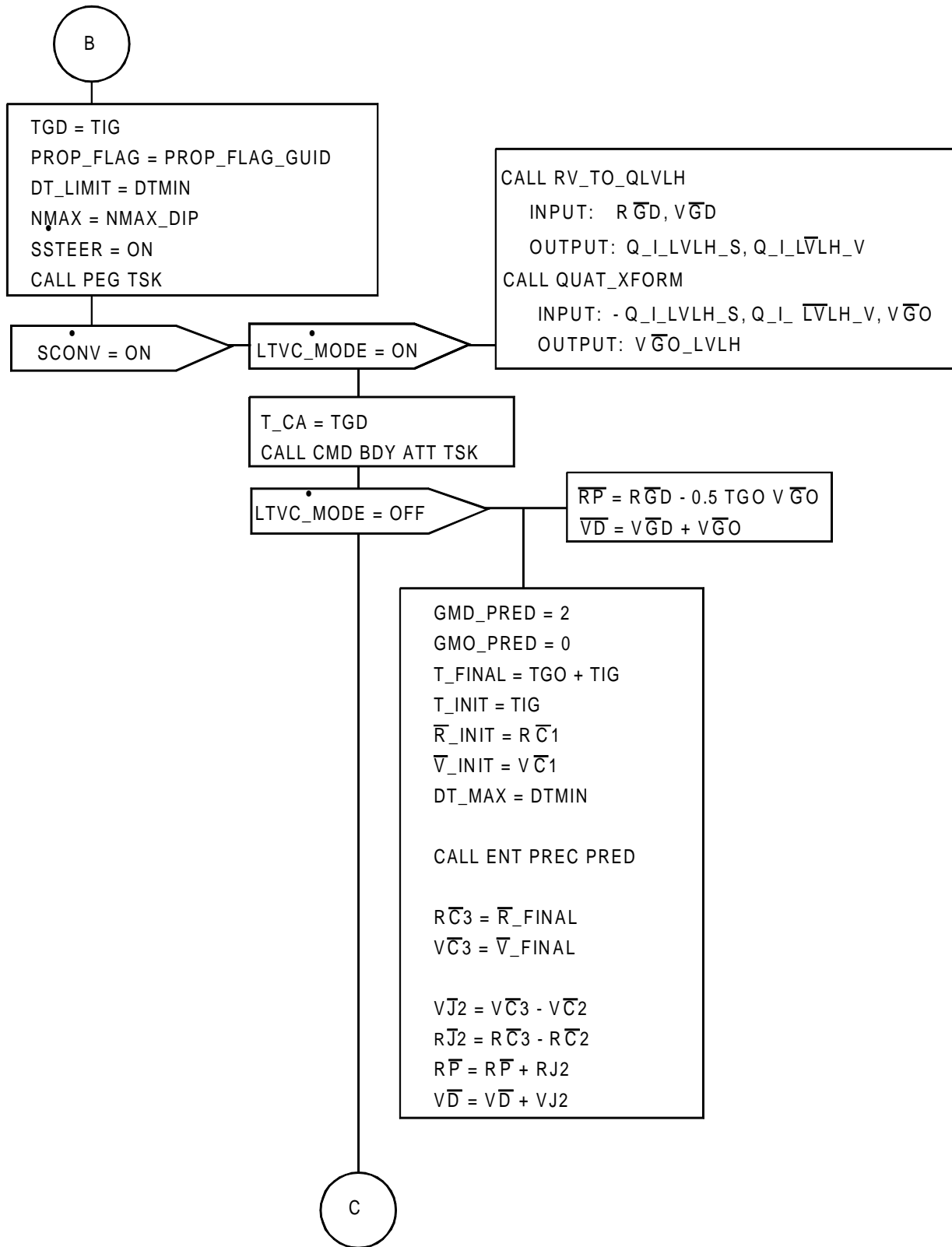


FIGURE A4.4.10.(3) PRE-MAN DISP SUPT TSK (Sheet 3 of 4)

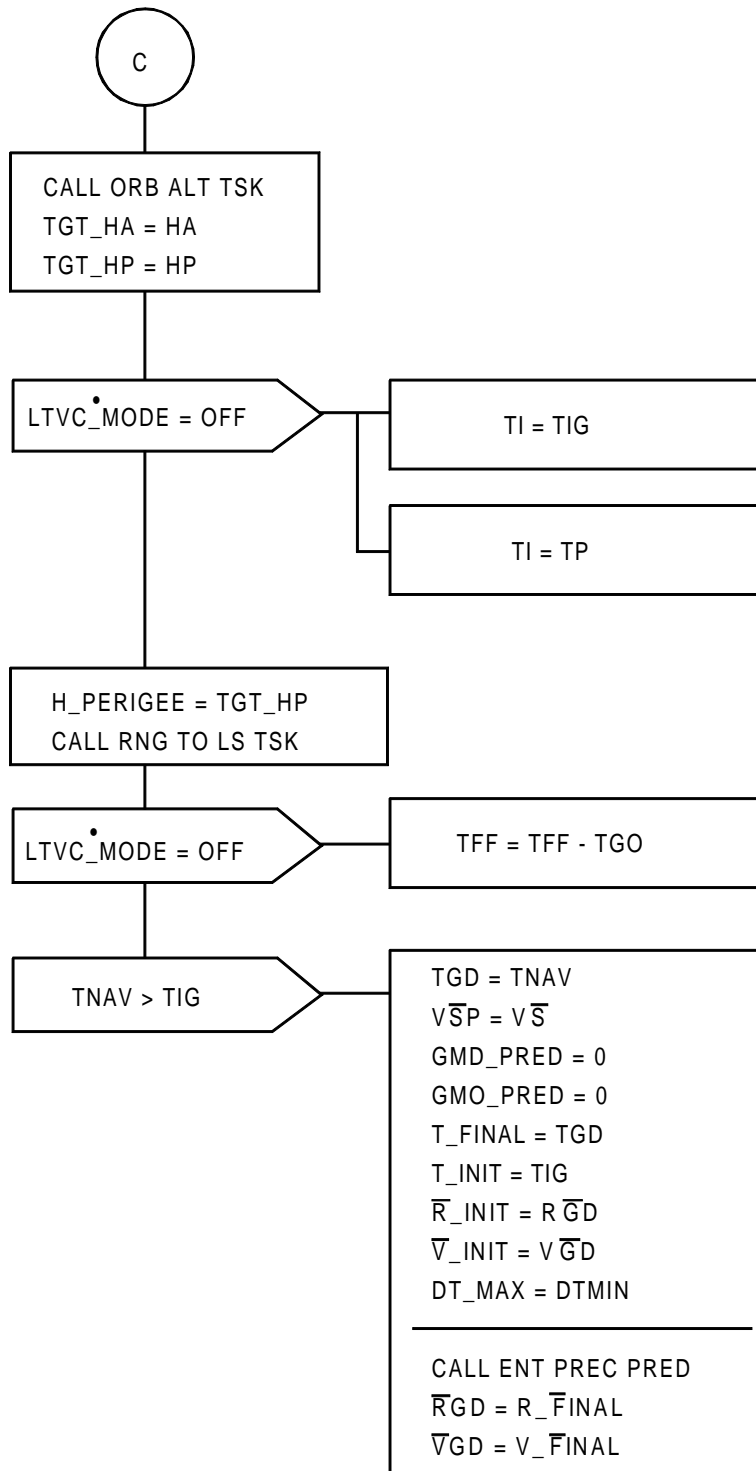


FIGURE A4.4.10.(4) PRE-MAN DISP SUPT TSK (Sheet 4 of 4)



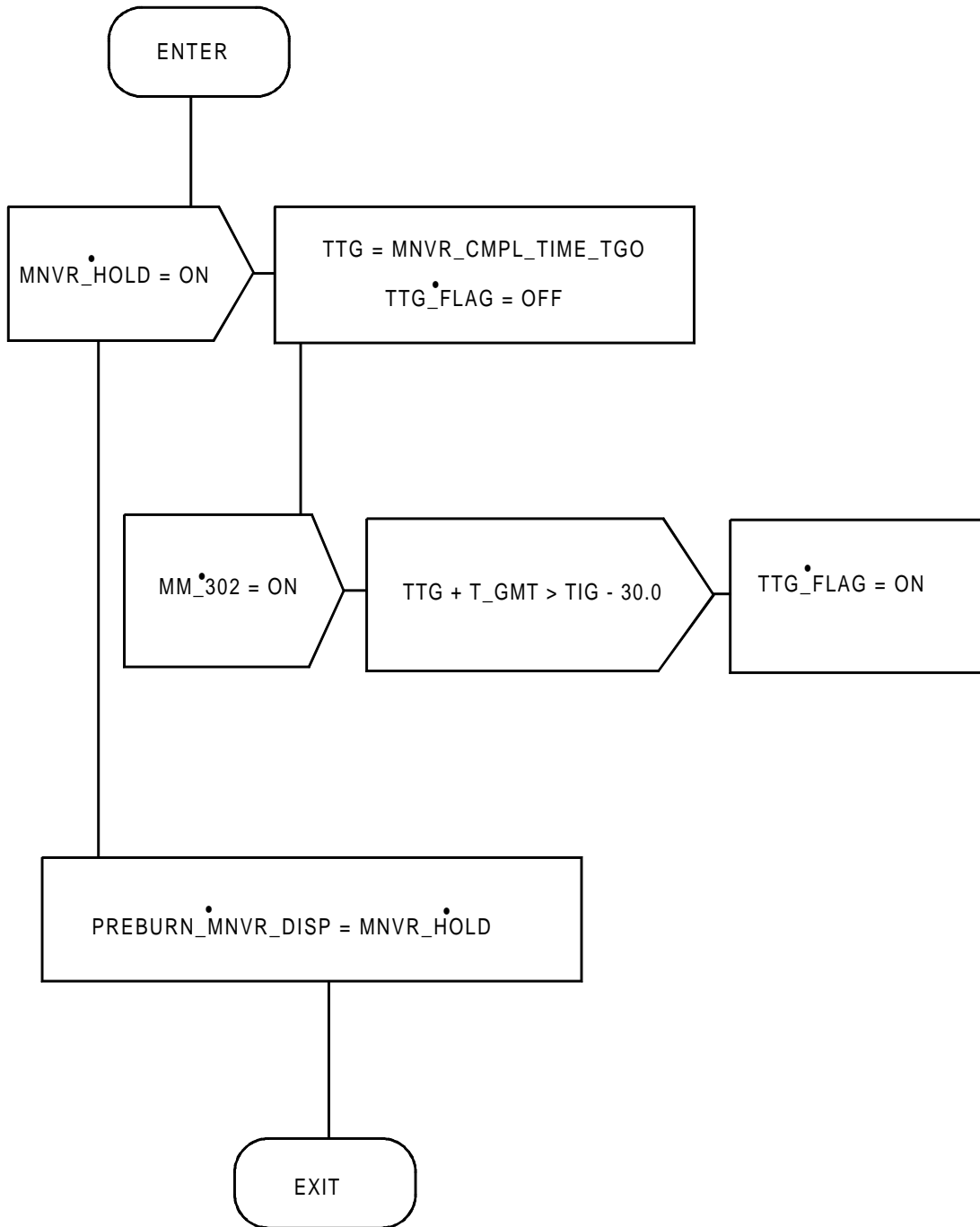


FIGURE A4.4.10A. PREBRN MNVR TTG TSK

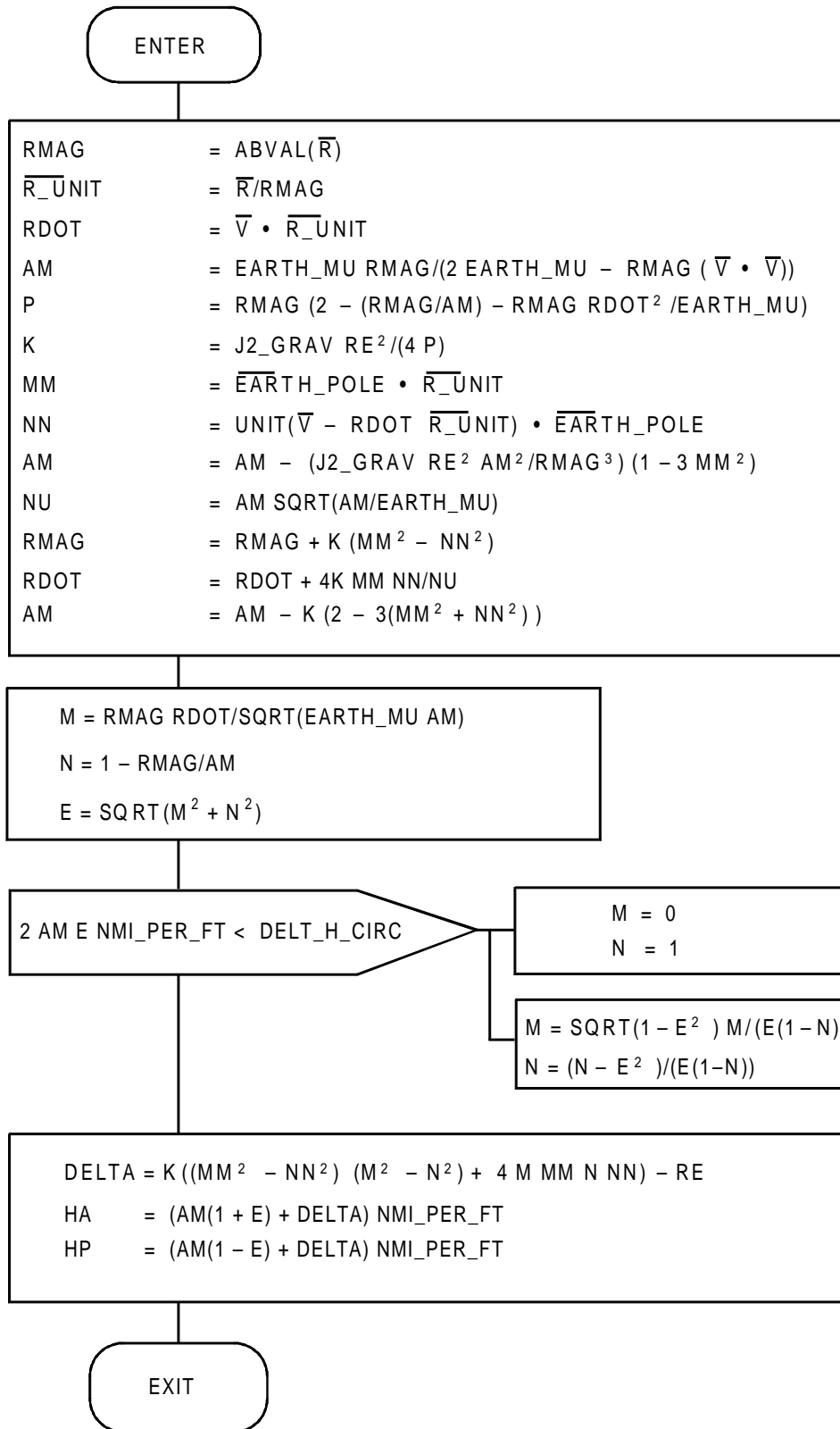


FIGURE A4.4.11. ORB ALT TSK

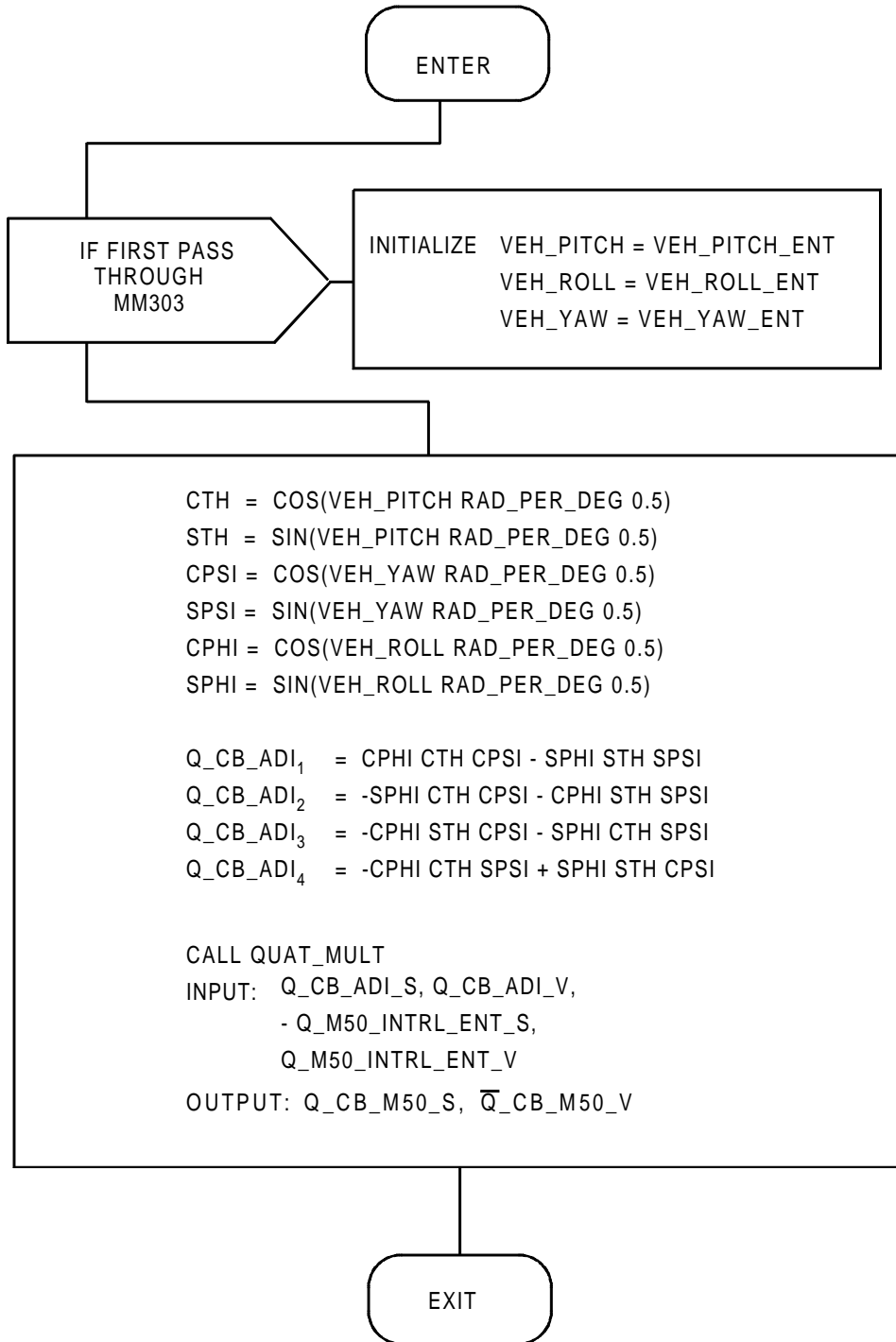


FIGURE A4.4.12. PRE-ENT ATT TSK

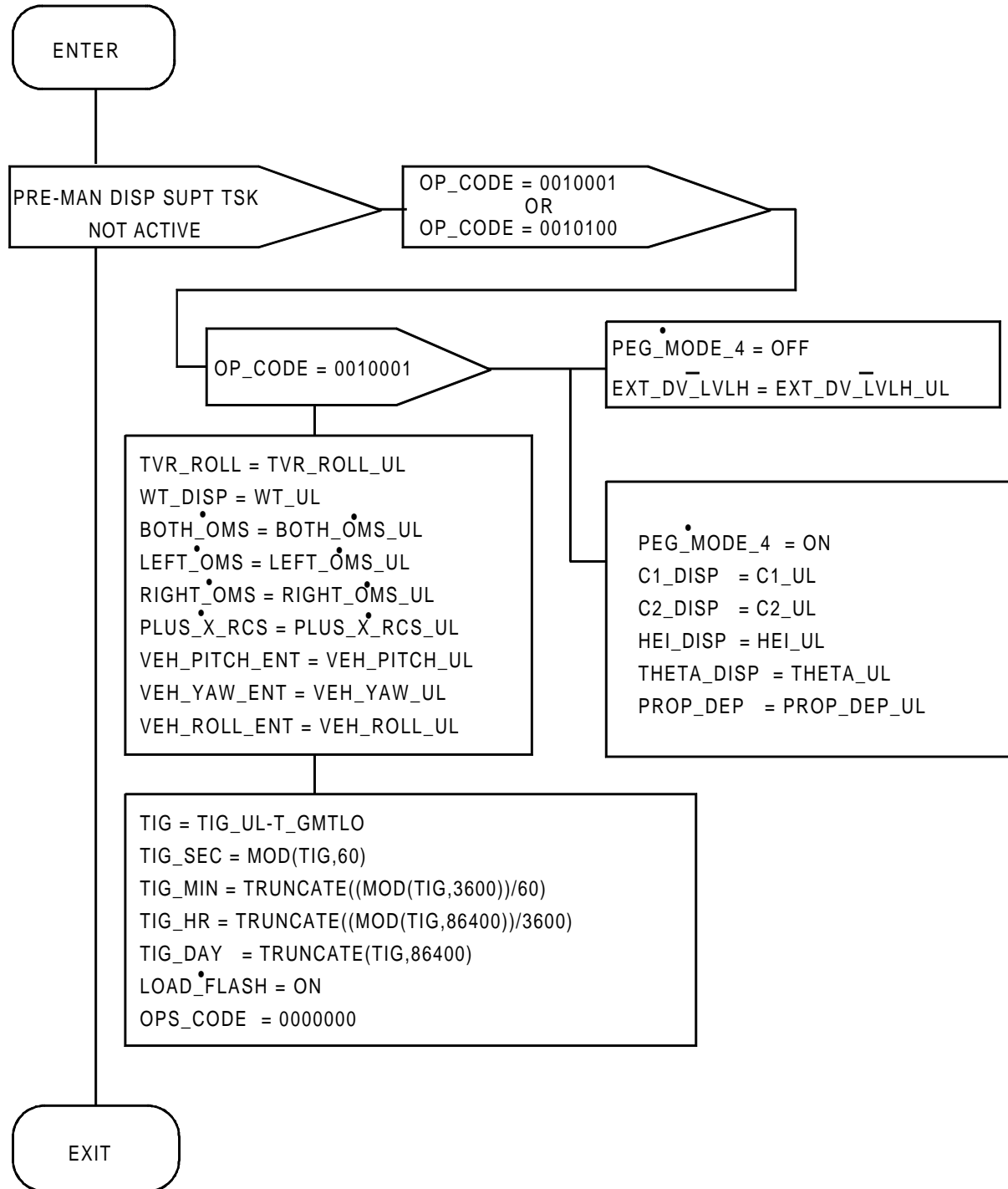


FIGURE A4.4.13. UL ACCESS TSK

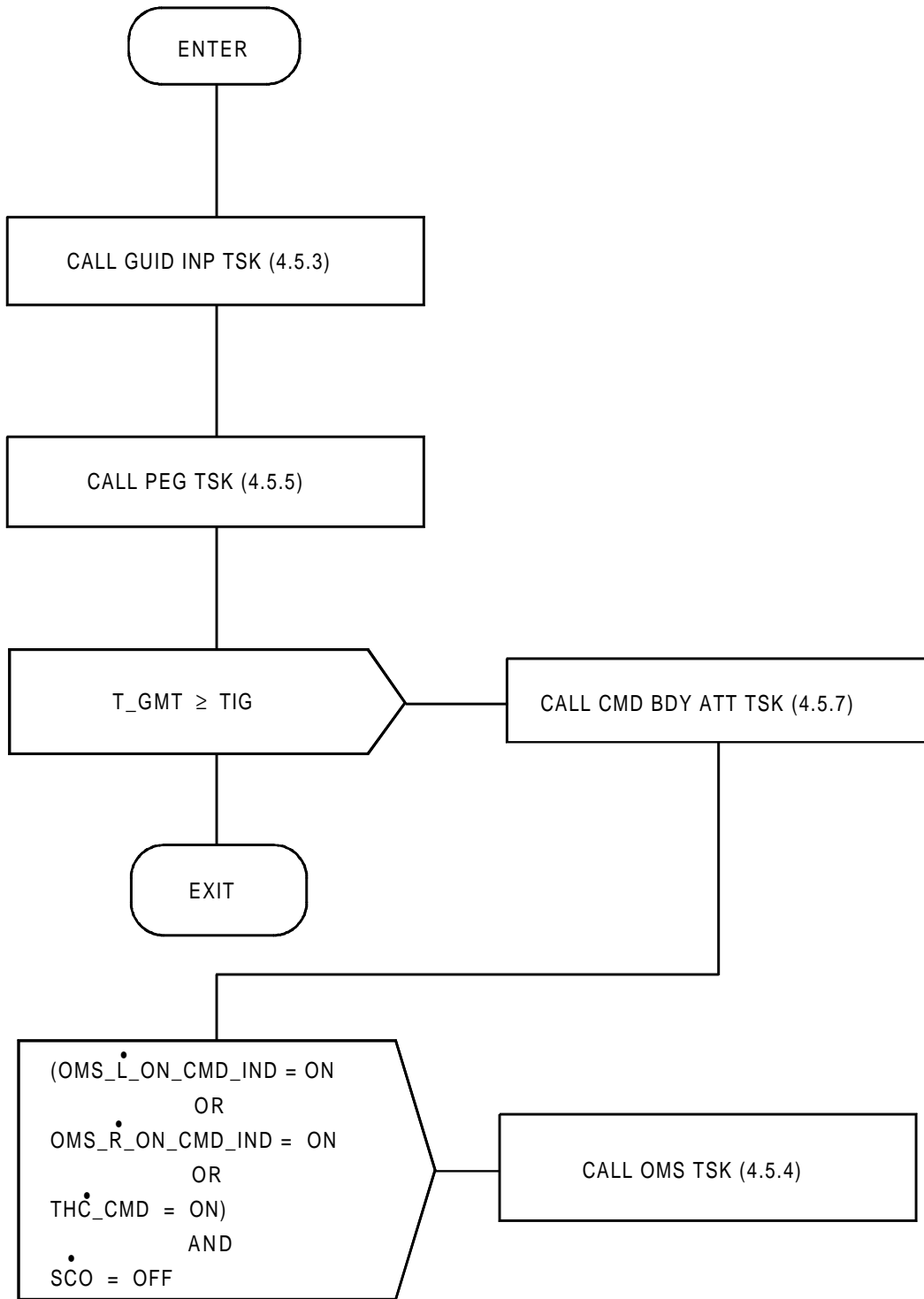


FIGURE A4.5.2. DEORB GUID SEQ



FIGURE A4.5.3.(2) DELETED

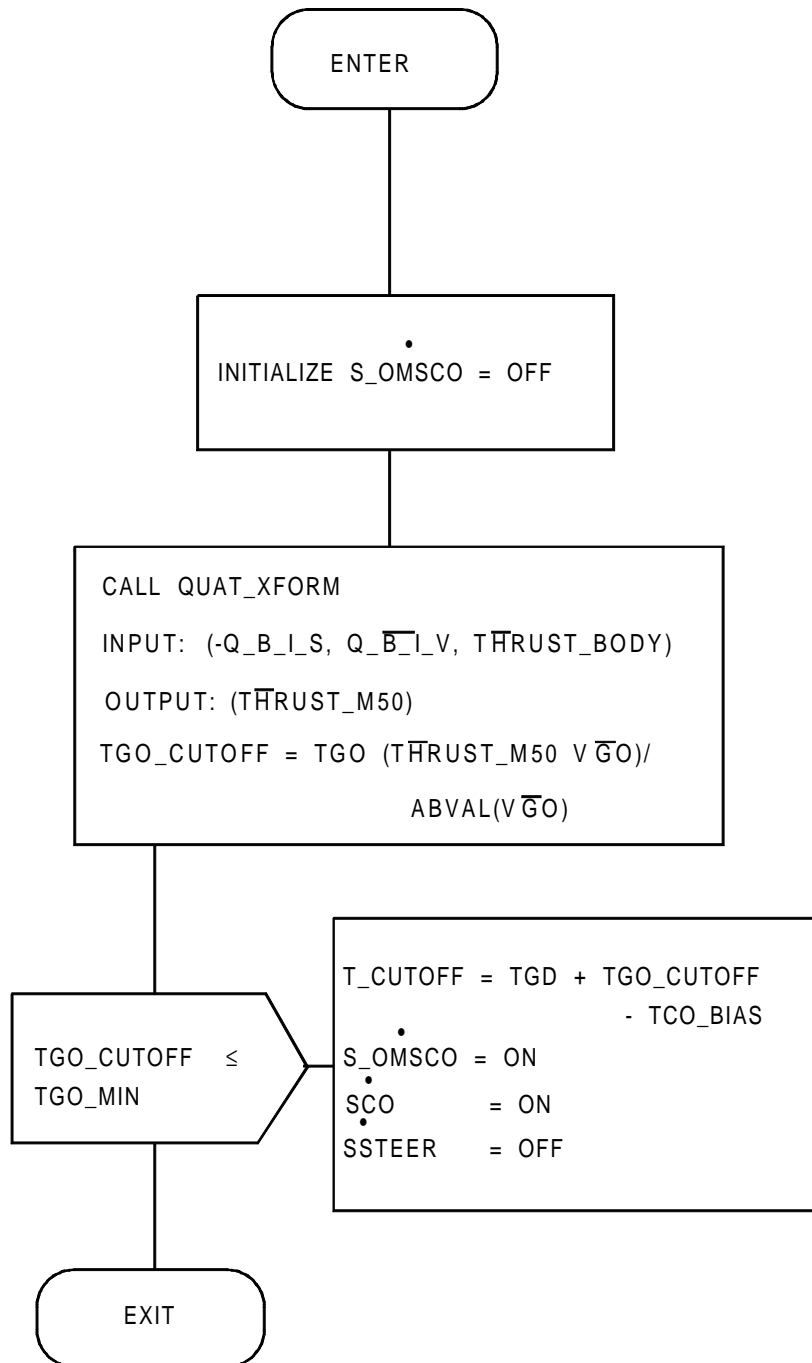


FIGURE A4.5.4. OMS TSK



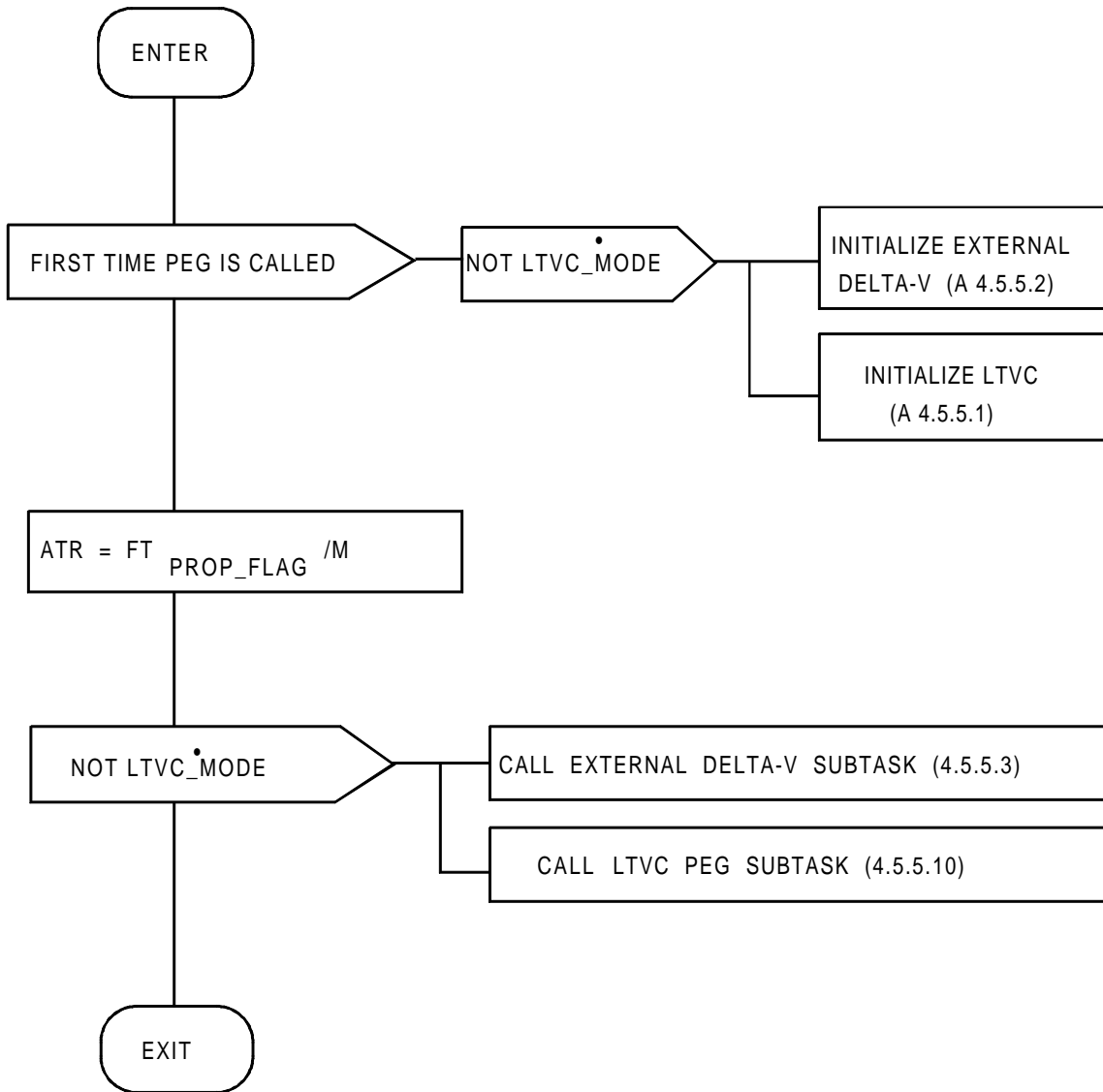


FIGURE A4.5.5. PEG TSK

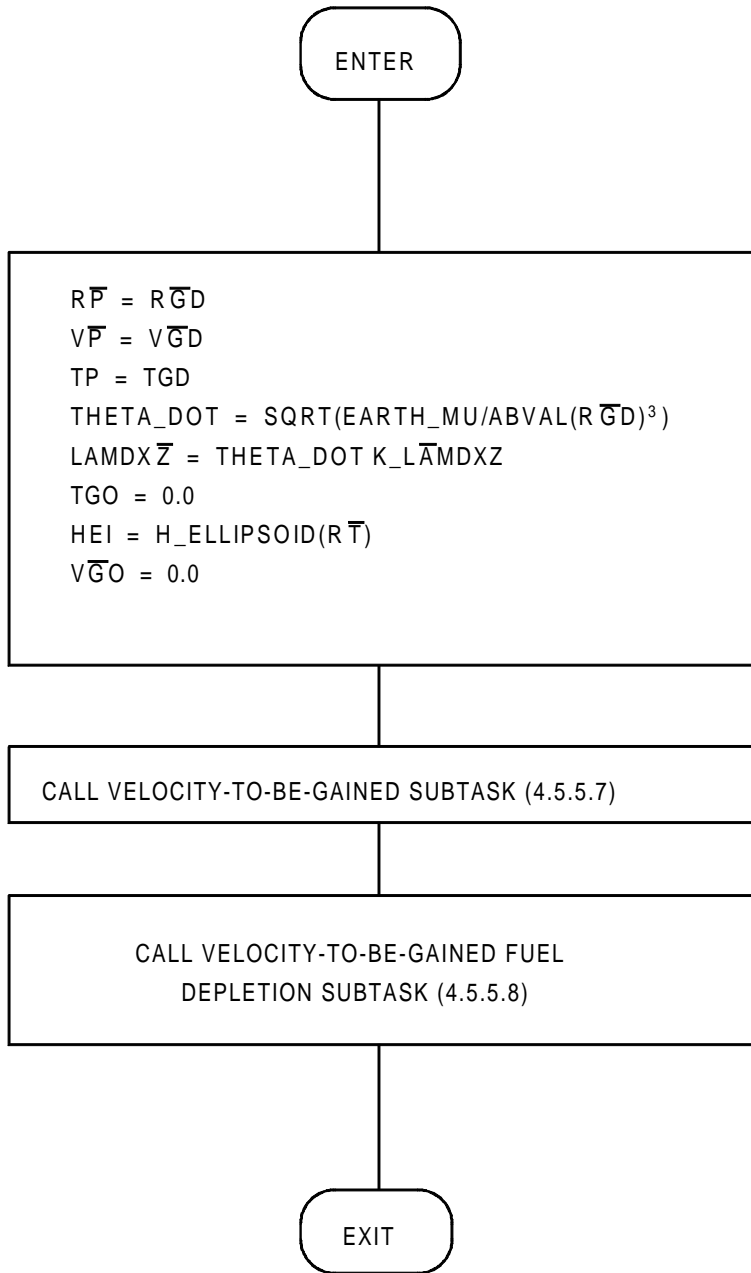


FIGURE A4.5.5.1. Initialize LTVC

INITIALIZE EXTERNAL DELTA-V

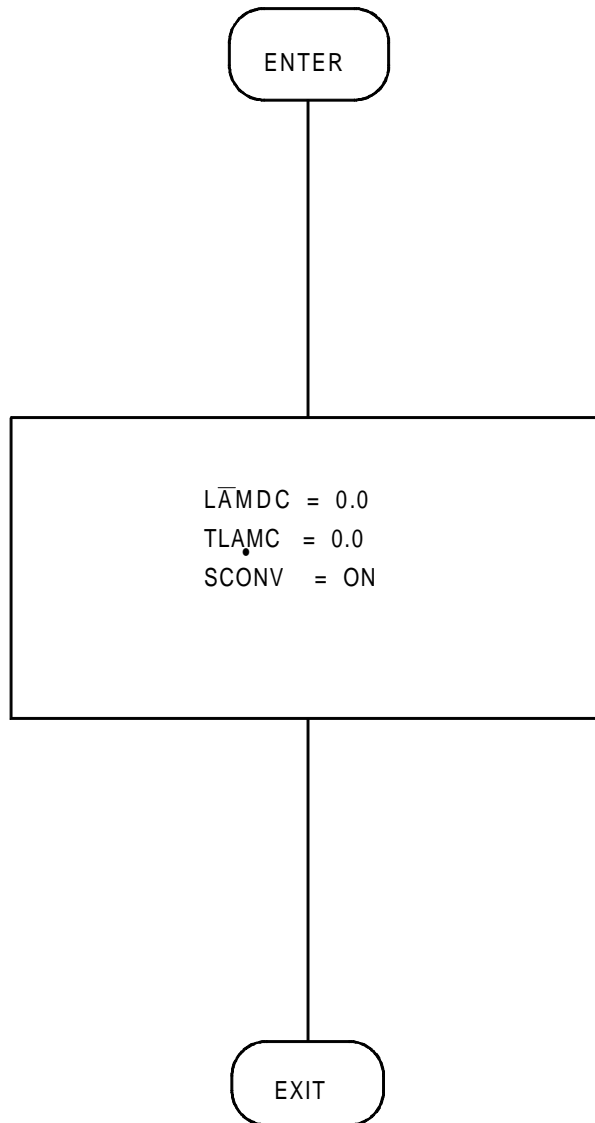


FIGURE A4.5.5.2. Initialization External Delta-V

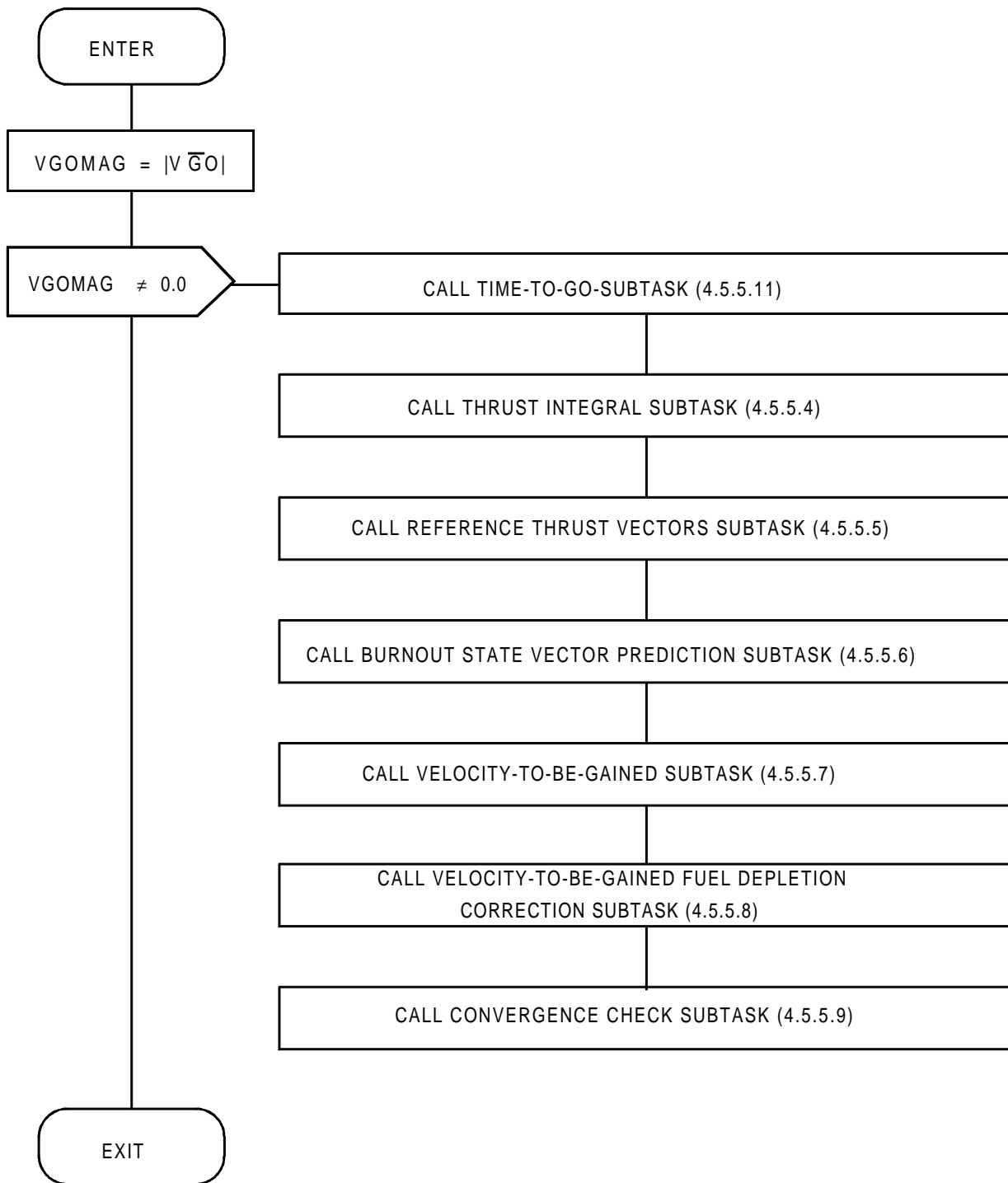


FIGURE A4.5.5.3. LTV PEG Subtask

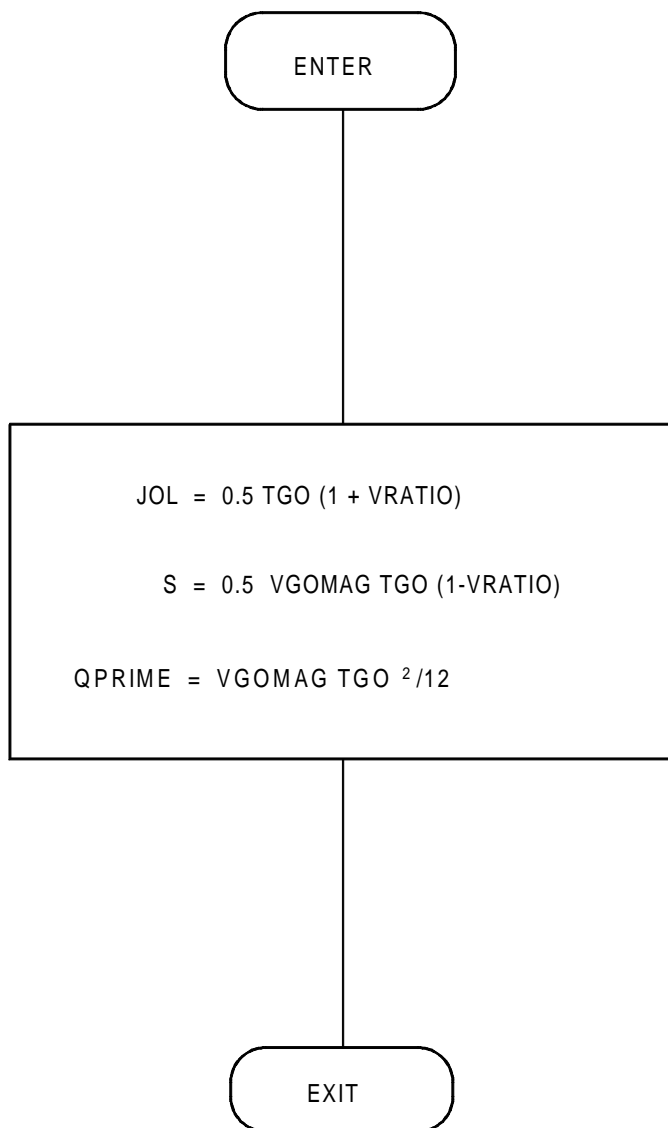


FIGURE A4.5.5.4. Thrust Integral Subtask

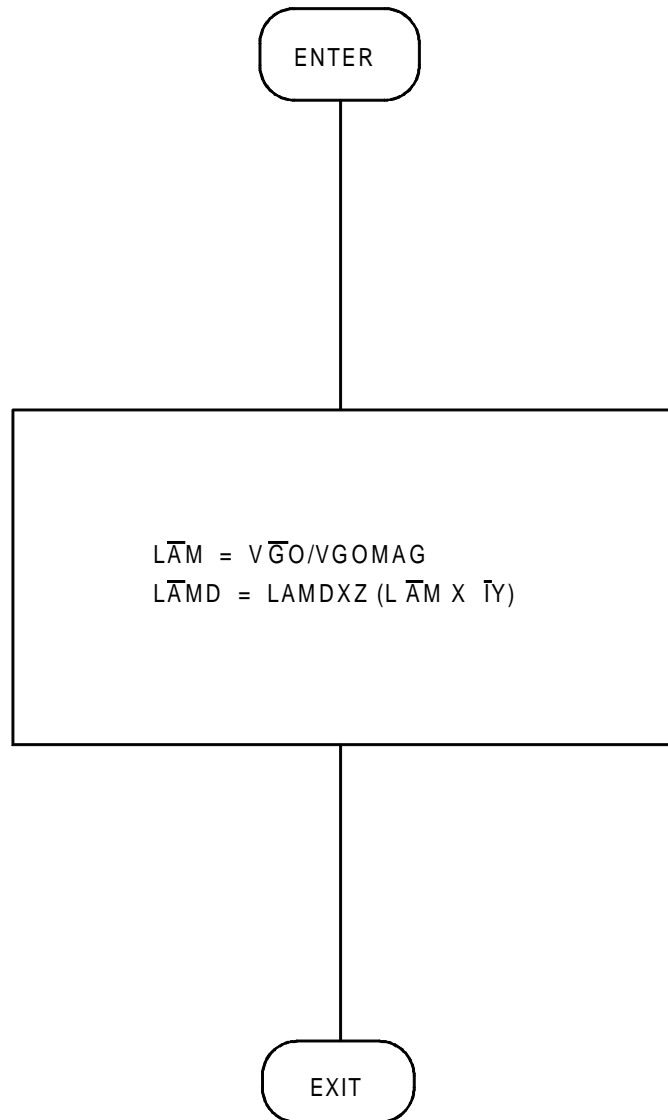


FIGURE A4.5.5.5. Reference Thrust Vector Subtask

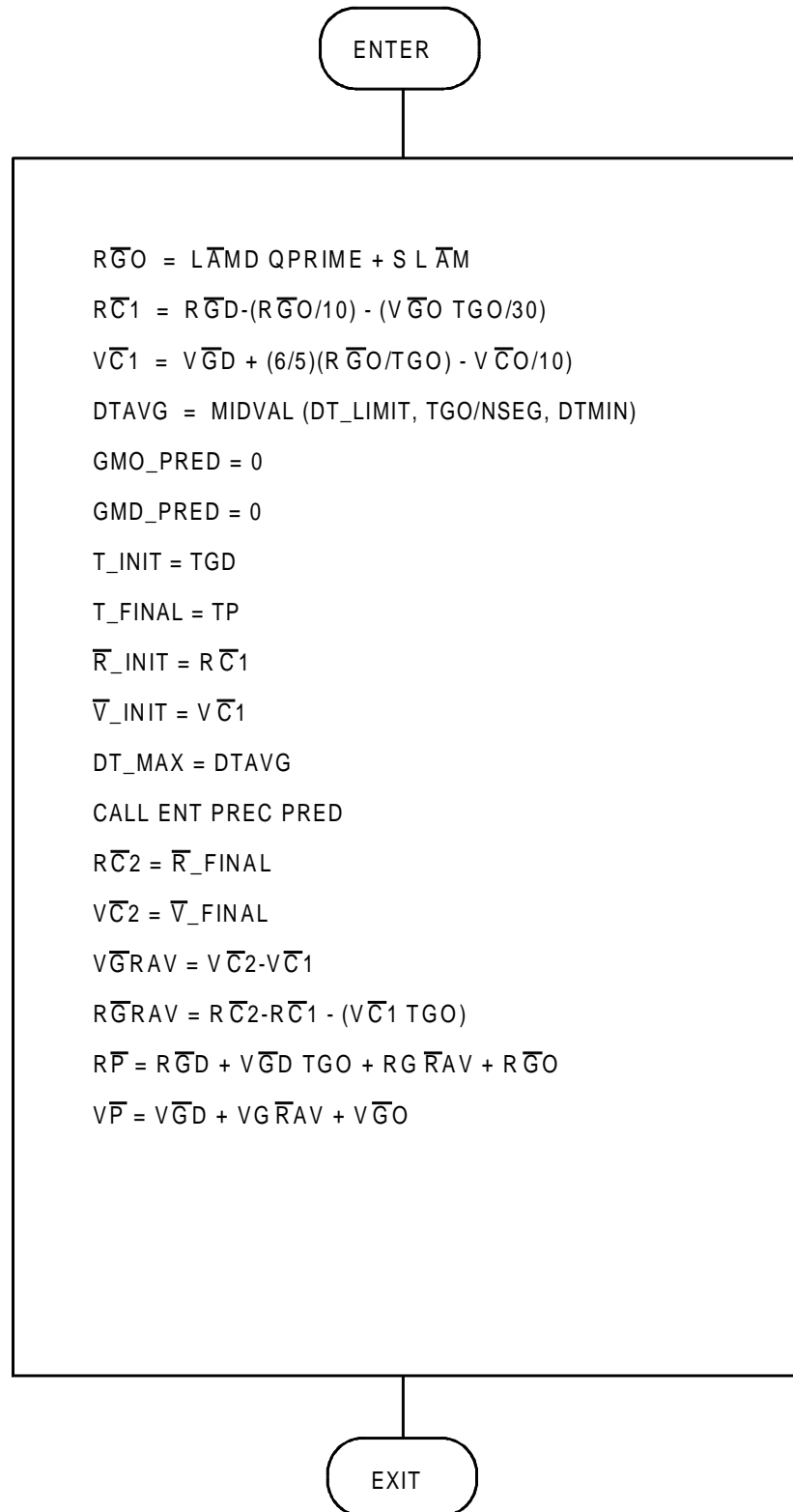


FIGURE A4.5.5.6. Burnout State Vector Prediction Subtask

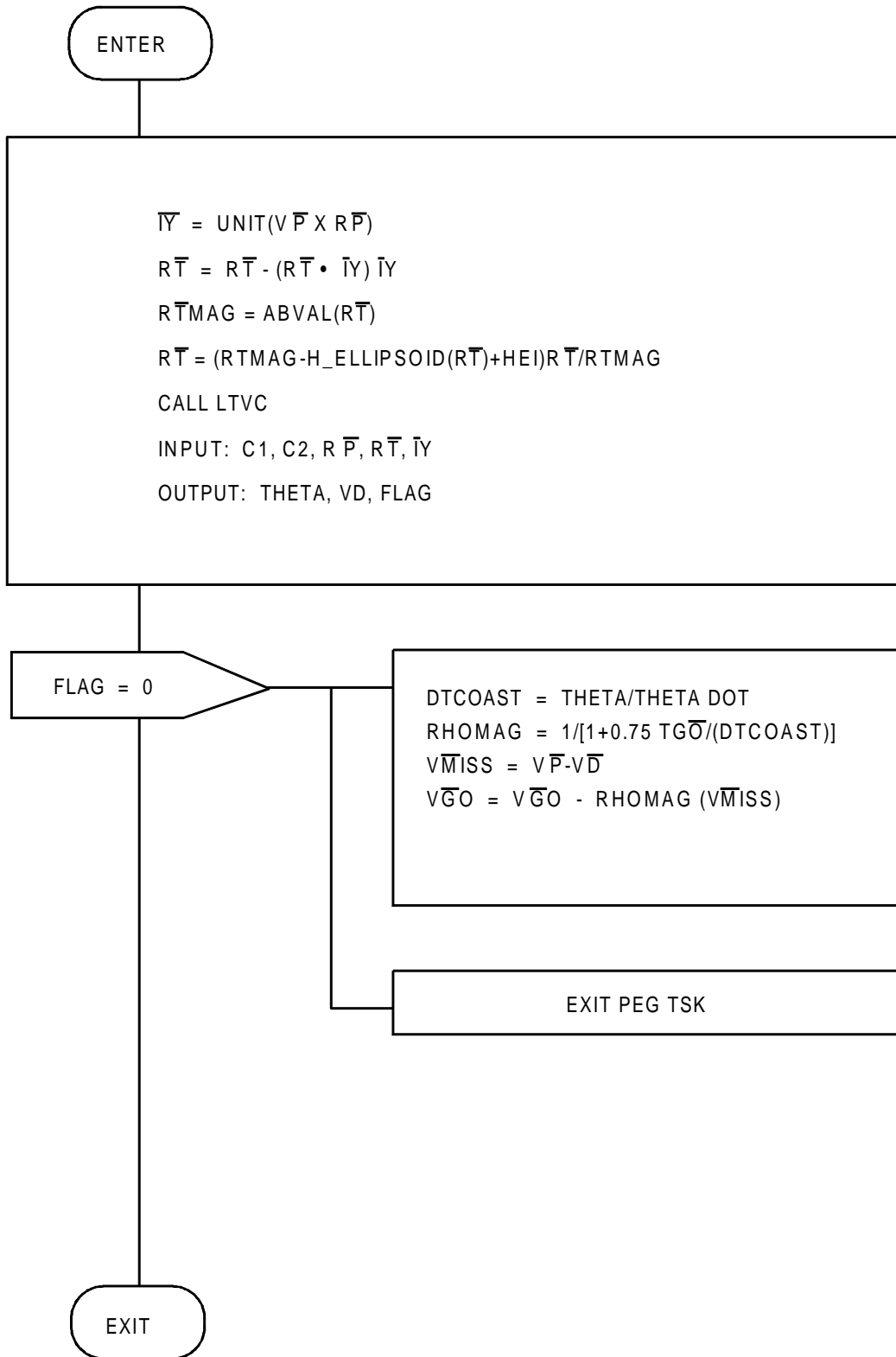


FIGURE A4.5.5.7. Velocity-To-Be-Gained Subtask



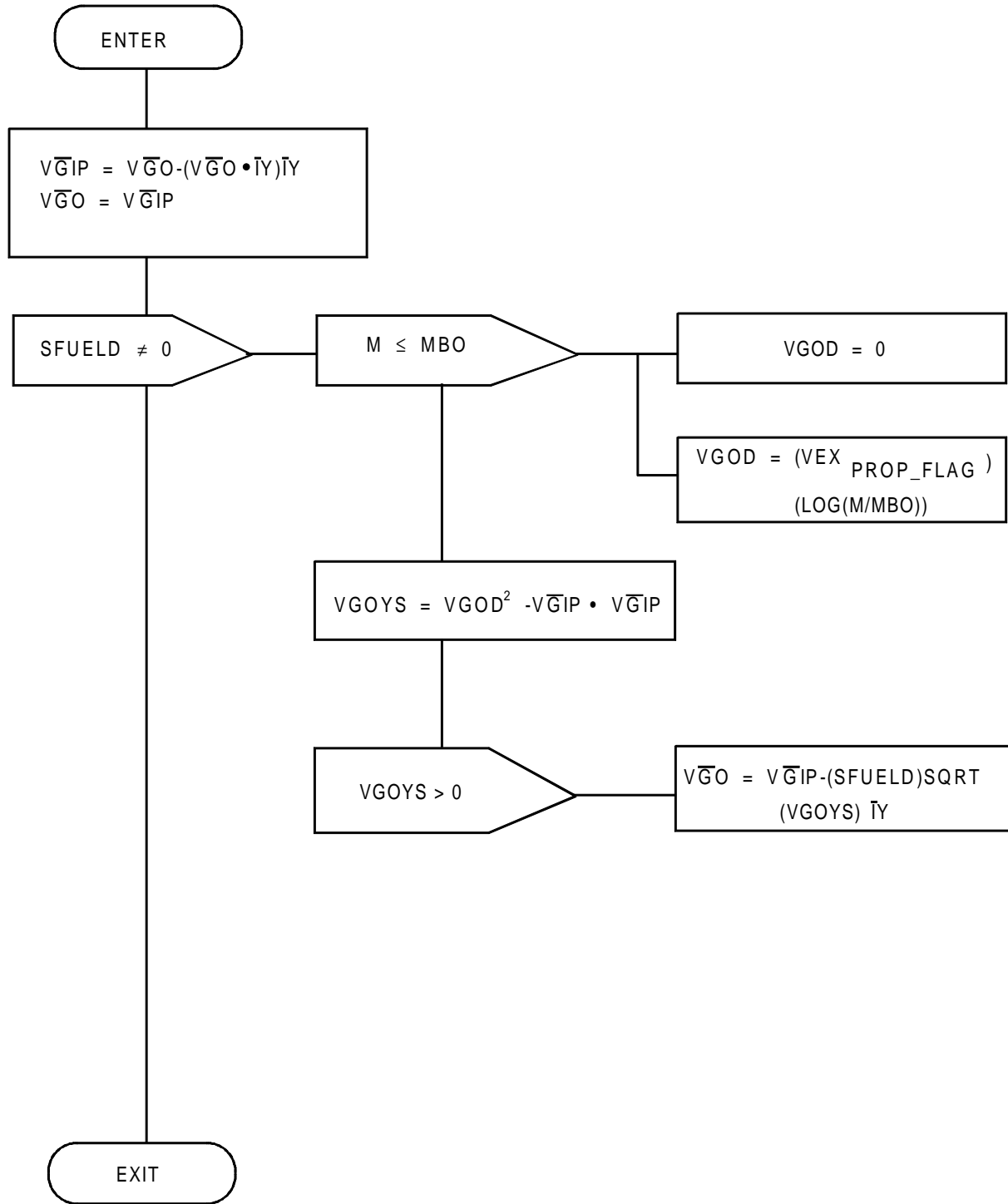


FIGURE A4.5.5.8. Velocity-To-Be-Gained Fuel Depletion Subtask

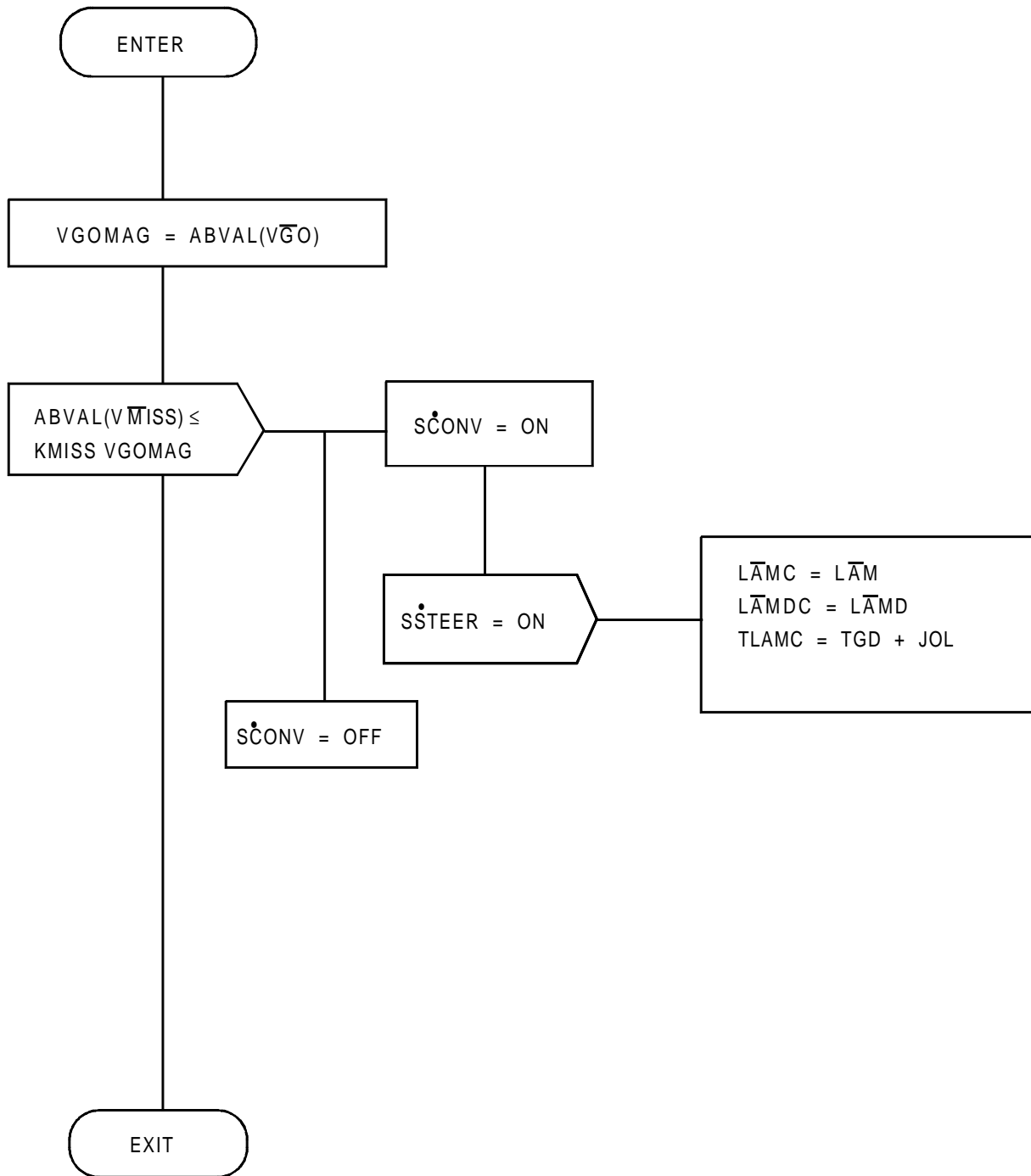


FIGURE A4.5.5.9. Convergence Check Subtask

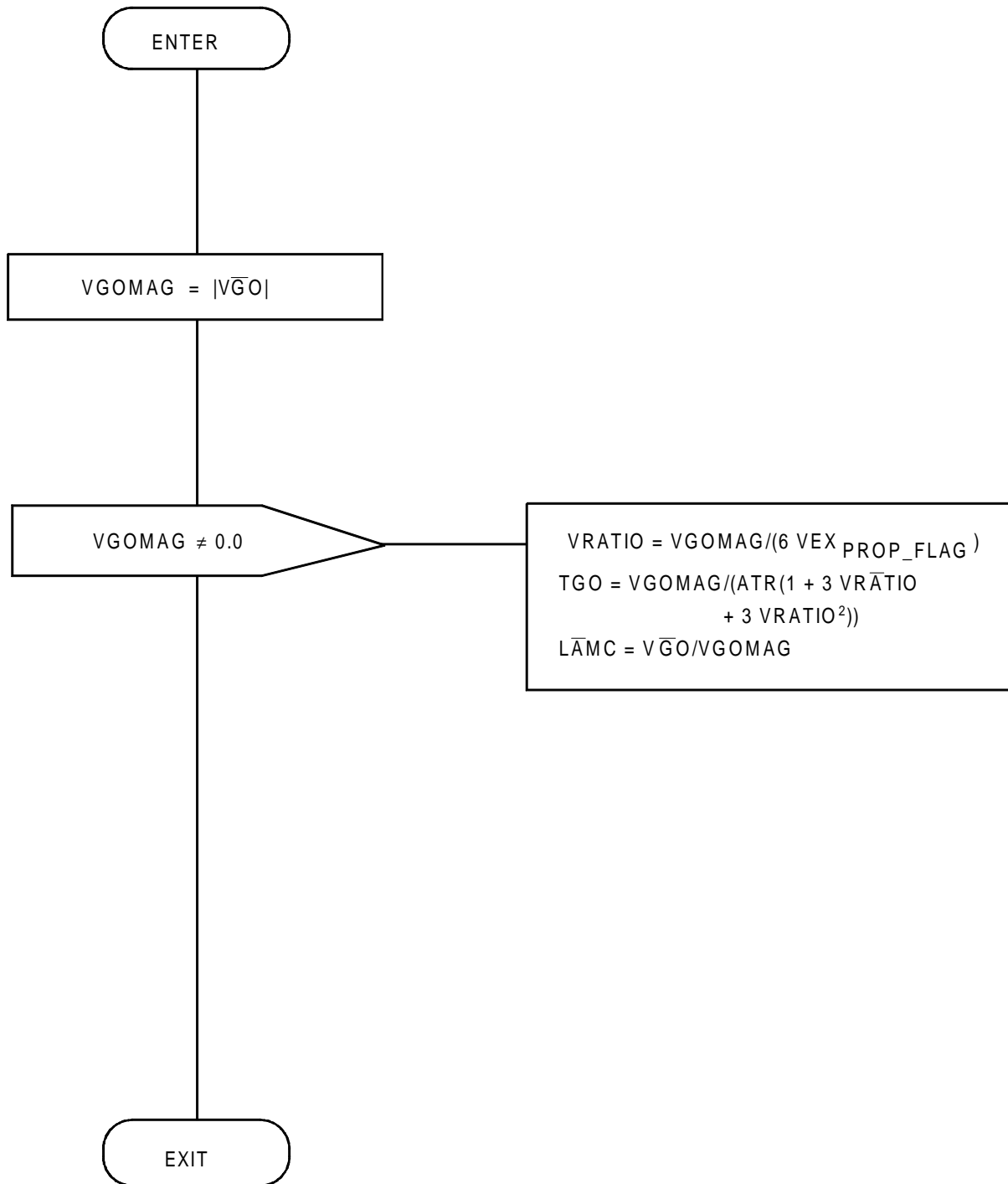


FIGURE A4.5.5.10. External Delta\_V Subtask

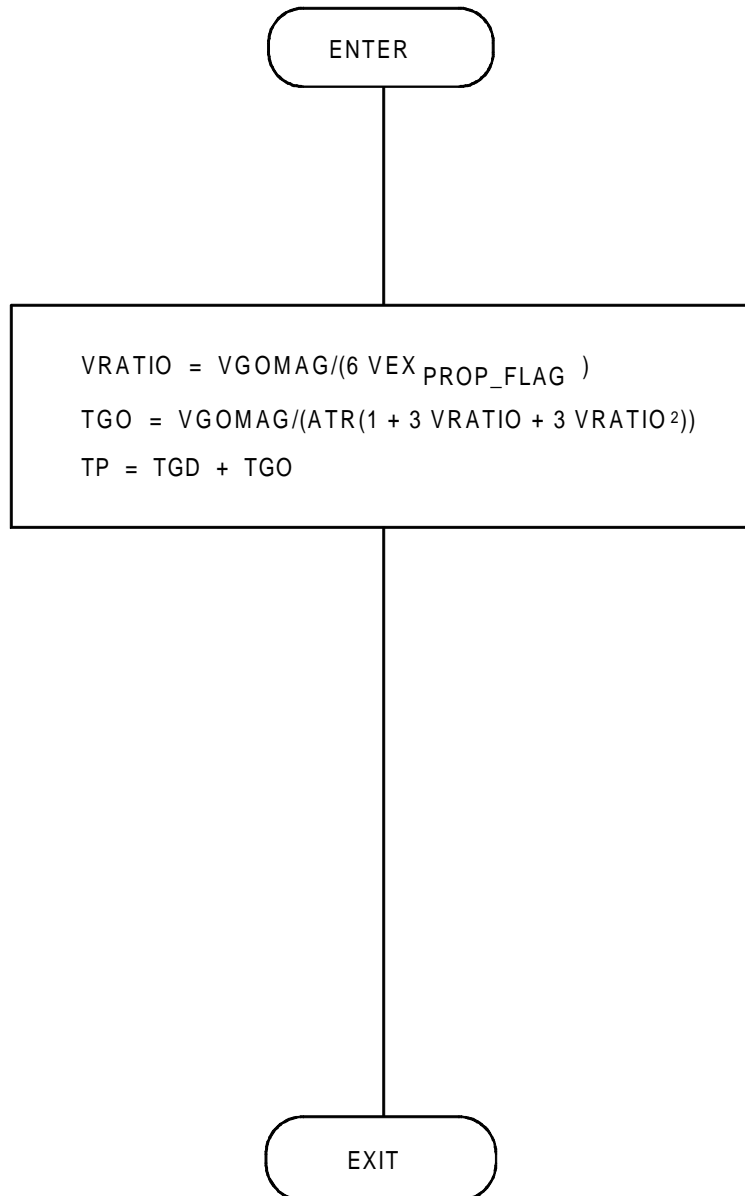


FIGURE A4.5.5.11. Time-To-Go Subtask

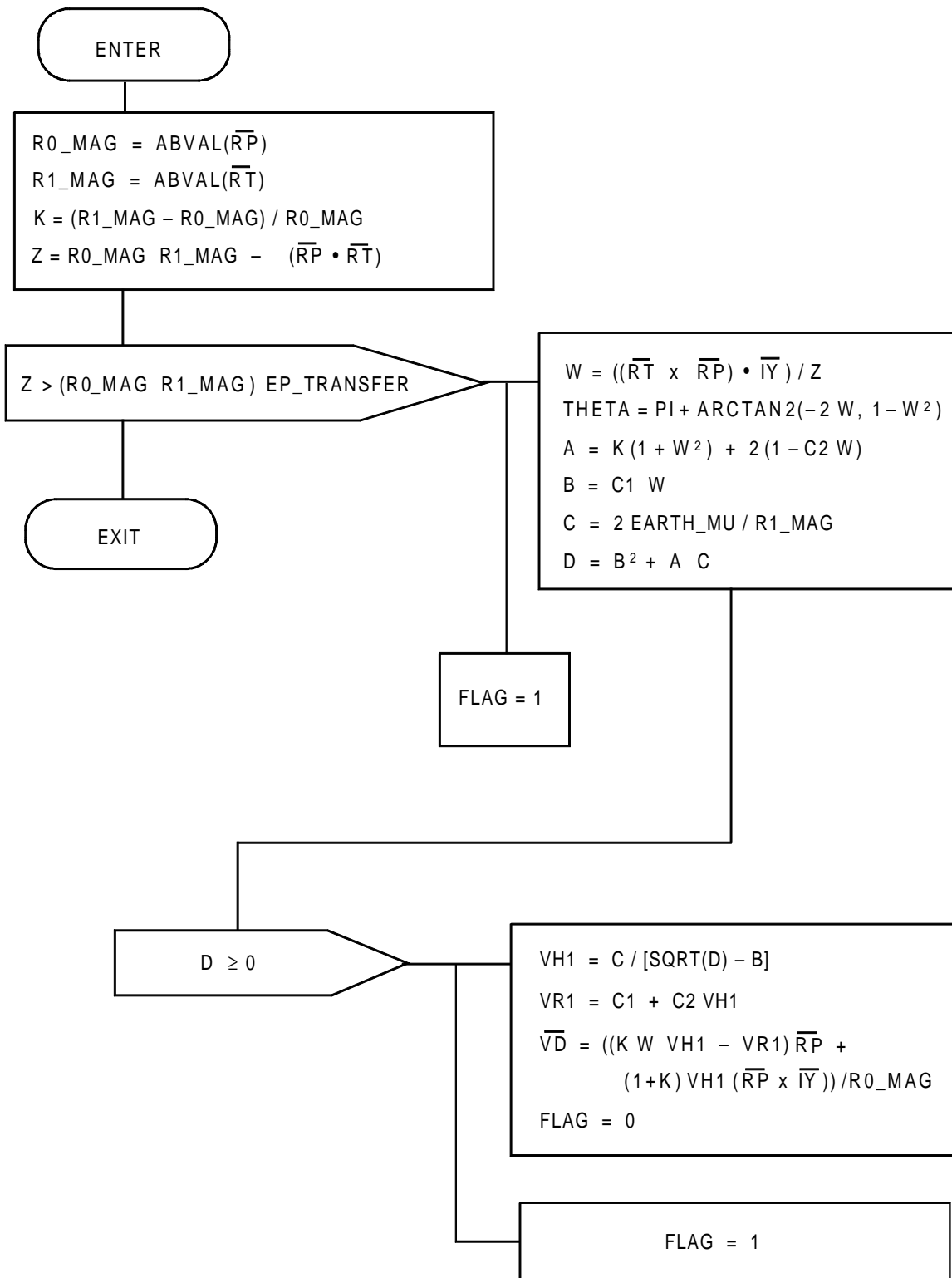


FIGURE A4.5.6. LTVC Task

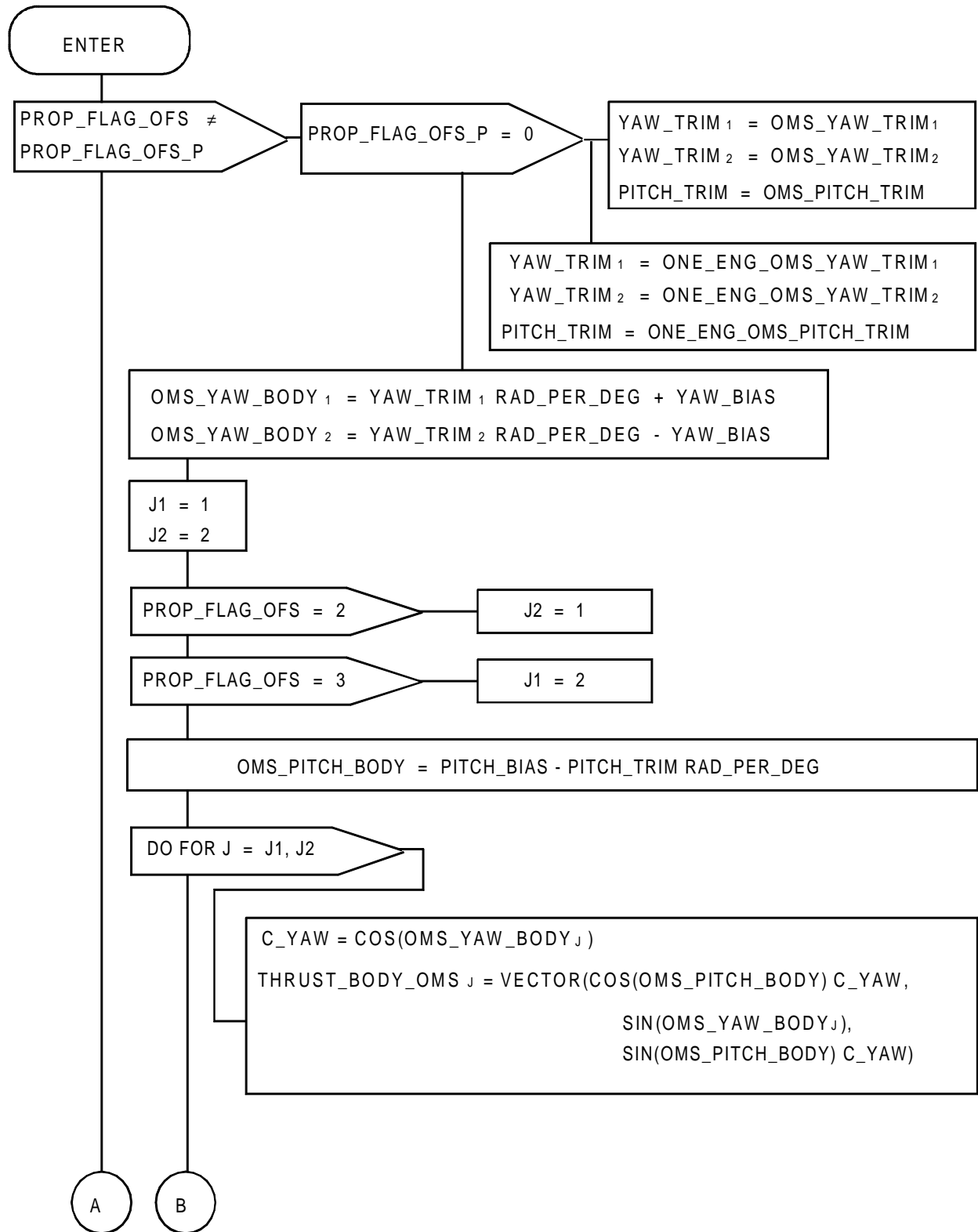


FIGURE A4.5.7.(1) CMD BDY ATT TSK (Sheet 1 of 3)

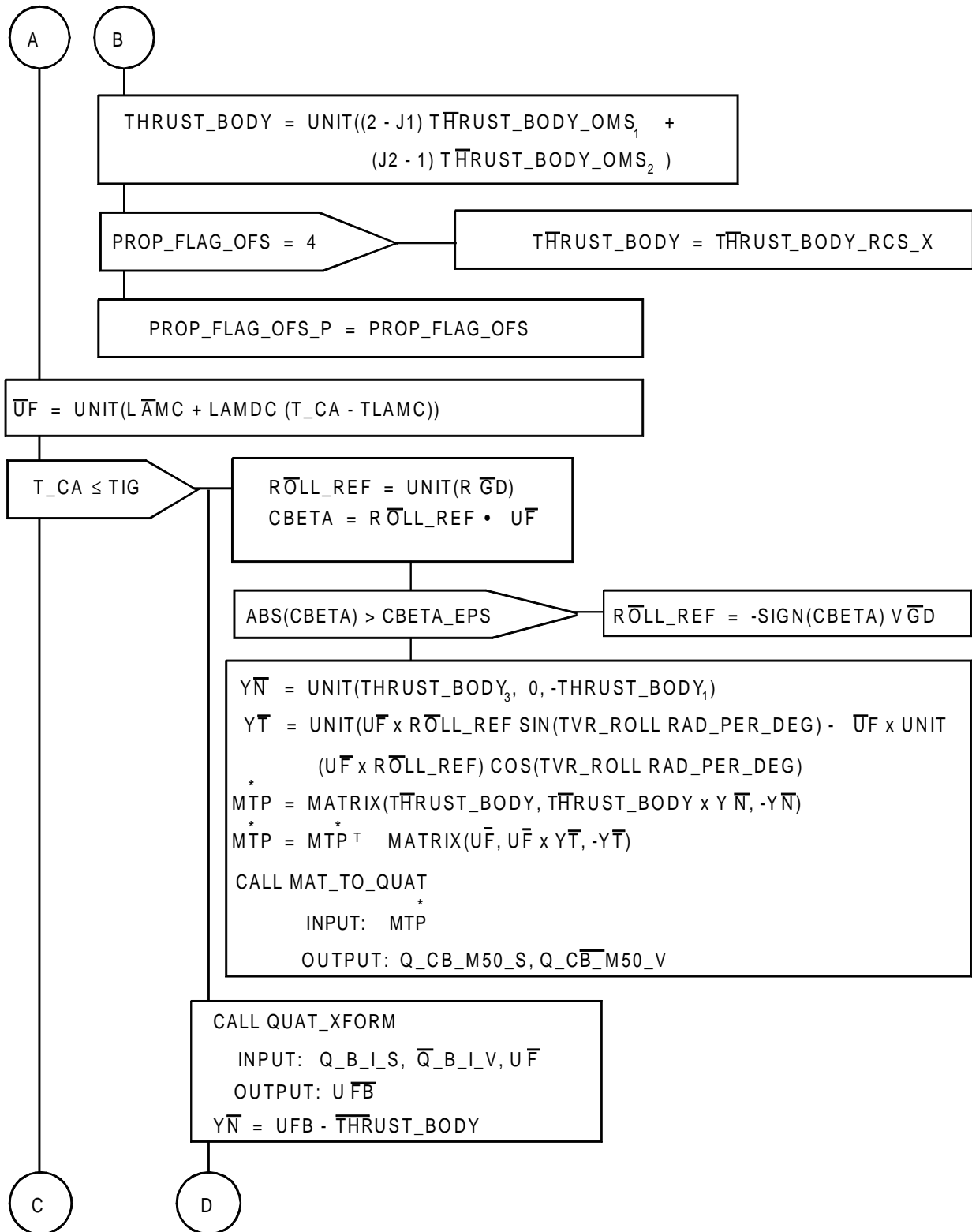


FIGURE A4.5.7.(2) CMD BDY ATT TSK (Sheet 2 of 3)

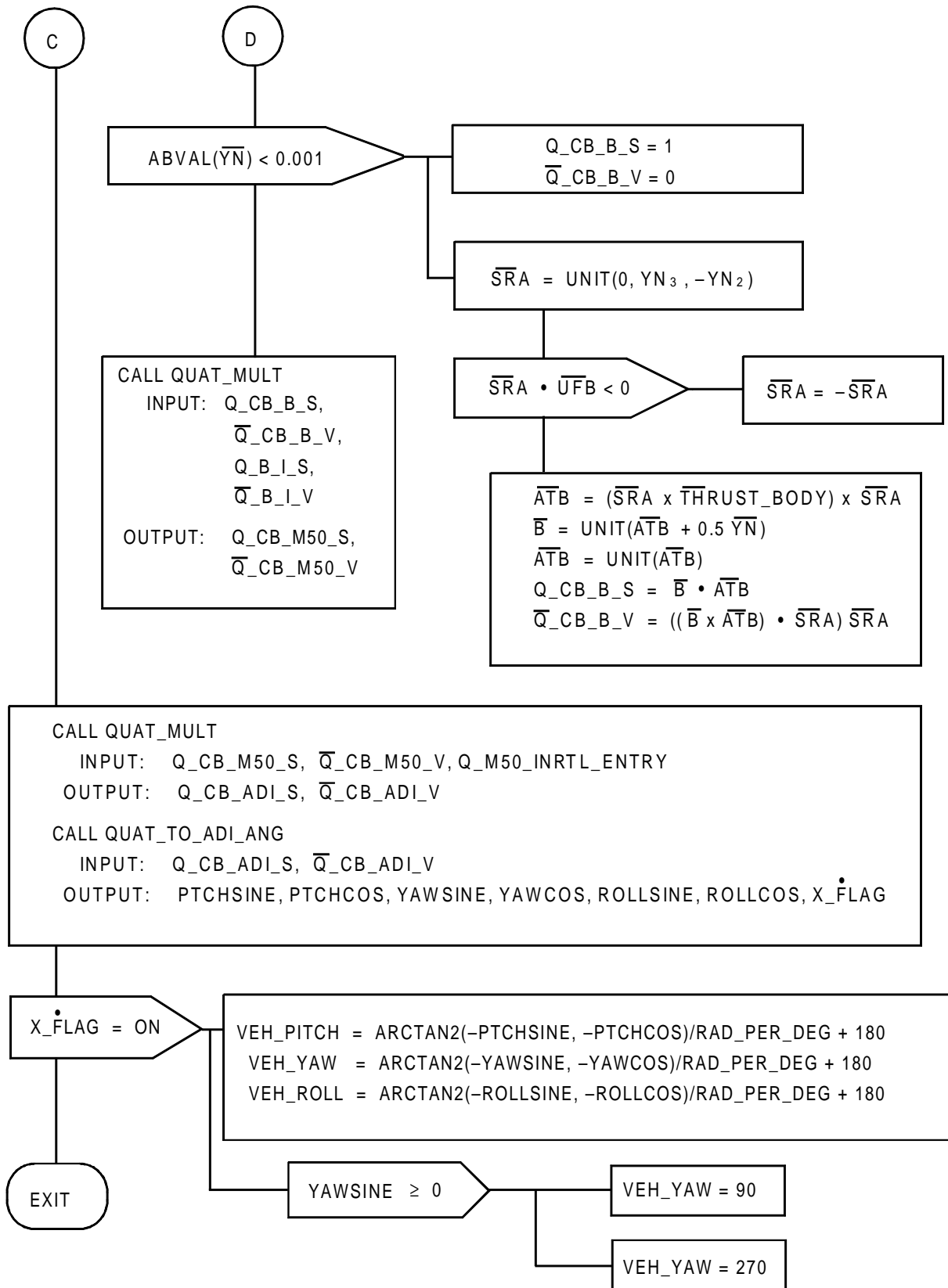


FIGURE A4.5.7.(3) CMD BDY ATT TSK (Sheet 3 of 3)



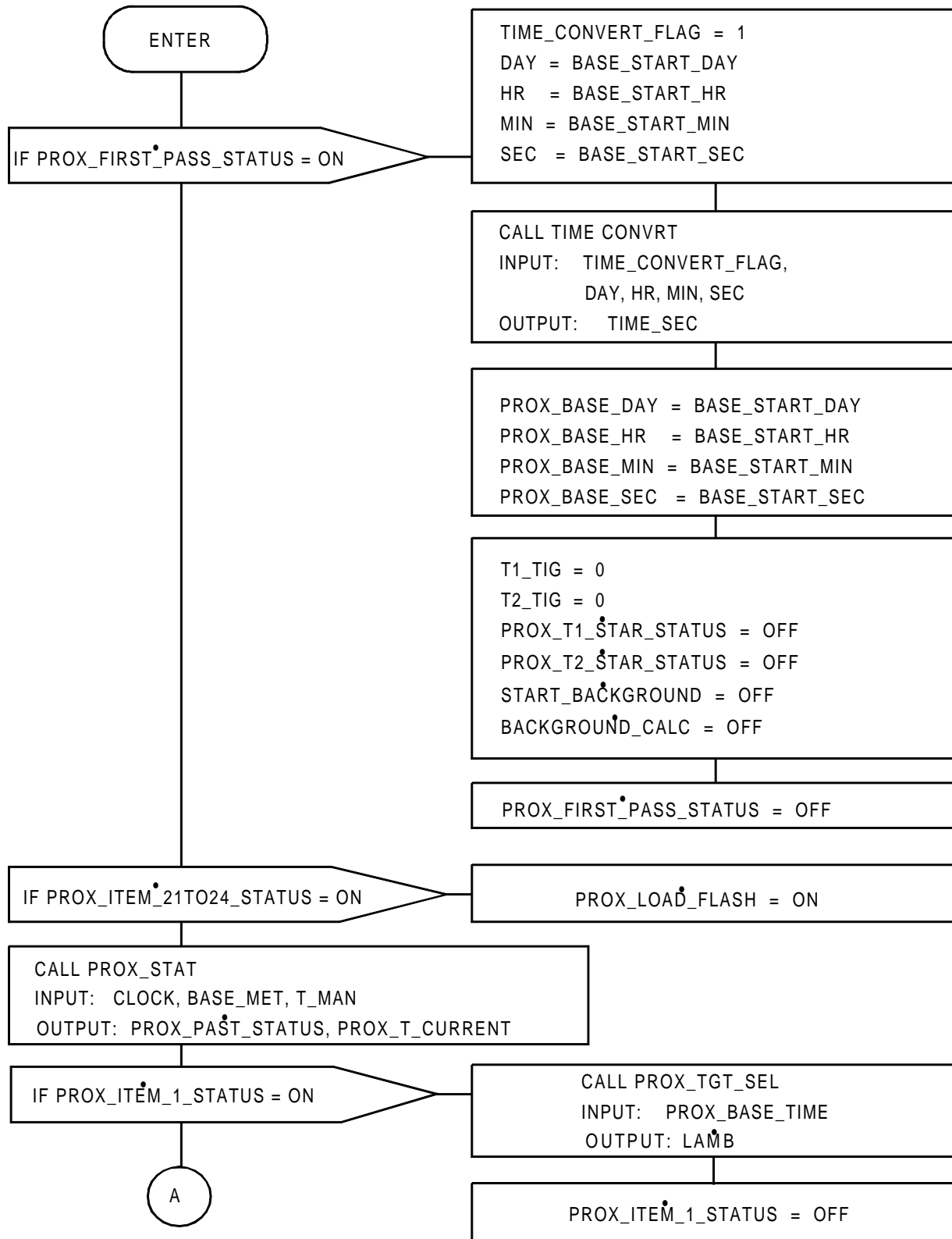


FIGURE A4.6.2.(1) PROC\_EXEC (Sheet 1 of 3)

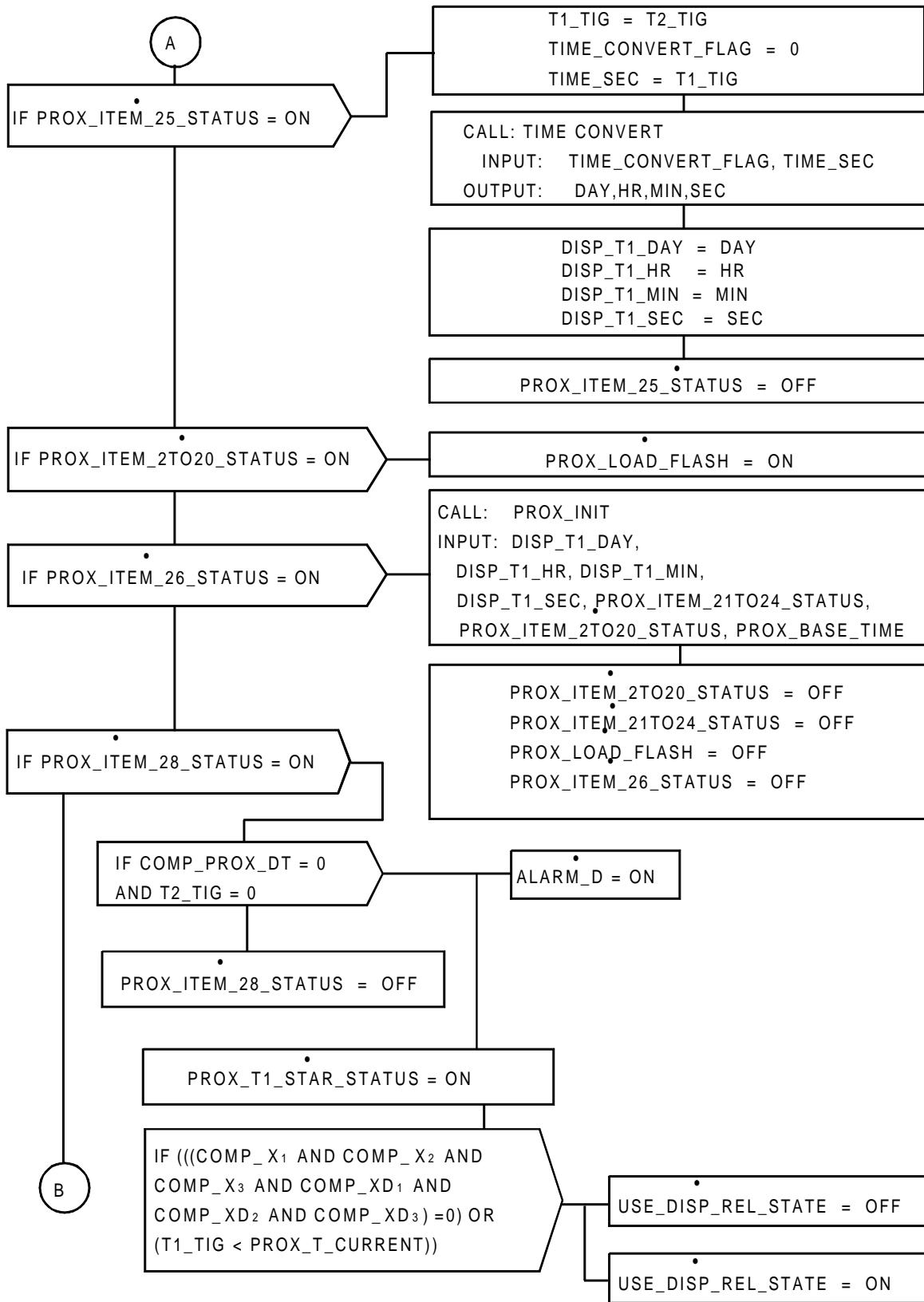


FIGURE A4.6.2.(2) PROX\_EXEC (Sheet 2 of 3)

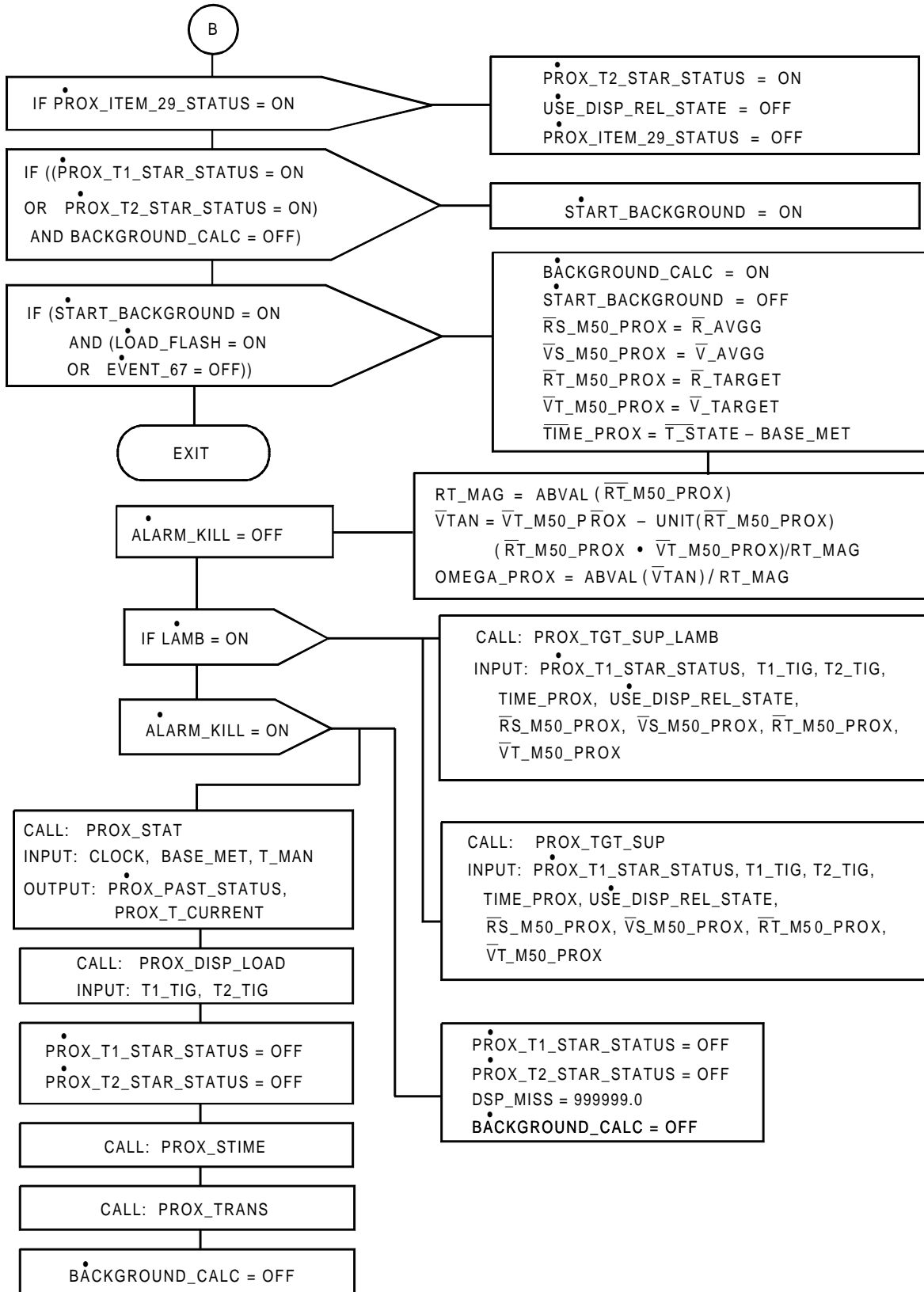


FIGURE A4.6.2.(3) PROX\_EXEC (Sheet 3 of 3)

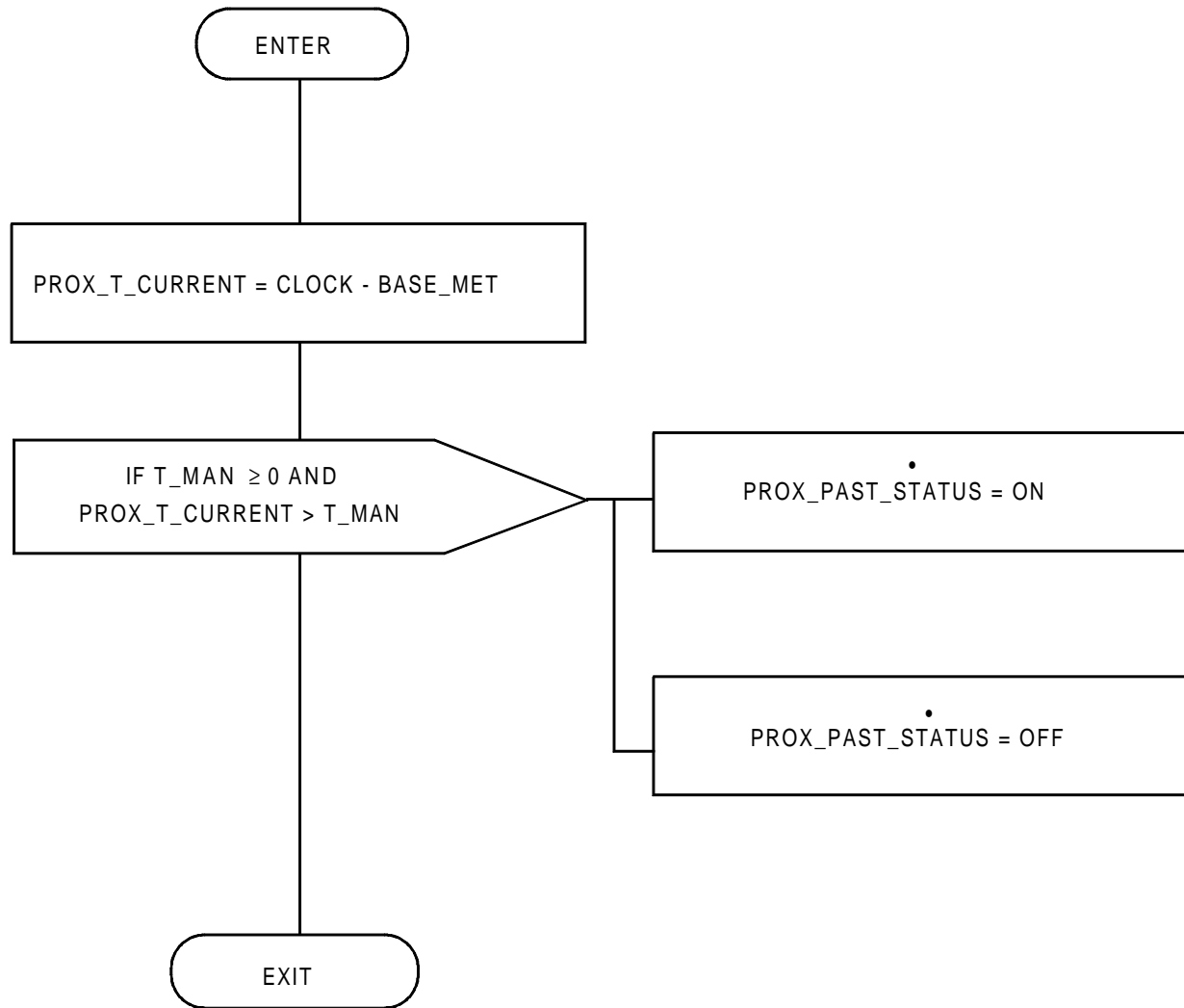


FIGURE A4.6.3. PROX\_STAT

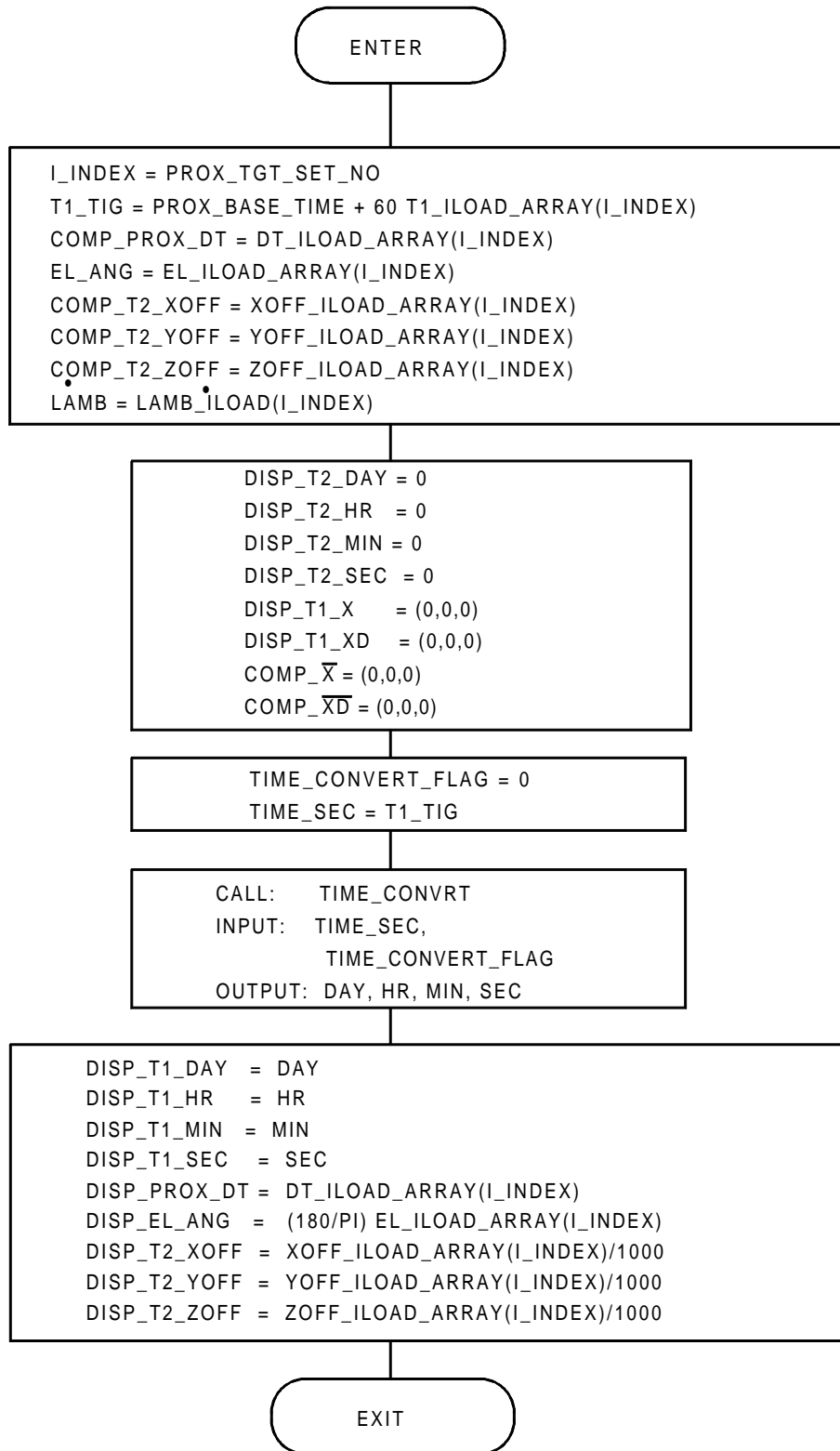


FIGURE A4.6.4 PROC\_TGT\_SEL

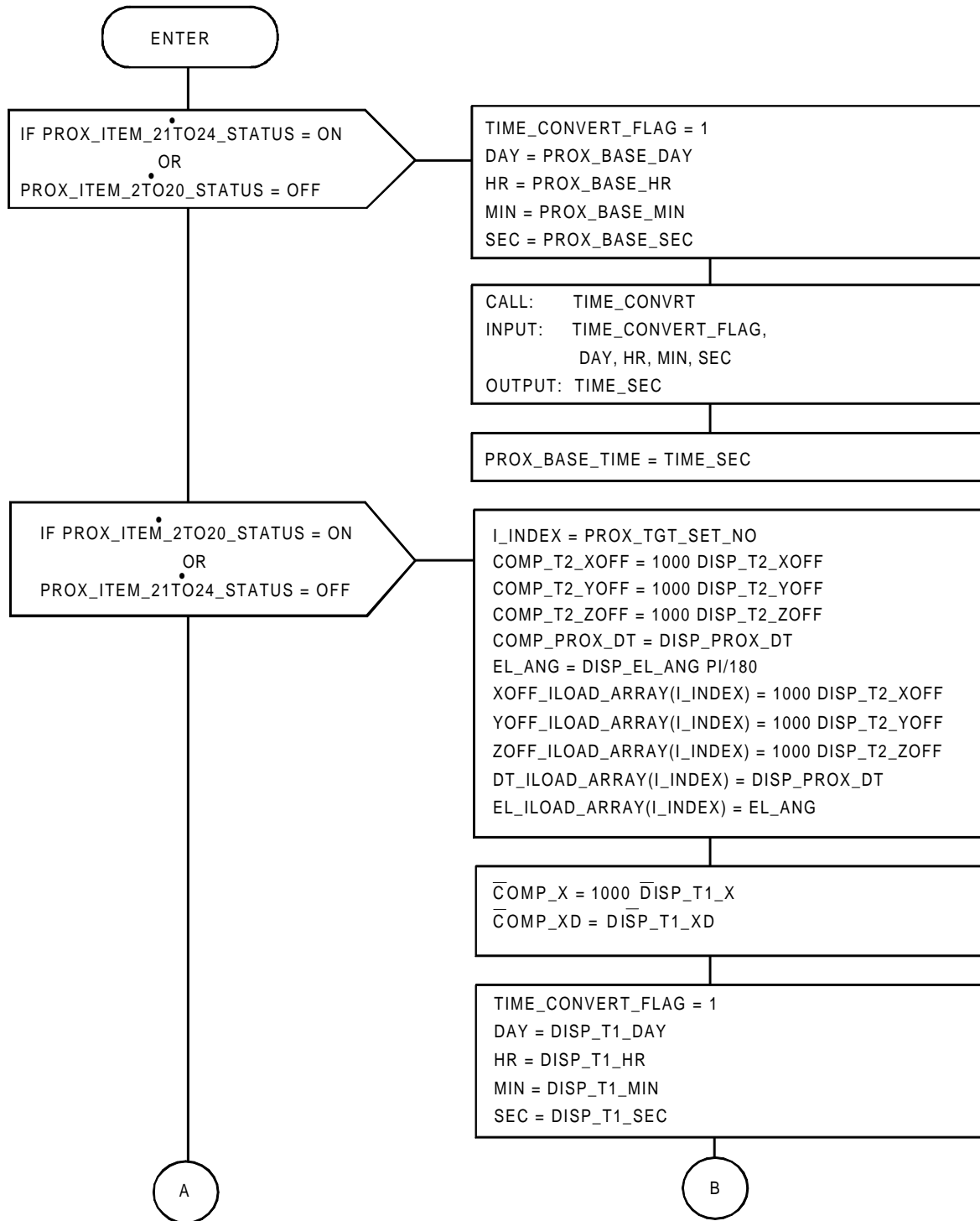


FIGURE A4.6.5.(1) PROX\_INIT (Sheet 1 of 2)



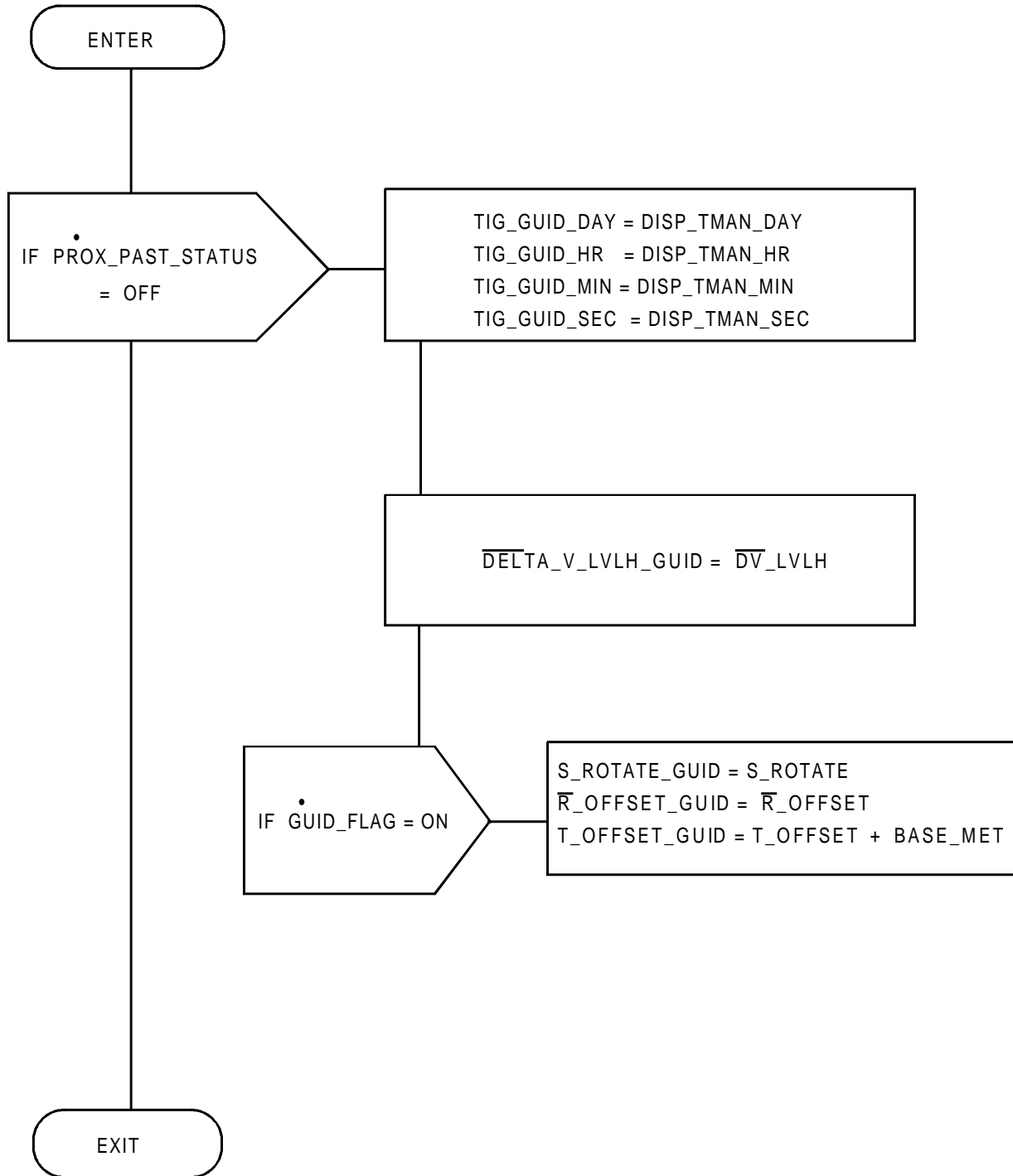


FIGURE A4.6.6. PROC\_TRANS



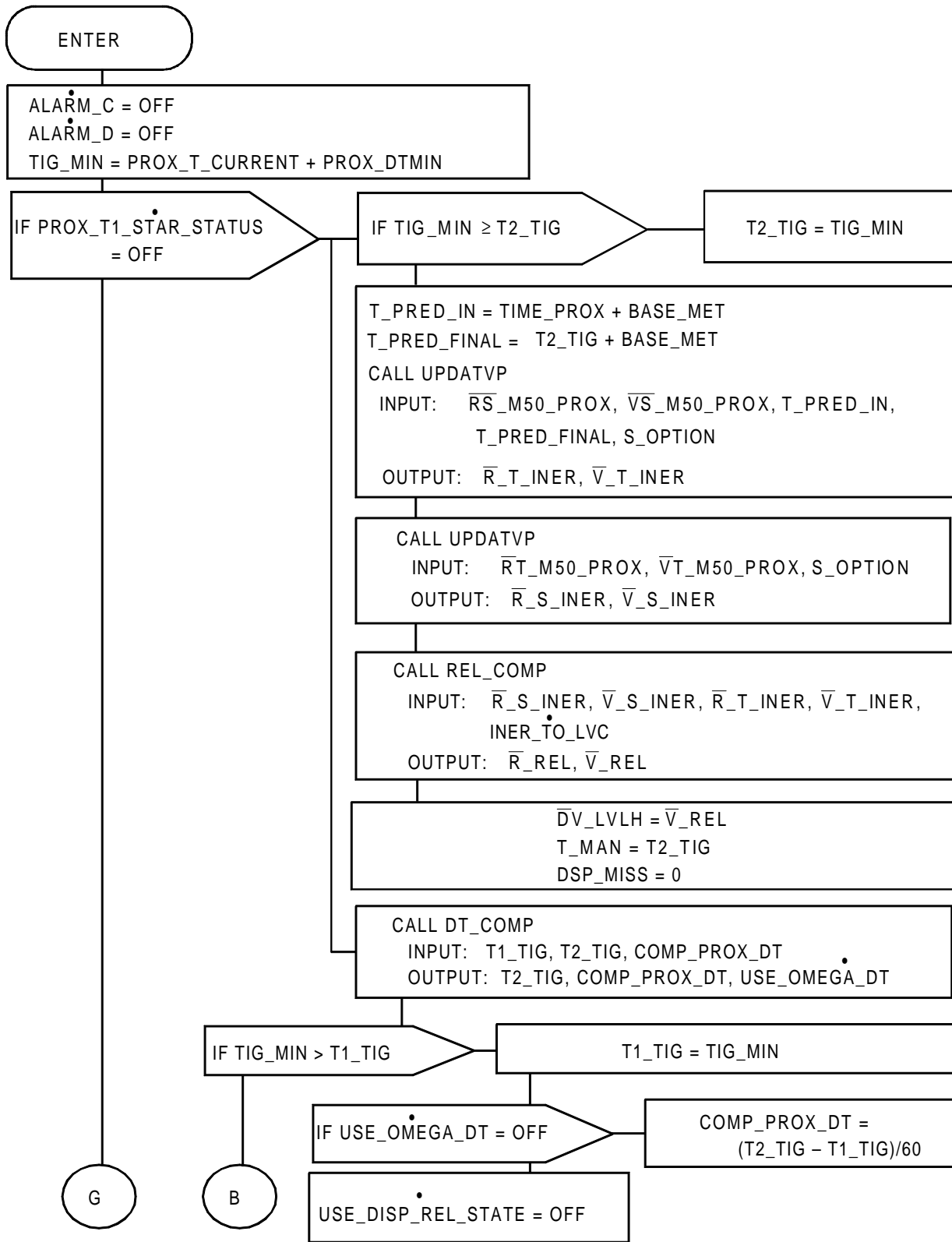


FIGURE A4.6.7.(1) PROX\_TGT\_SUP (Sheet 1 of 5)

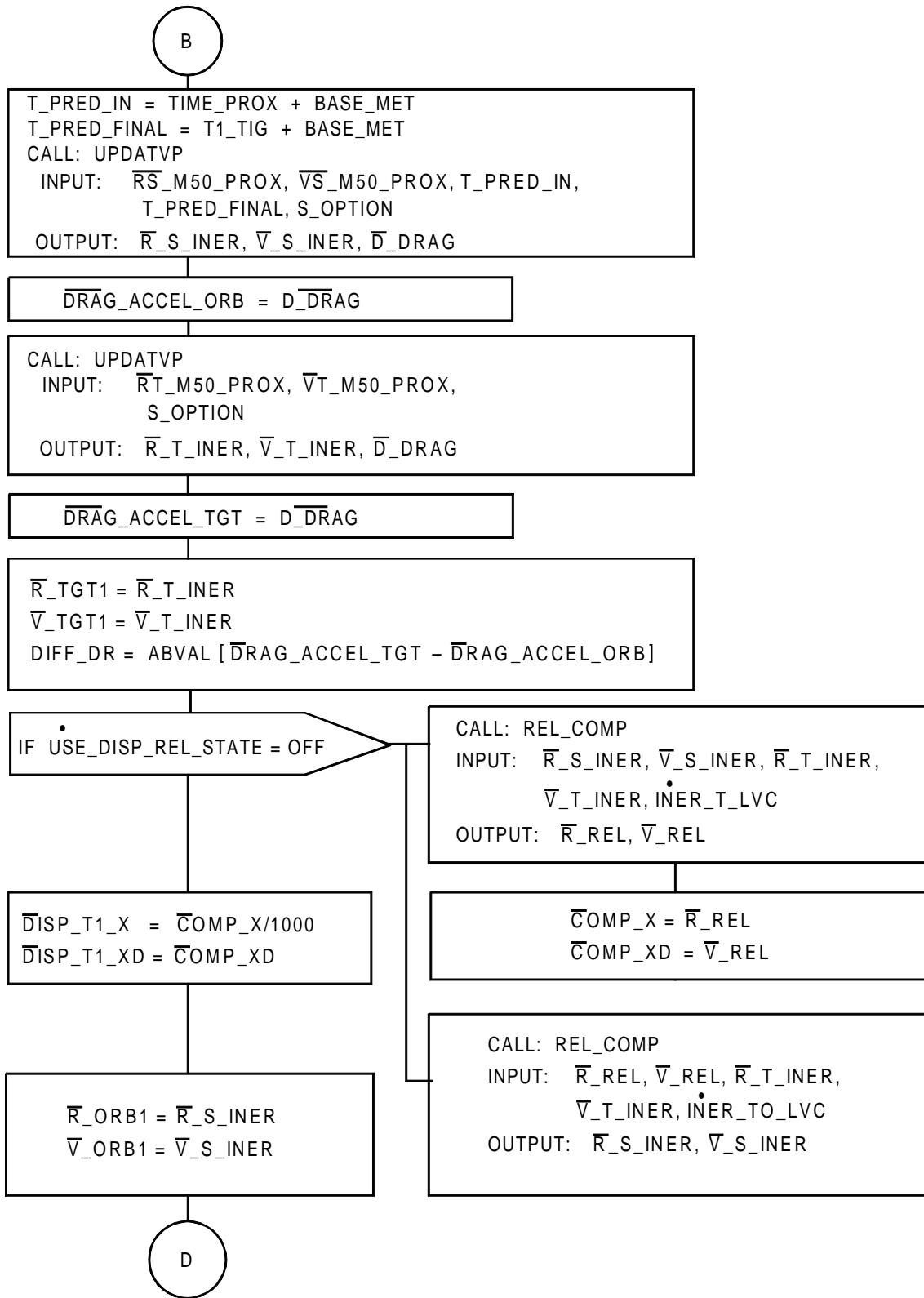


FIGURE A4.6.7.(2) PROX\_TGT\_SUP (Sheet 2 of 5)

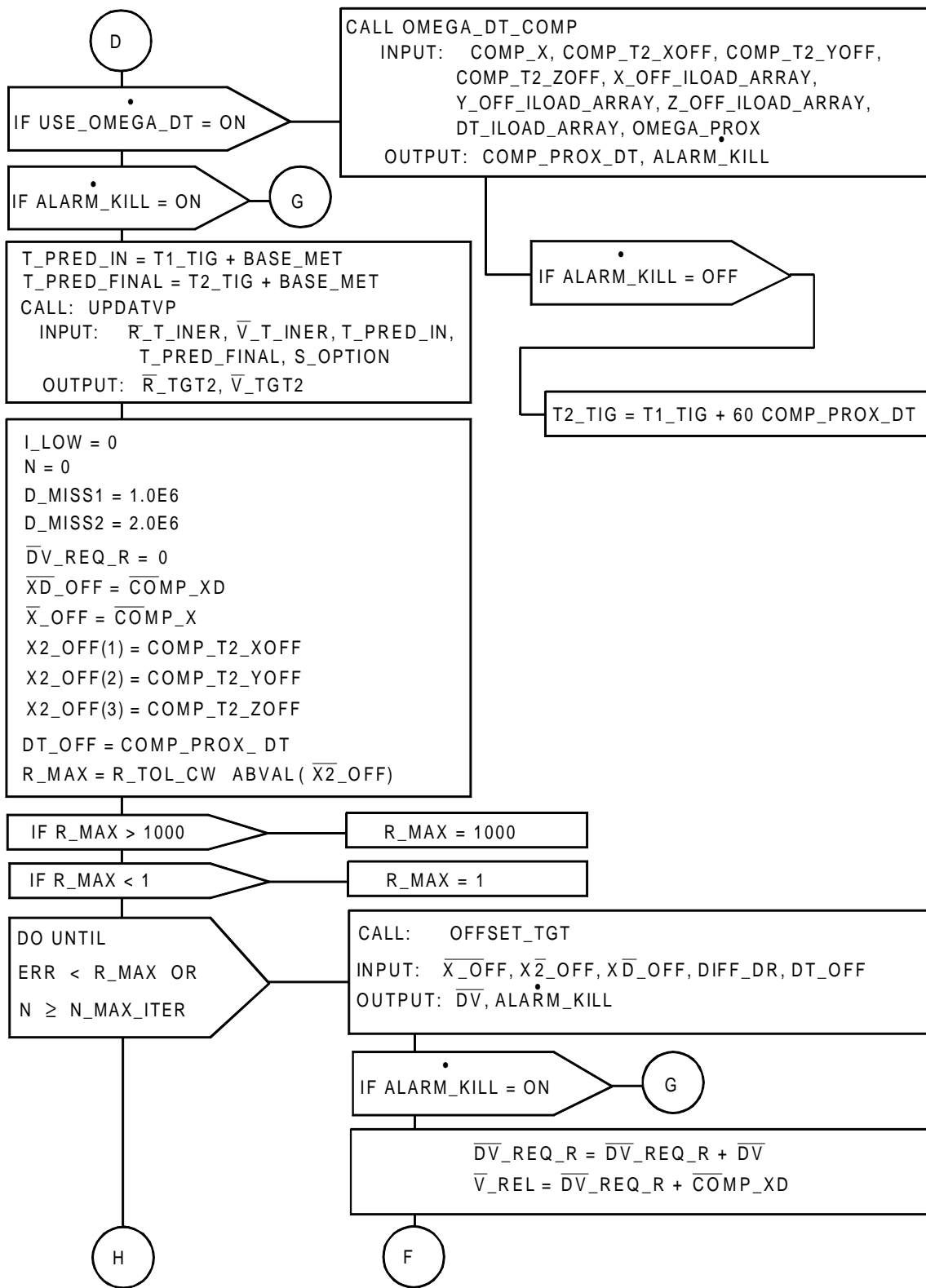


FIGURE A4.6.7.(3) PROX\_TGT\_SUP (Sheet 3 of 5)

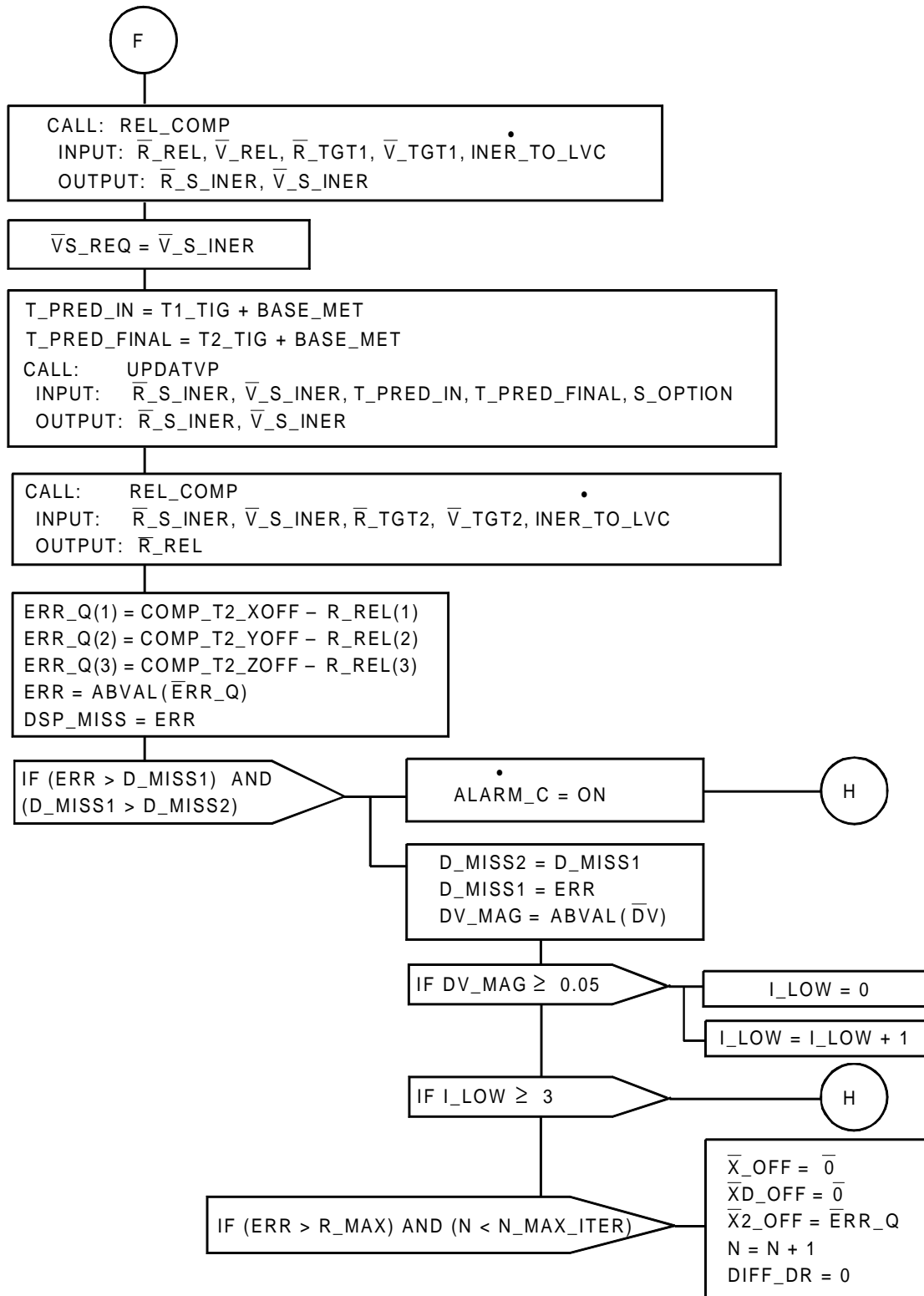


FIGURE A4.6.7.(4) PROX\_TGT\_SUP (Sheet 4 of 5)

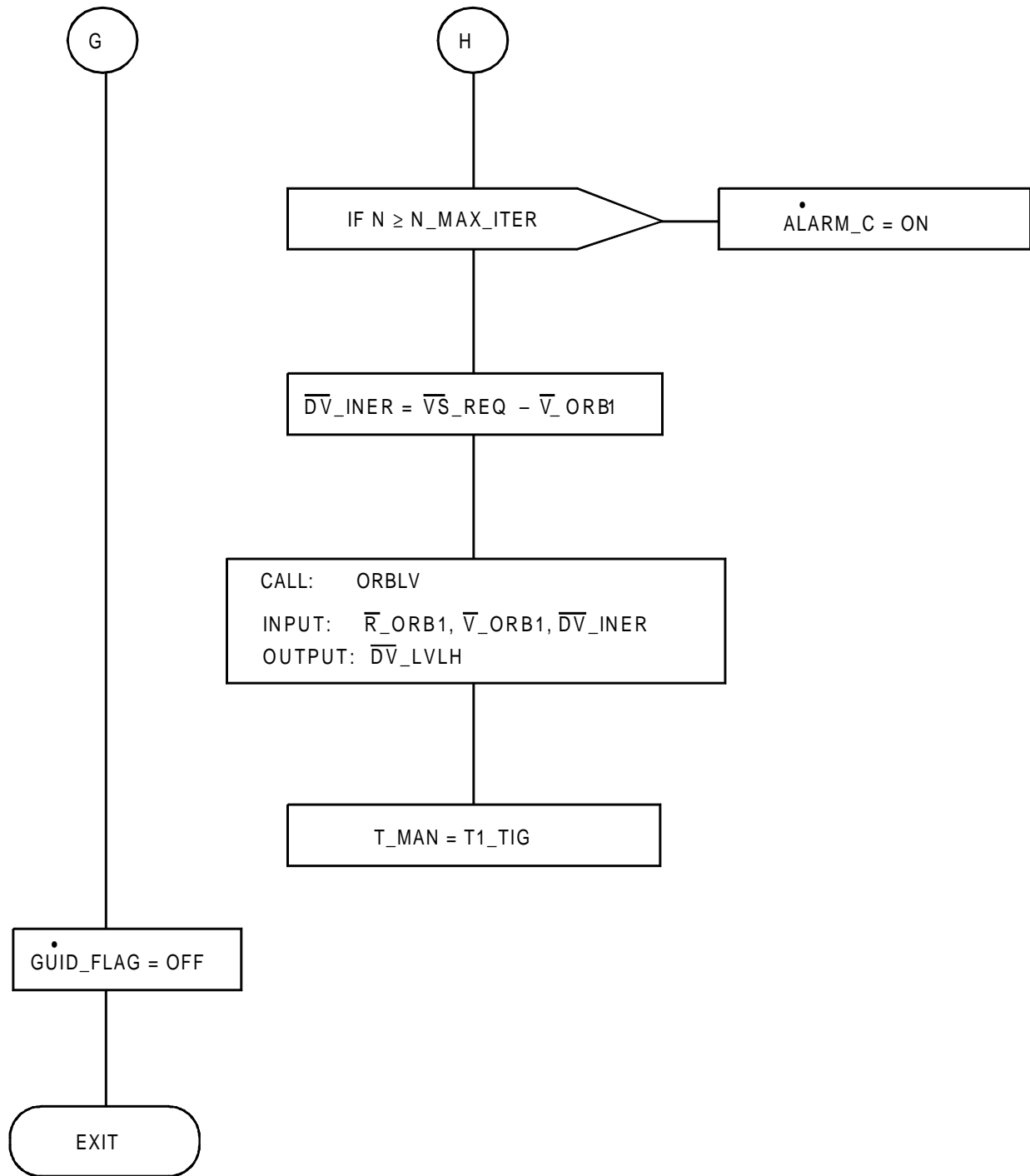


FIGURE A4.6.7.(5) PROX\_TGT\_SUP (Sheet 5 of 5)

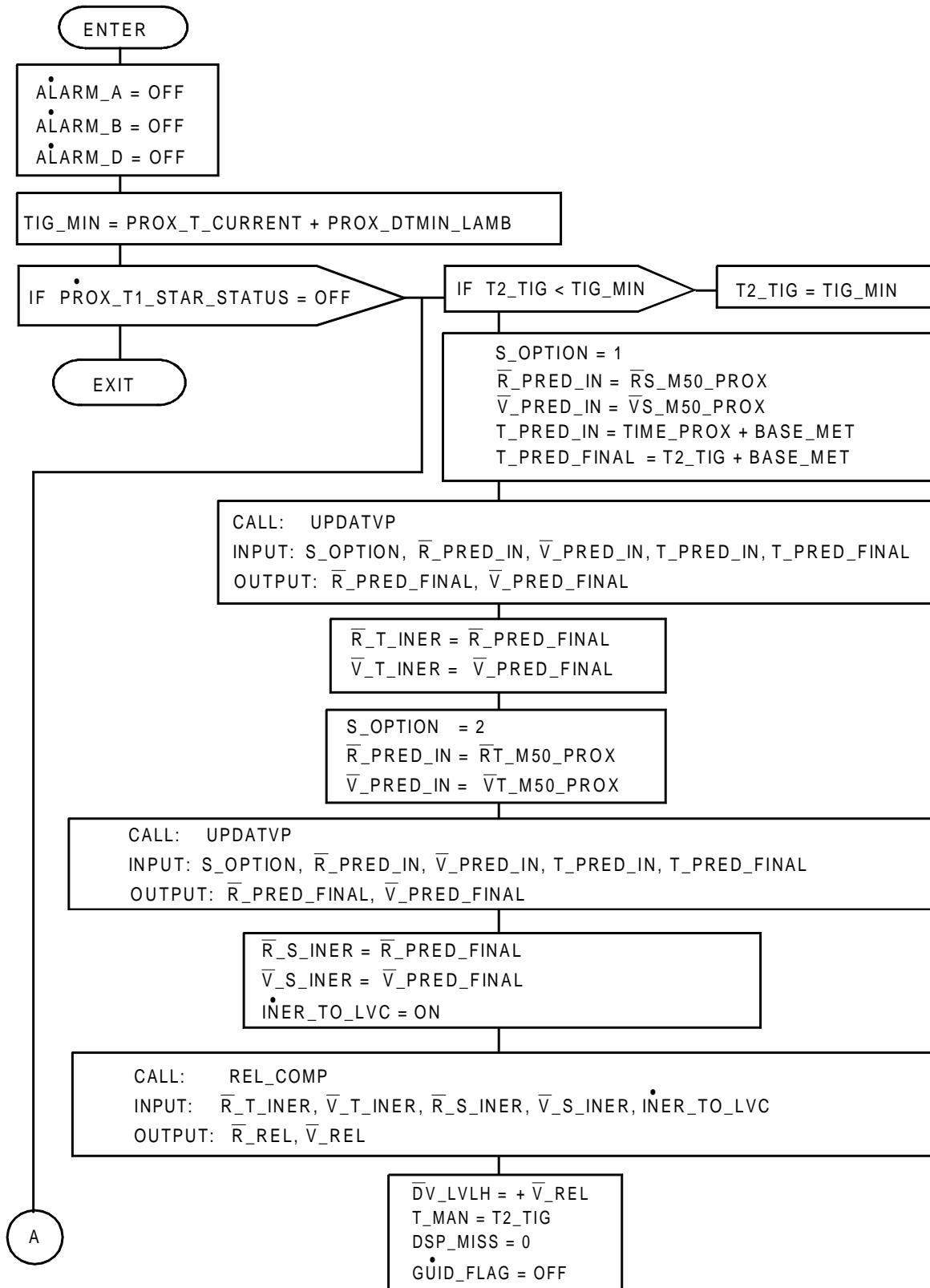


FIGURE A4.6.8.(1) PROC\_TGT\_SUP\_LAMB (Sheet 1 of 4)

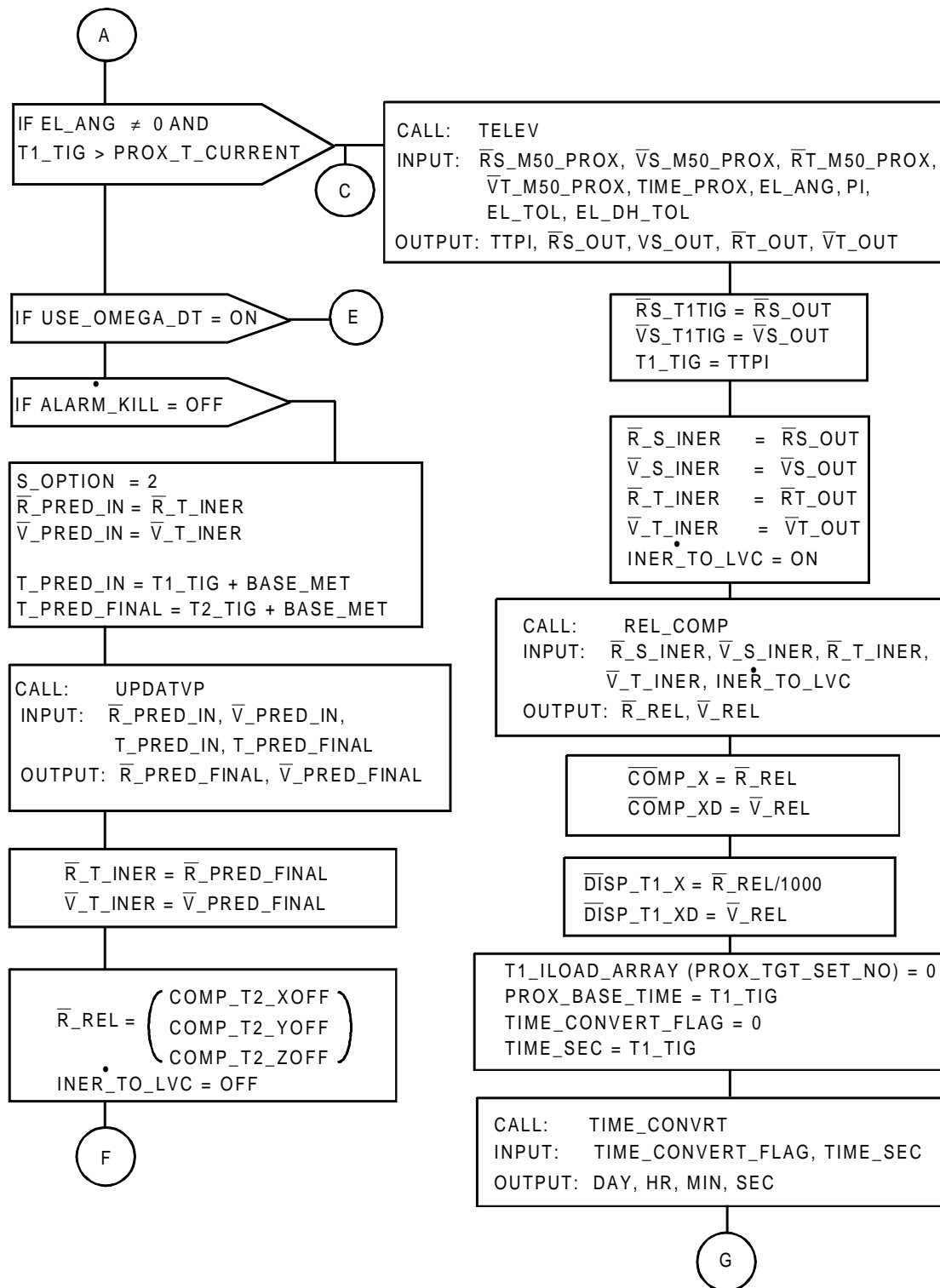


FIGURE A4.6.8.(2) PROX\_TGT\_SUP\_LAMB (Sheet 2 of 4)

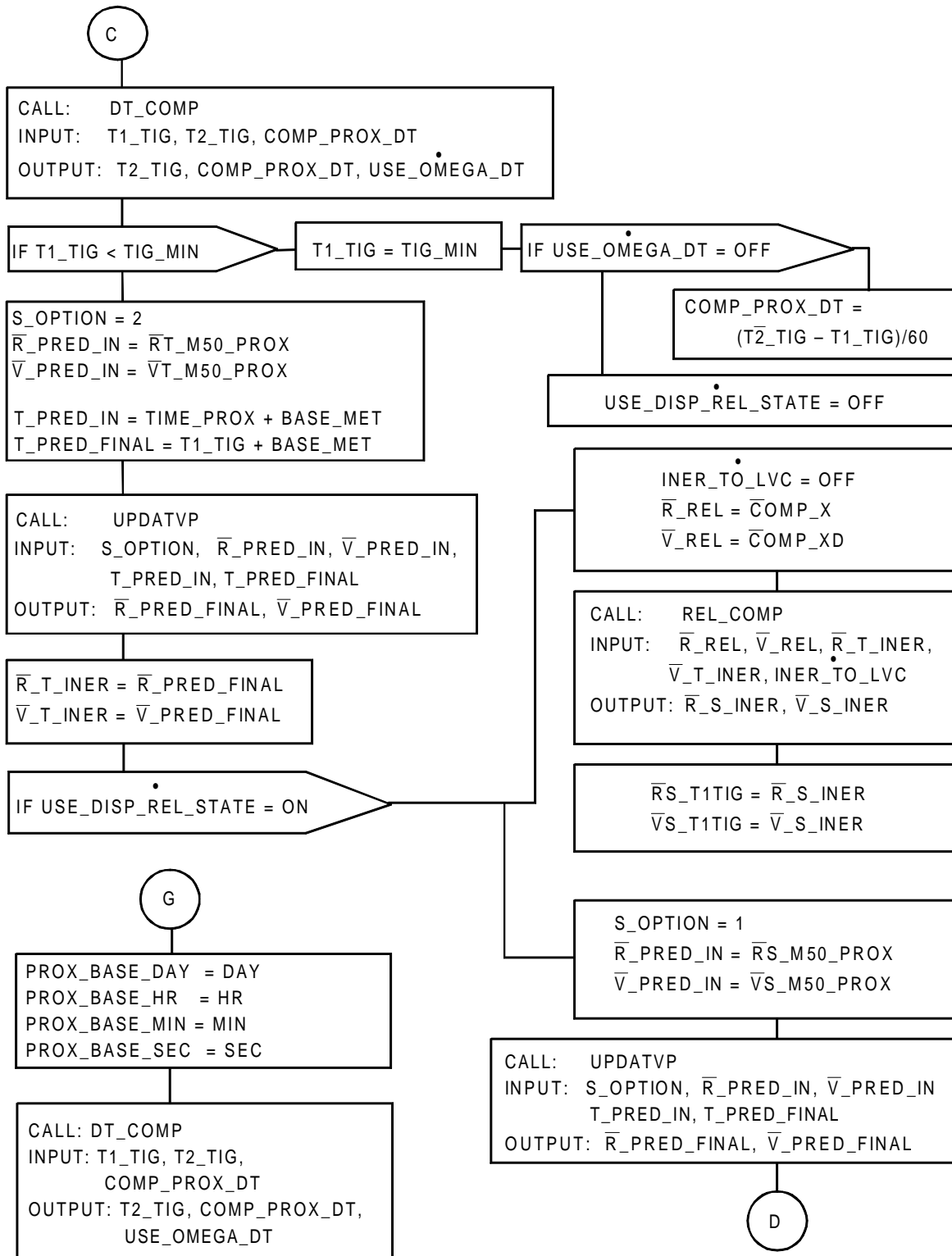


FIGURE A4.6.8.(3) PROC\_TGT\_SUP\_LAMB (Sheet 3 of 4)



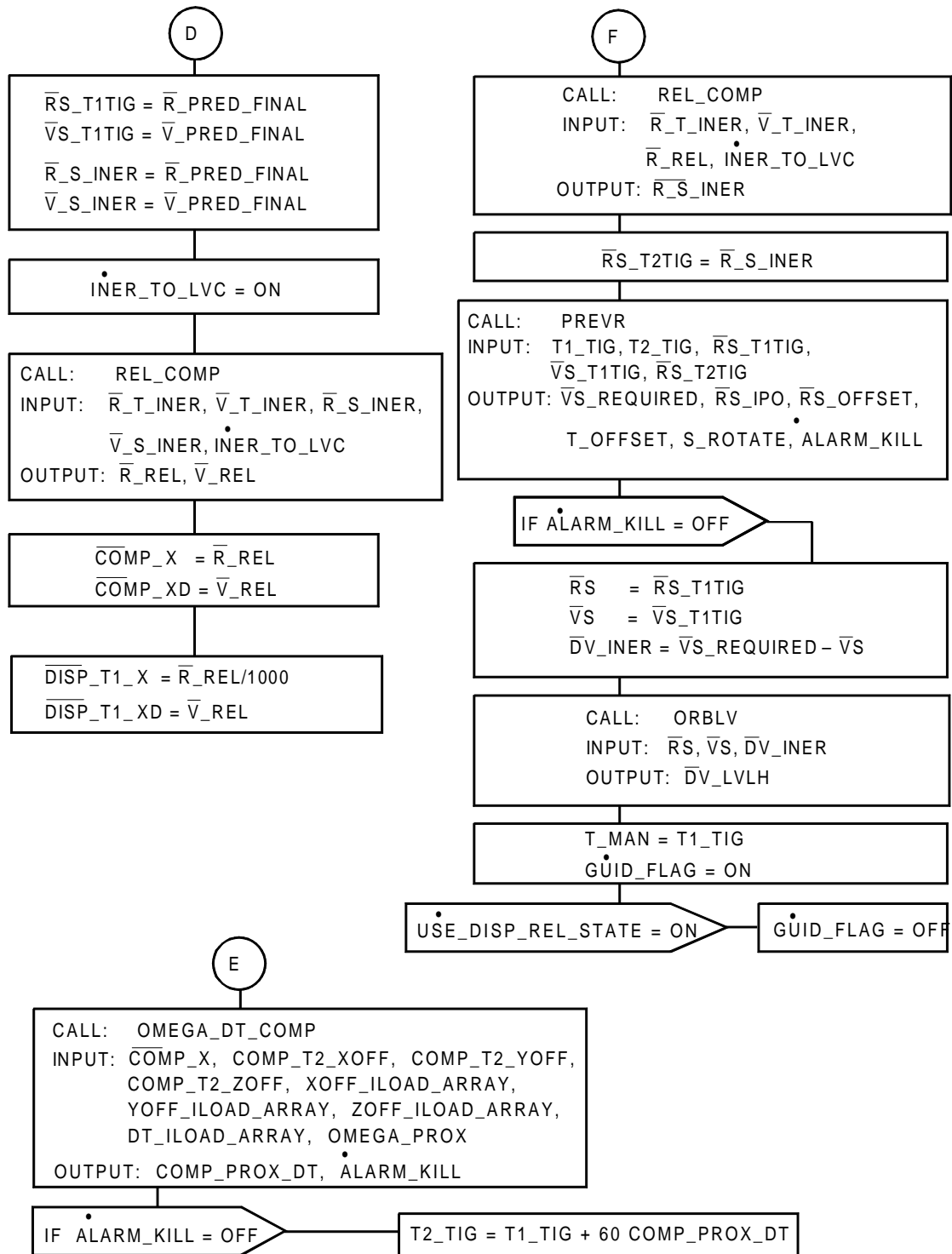


FIGURE A4.6.8.(4) PROX\_TGT\_SUP\_LAMB (Sheet 4 of 4)

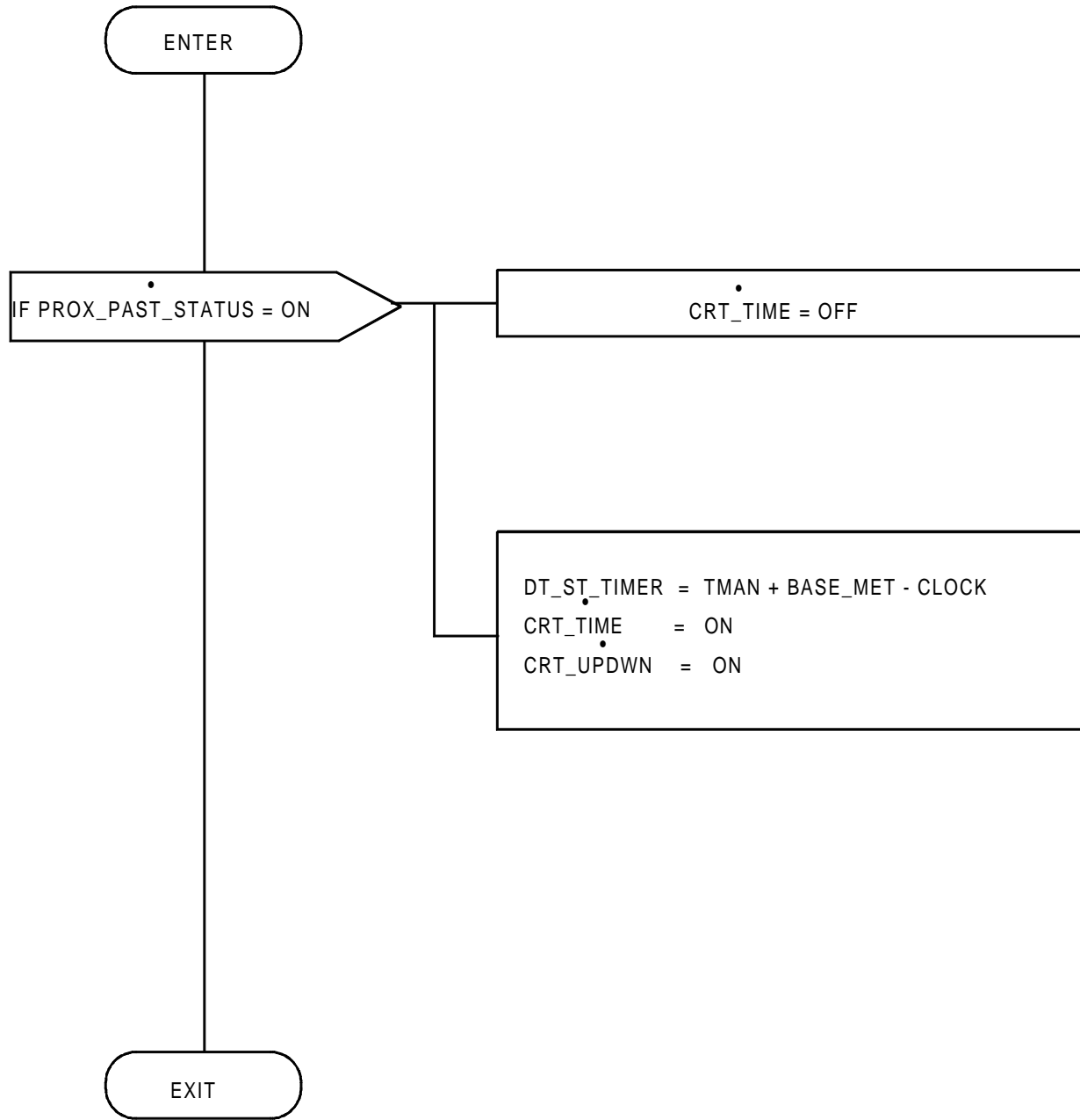


FIGURE A4.6.9. PROX\_STIME

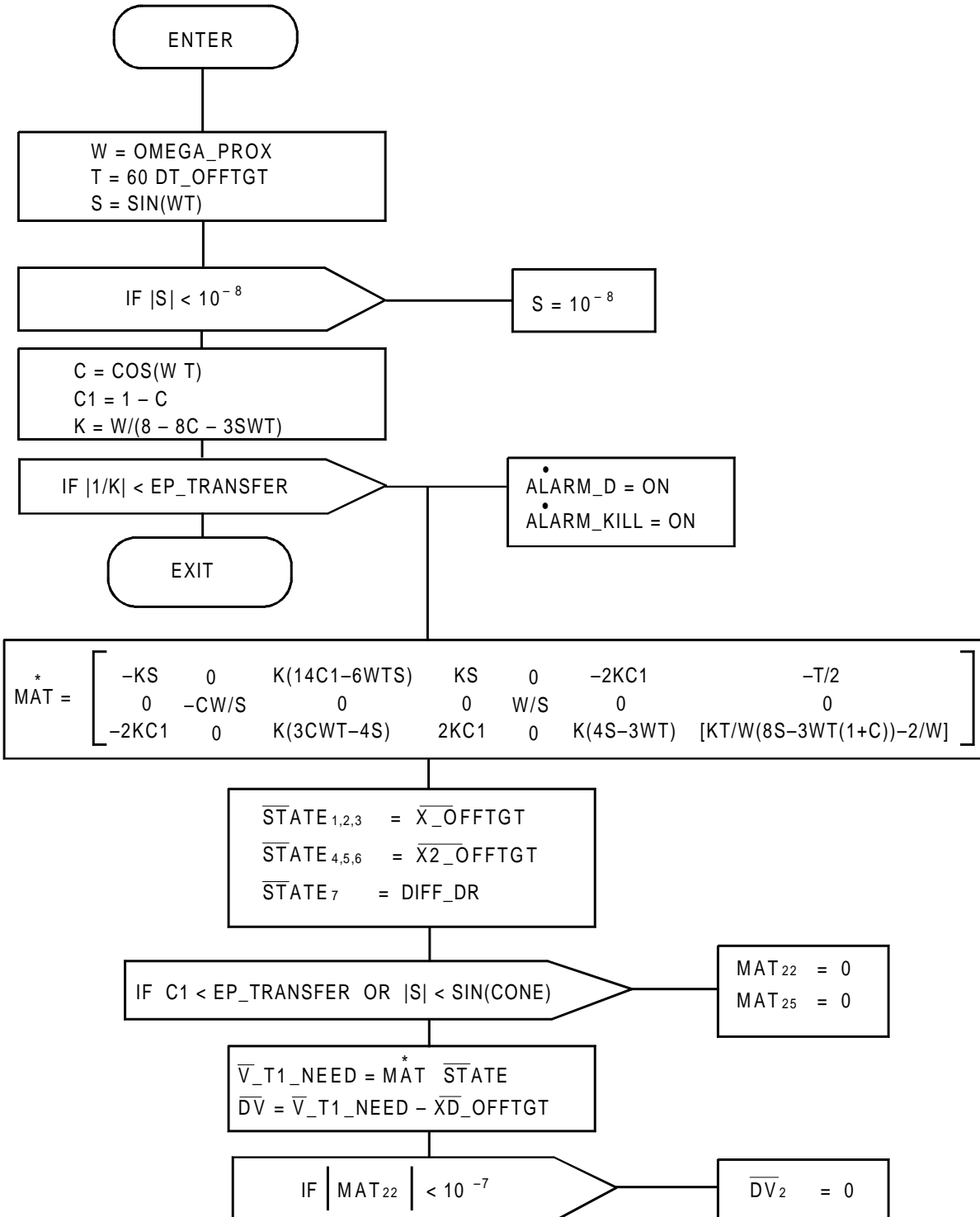


FIGURE A4.6.10. OFFSET\_TGT

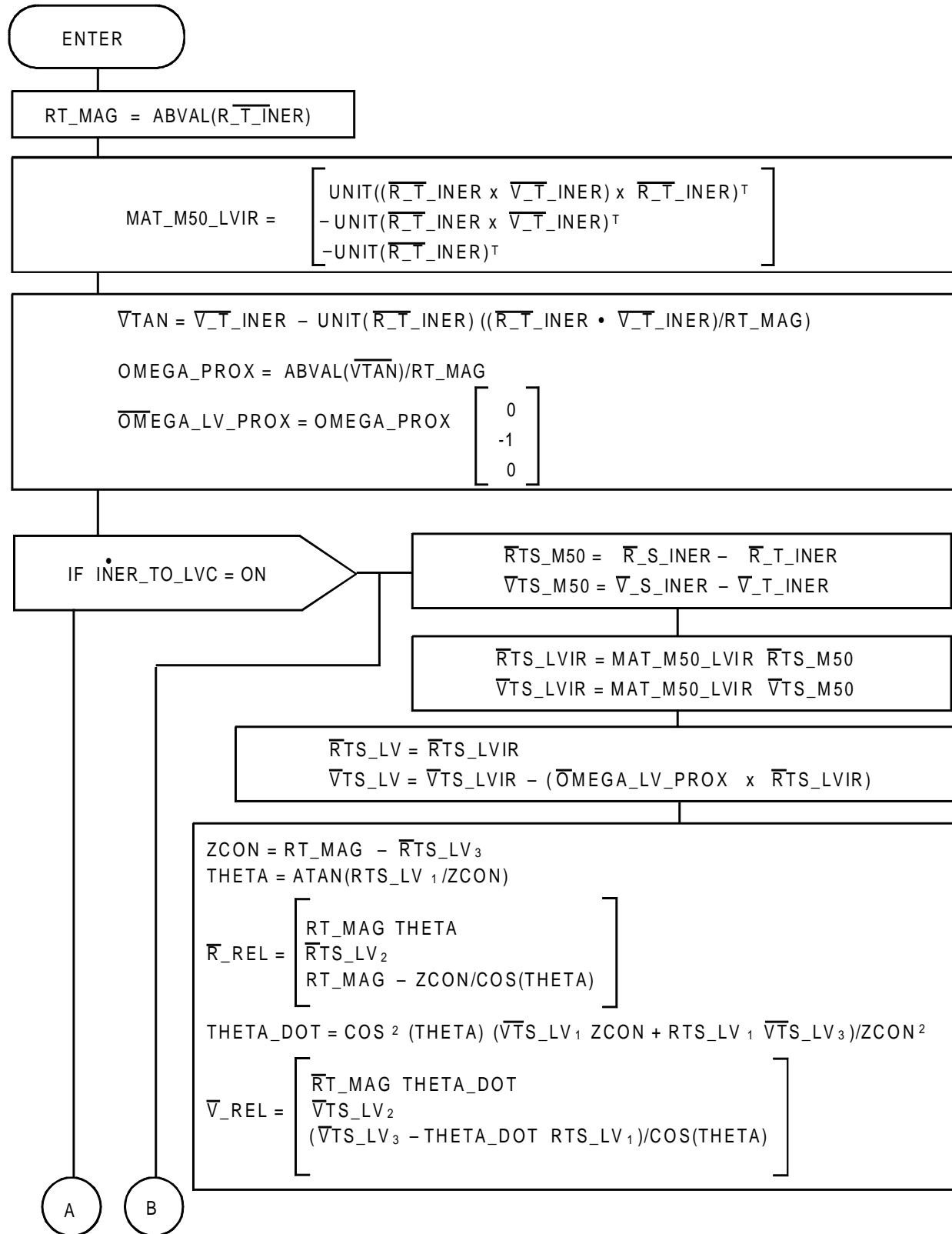


FIGURE A4.6.11.(1) REL\_COMP (Sheet 1 of 2)

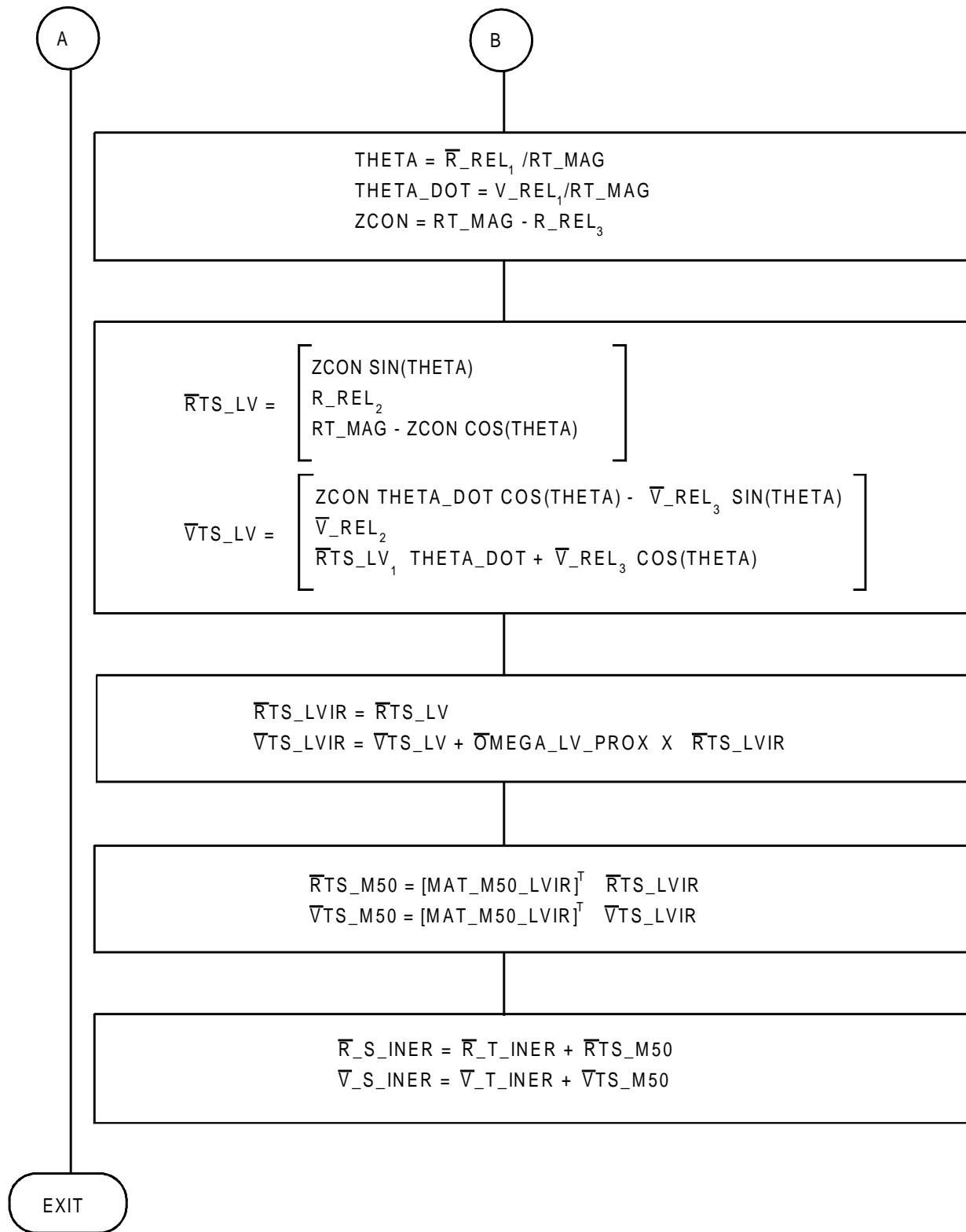


FIGURE A4.6.11.(2) REL\_COMP (Sheet 2 of 2)

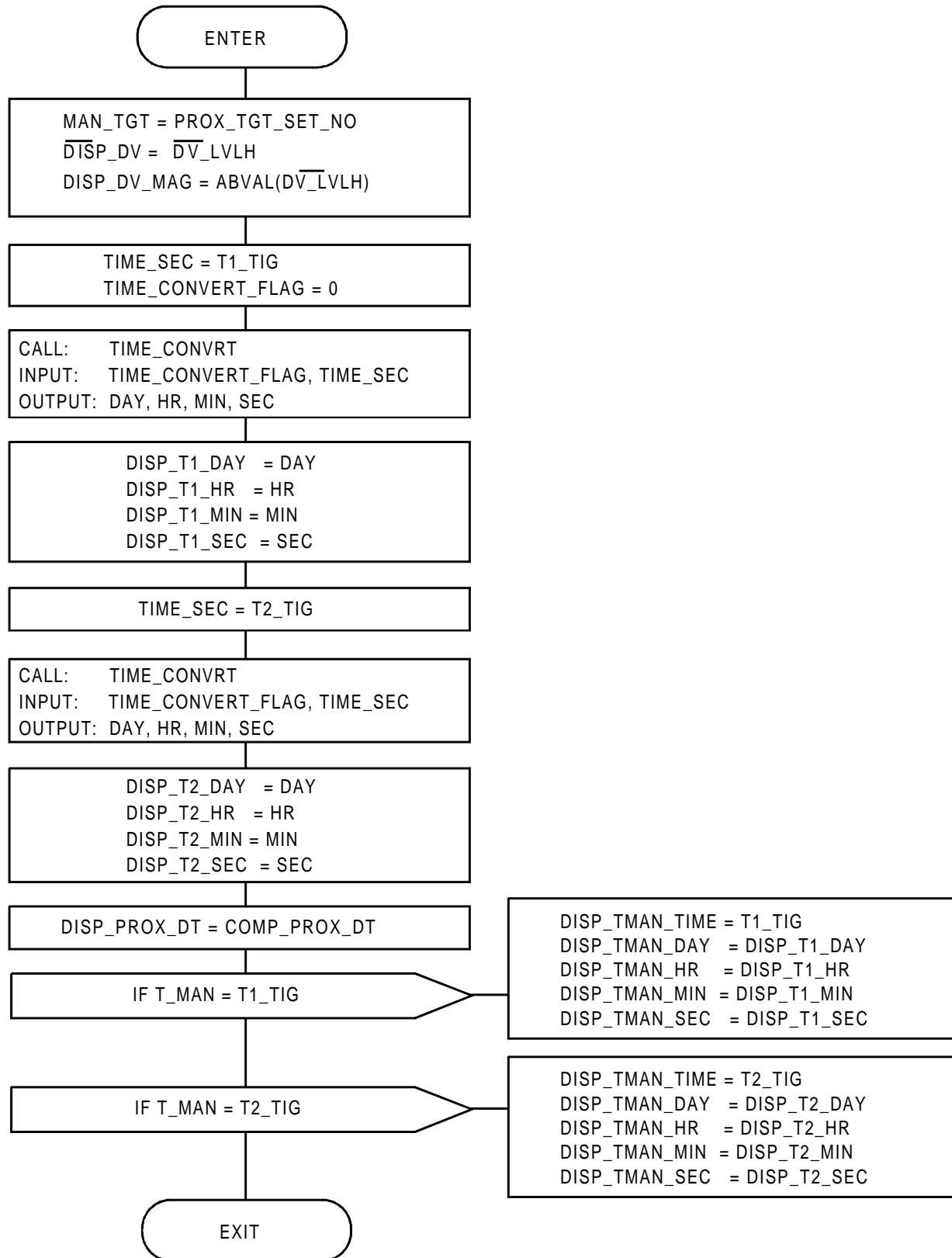


FIGURE A4.6.12. PROC\_DISP\_LOAD

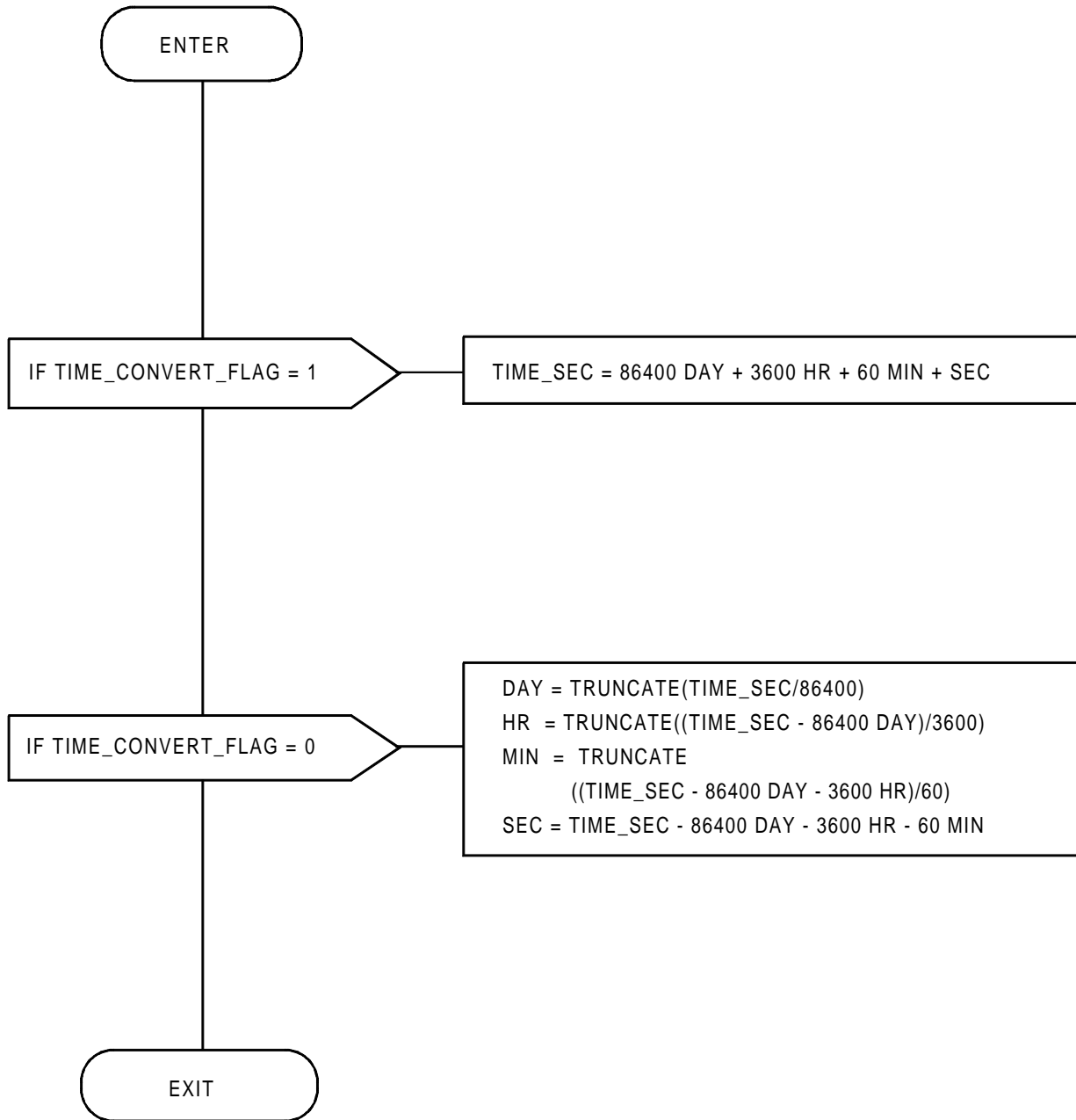


FIGURE A4.6.13. TIME\_CONVERT

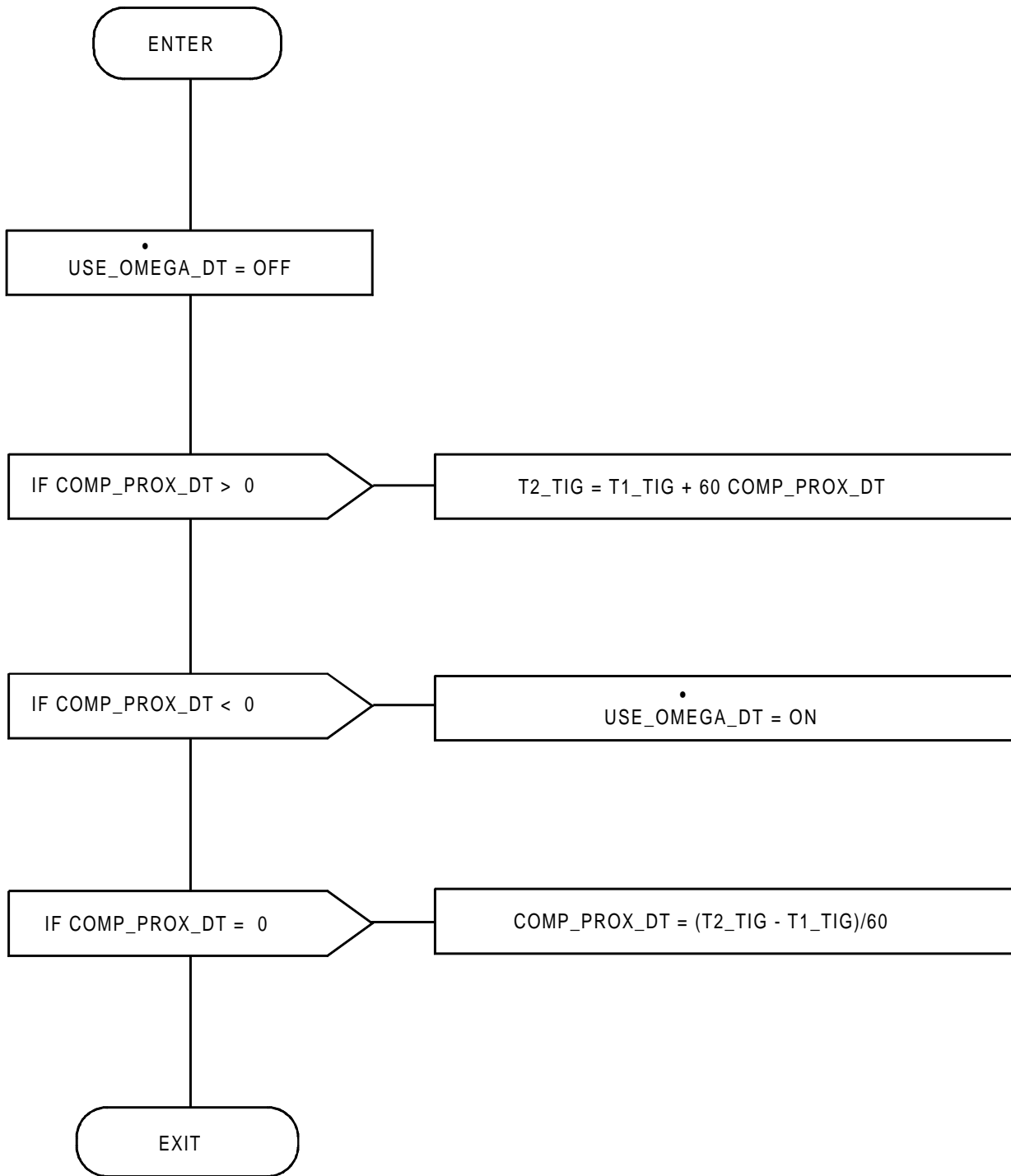


FIGURE A4.6.14. DT\_COMP



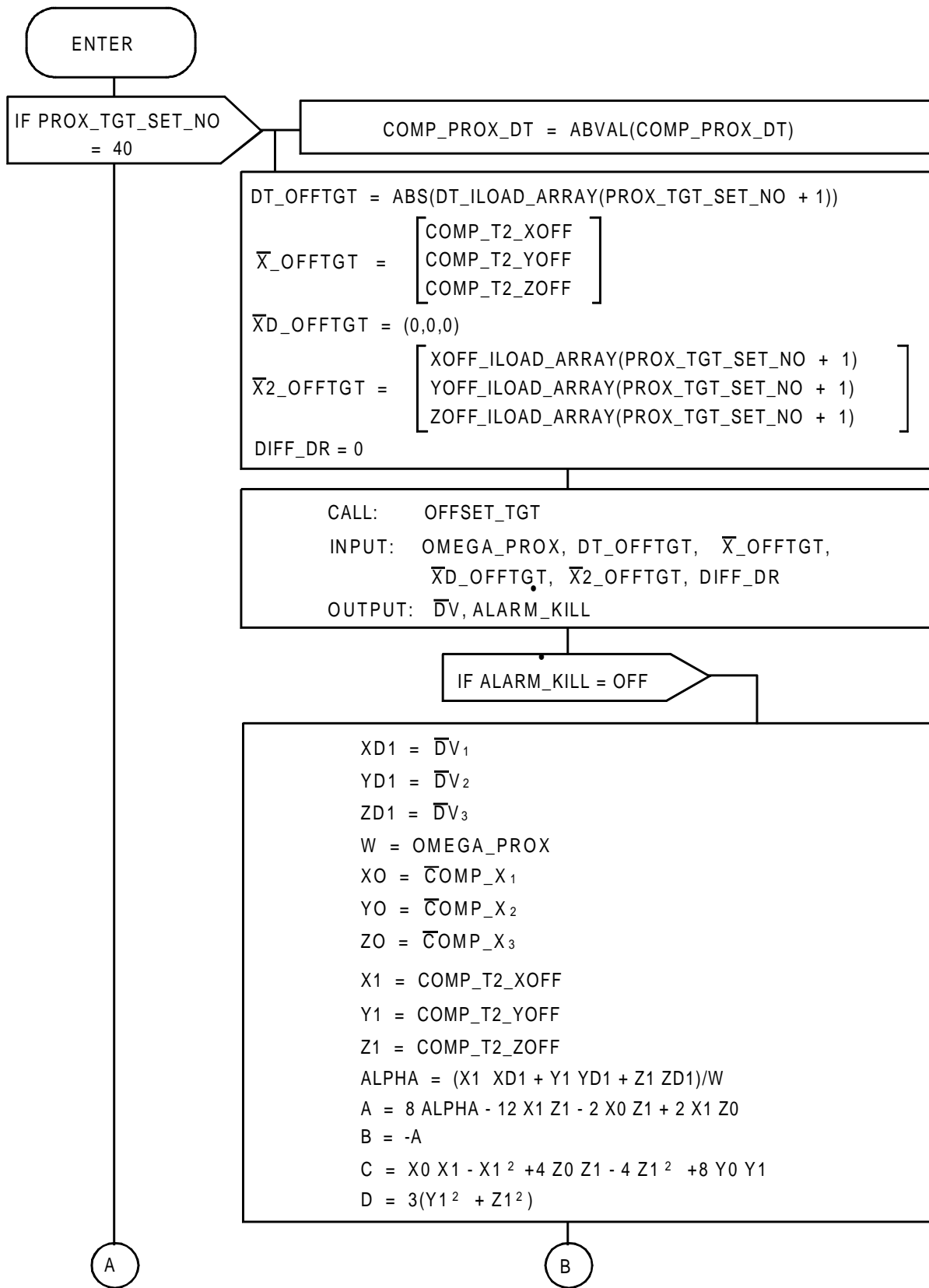


FIGURE A4.6.15.(1) OMEGA\_DT\_COMP (Sheet 1 of 2)

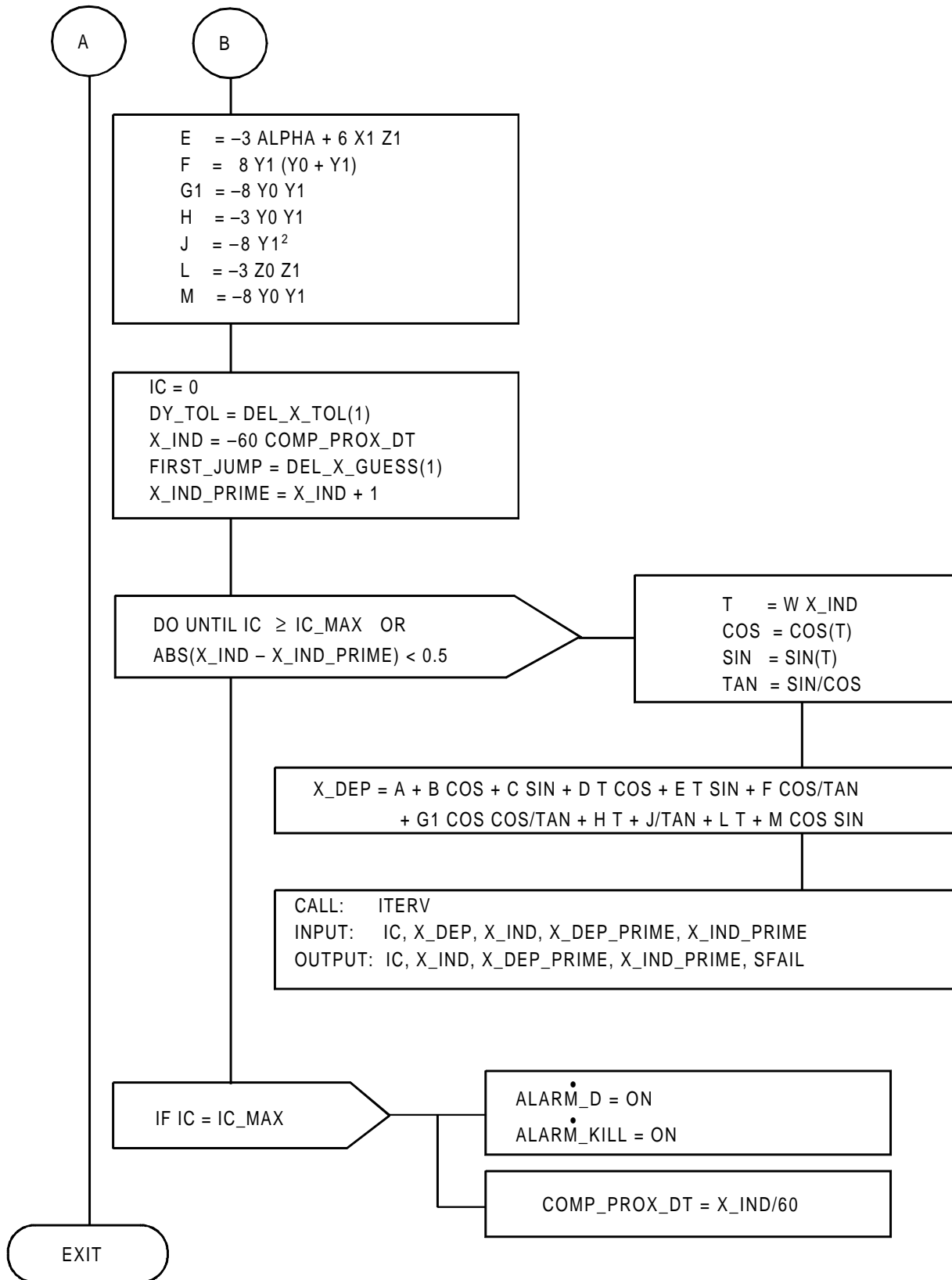


FIGURE A4.6.15.(2) OMEGA\_DT\_COMP (Sheet 2 of 2)

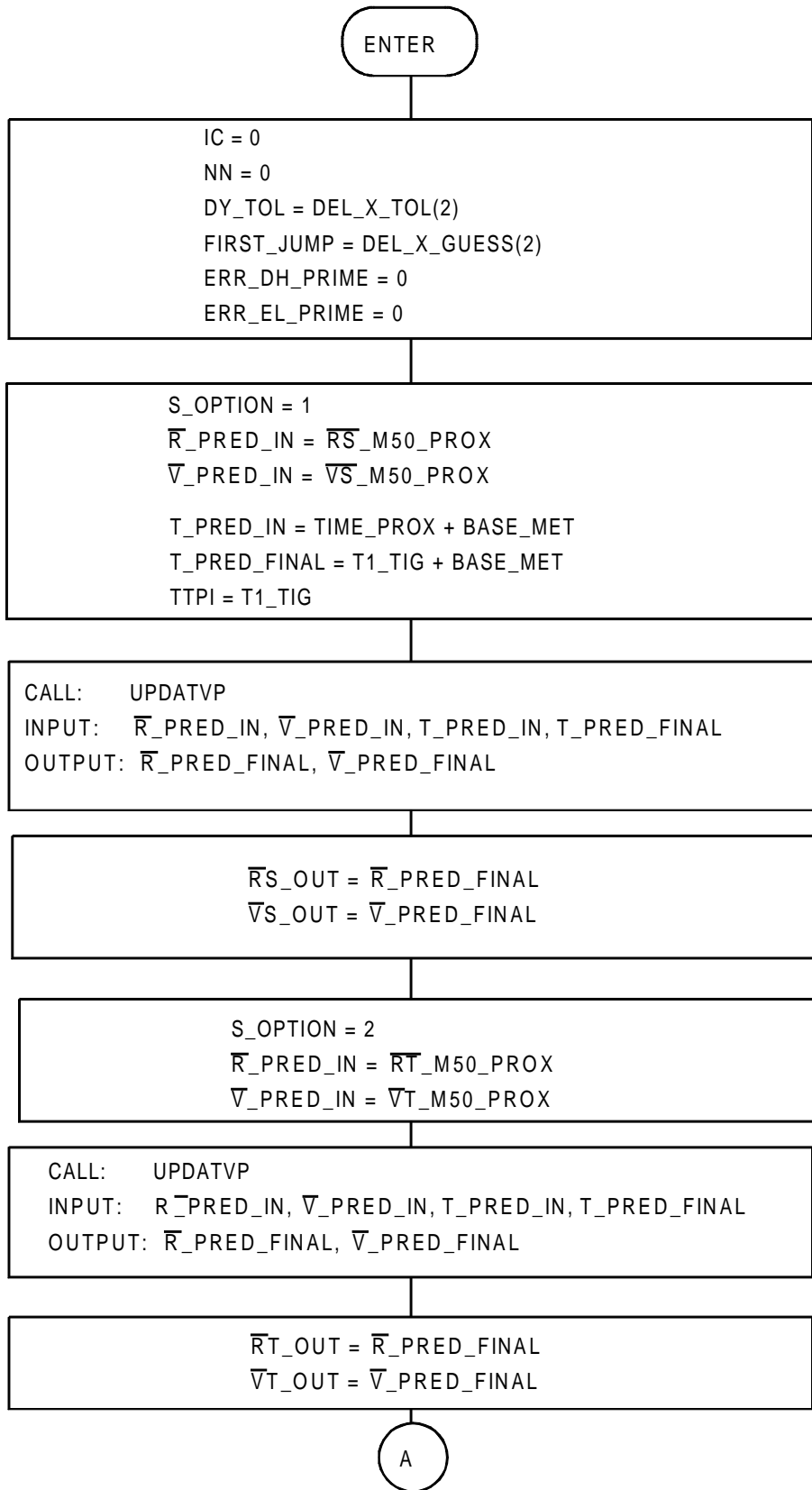


FIGURE A4.6.16.(1) TELEV (Sheet 1 of 3)

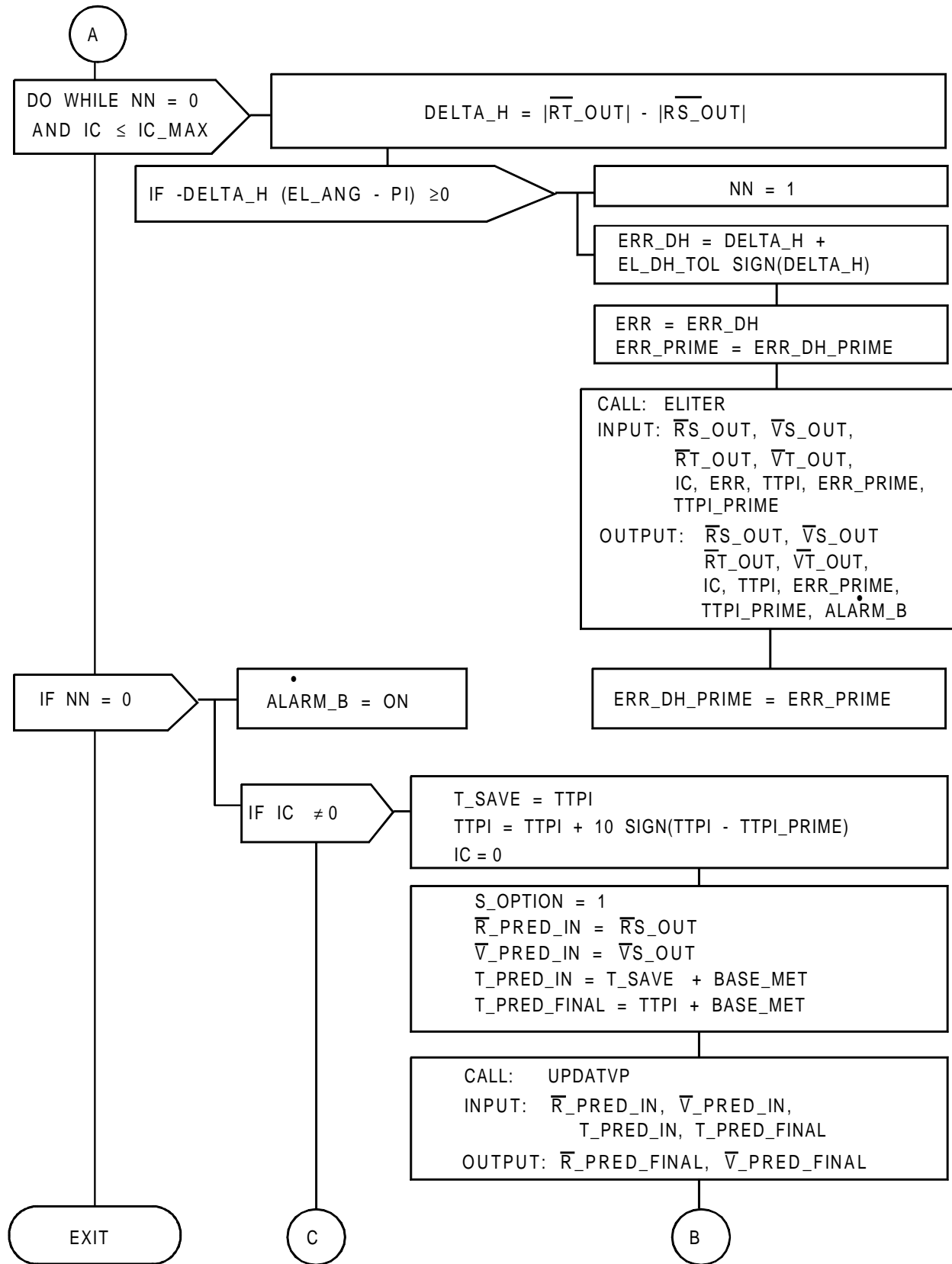


FIGURE A4.6.16.(2) TELEV (Sheet 2 of 3)

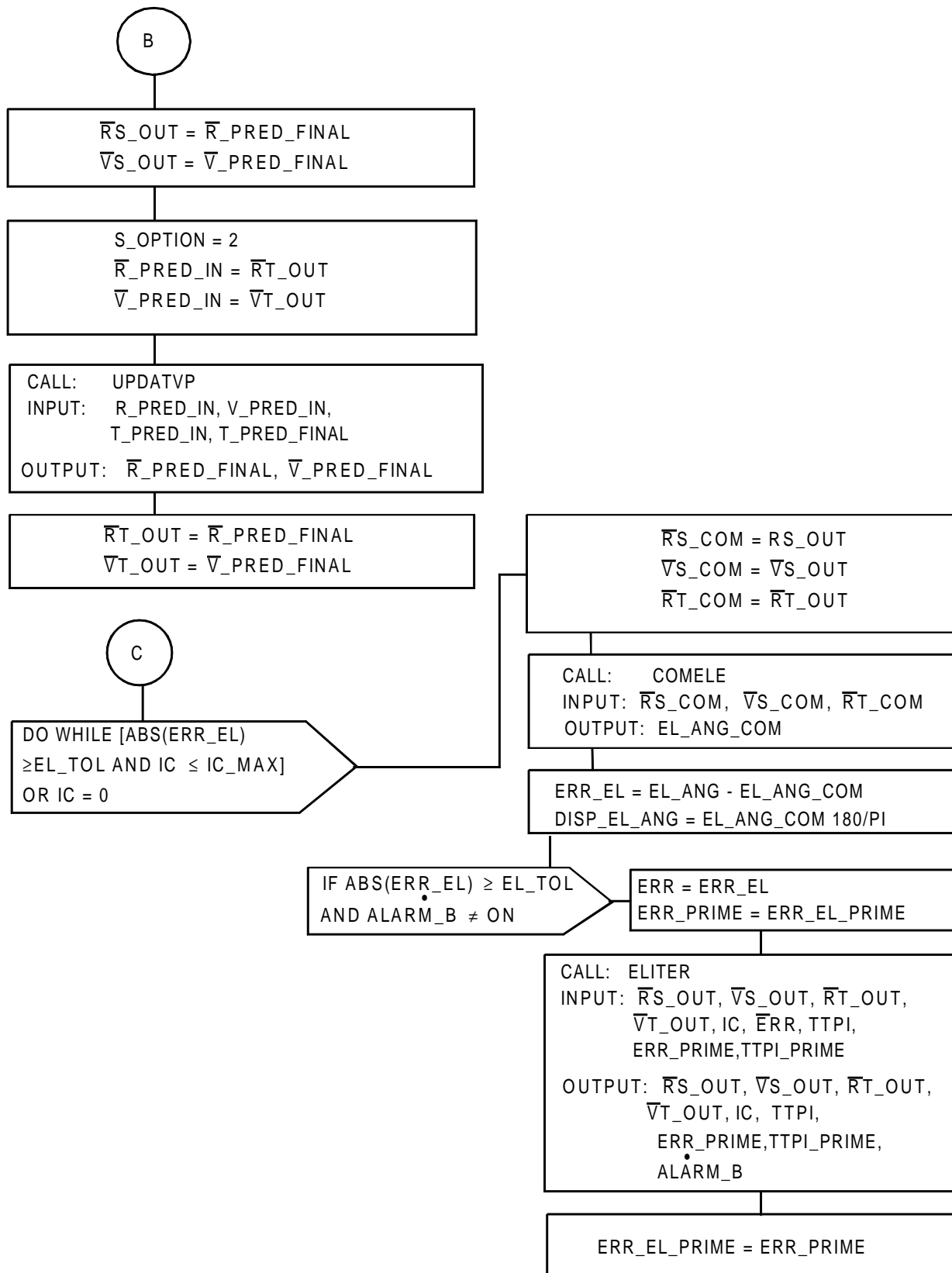


FIGURE A4.6.16.(3) TELEV (Sheet 3 of 3)

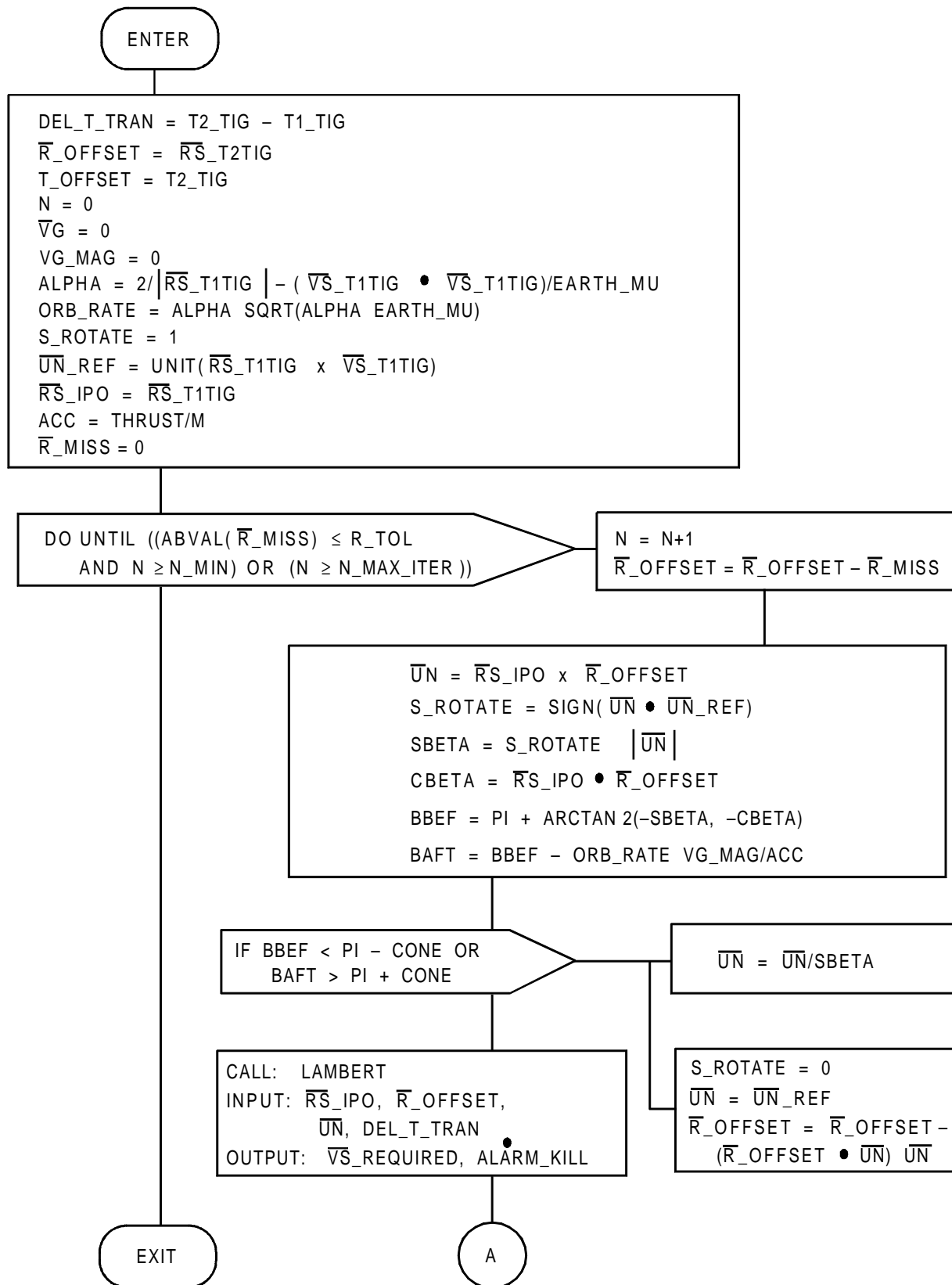


FIGURE A4.6.17.(1) PREVR (Sheet 1 of 2)

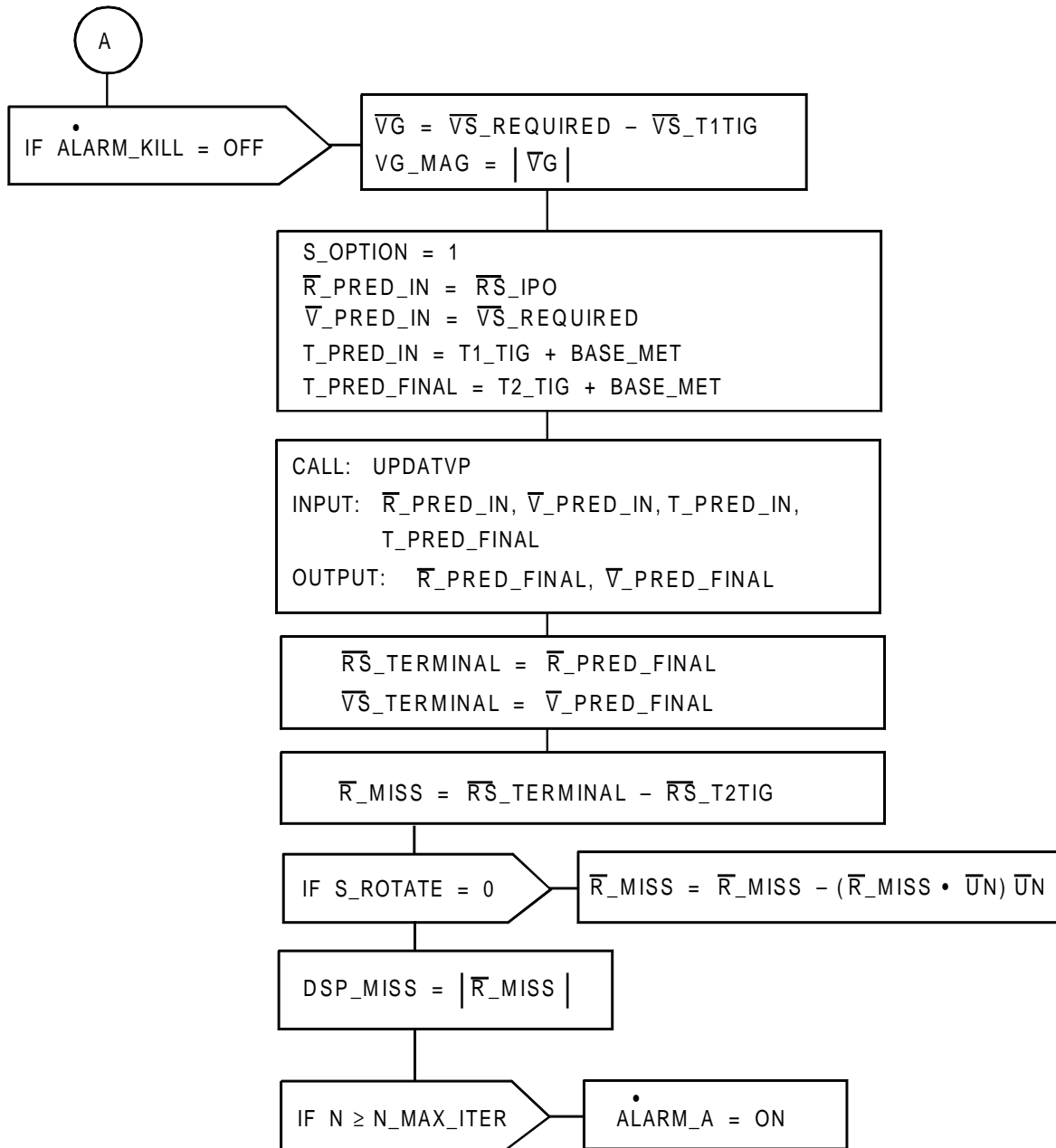


FIGURE A4.6.17.(2) PREVR (Sheet 2 of 2)

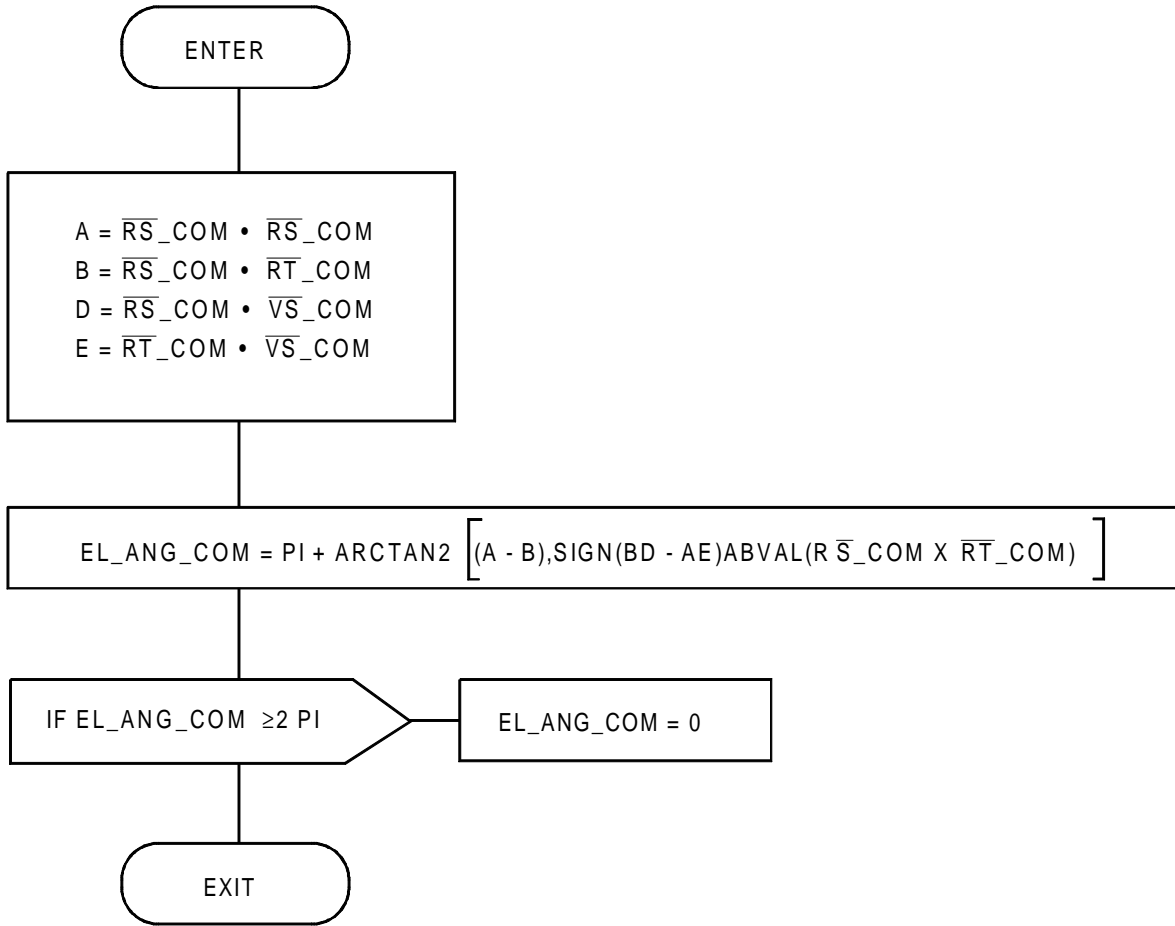


FIGURE A4.6.18. COMELE



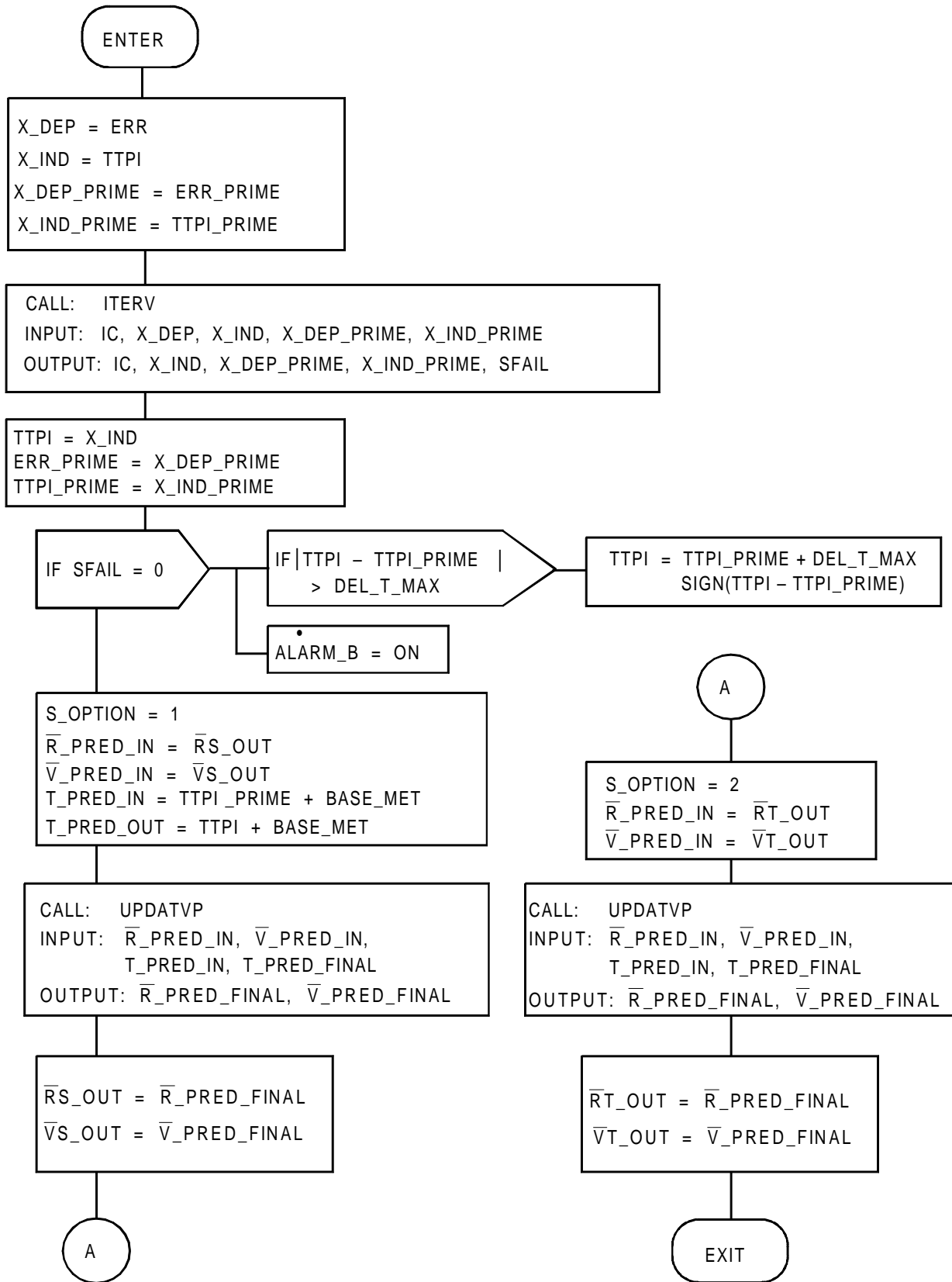


FIGURE A4.6.19. ELITER

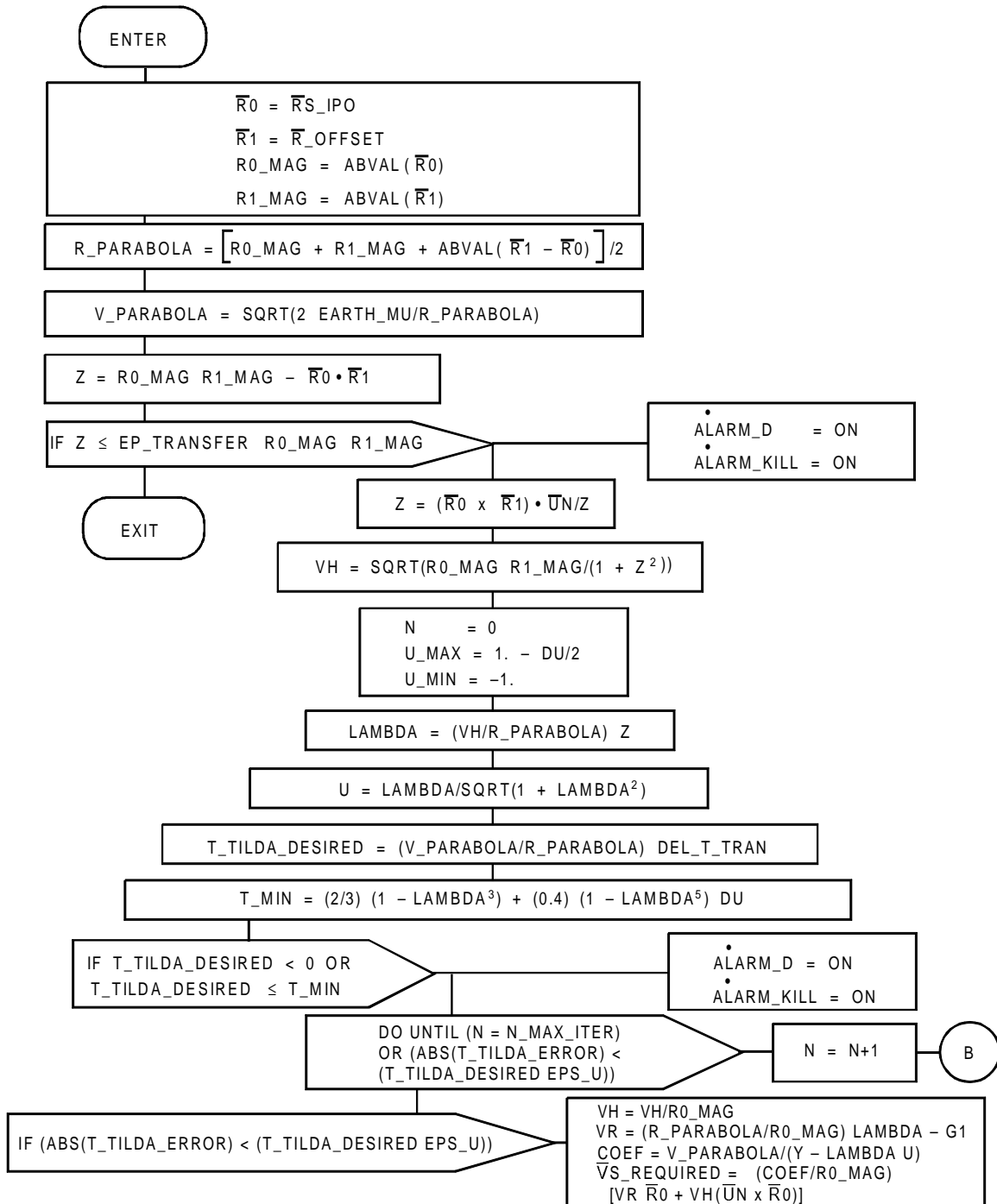


FIGURE A4.6.20.(1) LAMBERT (Sheet 1 of 2)

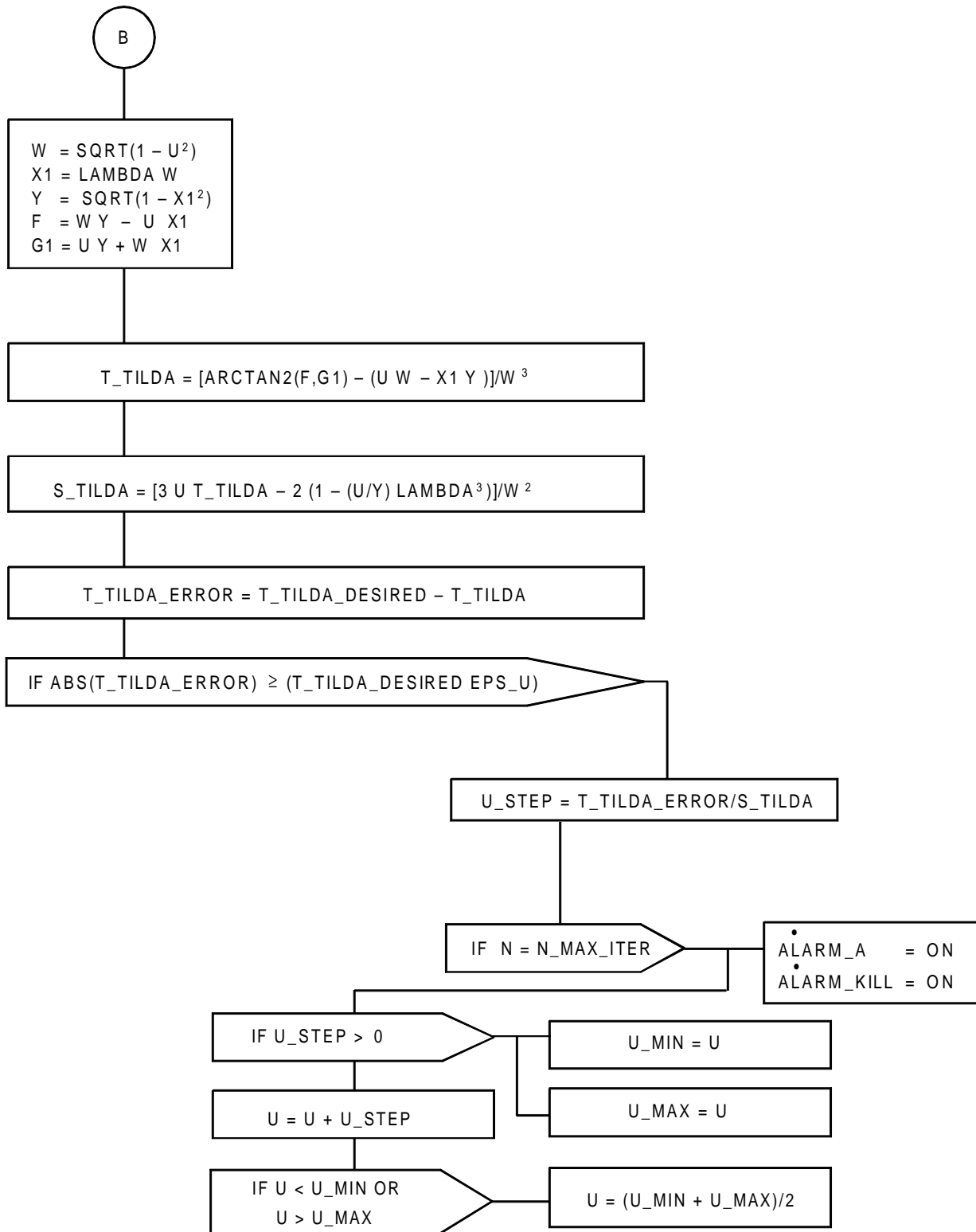


FIGURE A4.6.20.(2) LAMBERT (Sheet 2 of 2)

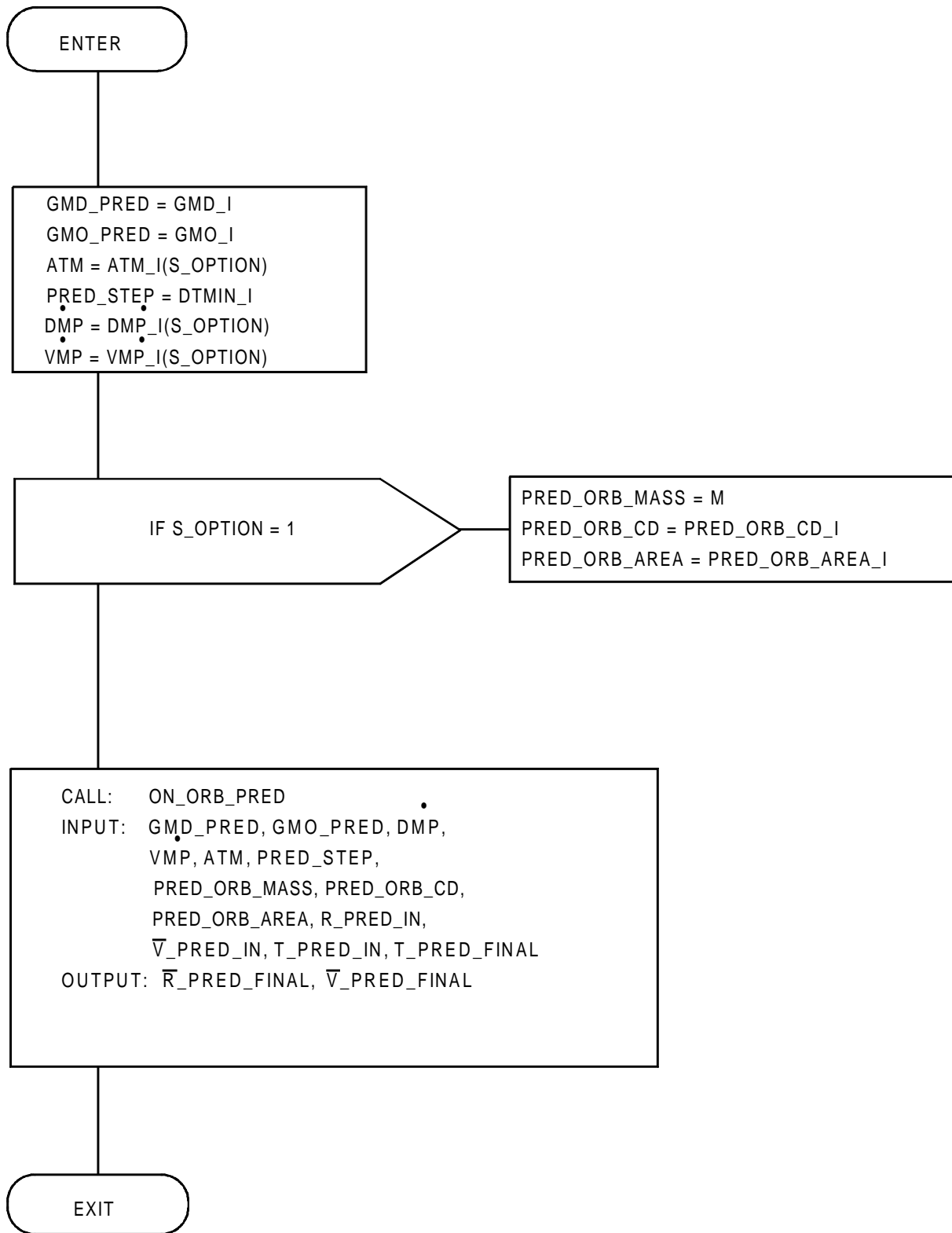


FIGURE A4.6.21. UPDATVP

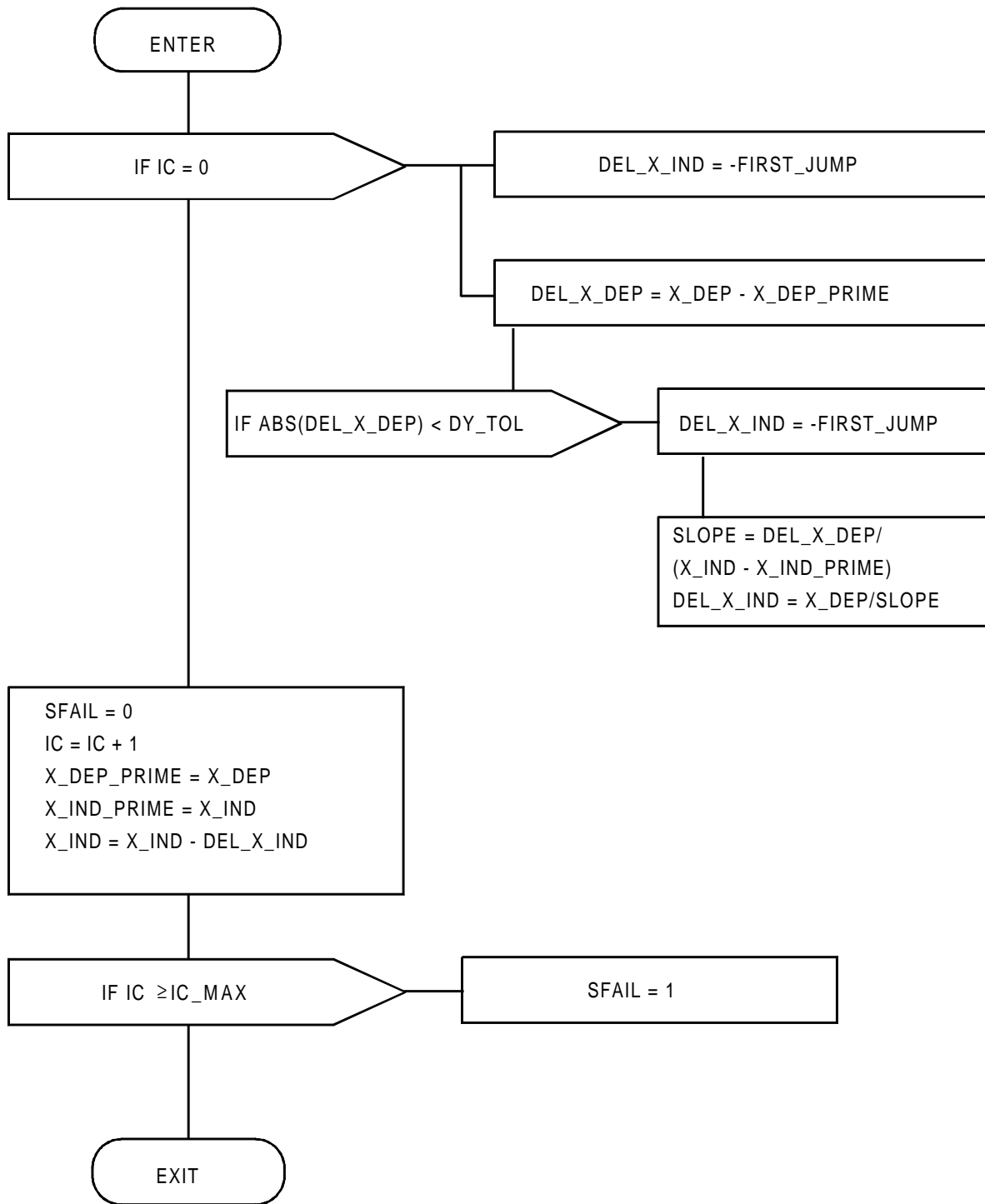


FIGURE A4.6.22. ITERV

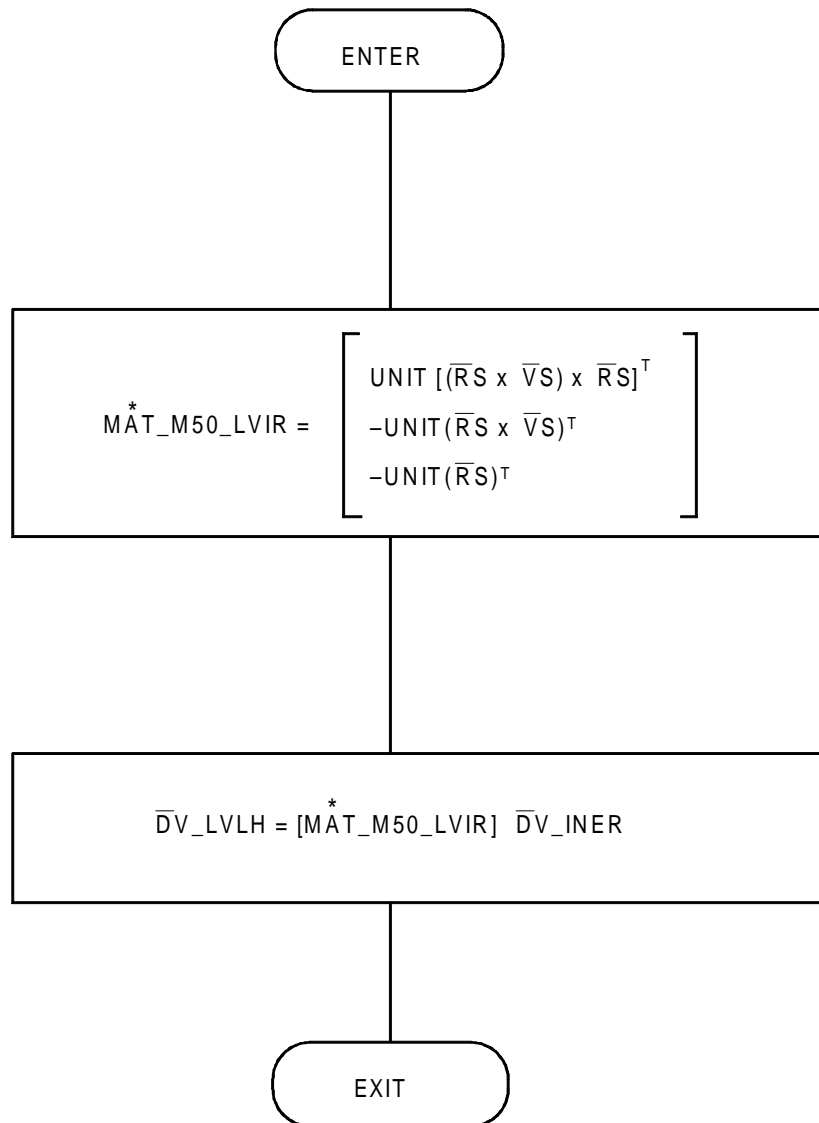


FIGURE A4.6.23. ORBLV

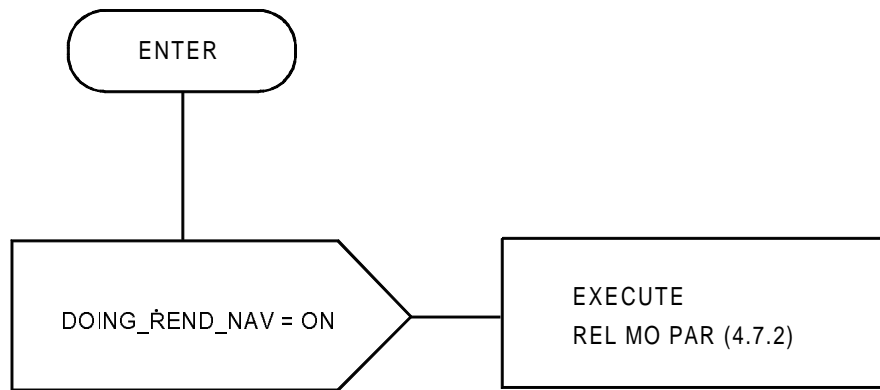


FIGURE A4.7.1. REL\_EXEC

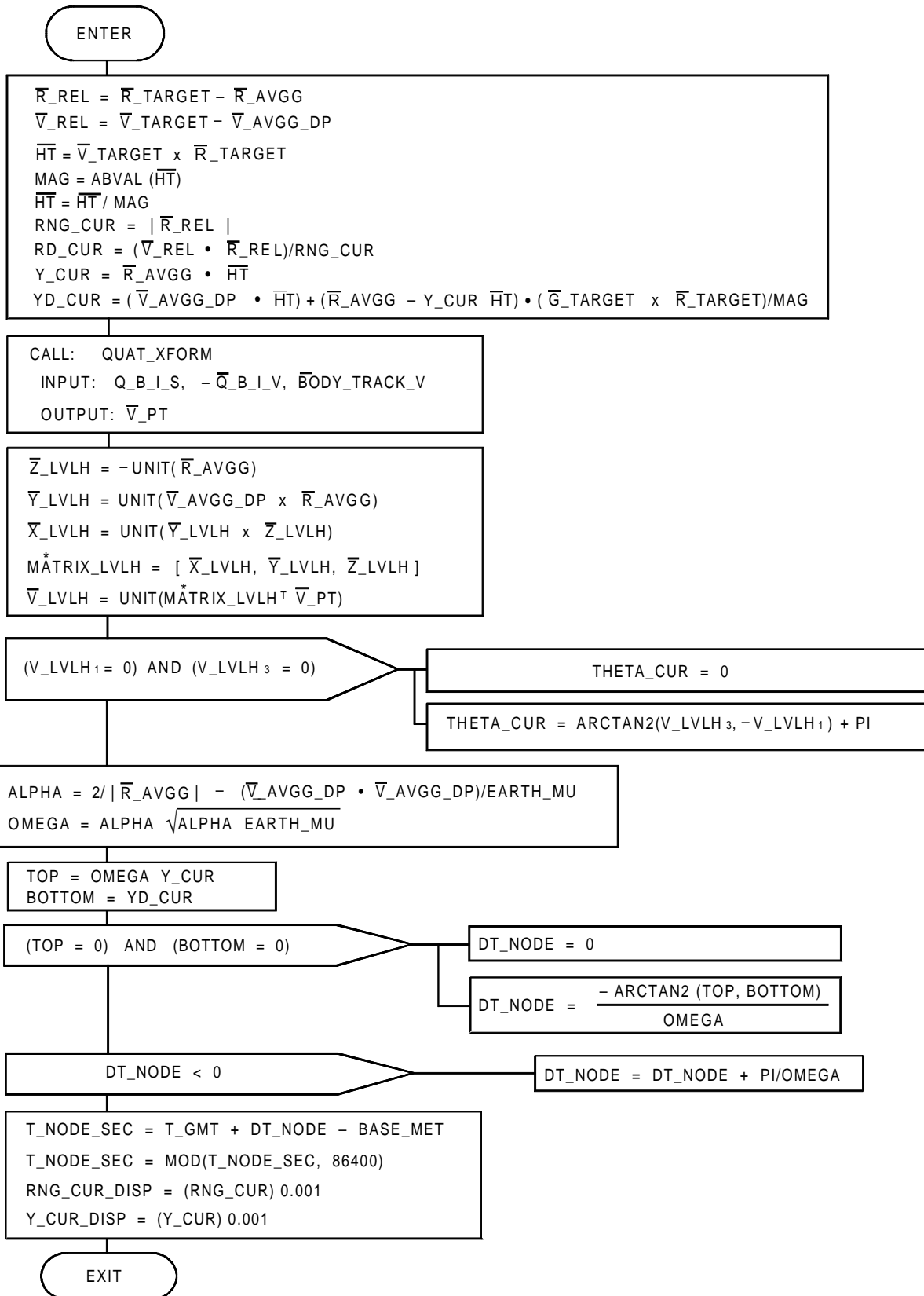


FIGURE A4.7.2. REL\_MO\_PAR



## APPENDIX B      VARIABLE DEFINITIONS

<u>Variable</u>	<u>Definition</u>
A	Scratch variable used in LTVCON
AE	Oblate earth's orbital semimajor axis corrected for gravitational effect
AE	Oblate earth's semimajor axis
ALPHA	Right ascension of target  Also the reciprocal of Shuttle semimajor axis in REL NAV
ALT	Altitude of target
ATM	Attitude mode flag
ATT_ERR	Displayed attitude errors
ATR	Thrust acceleration estimate
ATT_RATE	Displayed body attitude rates
ATT_CMD_CHG	Attitude change flag
AUTO	Auto mode discrete
AUTO_ALERT	Auto mode alert discrete
B	Scratch variable used in LTVCON
BASE_MET	MET_GMT reference time
BETA_DENOMINATOR	Denominator of the coefficient function used in the continued fraction evaluation of the hypergeometric function F
BETA_NUMERATOR	Numerator of the coefficient function used in the continued fraction evaluation of the hypergeometric function F
BOD_RATE	Estimate of body rate
BODV_ID	Body vector identifier

<u>Variable</u>	<u>Definition</u>
BODV_PITCH	Pitch component of body vector
BODV_YAW	Yaw component of body vector
$\bar{\text{BODY\_TRACK\_V}}$	Tracking body vector selected on Universal/Pointing display
BOTH_OMS	Both OMS engine select discrete
BOTTOM	Intermediate variable for calculating DT_NODE
BURN_ENABLE	Discrete to enable engine ignition
C	Scratch variable used in LTVCON
C1	Intercept of vertical versus horizontal velocity target line
C1_DISP	Displayed intercept of vertical versus horizontal velocity target line
C2	Slope of the vertical versus horizontal velocity target line
C2_DISP	Displayed slope of the vertical versus horizontal velocity target line
CNTL_ACT	Active control axis
CNTL_FUT	Future control axis
CNTL_SEL	Selected control axis
COS_THETA	Cosine of the transfer angle
COUNTDOWN	Flag to decrement CRT time to ignition
CPHI	Cosine of the roll attitude angle
CPSI	Cosine of the yaw attitude angle
CRATE	Rotation rate requested by Universal Pointing Specialist function
CRT_SEC	Time to ignition (total in seconds)
CRT_TIMER	Discrete to indicate CRT timer started
CTH	Cosine of pitch attitude angle
CUR_HA	Current apogee altitude
CUR_HP	Current perigee altitude
D	Scratch variable used in LTVCON

<u>Variable</u>	<u>Definition</u>
DAP_ERR	DAP phase plane errors
DAP_RATE	Magnitude of selected DAP maneuver rate
DATA_ENTER	Discrete indicating data entered
DC_1	Offset applied to true target velocity constraint, C (1), to obtain conic constraint
DC_1C	Error in C1 at entry interface between target and integrated value
DELTA	Declination of target
DELTA_T	Time duration of coast from cutoff to target
DELT_H_CIRC	Maximum difference in altitude for circular orbit
DMP	Drag model flag
DOING_PWRD_FLT_NAV	Powered flight navigation average-G ON/OFF flag
DOING_REND_NAV	Rendezvous navigation flag
DRATE	Desired rotation rate magnitude
$\overline{DR}_T$	Offset applied to true target to obtain conic target
$\overline{DR}_{TC}$	Error in position at entry interface between target and integrated value
DR_TMAX	Maximum value of $\overline{DR}_{TC}$ to allow calculation of C1 offset
DTCOAST	Time of coast from cutoff to target
DTGD	Elapsed time since last guidance update
DTMAX	Maximum integration step size
DTMIN	Minimum integration step size
DT_GUID	Time interval between successive updates to the guidance calculations
D_TIG_STEER	Time interval after TIG to allow active guidance steering
DT_IMU	Time associated with DV_IMU
DT_NODE	Time to upcoming common Shuttle-target node
DT_RNG	Maximum integration step size for calculating range-to-landing site

<u>Variable</u>	<u>Definition</u>
DT_TAILOFF	Tail-off time for OMS propulsion system
DV_TOT	Magnitude of velocity-to-go
E	Scratch variable used in the normalized transfer time interval computations
EA	Eigenangle of rotation
EARTH_MU	Earth's gravitational constant
EARTH_POLE	Unit angular momentum vector for the earth in M50
EF_TÖ_M50	Direction cosine matrix to M50 from Greenwich true of date coordinates
EPS_C1C	Tolerance on DC_1C allowable
EPS_RTC	Tolerance on DR_TC allowable
EPSTR	Maximum change in predicted cutoff time allowed for a guidance update on the output steering parameters
ERR_SEL	Total/DAP attitude error discretizes
EX	Eigenaxis of rotation
EXEC_CMD	Discrete for crew enabling engine ignition
EXT_DV_LVLH	External delta-V vector in LVLH
F	Hypergeometric function that is the transcendental portion of the normalized transfer time interval computation, which is evaluated by means of a continued fraction
FLAG	Error flag, LTVCON, 0 = no error 1 = no physically realizable solution—execution aborted 2 = solution resulted in a required velocity vector that was outward bound on a hyperbolic trajectory—execution aborted
F_OLD	Value of F computed at the previous level of the continued fraction
FT	Total vehicle thrust
GMD_PRED	Gravity degree flag
GMO_PRED	Gravity order flag

<u>Variable</u>	<u>Definition</u>
GMT	Current time from start of current year
GMTA	Greenwich mean time of target acquisition
GMTC	Time tag of current body quaternion
GMTS	Time to start rotation, point, or track option
GNC_ALERT	GN&C control alert discrete
GNC_PL_SEL	GN&C/payload attitude control discrete
G_TO_FPS2	Conversion factor g's to ft/s <sup>2</sup>
H	Orbital angular momentum
HA	Apogee altitude
H_ELLIPSOID	Denotes a function for determining the altitude above the Fischer ellipsoid of the argument vector, RT
HEI	Entry interface altitude
HEI_DISP	Entry interface altitude displayed
HP	Perigee altitude
$\bar{H}T$	Target negative orbital angular momentum
I	Index or subscript variable
IDAY	Attitude option start day
IDTAR	Location of target parameters in on-board target definition table
IHOURL	Attitude option start hour
IMIN	Attitude option start minute
INSID	Instrument selected from on-board instrument locker
ISEC	Attitude option start second
$\bar{I}R$	Unit value or R-TP
$\bar{I}X$	Unit vector desired thrust checkout position vector
$\bar{I}Y$	Unit vector normal to desired trajectory plane

<u>Variable</u>	<u>Definition</u>
JOL	Burn centroid time
J2_GRAV	Earth's second gravitational zonal harmonic (J2)
K	REL NAV initial pass flag
KMISS	Percent of velocity-to-go error allowed for PEG to converge
K_LAMDXZ	Fraction of orbital turning rate
KU_SEL	Ku-band antenna management enable/inhibit discrete
$\overline{\text{LAM}}$	Unit vector in direction of velocity-to-go
LAMBDA	Constant parameter of problem
$\overline{\text{LAMC}}$	Desired thrust vector turning rate in M50 coordinates
$\overline{\text{LAMD}}$	Derivative of unit vector instantaneously aligned along $\overline{\text{LAM}}$ , but rotating with desired thrust vector turning rate
$\overline{\text{LAMDC}}$	Command input to DAP that, together with $\overline{\text{LAMC}}$ and $\overline{\text{TLAM}}$ , defines desired thrust direction
LAMDXZ	Component of $\overline{\text{LAMD}}$ in the desired target plane
LAT	Earth's target latitude
LEFT_OMS	Left OMS engine discrete selection
LEVEL	Measure of level of continued fraction
LOAD_CMD	Discrete to transfer display data to software
LOAD_FLASH	Discrete to initiate flashing of display load
LON	Earth's target longitude
LVLH_ROLL	Angle of rotation about the thrust vector
LVLH_TO*_BOD	local vertical, local horizontal body attitude
M	Orbiter mass
M50_TO*_ADI	Direction cosine matrix from M50 to attitude director indicator reference coordinates (RELMAT)
M50_TO*_BOD	Current body attitude matrix

<u>Variable</u>	<u>Definition</u>
M50_TÖ_LVLH	Direction cosine matrix from M50 to local vertical, local horizontal coordinates
MASS_P	Previous value of MASS_ORBITAL
MÄTRIX_LVLH	LVLH to M50 transformation matrix
MAX_ITERATIONS	Maximum number of iteration loop passes to be allowed
MBO	Desired final orbiter mass
MDOT	Total vehicle mass flow rate
MET	Mission elapsed time
MM201	Major mode indicator discrete
MM202	Major mode indicator discrete
MM301	Major mode indicator discrete
MM302	Major mode indicator discrete
MM303	Major mode indicator discrete
MNVR_TIME	Universal pointing maneuver time remaining
MNVR_TITLE_ID	Maneuver title indicator
MNVR_TRACK_OPTION	Maneuver/tracking option discrete
NMAX	Maximum number of iterations allowed for PEG convergence
NMAX_BURN	Maximum number of iterations allowed for PEG convergence during a powered maneuver
NMAX_DIP	Maximum number of iterations allowed for PEG convergence for initial MNVR DIP
NM_PER_FT	Conversion of nautical miles to feet
NOMS_FAIL_PREV	Previous number of OMS engine failures
NSEG	Number of time intervals for integration
N_UNIT	Unit vector of desired angular momentum vector

<u>Variable</u>	<u>Definition</u>
OMEGA	Shuttle orbital rate
OMICRON	Rotation angle about pointing LOS
OMS_PITCH	OMS pitch trim angle
OMS_PITCH_DISP	Displayed OMS pitch trim angles
OMS_PITCH_BODY	OMS pitch thrust body vector
OMS_YAW_BODY	OMS yaw thrust body vector
OMS_YAW_DISP	Displayed OMS yaw trim angles
OMSL_ACT_SEL	Left OMS actuator select
OMSL_PITCH_FAIL	Left OMS pitch actuator fail indicator
OMSL_PITCH_PRI_FAULT	Left OMS pitch primary actuator COMMFAULT
OMSL_PITCH_SEC_FAULT	Left OMS pitch secondary actuator COMMFAULT
OMSL_PITCH_STATUS	Left OMS pitch actuator status
OMSL_YAW	Left OMS yaw trim angle
OMSL_YAW_FAIL	Left OMS yaw actuator fail indicator
OMSL_YAW_PRI_FAULT	Left OMS yaw primary actuator COMMFAULT
OMSL_YAW_SEC_FAULT	Left OMS yaw secondary actuator COMMFAULT
OMSL_YAW_STATUS	Left OMS yaw actuator status
OMSR_ACT_SEL	Right OMS actuator select
OMSR_PITCH_FAIL	Right OMS pitch actuator fail indicator
OMSR_PITCH_PRI_FAULT	Right OMS pitch primary actuator COMMFAULT
OMSR_PITCH_SEC_FAULT	Right OMS pitch secondary actuator COMMFAULT
OMSR_PITCH_STATUS	Right OMS pitch actuator status
OMSR_YAW	Right OMS yaw trim angle
OMSR_YAW_FAIL	Right OMS yaw actuator fail indicator
OMSR_YAW_PRI_FAULT	Right OMS yaw primary actuator COMMFAULT
OMSR_YAW_SEC_FAULT	Right OMS yaw secondary actuator COMMFAULT
OMSR_YAW_STATUS	Right OMS yaw actuator status



<u>Variable</u>	<u>Definition</u>
OPT_ACT	Active attitude option
OPT_FUT	Future attitude option
OPT_SEL	Selected attitude option
OPT_STOP	Option stop discrete
PI	Ratio of circumference of a circle to its diameter
PITCH_BIAS	OMS gimbal pitch trim bias (electrical null to vehicle body)
PITCHC	Current inertial pitch angle
PITCHI	Input inertial pitch angle
PITCHR	Required inertial pitch angle
$\bar{P}LOS$	Spacecraft pointing LOS
PLUS_X_RCS	Positive X RCS select (OPS 3)
PRE_BURN_ATT	Preburn attitude flag
PRED_ORB_AREA	Frontal area of orbiter for predictor use
PRED_ORB_CD	Drag coefficient of orbiter for predictor use
PRED_ORB_MASS	Mass of orbiter for predictor use
PROP_DEF	Propellant weight for out-of-plane wasting
PROP_FAIL	Propulsion system failure
PROP_FLAG	Propulsion system flag
PROP_FLAG_GUID	Prime propulsion system flag for guidance
PTEMP	Past value of pitch attitude
PWR_FLT_NAV_CMD	Powered flight navigation average-G on/off
Q_B_I_S	M50 to current body quaternion
Q_B_I_V	M50 to current body quaternion, elements 2 to 4
Q_BOD_M50	Current body to M50 quaternion
Q_CB_ADI	ADI to commanded body quaternion
Q_LVLH_I	M50 to LVLH quaternion

<u>Variable</u>	<u>Definition</u>
Q_MNVR	Maneuver option quaternion
Q_M50_ADI	ADI to M50 quaternion
Q_PBOD_M50	M50 to body quaternion for prethrust attitude
Q_PRIME	Intermediate parameter used in PEG
Q_RBOD_M50	Required body to M50 quaternion
$\bar{R}$	Position vector of orbiter
RA	Right ascension of target
RAD_PER_DEG	Conversion of degrees to radians
$\bar{R}_{AVGG}$	Current Shuttle position vector
R1	Inertial position vector
RC1	Position vector at start of PEG gravity computation
RC2	Position vector at end of PEG gravity computation
R_CIRCULAR	Magnitude of initial position vector, RD, and used as the basis for normalization of equations
RCS_ARM_DISP	Forward RCS arm discrete
RCS_DUMP_DAP	Forward RCS dump discrete for DAP
RCS_DUMP_DISP	Forward RCS dump discrete
RCS_DUMP_DRV	Forward RCS dump discrete drive
RCS_DUMP_IND	Forward RCS dump discrete internal
RCS_INH_DISP	Forward RCS off discrete
$\bar{RD}$	Desired thrust cutoff position
RD_CUR	REL NAV current range rate
RDOT	Vertical velocity vector
RE	Radius of the earth
REF_ORB_AREA	Orbiter frontal area for constant area drag
REF_ORB_CD	Orbiter drag coefficient for constant area drag
REI_LS	Range-to-landing-site at entry interface

<u>Variable</u>	<u>Definition</u>
REL_ITEM_2_STATUS	Reset delta-velocity components flag
REL_ITEM_3_STATUS	Reset delta-velocity total flag
$\overline{REQD\_BRATE}$	Required body attitude rate (tracking rate)
$\overline{RGD}$	Current vehicle position vector assumed by guidance
$\overline{RGO}$	Position to-be-gained
RGRAV	Second integral of gravity acceleration
RHOMAG	Damping factor for VMISS
RIGHT_OMS	Right OMS engine select
RMAG	Magnitude of vehicle position vector
$\overline{RNAV}$	Current Shuttle position vector
RNG_CUR_DISP	REL NAV current line-of-sight range
RNG_CUR	REL NAV current line-of-sight range
$\overline{R0}$	Initial inertial position vector input to LTVCON
ROBJ	Position vector of orbital object
ROLLC	Current inertial roll angle
ROLLI	Input inertial roll angle
ROLLR	Required inertial roll angle
$\overline{ROLL\_REF}$	Roll reference vector
R0_MAG	Magnitude of initial position vector
ROTR_RATE	Input rotation rate about body vector
$\overline{R0\_UNIT}$	Unit vector in direction of initial position vector, $\overline{R0}$
RP	Predicted thrust cutoff position
$\overline{RPOS}$	Position vector of orbiter at GTMA
R_PRED_INIT	Initial position for prediction
RORB	Radius vector of orbiter
$\overline{RS}$	Current Shuttle position vector
$\overline{RS\_NAV}$	Current Shuttle position vector

<u>Variable</u>	<u>Definition</u>
$\bar{R}_{SUN}$	Sun position vector
$\bar{R}_{REL}$	Relative position vector (orbiter to orbital target)
$\bar{R}_{TARGET}$	Target position vector
RTEMP	Past value of roll attitude
RTMAG	Magnitude of target position vector
$\bar{R}_{TLOS}$	Body referenced rendezvous target LOS
$\bar{R}_{TMAG}$	Magnitude of RT vector
$\bar{R}_{UNIT}$	Unit radius vector
$\bar{R}_I$	Extrapolated inertial position vector
RI_MAG	Magnitude of target position vector
$\bar{R}_I_{UNIT}$	Unit of RI vector
S	Semiperimeter of a triangle described by the sides of RO_MAG, RI_MAG, and C in LTVCON or double-time integral from zero to T, then zero to TGO of (ft/m) in PEG.
SCONV	Guidance convergence discrete
S_CUTOFF	Guidance cutoff switch
SFUELD	Flag for out-of-plane fuel wasting
SIN_THETA	Sine of transfer angle
S_LOMS_FAIL	Left OMS fail discrete
SMODE	Maneuver mode switch
S_OMSCO	OMS engine cutoff switch
S_ONE_PASS_OFF	Alternate engine subtask one pass switch
SPHI	Sine of roll attitude
S_PROP_FAIL	Switch for prime propulsion system failed
SPSI	Sine of yaw attitude
S_ROMS_FAIL	Right OMS fail discrete

<u>Variable</u>	<u>Definition</u>
SSTEER	Discrete to indicate if steering enables (ON) or not (OFF)
ST_CRT_TIMER	Discrete to start CRT timer
STH	Sine of pitch attitude
T	Current ground–elapsed time
T1	Initial time used by predictor
T2	Final time used by predictor
TAU	Ratio of mass–to–mass flow rate
TB_ENABLE	Time base time enable discrete
TB_TIME	Time–base time
TB5	Time–base five time
TCO_BIAS	Time–to–go to engine cutoff bias
T_CROSS_OVER	Time to cross over from one OMS tank to another
T_CUTOFF	Time of OMS cutoff
TFF	Time of free fall
TGD	Time of RGD and VGD
TGDP	Past value of TGD
T_GMT	Current clock time
T_GMT_C_DAY	Current clock time of day
T_GMT_C_DAYS	Current clock time at start of day
TGO	Time–to–go to engine cutoff
TGO_MIN	Time–to–go to engine cutoff
TGO_OMS	Time–to–go when active guidance inhibited
$\overline{\text{TGPOS}}$	Earth–fixed target position vector
TGT_HA	Target apogee altitude
TGT_HD	Target perigee altitude
T_GUID_STEER	Time to allow active guidance steering

<u>Variable</u>	<u>Definition</u>
THETA_CUR	Pointing vector elevation angle from local horizontal
THETA_DISP	Target central angle from ignition position
THREE_AXIS	Three-axis tracking flag
THRUST $\bar{\text{B}}$ ODY	Thrust vector in body coordinates
THRUST $\bar{\text{B}}$ ODY_OMS	OMS thrust vector in body coordinates
THRUST $\bar{\text{B}}$ ODY_RCS	RCS thrust vector in body coordinates
TIG	Time of ignition
TIG_HR	Time of ignition in hours
TIG_MIN	Time of ignition in minutes
TIG_SEC	Time of ignition in seconds
TIG_MINUS5_FLAG	Flag set at TIG minus five seconds
TLAMC	Time reference for LAMC and LAMDC
T $\bar{\text{L}}$ OS	Target LOS or tracking vector
TMET	Time of MSC
TNAV	Current navigation time
TNAV_PREV	Navigation time past value
T_NODE_SEC	Orbiter-target node time
T_OMS_SWITCH	Time to cross over for OMS-to-OMS
TOP	Intermediate variable for calculating PT-NODE
TOT_ERR	Total attitude errors
TP	Predicted thrust cutoff time
T_PRED_FINAL	Final prediction time
T_PRED_INIT	Initial prediction time
T_PREV	T_GMT of previous REL NAV cycle
$\bar{\text{V}}$ _LVLH	Tracking body vector in LVLH coordinates
$\bar{\text{V}}$ _PT	Tracking body vector in inertial coordinates

<u>Variable</u>	<u>Definition</u>
$\bar{V}_{REL}$	Relative velocity vector (orbiter to target)
$\bar{V}_{AVGG\_DP}$	Shuttle velocity vector (double precision)
$\bar{V}_{TARGET}$	Target velocity vector
$\bar{X}_{LVLH}$	X unit vector in Shuttle LVLH coordinates
$\bar{Y}_{LVLH}$	Y unit vector in Shuttle LVLH coordinates
Y_CUR	REL NAV current out-of-plane position
Y_CUR_DISP	REL NAV current out-of-plane position
YD_CUR	REL NAV current out-of-plane velocity
Y_PREV	Out-of-plane distance of previous REL NAV cycle
$\bar{Z}_{LVLH}$	Z unit vector in Shuttle LVLH coordinates
Z	A Scratch variable used in LTVCON

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**APPENDIX R CHANGE AUTHORIZATION REFERENCES**

**R.1 CR REFERENCE SUMMARY**

Table R.1-1. lists the paragraphs, tables (T), and figures (F) that have been changed as a result of approved change requests commencing with OI-26 up to the current OI.Changes incorporated prior to OI-26 are listed in the Historical Change Request Summary.

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
N/A	92307	29	FSSR Format Change - Documentation Only
	92739D	30	STS 83-0003 Errata Cleanup
	92973	32	Reassign Effectivity of SCR 92542D & 92743D to OI-32
	92992	32	Reassign Effectivity of SCR 92876B to OI-32
	93009	32	Reassign Effectivity of SCR 92843B to OI-32
1.3-1.(T)	92103A	26B	FSSR Parameter Table Upgrade
4.1.1	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	93023D	32	OI-32 Remote Control Orbiter Capability
4.1-1.(F)	92510E	30	Modification to Maneuver Execute Display
4.1.1-1.(F)	92510E	30	Modification to Maneuver Execute Display
4.1.1-2.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.1.1-3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	93023D	32	OI-32 Remote Control Orbiter Capability
4.1.2	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.1.3	93023D	32	OI-32 Remote Control Orbiter Capability
4.1.3-1.(T)	93023D	32	OI-32 Remote Control Orbiter Capability
4.1.6	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92843B	32	Lambert Guidance Improvement
	92843B	32	Lambert Guidance Improvement
4.1.6-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	92843B	32	Lambert Guidance Improvement
4.1.6A	92510E	30	Modification to Maneuver Execute Display

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.1.6A-1.(T)	92510E	30	Modification to Maneuver Execute Display
4.1.6A-2.(T)	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.1.9	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	93023D	32	OI-32 Remote Control Orbiter Capability
4.1.9-1.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92843B	32	Lambert Guidance Improvement
4.1.10-1.(T)	92025B	26B	Onorbit TACAN Deletion
	92069B	26B	Single-String GPS Documentation Cleanup
	92067D	27	Three String GPS Capability
	92329E	29	Onboard Calculation of RNP Matrix
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92510E	30	Modification to Maneuver Execute Display
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
	92843B	32	Lambert Guidance Improvement
	93023D	32	OI-32 Remote Control Orbiter Capability
	93090E	33	Bearing Displays
4.1.10-2.(T)	92354	27	Delete Erroneous TLM Destinations
	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
	92843B	32	Lambert Guidance Improvement
	92876B	32	Remove BURN_ENABLE from Downlist
4.1.10-3.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.1.10-4.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	90924B	29	Correct OMS Engine Parameters to Match SODB Values
	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.1.10–5.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92069B	26B	Single-String GPS Documentation Cleanup
	92067D	27	Three String GPS Capability
	92329E	29	Onboard Calculation of RNP Matrix
	92389C	29	Spiral HAC in TAEM Area Navigation
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93090E	33	Bearing Displays
4.2.1–2.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
4.2.1–3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92843B	32	Lambert Guidance Improvement
4.2.1	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.2.2	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.2.3	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
	92843B	32	Lambert Guidance Improvement
4.2.3–1.(T)	92843B	32	Lambert Guidance Improvement
4.2.3–2.(T)	92843B	32	Lambert Guidance Improvement
4.2.4	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.2.6	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
	92843B	32	Lambert Guidance Improvement
	92843B	32	Lambert Guidance Improvement
4.2.7–1.(T)	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
	92843B	32	Lambert Guidance Improvement
4.2.7–2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
4.2.7–3.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.2.7–4.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	90924B	29	Correct OMS Engine Parameters to Match SODB Values

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.2.7-5.(T)	92389C	29	Spiral HAC in TAEM Area Navigation
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays
	93090E	33	Bearing Displays
4.3	92187F	28	Automatic Reboost
4.3.1	92187F	28	Automatic Reboost
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3-1.(F)	92187F	28	Automatic Reboost
4.3.1-2.(1)(F)	92187F	28	Automatic Reboost
4.3.1-2.(2)(F)	92187F	28	Automatic Reboost
4.3.1-3.(F)	92187F	28	Automatic Reboost
4.3.2-3.(3)(F)	92187F	28	Automatic Reboost
4.3.2	92187F	28	Automatic Reboost
4.3.2-1.(T)	92187F	28	Automatic Reboost
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.2-2.(T)	92187F	28	Automatic Reboost
4.3.3	92187F	28	Automatic Reboost
	92835B	29	UNIV PTG PROC Rotation Option and RA/DEC Clean-up
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.3-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.3-1.(1)(F)	92187F	28	Automatic Reboost
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.3-1.(2)(F)	92835B	29	UNIV PTG PROC Rotation Option and RA/DEC Clean-up
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.3-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.4-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.5	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.5-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.3.6	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.6-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.6-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.7	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.7-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.8-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.8-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.9-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.11-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.11-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.13	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.13-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.14	92835B	29	UNIV PTG PROC Rotation Option and RA/DEC Clean-up
4.3.16	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.16-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.19	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.19-1.(T)	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.19-1.(F)	93078B	33	Universal Pointing Attitude Errors Clean-Up
4.3.19-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.3.20	92694	30	Correct DR 58926 - Incorrect Calculation of Displayed RPY Angles
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up

Table R.1-1. CR Reference Summary				
Paragraph	CR No.	OI	CR Title	
4.3.20-1.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
4.3.20-2.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
4.3.24-1.(T)	92025B	26B	Onorbit TACAN Deletion	
	92067D	27	Three String GPS Capability	
	90704F	28	DAP Hotstick Downmode Alert and Message	
	92187F	28	Automatic Reboost	
	92329E	29	Onboard Calculation of RNP Matrix	
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B	
	92510E	30	Modification to Maneuver Execute Display	
	92522D	30	Overhaul MEDS Composite Flight Instrument Display	
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
	93078B	33	Universal Pointing Attitude Errors Clean-Up	
4.3.24-2.(T)	93090E	33	Bearing Displays	
	92187F	28	Automatic Reboost	
4.3.24-4.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
4.3.24-5.(T)	91051K	26B	Streamlined Shuttle GPS Capability	
	92069B	26B	Single-String GPS Documentation Cleanup	
	92067D	27	Three String GPS Capability	
	92389C	29	Spiral HAC in TAEM Area Navigation	
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays	
	92522D	30	Overhaul MEDS Composite Flight Instrument Display	
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
	93090E	33	Bearing Displays	
	4.4.1	92510E	30	Modification to Maneuver Execute Display
	4.4-1.(F)	92510E	30	Modification to Maneuver Execute Display
4.4.1-1.(F)	92510E	30	Modification to Maneuver Execute Display	
4.4.1-2.(1) (F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude	
4.4.1-2.(2)(F)	92510E	30	Modification to Maneuver Execute Display	
	92859C	30	Preburn Maneuver Time To Go Clean-up	

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.4.1–3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	93023D	32	OI-32 Remote Control Orbiter Capability
4.4.2	92510E	30	Modification to Maneuver Execute Display
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.4.5–1.(T)	93023D	32	OI-32 Remote Control Orbiter Capability
4.4.10–2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
4.4.10A	92510E	30	Modification to Maneuver Execute Display
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.4.10A–1.(T)	92510E	30	Modification to Maneuver Execute Display
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
4.4.10A–2.(T)	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
4.4.13–2.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.4.14–1.(T)	92025B	26B	Onorbit TACAN Deletion
	92069B	26B	Single-String GPS Documentation Cleanup
	92067D	27	Three String GPS Capability
	92208C	28	GPS Issues for Correction on OI-28
	92354	27	Delete Erroneous TLM Destinations
	92225A	29	ET SEP Switch Default to Auto on a TAL Abort
	92329E	29	Onboard Calculation of RNP Matrix
	92355B	29	GPC Major Mode to MEDS
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92510E	30	Modification to Maneuver Execute Display
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93023D	32	OI-32 Remote Control Orbiter Capability
	93064D	32	Errata Issue Clean-Up Part II
93090E	33	Bearing Displays	
4.4.14–2.(T)	92354	27	Delete Erroneous TLM Destinations

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.4.14-3.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	92859C	30	Preburn Maneuver Time To Go Clean-up
	92876B	32	Remove BURN_ENABLE from Downlist
	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.4.14-4.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	90924B	29	Correct OMS Engine Parameters to Match SODB Values
4.4.14-5.(T)	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
	91051K	26B	Streamlined Shuttle GPS Capability
	92069B	26B	Single-String GPS Documentation Cleanup
	92067D	27	Three String GPS Capability
	92389C	29	Spiral HAC in TAEM Area Navigation
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93090E	33	Bearing Displays
4.5.1-2.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
4.5.1-3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
4.5.1	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.5.2	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.5.2-1.(F)	93023D	32	OI-32 Remote Control Orbiter Capability
4.5.3	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.5.3-1.(T)	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.5.5-1.(T)	90924B	29	Correct OMS Engine Parameters to Match SODB Values
4.5.7	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92751B	30	Documentation Update of Deorbit/On-orbit Guidance Initialization
4.5.7-1.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.5.7-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
4.5.8-1.(T)	92025B	26B	Onorbit TACAN Deletion
	92067D	27	Three String GPS Capability



Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.5.8-2.(T)	92389C	29	Spiral HAC in TAEM Area Navigation
	92329E	29	Onboard Calculation of RNP Matrix
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93023D	32	OI-32 Remote Control Orbiter Capability
	93090E	33	Bearing Displays
	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	93090E	33	Bearing Displays
	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.5.8-3.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
4.5.8-4.(T)	91019A	26	Guidance K-Loads to I-Loads for Second Stage Roll-to-Heads-Up
	90924B	29	Correct OMS Engine Parameters to Match SODB Values
	92329E	29	Onboard Calculation of RNP Matrix
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays
4.5.8-5.(T)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93090E	33	Bearing Displays
	90974A	26	Orbit Targeting Lambert Iteration Loop Exit Logic Correction
4.6.20	90974A	26	Orbit Targeting Lambert Iteration Loop Exit Logic Correction
	90974A	26	Orbit Targeting Lambert Iteration Loop Exit Logic Correction
4.6.24-1.(T)	92025B	26B	Onorbit TACAN Deletion
	92067D	27	Three String GPS Capability
	92354	27	Delete Erroneous TLM Destinations
	92355B	29	GPC Major Mode to MEDS
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
	93090E	33	Bearing Displays
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.6.24-5.(T)	93090E	33	Bearing Displays
	92329E	29	Onboard Calculation of RNP Matrix
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.7	93090E	33	Bearing Displays
	92067D	27	Three String GPS Capability
4.7.1	92208C	28	GPS Issues for Correction on OI-28
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.7-1.(T)	92067D	27	Three String GPS Capability
4.7-1.(F)	92067D	27	Three String GPS Capability
4.7.2	92688B	30	Fix for DR 50120 - Time To Node Oscillation
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
4.7.2-1.(T)	92688B	30	Fix for DR 50120 - Time To Node Oscillation
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
4.7-2.(F)	92067D	27	Three String GPS Capability
4.7-3.(F)	92067D	27	Three String GPS Capability
4.7-4.(F)	92067D	27	Three String GPS Capability
4.7.4-1.(T)	92025B	26B	Onorbit TACAN Deletion
	92067D	27	Three String GPS Capability
	92208C	28	GPS Issues for correction on OI-28
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92688B	30	Fix for DR 50120 - Time To Node Oscillation
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
	93090E	33	Bearing Displays
4.7.4-2.(T)	92067D	27	Three String GPS Capability
4.7.4-5.(T)	92329E	29	Onboard Calculation of RNP Matrix
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93090E	33	Bearing Displays
A4.1.2.(F)	92859C	30	Preburn Maneuver Time To Go Clean-up
A4.1.6.(1)(F)	92843B	32	Lambert Guidance Improvement
A4.1.6.(2)(F)	92843B	32	Lambert Guidance Improvement
A4.1.6.(4)(F)	92843B	32	Lambert Guidance Improvement
A4.1.6A.(F)	92859C	30	Preburn Maneuver Time To Go Clean-up
A4.1.9.(5)(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
A4.2.3.(1)(F)	92843B	32	Lambert Guidance Improvement
A4.2.6.(F)	92843B	32	Lambert Guidance Improvement
A4.3.2.(1)(F)	93078B	33	Universal Pointing Attitude Errors Clean-Up
A4.3.3.(1)(F)	93078B	33	Universal Pointing Attitude Errors Clean-Up
A4.3.3.(2)(F)	92835B	29	UNIV PTG PROC Rotation Option and RA/DEC Clean-up
	93078B	33	Universal Pointing Attitude Errors Clean-Up

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
A4.3.5.(F)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.3.6.(F)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.3.7.(F)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.3.13.(F)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.3.14.(F)	92835B	29	UNIV PTG PROC Rotation Option and RA/DEC Clean-up
A4.3.16.(F)	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.3.19.(1)(F)	93078B	33	Universal Pointing Attitude Errors Clean-Up
A4.3.20.(F)	92694	30	Correct DR 58926 - Incorrect Calculation of Displayed RPY Angles
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
A4.4.2.(2)(F)	92859C	30	Preburn Maneuver Time To Go Clean-up
A4.4.10A.(F)	92859C	30	Preburn Maneuver Time To Go Clean-up
A4.5.7.(3)(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
A4.6.20.(F)	90974A	26	Orbit Targeting Lambert Iteration Loop Exit Logic Correction
A4.7.1.(F)	92067D	27	Three String GPS Capability
A4.7.2.(F)	92688B	30	Fix for DR 50120 - Time To Node Oscillation
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV
A4.7.3.(F)	92067D	27	Three String GPS Capability
Appendix B	92067D	27	Three String GPS Capability
	92748B	30	Make a Double Precision Copy of V_AVGG for REL NAV

## R.2 HISTORICAL CHANGE REQUEST SUMMARY

Table R.2-1. is an historical record of approved change requests incorporated since the initial baseline up to OI-25. Change requests commencing with OI-26 are reformatted and listed in the CR Reference Summary.

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
2576		On-Orbit Guidance Cleanup
2599B		FSSR Rel Motion Specification
12001		ADD Pitch ATT Tape Scale
12019		Stand FSSR Principal Functions
12071A		Maneuver Execution Disposition Change
12090		Deorbit DIP Trim Angles
12109		On-orbit 1, I/O Update
12190D		PFG Changes ASC/RTLS Guidance
12225B		GNC Level C U/L Requirements
12229		ADD S/W Capability in Deorbit
12270A		Block Update to OPS 3 Deorbit Guidance
12326		Change to Rendezvous Navigation
12334		Elimination of Interface Between Deorbit DIP and TRANS DAP
12336		I-Load OFT-1 M/L
12337		I-Load OFT-1 D
12338		I-Load OFT-1 Baseline Constants
12339		I-Load OFT-1 Baseline Removal
12341		Range to Landing Site
12343B		Maximum Integrated Step Size
12345		Time-to-Next-APSYS Corrections
12411B		OMS Engine FDI Simplification
12432A		Modification to the Area Navigation PF
12442A		Integrated ENT Navigation
12443		I-Load ENT FACI 5/1/78 Delivery
12465		Orb Alt/Time Task Accuracy
12478		Update to Vehicle Mass
12510		Peg Time-to-Go and Thrust
12522		Route Current Vehicle
12586		Integrated Signal
12588A		Recycle OMS Ignition Capability
12600C		Integrated MSIAssign U/L OPS 1, 2, 3, 6, and 9
12689B		Commanded Body Attitude During OMS
12716A		Maneuver Execution Display
12744		Vehicle Thrust Body Geometry
12745		Deletion of OMS/OMS Interconnect
12781		Vehicle OMS Trim
12809A		Modification Universal Pointing (6.27)
12812A		Relative Navigation Display

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
12813A		Orbit Targeting
12842		Reestablish TV Roll
12843		Update On-Orbit (OPS-2) Guidance S/W Requirements to OFT-3 Configuration
12848H		Optical TAEM Targeting
12895		Range to Landing Sites Task
12924A		Cleanup to CR 12588A
12948		Addition of Automatic Maneuver
12951B		Universal Point Specification Function I-Load Changes OFT-1
12971E		Orbit Targeting Prox (OPS)
12981D		On-Orbit Flight Control
12988		Relative Motion Documentation
19014A		On-Orbit Software Requirements Documentation
19018B		Universal Point (Flight 2 Sub)
19019		Vehicle OMS Trim Angle Interface Requirements
19031C		Correction to Interface Discrepancies
19072A		COMFAULT Addition to OMS TVC FB SOP
19073A		U/D Active ATT Option Indicator Signal Interface to Orbit Display
19100		FSSR Update 1
19130		Maneuver Execution Make Work Changes
19169		MPAD I-Load for Cycle 2 Update
19198		Cleanup to OMS Recycle (CR's 12588A and 12924)
19229		Document Correction to CR 12745
19300		FSSR Update 2
19361A		Navigation U/D STS-2
19377B		COSOL I-Loads for Premaneuver Related Timing
19379		Clarify Uplink Target
19386A		Deletion of Multiple Defined I/L Parameters
19452B		I/L Corrections Necessary for 3/19 Release and STS-1 Flight
19455		Measurement Attribute Corrections STS-1
19458		Correction to Universal Point Ink Rate Vector STS-2
19471B		Orbit Targeting Cleanup
19491A		Universal Point Document Cleanup STS-2
19500		FSSR Update 3
19550		Document Change to Reflect CR 19220A
19552		CYC U/D of Vehicle WT and Propellant on Maneuver EX Display
19580		Delete OP Code Done From I/L
19581B		Correction to I/L Paper Baseline STS-1

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
19678		OMS Guidance/RM Cleanup
19700		FSSR Update 4
19771B		On-Orbit Guidance STS-2 Downlist Requirements
19785B		Relative Navigation Specification and Disposition Requirement and Interface Corrections
19872A		IVR-Roll I/L and Formulation Changes, STS-2
19874A		Universal Point Changes
19900		FSSR Update 5
19976A		New OMS Cutoff Time Bias I-Load Value
29017A		Universal Pointing Downlist Parameters
29032B		Deorbit Guidance Short Burn Logic
29071		Corrections to OMS Evaluation Constrain Logic
29088		STS-1 Universal Point FSSR Cleanup
29141A		Orbit Targeting I-Loads Change
29142B		MPAD I/L U/D 4, STS-1, Cycle 3
29149B		ADD Program Interrupt Handling
29162A		I/L Changes Resulting From Owners Audit
29164C		BFS I-Load Cleanup (Ref Only)
29250		Universal Point Changes
29300A		FSSR Update 6
29407		Maneuver Execute Disposition PFS 18/BFS 12
29426A		Relative Navigation Update
29456		Orbiter Targeting I-Load Modification (Ref Only)
29471B		HFE Overrun Definition
29500		FSSR Update 7
29520F		Ku-Band Communication/Radar Control Interface, Channel 1 (FLMDM) (Rendezvous Radar Portions)
29559A		Guidance Velocity Vector PREC Correction (R-18)
29602A		Make PFG I-Loads Constants
29641B		Universal PT I/L (R-18) (Ref Only)
29645		Deorbit Guidance Velocity Precision Increase (R-18)
29650A		CR IMP Baseline Report 1037, May 1980
29652		Estimate Mass Until TGO = 0
29653B		On-Orbit Guidance Update (R-18)
29657C		STS-1 Cycle 3.1.1 MPAD I/L (R-16)
29660A		Current Vehicle Mass U/D (R-18)
29694B		STS-1 Cycle 3.1.1 MPAD Abort (R-18)
29726		Maneuver DIP/Guidance I/L Cleanup (R-16)

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
29728A		Data Correction on Universal Point Disposition
29800		FSSR Update 8
29810E		Universal PTG Display Update
29815B		Cleanup On-Orbit Guidance I-Loads
29866		Universal Pointing Document Update
29900		Change Value of DT_MAX
29902A		Cycle 3.2.2 I/L 3-10-81 Launch
29938		STS-1 Cycle 3.2.2 AOA to EDW
29975A		Orbital Maneuver DIP Prediction Step Size (Reference Only)
29976A		OPS 3 Mass Initialization (Reference Only)
29999A		Optional TAEM Targeting Rewrite
39000		FSSR Update 9
39006		Correct Orbit Navigation Orbit Guidance Interface
39051		On-Orbit Guidance REL 18/REL 19 Baseline
39135A		Delete I-Load NMAX_BURN
39173		I/L Discrepancy Cleanup (Reference Only)
39181		Orbit Targeting Mods
39182		Orbit Target Cleanup and Modification
39192A		Cycle 3.3.3 I-Loads (Reference Only)
39229A		Value for HP_MAX Constant
39235A		Value for HP_MAX I-Load
39323A		STS-2 Cycle 1 MPAD Abort I/L (Reference Only)
39400		FSSR Update 10 (R18), #1 (R19)
39403A		OMS Guidance Improvement (2) Superseded by CR 69600D
39439		On-Orbit Guidance I-Load Correction (STS-3 Reference Only)
39530F		STS-2 Cycle 2 I-Loads (Reference Only)
39534		OPS-3 Guidance I-Loads (Reference Only)
39569		STS-2 Cycle 2 AOA to NOR (Reference Only)
39601		STS-3 Cycle 2 Ascent and Abort (Reference Only)
39604B		STS-3 Cycle 2 AOA to NOR-Guidance (STS-3; Reference Only)
39611A		Universal Pointing CUR and FUT Indicators
39640		STS-2 Cycle 2 AOA to NOR (Reference Only)
39653A		TAL Guidance Corrections (STS-3)
39674		I-Load MSID Reassignment (Reference Only; STS-9)
39710A		STS-4 Cycle 1 MPAD ASC Abort (STS-4; Reference Only)
39725A		Deorbit Uplink After OMS Burn
39785		MM 302 With TIG in the Past (STS-3)
39816A		Update Maneuver Data at Disposition Rate (STS-3)

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
39832D		Orbit Targeting Update (STS-9 IDD Reference Only)
39898B		I-Load Precision Change (STS-3)
39940		Vehicle Mass for Entry (STS-3; Reference Only)
39950		FSSR Update #12/18 (Reference Only)
39980A		CR Implementation Baseline—February, 1982
39990D		STS-5 Cycle 3 Ascent I-Loads (STS-5;Reference)
39996A		Document Update—Orbit Maneuver DIP (STS-4)
59001		Orbit Target Tolerance (STS-9)
59010D		Universal Printing Upgrade
59016D		STS-5 Cycle 3 Ascent Abort (STS-5; Reference)
59025A		STS-4 Cycle 3 Ascent/Abort IL Update (Reference Only)
59036		Orbit Target Lambert Guidance Time
59050		FSSR Update 13 (R18), #4 (R19)
59099		DTMIN From I-Load to Constant (STS-5)
59111A		Correct STS-5 Cycle 3 I-Load (STS-5; Reference)
59130A		Update Rendezvous I-Loads (STS-9; Reference)
59131B		STS-6 Cycle 2 Ascent Abort (STS-6; Reference)
59220		CR Implementation Baseline—July 1982
59261		STS-5 Cycle 5 Ascent Abort I/L (STS-5 Only; Reference)
59362A		Terminate Precise Predictor (IDD Reference Only)
59375		CR Implementation Baseline—September, 1982
59380A		Orbit Targeting Cleanup
59406		Change Sign in Lambert Guidance
59440B		Orbiting Targeting Documentation Update
59464F		Star Catalog Increase
59468E		Orbit Targeting Alarms
59469C		Orbit Target Stable Orbit I/L (Reference IL Only)
59513		I-Load Special and Code Conflict (STS-6;Reference Only)
59516		Orbit Target Tuned Coelliptic I/L (Reference IL Only)
59522C		I-Load Dependency Change (IL STS-7;Reference Only)
59650		CR Implementation Baseline—March 1983
59657A		Delete RNDZ TGE Vehicle Homo Set (Reference Only)
59750		FSSR Update #2
59933B		Orbit Targeting STS'11 I/L's (Only)
59955		I-Load Scrub: 6
59956		I-Load Scrub: OMS
59992		CHG I/L PREC in FSSR and IDT
69034A		Orbit Targeting I-Loads (Only)



Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
69095A		Universal Pointing Runs Postburn Maneuver
69365		Orbit Maneuver Display Cleanup
69447B		On-Orbit Guidance/UPP Requirements Update
69448		Clarify DEV/GPC Distribution (Reference Only)
69600D		OMS Guid Improvement (3)
69622		STS-14 Post Cycle 2 ASC/ART Update (Reference Only)
69643B		Universal Pointing Document Correction-Track Rate
69691		51-B Cycle 1 Ascent/Abort I-Loads
69748		Correct CR 59380A
69773D		Document Cleanup of CR 29886C
69978A		51-D Cycle 1 Ascent/Abort I-Loads
79013A		Corrections to CR 69095A
79042		51-B Cycle 2 Ascent/Abort I-Loads
79048A		51-F Cycle 1 Ascent/Abort I-Loads
79092A		51-G Cycle 1 Ascent/Abort I-Loads
79181B		TL Cycle 1 Ascent/Abort I-Loads
79247		51-G Cycle 2 Ascent/Abort I-Loads
79275C		51-I Cycle 1 Ascent/Abort I-Loads
79280A		51-B Cycle 3 Ascent/Abort I-Loads
79328		51-D Cycle 3 Ascent/Abort I-Loads
79335D		OMS/RCS OPS Downlist Changes
79499		FSSR Update
79514		51-I Cycle 3 ASC/ABT CAT A2P1 (I-Loads Only)
79579		61A Cycle 2 ASC/ABT I/L Occur (I-Loads Only)
79623		61B Cycle 2 ASC/ABT TAL to MORON (I-Loads Only)
79662		61G Cycle 1 ASC/ABT I/L Occur (I-Loads Only)
79693		61G Cycle 2 ASC/ABT I/L'S (I-Loads Only)
79695		61G Cycle 1 ASC/ABT I/L Occur (I-Loads Only)
79743		61C Cycle 2 and Alternate Mission Definition (I-Loads Only)
79747C	20	Lambert Targeting/Guidance Error Protection
79769A		61F Cycle 1 ASC/ABT I/L Occur (I-Loads Only)
79776		61C Cycle 2 TAL I/L (I-Loads Only)
79790A		CR Implementation Baseline—November 1985
79962F		Entry/GRTLS DAP OI-8C Scrub
89111C		Errata STS 83-0003A
89150H		Abort Control Sequence Scrub
89245D		Post-MECO TAL Declaration
89250B		Bailout Control System

Table R.2-1. Historical Change Request Summary		
CR No.	OI	CR Title
89461A		STS 83-0001B Errata B/L
89462		STS 83-0003B Errata/Baseline
89542A		K/L Chgs STS 83-0003B
89599C		Cleanup Level B GN&C Document
89622A		I/L Chgs STS 83-0003B
89662B		FSSR STS 83-0003B Errata/Baseline
89692B	20	Orbit Targeting Protection and Alarms
89901A	21	Convert Att/Ptg I-Loads to K-Loads
89990E	21	Single Engine Auto Contingency Abort
89991E	21	Entry SSME Repositioning (For Drag Chute)
90119		OMS Guidance Document Cleanup
90120B		UPD Guidance Downmode Requirements
90121B		Change ASC PRECISE PREDICTOR Term - OPS Transition
90185A	20	Add CR Field to FSSR I/O Tables
90221		Change TLAMC From MET to GMT
90243C	22	Second Stage Auto Recognition of Second Engine Out
90329C	22	Guidance I-Loads to K-Loads
90374C	20	Automated FSSR Constants
90476F	25	Wraparound Yaw Jet System W/PTI Effector
90528A	22	Earth Pole Initialization
90690A	24	Deletion of EQTN MSID Column from FSSR K-Load tables
90701A	22	Orbit Targeting Integration Loop Correction
90705H	25	3 Engines Out Auto Contingency
90712	22	Orbit Targeting (Documentation Only)
90781C	24	Define Parameter Data Nomenclature
90790	24	Add Memory Configuration to the FSSR I-Load Tables
90814C	24	Add Description of Database Generated FSSR Parameter Tables
90881A	25	FSSR STS83-0001 Documentation Changes
90882B	23	FSSR DOC Only Changes, GN&C On-Orbit/Deorbit
90900D	25	FSSR-9 Orbit Flight Control Documentation Changes
90966A	24	Deletion of Qualifier from the FSSR I-Load Tables
91005B	25	OI-23 GN&C Doc Issues Cleanup
91066D	25	Standardize the FSSR Correlation Tables
91072D	24	OI-24 GN&C Doc Issues Cleanup
92027B	25	TDMS-2 Required FSSR Changes