

Space Program Operations Contract

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

GUIDANCE ASCENT/RTLS

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 ASCENT/RTLs**

Issue Date: December 14, 2007

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**The Boeing Company
Space Exploration**

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Prepared by

/s/ **C. Bergman**

C. Bergman
FSSR Documentation

/s/ **A. Flottorp**

A. Flottorp
G4.1 ASC 1STG GUID

/s/ **M. West**

M. West
G4.2 ASC 2STG GUID
G4.4 PW RTLS GUID

/s/ **C. Chlouber**

C. Chlouber
G4.3 ORB INS GUID
G4.13 AOA/ATO TGT
G4.210 ASC MNVR DIP

/s/ **A. Berndt**

A. Berndt
G4.5 PW CONT GUID
G4.6 E/O CONT GUID

Approved by
/s/ **D. Owen**

D. Owen, Product Manager
Flight Software Requirements & Verification
Flight Systems & Software Engineering

Approved by
/s/ **D. Bateman**

D. Bateman, Manager
FSSR Documentation
Flight Systems & Software Engineering

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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 Levels 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.

DOCUMENT CHANGE RECORD			
Issue and Date	Change Summary/Effectivity		
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 (YERO) Reset
	93167A	33	Bearing Displays Documentation Clean-up
	93175	32	Expand Effectivity of SCR 93160B
	93177D	32	Clarify LOAD Item Entry
	93182B	33	Make LTVCON More Robust

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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.

CHANGE REQUEST SUMMARY			
Paragraph	CR No.	OI	CR Title
N/A	93175	32	Expand Effectivity of SCR 93160B
1.3-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.2.5-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.2.5-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.3.5-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.3.5-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.4.1.1	93177D	32	Clarify LOAD Item Entry
4.4.1.2	93177D	32	Clarify LOAD Item Entry
4.4.4-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.4.4-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.4.4-3.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93182B	33	Make LTVCON More Robust
4.5.6-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.5.6-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.6.7-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.6.7-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.7.4	93177D	32	Clarify LOAD Item Entry
4.7.4-2.(T)	93177D	32	Clarify LOAD Item Entry
4.7.10-1.(T)	93160B	32	Year End Roll Over (YERO) Reset
	93177D	32	Clarify LOAD Item Entry
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.7.10-2.(T)	93177D	32	Clarify LOAD Item Entry
	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.8.4	93182B	33	Make LTVCON More Robust
4.8.4-1.(T)	93182B	33	Make LTVCON More Robust
4.9.12-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.9.12-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.10.4-1.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
4.10.4-2.(T)	93017G	33	Baseline RSS99D0100 with Expanded Downlist
	93167A	33	Bearing Displays Documentation Clean-up
A4.7.4.(F)	93177D	32	Clarify LOAD Item Entry
A4.8.4.(F)	93182B	33	Make LTVCON More Robust
B-1.(T)	93182B	33	Make LTVCON More Robust

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Level C Guidance document is to present the detailed requirements and formulations of the Level B Guidance functional requirements for the orbiter flight software.

1.2 SCOPE

This document contains the detailed requirements and formulations for those guidance functions that are operative during ascent, abort–once–around (AOA), abort–to–orbit (ATO), and transatlantic abort landing (TAL) in operational sequence one (OPS–1) and the powered phases of return–to–launch site (RTL) aborts in operational sequence six (OPS–6), as defined in the Level B GN&C computer program development specifications (CPDS) document. These functions are ascent first–stage guidance, ascent second–stage guidance, orbit insertion guidance, AOA/ATO targeting, powered RTL guidance, and ascent maneuver display interface processor. In addition, several general guidance and targeting tasks, which are used by one or more of the principal functions previously stated, are defined in this document.

In general, the performance requirements and vehicle constraints, from which the software requirements are derived, are not discussed in this document.

1.3 ORGANIZATION

This document is organized into the following sections.

- 1.0 Introduction
 - 2.0 Applicable Documents
 - 3.0 Overview
 - 4.0 Detail Requirements
 - 5.0 Supplementary Material
- Appendixes
- A. Detailed Flow Charts
 - B. Temporary Variables
 - C. OPS–1 Utility Routines

Section 1 defines the purpose, scope, and organization. Section 2 lists the applicable documents. Section 3 provides an overview of the software functions. Section 4 specifies the detailed requirements. 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 provides supplemental material, including coordinate systems, acronyms and abbreviations, and HAL programming language syntax. The appendixes contain detailed flow charts (Appendix A), temporary variables (Appendix B), and OPS–1 utility routines (Appendix C).

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

Table 1.3-1. Parameter Element Description

Title	Definition	Valid Entries
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.
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 9th 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 <ul style="list-style-type: none">• 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 INTERFACE CONTROL 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

3.1 OPERATIONAL FLIGHT PROGRAM

The operational flight program (OFP) is the total computer program in the orbiter general-purpose flight computer subsystem. The requirements are specified at three levels: system level (A), functional level (B), and detailed level (C). The Level B and C requirements are specified in separate documents for guidance, navigation, and control (GN&C) and for system management (SM).

The basic GN&C components of the OFP are guidance, navigation, flight control, redundancy management, subsystem operating programs, and displays and controls. Each of these major components contain several software major functions; e.g., the first-stage guidance is a principal function. The GN&C principal functions are defined in the Level B GN&C computer program development specifications (CPDS).

The guidance software functions described in Section 4 are activated by the software scheduling function at the proper times so that the required guidance inputs from other software elements (such as navigation) and guidance outputs to flight control, etc., are available when required. The guidance interfaces with other software functions are defined by tables and illustrations in Section 4.

This document is the guidance part of the GN&C Level C OFP requirements for ascent, abort-once-around (AOA), abort-to-orbit (ATO), and transatlantic abort landing (TAL) in operation sequence one (OPS-1), and the powered phases of RTLS abort in operation sequence six (OPS-6).

3.2 ASCENT

The primary objective of ascent guidance is to provide guidance commands to the Space Shuttle during the ascent phases of flight, accomplish the nominal mission objective, and support the abort requirements. Figure 3-1 depicts the Space Shuttle ascent scenario for ascent operations (OPS-1) and return-to-launch-site (RTLS) aborts.

The ascent flight phase begins at lift-off and ends at insertion into a circular or elliptical orbit. It consists of four subphases: first stage, second stage, OMS-1, and OMS-2.

3.2.1 Aborted Missions

The general approach to abort targeting is discussed in the introduction to Section 4.5.

3.3 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.

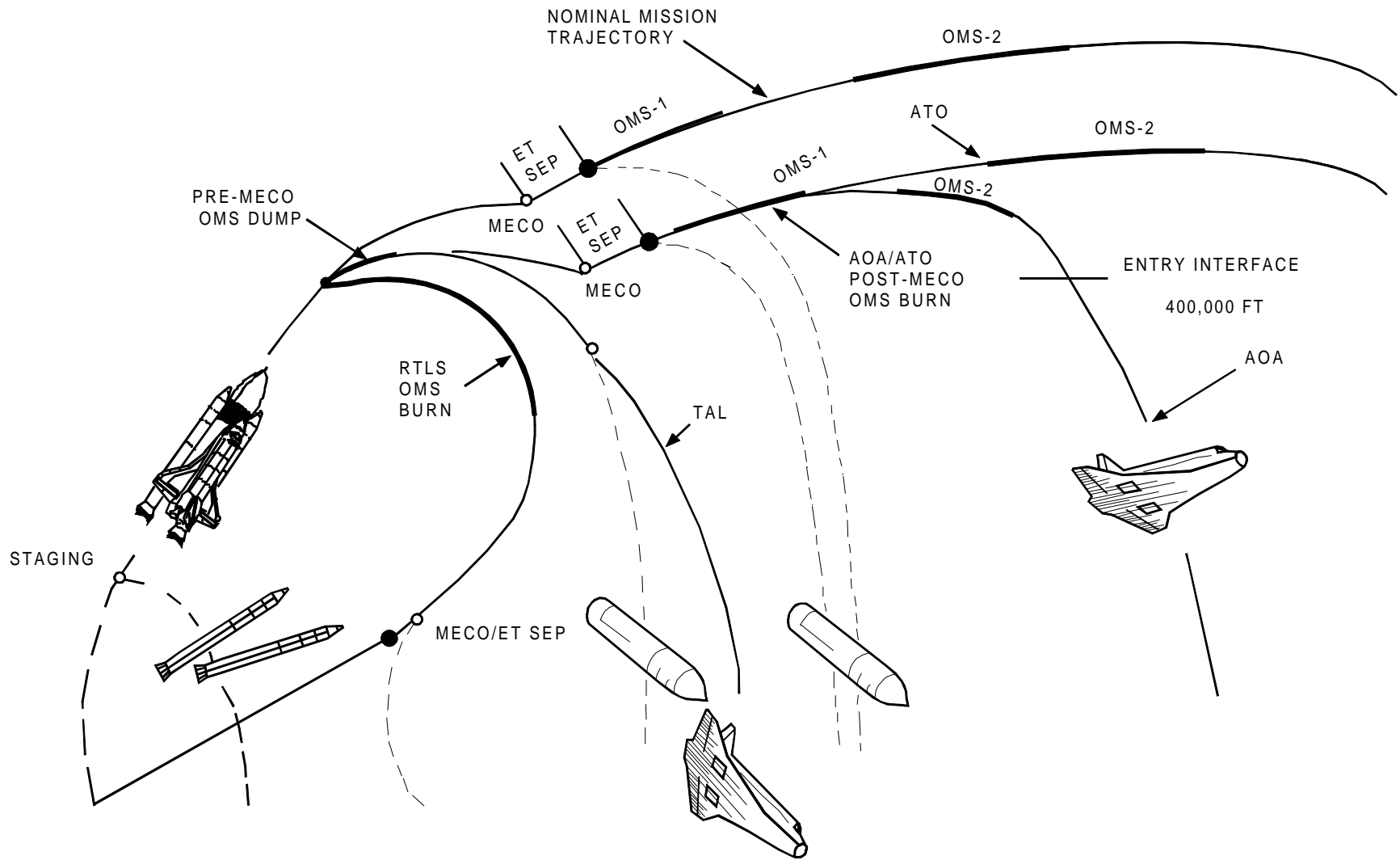


FIGURE 3-1. Space Shuttle Ascent Scenario

4.0 GUIDANCE FUNCTIONAL SOFTWARE REQUIREMENTS

This section presents Level C detailed guidance and targeting requirements for the ascent program (OPS-1 and OPS-6) of the Shuttle orbital flight test project. This set of requirements covers both nominal mission ascent phases, AOA, TAL, and ATO ascent abort phases, and the RTLS abort powered phase.

Software requirements are defined at three levels in the following subsections: principal function, task, and subtask. Principal functions in this Level C document agree with those defined in the CPDS, Level B, GN&C document. Tasks and subtasks are convenient partitionings of the total requirements for each principal function. The task and subtask breakdown has been adopted to clarify the software requirements only and is not meant to define blocks of code or the flight program structure. Definitions of the three levels of requirements are:

Principal Function. A set of requirements which, when taken together, satisfy a particular mission objective and the associated vehicle constraints. For example, the second-stage guidance principal function performs the guidance calculations and issues thrust attitude and SSME commands to achieve desired trajectory conditions at MECO without exceeding the 3g acceleration limit. In some cases, the partitioning of the overall software requirements into principal functions is based on historical precedent.

Task. A group of related requirements which constitute part of the overall requirements for a principal function or functions. The partitioning of a principal function into tasks may be based on differences in execution rate or time span for the various requirements. The aggregate of tasks of a principal function when properly sequenced satisfies the requirements of the principal function.

Subtask. A single requirement or small set of related requirements which are a further division of the task requirements. Subtasks generally are unique to a specific task. Subtasks within a task may be executed over different time spans.

A principal function is defined for the guidance requirement for each of the ascent or RTLS phases as follows:

1. Terminal count requirements (MM 101)
2. First-stage requirements (MM 102)
3. Second-stage requirements (MM 103)
4. Orbit insertion requirements (MM's 104 and 105)
5. Powered RTLS requirements (MM 601)

The detailed requirements for these principal functions are described in Sections 4.1 through 4.4 and Section 4.6. Each major mode description contains a discussion of the conditions necessary to initiate and terminate the mode, the desired terminal conditions, the maneuvers required, the maneuver constraints imposed, and a typical time line. In addition, traceability to Level B documentation is provided by identification of major modes, principal functions, and their major events.

Three other guidance-related principal functions are required to support the guidance software:

1. AOA/ATO targeting (MM's 103, 104, 105, and 106)
2. Ascent maneuver display interface processing (MM's 104, 105, and 106)
3. Powered contingency guidance (MM's 103 and 601)

The requirements for these principal functions are contained in Sections 4.5, 4.7 and 4.9.

The I-load and K-load parameters used in the ascent and powered RTLS guidance and targeting functions are listed for each principal function within Section 4.

Interface (input/output and constant) tables for each principal function also appear in Section 4.

A diagram of the OPS-1 guidance-related principal functions and major mode progression is shown in Figure 4-1.

Each principal function contains, or executes, several tasks which are further divided (in most cases) into subtasks. Each task description contains the detailed requirements, interface requirements (between other guidance/ targeting tasks and other principal functions), processing requirements, and initialization requirements for the task. Task interface variables (input and output) are defined as a group at the end of each task section. A functional flow to assist in understanding the logic decisions of each task is presented for those task descriptions whose complexity requires this additional aid.

Several tasks are required to support more than one principal function, such as the powered explicit guidance (PEG), which supports the second-stage, orbit insertion, and powered RTLS requirements. These tasks are grouped together under Section 4.8, General Guidance and Targeting Tasks. In general, these tasks perform the detailed guidance and targeting calculations. Other functions, such as H_ELLIPSOID and MAT_TO_QUAT, which are documented in other FSSR's, are assumed to be available (see Appendix C). Other principal functions which supply input data to one or more of the principal functions described herein are precision state prediction (A/E PREC PRED), ascent user parameter processing (ASCENT UPP), OMS fault detection and identification (OMS RM), attitude processing (A/E ATT PROC), RTLS user parameter processing (RTLS UPP), GN&C switch processor (GN&C SW RM), SSME subsystem operating program (SSME SOP), abort control sequencer (ABT CNTL SEQ), and maneuver display (MNVR DISP).

Section 5.1 defines the four Cartesian coordinate systems upon which the guidance software is based, and which are sometimes referred to in the text. These coordinate systems are:

1. Aries-mean-of-1950 Cartesian coordinate system (Figure 5.1-1)
2. Boost reference coordinate system (Figure 5.1-2)
3. UVW coordinate system (Figure 5.1-3)
4. Body axis coordinate system (Figure 5.1-4)

The first and fourth systems are pertinent to all flight phases while the second and third are pertinent only to the first-stage and orbit insertion phases respectively. The first three systems are inertial (the third is quasi-inertial) with respect to the first system. The first system is referred to throughout this document as M50. The fourth, or body axis system, is used to relate guidance attitude commands to flight control attitude commands and is generally implicitly referenced.

In addition to the above coordinate systems, the PEG equations utilize a Cartesian system referenced to the expected thrust cutoff point in which the X-axis is radial, the Z-axis is downrange, and the Y-axis is normal to the direction of travel. These three axes are oriented to form a right-handed system.

An additional coordinate system is used during powered contingency guidance flight. A cartesian coordinate system is constructed in a local horizontal, local vertical frame. The X-axis is radial, the Y-axis is out-of-plane and the Z-axis is horizontal in the direction of travel at MECO.

Throughout this document, HAL programming language equations and symbols will be used for illustrative purposes. The 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 . In addition, the following symbols, when placed above the variable name, were used to denote types of variables: vectors (\rightarrow), matrices (*), quaternions (+), and Booleans (.). Further information on 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.

Acronyms used in this document for the purpose of conciseness are defined in Section 5.3.

Appendix A presents detailed flow charts for each task and subtask of Section 4. If there is a conflict between the data in the flow diagrams and the written requirements, the written requirements shall have precedence.

Appendix B lists the variables internal to the various tasks and their precision.

Appendix C gives the input variable lists for other routines (e.g., MAT_TO_QUAT, ASC PREC PRED) used by the guidance and targeting functions in this document.

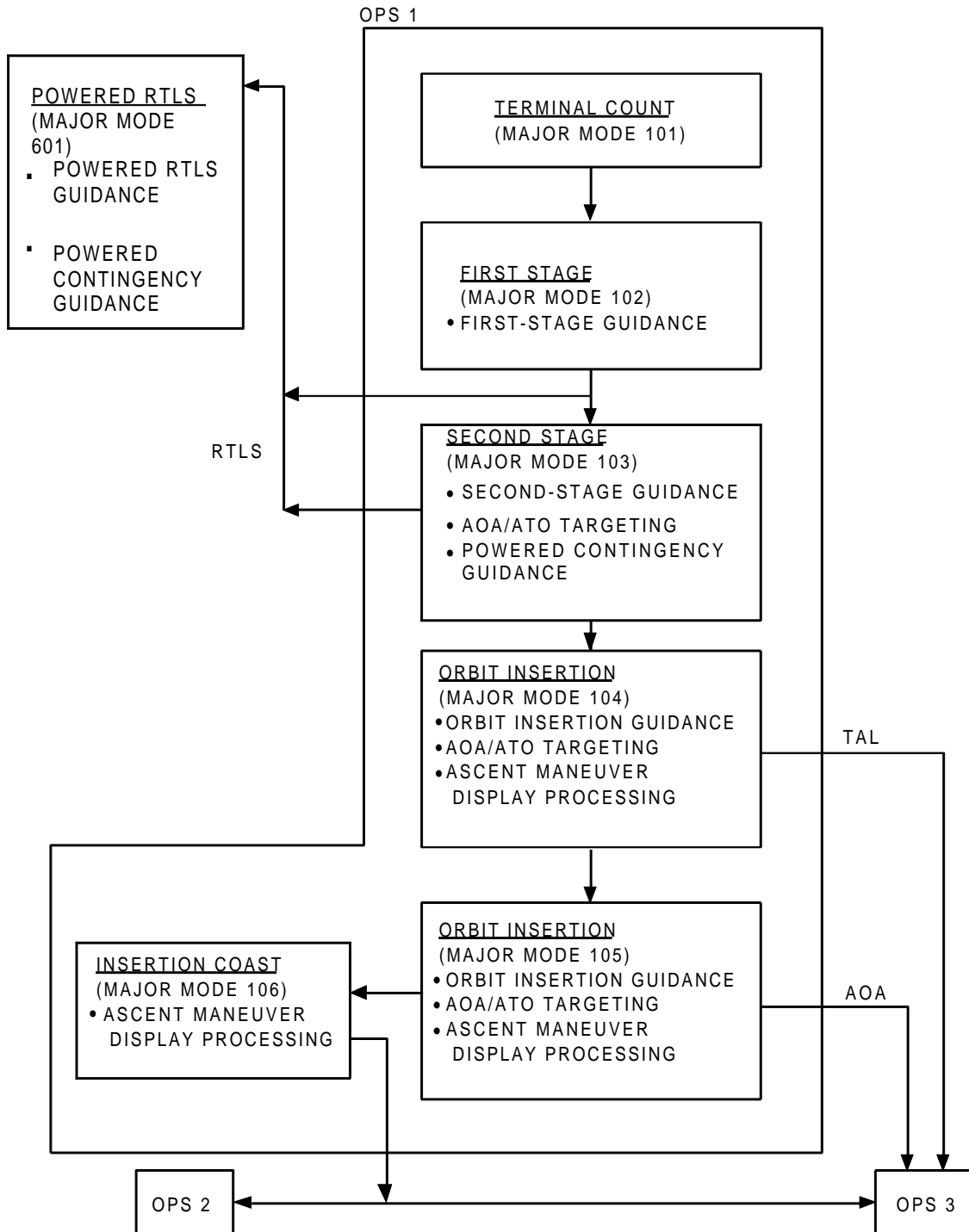


FIGURE 4-1. Guidance Principal Functions by Major Mode for OPS-1

4.0.1 Software Implementation Constraints

Several constraints and assumptions apply to the flight software implementation of the requirements in the following sections. These constraints are discussed in the following paragraphs.

Variables listed in the interface tables for each task and principal function are characterized as single precision (SP) or double precision (DP). The SP or DP designations are requirements only, and do not preclude a single precision variable from being coded in double precision if that simplifies the software design. In general, the only variables which require double precision are clock or event time in GMT, position components and related variables such as altitude or range angle, accumulated sensed velocity, and the PEG thrust integrals.

It is assumed in defining the software requirements that all vectors, quaternions, and matrices computed in the guidance and targeting principal functions and transferred to other principal functions are time homogeneous.

The guidance flight software shall be capable of recovering from transient erroneous inputs without causing a processing halt. Check or error interrupts shall be prevented by appropriate safeguards. Specifically, the standard fixup described in Level A CPDS, Section 4.6.4 shall be provided and processing continued.

4.0.2 Traceability of Requirements

The software baseline documents 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 4.0.2-1 shows the traceability of the software paragraphs in this FSSR with respect to the corresponding principal function (PF) numbers defined in the Level B CPDS document. In addition, Table 4.0.2-2 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.

4.0.3 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.

The automated Interface Definition Document (IDD) tables define signal (parameter) interface requirements either between hardware (LRU) and software elements or between software elements and other software elements. The GN&C software element is either a sequenced principal function, 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. (MSID definitions per DIP JSC-18206, except 10th character use for multiple source references)

2. If there is a conflict between the data in the flow diagrams and the written requirements, the written requirements shall have precedence.

Table 4.0.2-1.Level B to Level C Traceability		
Level B PF No.	Level B PF Name (Acronym)	Level C FSSR Section No.
N/A	N/A	4.1
4.1	Ascent First-Stage Guidance (ASC 1STG GUID)	4.2
4.2	Ascent Second-Stage Guidance (ASC 2STG GUID)	4.3
4.3	Orbit Insertion Guidance (ORB INS GUID)	4.4
4.13	AOA/ATO Targeting (AOA/ATO TGT)	4.5
4.4	Powered RTLS Guidance (PW RTLS GUID)	4.6
4.210	Ascent Maneuver DIP (ASC MNVR DIP)	4.7
4.5	Powered Contingency Guidance (PW CONT GUID)	4.9
4.6	Contingency 3E/O Guidance (CONT 3E/O GUID)	4.10

Table 4.0.2-2. Ascent/RTLS Guidance FSSR/PRD Correlation					
Principal Function	FSSR Paragraph	FSSR Title	BFS PRD	PRD Paragraph	BFS Title
G4.1	4.2	Ascent First Stage Guidance	MG038104	3.2.3.1.10.2	First Stage Guidance
G4.2	4.3	Ascent Second Stage Guidance	MG038104	3.2.3.1.10.3	Second Stage Guidance
G4.3	4.4	Orbit Insertion Guidance	MG038104	3.2.3.1.10.4	OMS Guidance
G4.4	4.6	Powered RTLS Guidance	MG038104	3.2.3.1.10.3.2	Powered RTLS Guidance
G4.5	4.9	Powered Contingency Guidance	N/A	N/A	N/A
G4.6	4.10	3 Engine Out Contingency Guidance	N/A	N/A	N/A
G4.13	4.5	Abort-Once-Around/Abort-to-Orbit Targeting	MG038104 MG038104	3.2.3.1.10.3 3.2.3.1.10.4	Second Stage Guidance OMS Guidance
G4.210	4.7	Ascent Maneuver Display Interface Processing	MG038104	3.2.3.1.10.11	OMS Maneuver Display Intf. Processor (OMS_MNVR_DIP)

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4.1 TERMINAL COUNT REQUIREMENTS (MM 101)

This section is reserved for the guidance requirements for the terminal count major mode. At the present time there are no known requirements.

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4.2 FIRST-STAGE REQUIREMENTS (MM 102)

Principal function AS 1STG GUID (CPDS, Level B, principal function 4.1). The general guidance and targeting task required to perform this principal function is the SSME-Out Safing task (Section 4.8.9).

The first-stage major mode begins at the SRB ignition command (Event 19) and terminates at the SRB separation command (Event 28) (Figure 4.2-1).

Note: The SRB ignition is inhibited until terminal count requirements are met, including all three SSME's producing at least 90 percent rated power level (RPL) thrust.

The first-stage trajectory must be designed so that aerodynamic loads are within the Shuttle mated vehicle structural capability for nominal and perturbed conditions, the Shuttle avoids contact with the launch tower and recontact with the jettisoned SRB's, and vehicle performance is near maximum. An attitude versus velocity history that satisfies these requirements is determined prior to the mission. The proposed guidance and flight control attitude profile is simulated with launch vehicle and flight environment dispersions to verify that performance loads are within acceptable limits in all cases.

The first-stage trajectory is divided into two distinct phases – a vertical rise phase and a tilt phase. During the vertical rise phase, the launch pad nominal attitude is commanded until a specified earth-relative velocity magnitude sufficient to assure launch tower clearance is achieved. The tilt maneuver begins upon termination of the vertical rise phase. Preprogrammed pitch, yaw, and roll attitude angle histories (as a function of aerodynamic reference velocity) determine the desired Shuttle attitude during first stage. These Euler angles are defined in the boost reference coordinate system (refer to Section 5.1, Figure 5.1-2), and the order of body rotations is yaw, pitch, and roll (refer to Section 5.1, Figure 5.1-4).

The first-stage guidance principal function calculates the desired Shuttle attitude in the form of a quaternion, and the guidance and control steering interface principal function calculates the body attitude errors from this quaternion. Preprogrammed SSME throttling is performed (except in the case of an SSME failure or when manual throttling is being performed) to limit the maximum dynamic pressure and to achieve the required performance during atmospheric flight. The throttle profile is determined prior to the mission. Throttle commands are issued to the SSME SOP principal function. Also, in the event of an acceleration dispersion (primarily SRB), the pitch attitude and throttle commands are modified to maintain design dynamic pressure. For rendezvous missions and SSME failures the yaw and roll attitude commands are biased to improve performance and reduce the aerodynamic angle changes induced by the crosswinds resulting from the biased yaw attitude command.

If an SSME failure occurs during first-stage ascent, the two remaining SSME's are set to the maximum allowable power level, unless manual throttling is being performed, to obtain maximum performance. This maximum allowable throttle level is either a function of abort mode regions defined by velocity switch breakpoints, or is a function of crew display selection. Additionally, a pitch bias is calculated and applied to the nominal pitch attitude history to improve abort performance by lofting the trajectory. This pitch command is limited in late first stage to control the angle of attack profile in this region. This protects thermal constraints and keeps the vehicle within the Shuttle certification aerodynamic database.

Five tasks are performed to complete this principal function. These tasks are:

1. KMAX override update task (KMAX UPDT TSK)
2. First-stage guidance input task (1STG GUID INP TSK)

3. Boost guidance task (BST GUID TSK)
4. Boost throttling task (BST THROT TSK)
5. SSME-out safing task (SSME-OUT SAF TSK)

A functional organization of the first-stage guidance principal function is shown in Figure 4.2-2.

A detailed description of tasks two through four is contained in Sections 4.2.2 through 4.2.4. The SSME-out safing task is described in Section 4.8.9. The KMAX override update task is described in Section 4.8.13.

A functional flow and data flow for the first-stage guidance principal function are shown in Figures 4.2-3 and 4.2-4. The input and output principal function interface parameters are given in Section 4.2.5.

Certain I-loads supporting this principal function are required to be in contiguous areas of memory in a specific sequence. Section 4.11 describes this requirement.

Several parameters used within the Ascent First Stage Guidance principal function have been designated as Day Of Launch I-Load Uplink (DOLILU) parameters. These parameters are a set of I-Loads that can be uplinked on the day of launch to improve the possibility of not violating weather-related restrictions. The parameters designated as DOLILU are listed in Table 4.2-1.

Table 4.2-1. Day of Launch I-Load Uplink (DOLILU) Parameters	
Description	FSSR Name
Tabular values for boost throttling	THROT _J * (J=1,4)
Tabular values of independent variable for boost throttling	QPOLY _J (J=1,4)
Design reference time to obtain reference velocity	TREF_ADJUST
East component of wind	WNDE_TAB _J (J=1,8)
North component of wind	WNDN_TAB _J (J=1,8)
Segment start values for dependent values of yaw polynomial	PSI _J (J=1,30)
Segment start values for dependent values of pitch polynomial	THET _{1J} (J=1,30)
* These parameters are not calculated on day of launch and would not be updated under current operational plans.	

4.2.1 First-Stage Sequencing (1STG SEQ)

In first-stage ascent, several tasks that support the first-stage guidance principal function are performed periodically or on specific events. (These events are identified in the CPDS, Level B, Volume 5, Book 1.) These tasks are:

1. KMAX override update task (KMAX UPDT TSK)
2. First-stage guidance input task (1STG GUID INP TSK)
3. Boost guidance task (BST GUID TSK)
4. Boost throttling task (BST THROT TSK)
5. SSME-out safing task (SSME-OUT SAF TSK)

A. Detailed Requirements.

The tasks must be sequenced as follows:

1. The KMAX override update task (Section 4.8.13) is performed on demand from the SRB ignition command (Event 19) to the SRB separation command (Event 28 or A30) when either item 4, 50, or 51 is entered on the Override Display (SPEC 51).
2. The first-stage guidance input task is performed repetitively from the SRB ignition command (Event 19) to the SRB separation command (Event 28 or A30).
3. The boost guidance task is performed repetitively from Event 19 to Event 28 or A30.
4. The boost throttling task is performed repetitively from Event 19 to Event 28 or A30.
5. The SSME-out safing task (Section 4.8.9) is performed when N_SSME is less than N_SSME_PREV. N_SSME_PREV is updated to the value of N_SSME at the end of each pass through 1STG SEQ.

B. Interface Requirements.

The input parameters for first-stage sequencing are given in Table 4.2.1-1.

C. Processing Requirements.

Recommended execution rates for the tasks are:

Task 1	One time within 0.16 second of each item entry event
Tasks 2-4	0.16 second
Task 5	One time within 0.16 second of event

D. Initialization Requirements. The following variable must be initialized: N_SSME_PREV= 3

Table 4.2.1-1.First-Stage Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Number of active SSME's	N_SSME	1STG GUID INP TSK	I	N/A

4.2.2 First-Stage Guidance Input Task (1STG GUID INP TSK)

This task calculates an input for the boost guidance task, the number of thrusting SSME's, and the orbiter mass to be used in second-stage or powered RTLS guidance.

A. Detailed Requirements. The following subtasks are performed:

1. T_NAV_PREV is set to T_NAV upon initial entry into this task.
2. The number of thrusting SSME's is calculated

$$N_{SSME} = 3 - \text{SUM} [\text{INTEGER} (S_{\dot{E}O_E1}, S_{\dot{E}O_E2}, S_{\dot{E}O_E3})]$$

3. The calculations for boost guidance input and mass integration are as follows:

$$DTGD = T_{NAV} - T_{NAV_PREV}$$

$$T_{NAV_PREV} = T_{NAV}$$

$$M = M - .01 (DTGD K_CMD MDOT_{SSME} N_{SSME})$$

4. If an SSME fails during MM 102, the RTLS fuel dissipation reference velocity magnitude (V_RTLS_FD) must be set to the magnitude of vehicle relative velocity (V_RHO_MAG) and the reference altitude rate (H_DOT_FD) must be set to the magnitude of the vehicle altitude rate (H_DOT_ELLIPSOID) at the end of the last guidance cycle of MM 102:

$$V_{RTLS_FD} = V_{RHO_MAG}$$

$$H_{DOT_FD} = H_{DOT_ELLIPSOID}$$

5. On each cycle during which one of the three mutually exclusive display throttle level commands is actuated ($\dot{N}OM_THROT_CMD = ON$ and $\dot{N}OM_CMD_PREV = OFF$) or ($\dot{A}BT_THROT_CMD = ON$ and $\dot{A}BT_CMD_PREV = OFF$) or ($\dot{M}AX_THROT_CMD = ON$ and $\dot{M}AX_CMD_PREV = OFF$), the following must occur:

- a. $K_CMD_MODE_BNDRY = KMAX$

- b. If manual throttling is not being performed ($S_{\dot{M}AN_THROT} = OFF$), and the number of SSME's is less than three ($N_{SSME} < 3$), then execute the following:

$$K_CMD = KMAX$$

6. Set the previous throttle command indicators to the current values.

$$\dot{N}OM_CMD_PREV = \dot{N}OM_THROT_CMD$$

$$\dot{A}BT_CMD_PREV = \dot{A}BT_THROT_CMD$$

$$\dot{M}AX_CMD_PREV = \dot{M}AX_THROT_CMD$$

B. Interface Requirements. The input and output parameters for the first-stage guidance input task are given in Tables 4.2.2-1 and 4.2.2-2.

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C. Processing Requirements. Subtask 1 is performed only once upon initial entry into the task. Subtasks 2, 3, 4, and 5 are performed every first-stage guidance input cycle.

D. Initialization Requirements. The previous values of the maximum throttle level limit commands (NOM_CMD_PREV, ABT_CMD_PREV, and MAX_CMD_PREV) are initialized OFF. The initial mass of the orbiter plus the external tank is I-loaded.

Table 4.2.2-1. First-Stage Guidance Input Task Inputs

Definition	Symbol	Source	Prec	Units
Commanded SSME throttle setting	K_CMD	BST THROT TSK, SSME-OUT SAF TSK, SBTC SOP	I	pct
SSME mass flow rate	MDOT_SSME	I-LOAD	SP	slug/ sec
Current vehicle mass(orbiter/ET only)	M	I-LOAD, UPLINK	SP	slugs
Time tag associated with current state	T_NAV	ASC UPP	DP	sec
Magnitude of vehicle relative velocity	V_RHO_MAG	ASC UPP	SP	fps
MPS engine-out flags	S_EO_E1, S_EO_E2, S_EO_E3	SSME OPS	D	N/A
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Maximum throttle level command	MAX_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	ABT_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Nominal throttle level command	NOM_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Estimated altitude rate	H_DOT_ELLIPSOID	ASC UPP	SP	fps
Maximum throttle setting for SSME	KMAX	KMAX UPDT TSK, SSME-OUT SAF TSK, I-LOAD	I	pct

Table 4.2.2-2. First-Stage Guidance Input Task Outputs

Definition	Symbol	Destination	Prec	Units
Current vehicle mass (orbiter with external tank only)	M	ACC MASS UPD TSK, TLM, OMS RM, ASC DAP, G/C STEER	SP	slugs
Number of active SSME's	N_SSME	ATO MECO TGT SEL TSK, TLM, BST GUID TSK, BST THROT TSK, PFG INP TSK, 1STG SEQ	I	N/A
RTLS fuel dissipation reference velocity magnitude	V_RTLS_FD	PITCH CMD TSK	SP	fps
Previous value of time tag associated with current state (T_NAV)	T_NAV_PREV	BST GUID TSK, PFG INP TSK	DP	sec
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, FLYBK TSK, FUL DISS TSK, G-LIM TSK, SSME-OUT SAF TSK, SBTC SOP, ASC DAP, XXXXXX TRAJ 1 DISP	I	pct
Nominal SSME throttle setting after RTLS/AOA mode boundary	K_CMD_MODE_BNDRY	GUID PRMT RINT TSK	I	pct
RTLS Fuel Dissp Ref HDOT	H_DOT_FD	PITCH CMD TSK	SP	fps
Guidance time delta	DTGD	BST GUID TSK	SP	sec
Previous value of nominal throttle level command	N \dot{O} M_CMD_PREV	ASC GUID TSK, FUL DISS TSK	D	N/A
Previous value of abort throttle level command	A \dot{B} T_CMD_PREV	ASC GUID TSK, FUL DISS TSK	D	N/A
Previous value of maximum throttle level command	M \dot{A} X_CMD_PREV	ASC GUID TSK, FUL DISS TSK	D	N/A

4.2.3 Boost Guidance Task (BST GUID TSK)

This task provides pitch and yaw commands which achieve the desired α and β histories for both the nominal and SSME-out ascent, and a roll command which achieves the desired roll attitude after the vertical rise. During the vertical rise, the nominal launch pad attitude is commanded.

A. Detailed Requirements. The following subtasks are performed in the boost guidance task.

1. Velocity to reference aerodynamic dependent variables is computed based on a linear equation for speed of sound and a wind table.

$$\bar{V}_{RHO_BR} = QUAT_XFORM(Q_BR_M50, \bar{V}_{RHO})$$

If $ALT > ALTP$ and $I > 1$, then

$$ALTG = ALT$$

$$ALTP = ALT$$

otherwise,

$$ALTG = ALTG - DTGD V_RHO_BR_3$$

If $ALTG < ALTSS$, then

$$SS = SSSL - DSSA ALTG$$

DO WHILE $ALTG > ALT_WND_{IALT+1}$ and $IALT < 7$

$$IALT = IALT + 1$$

$$DALT = ALT_WND_{IALT+1} - ALT_WND_{IALT}$$

$$DWNDE = (WNDE_TAB_{IALT+1} - WNDE_TAB_{IALT}) / DALT$$

$$DWNDN = (WNDN_TAB_{IALT+1} - WNDN_TAB_{IALT}) / DALT$$

If $I > 1$ and $IALT > 0$ and $ALTG < ALT_WND_8$, then

$$DELTA = ALTG - ALT_WND_{IALT}$$

$$EWND = WNDE_TAB_{IALT} + DWNDE DELTA$$

$$NWND = WNDN_TAB_{IALT} + DWNDN DELTA$$

Calculate the Aerodynamic Reference Velocity ($VREL_AERO_REF$) from the components of the Boost Reference Earth Relative Velocity (V_RHO_BR) and interpolated onboard wind components.

$$VREL_AERO_REF = SQRT((V_RHO_BR_1 - NWND)^2 +$$

$$(V_RHO_BR_2 - EWND)^2 + V_RHO_BR_3^2) SSSL / SS$$

2. The correct segment of the tilt maneuver attitude table is determined. If $VREL_AERO_REF \geq PPOLY_{I+1}$, I is incremented by one ($I = I+1$) while $VREL_AERO_REF \geq PPOLY_{I+1}$ and $I < 29$. The following calculations are then made:

$$TMET = T_NAV_PREV - T_GMTLO$$

$$DENOM = PPOLY_{I+1} - PPOLY_I$$

$$THETP = (THET_{I,I+1} - THET_{I,I}) / DENOM$$

$$PSIP = (PSI_{I+1} - PSI_I) / DENOM$$

If $I < 15$,

$$PHIP = (PHI_{I+1} - PHI_I) / DENOM$$

3. The change in independent variable is computed as:

$$DELTA = VREL_AERO_REF - PPOLY_I$$

4. The desired pitch angle is evaluated.

$$THETC = THET_{I,I} + THETP \cdot DELTA$$

For engine failure, the pitch command is computed by fading and adding in the delta pitch table:

If $L > 1$ and $I > 1$

$$THETC_EO = THET_{L,I} + (THET_{L,I+1} - THET_{L,I}) \cdot DELTA / DENOM$$

$$\text{If } NF < NF_EOG \text{ then } NF = NF + 1$$

$$THETC = THETC + THETC_EO \cdot NF / NF_EOG$$

5. For acceleration dispersion detected at the reference velocity, the throttle and pitch commands are modified as follows.

When V_RHO_MAG becomes greater than $VREF_ADJUST$ with no engine failures, a one time computation of the time difference to obtain $VREF_ADJUST$ from design is computed.

If $V_RHO_MAG > VREF_ADJUST$ and $S_THRT_INIT = OFF$ and $L = 1$, then:

$$S_THRT_INIT = ON$$

$$TDEL_ADJUST = TMET - TREF_ADJUST$$

The absolute value of $TDEL_ADJUST$ is compared to the deadband value ($TDEL_ADJUST_DEADBAND$) to check for small SRB dispersions. Dependent on this test, the value of $TDEL_ADJUST_USE$ is set to be used for calculations allowing the correct value of $TDEL_ADJUST$ to be downlisted.

If $ABS(TDEL_ADJUST) < TDEL_ADJUST_DEADBAND$, then,

$$TDEL_ADJUST_USE = 0.0$$

Otherwise,

$$TDEL_ADJUST_USE = TDEL_ADJUST$$

The pitch and throttle factors are reset for the low acceleration case ($TDEL_ADJUST_USE > 0.0$). Also, a new throttle profile is computed for control of maximum dynamic pressure.

If $TDEL_ADJUST_USE > 0.0$, then:

$$PTCH_FAC = PTCH_FACL$$

$$KMIN_ALT = 65$$

$$THRT_FAC = THRT_FACL$$

$$L_THRT = L_THRTL$$

$$THROT_{L_THRT} = THROT_{L_THRT} + ROUND\left(\frac{THRT_FAC \ TDEL_ADJUST_USE}{QPOLY_{L_THRT+1} - QPOLY_{L_THRT}}\right)$$

$$THROT_{L_THRT} = MIDVAL(KMIN_ALT, THROT_{L_THRT}, THROT_4)$$

If an engine fails prior to $VREL_GAIN_TAB_3$, the pitch adjustment is transitioned to zero over N_PTCHF_TOT guidance cycles for a cold SRB ($TDEL_ADJUST_USE > 0.0$). The discrete S_AGT_EO is turned on to ensure proper transitioning of $PTCH_FAC$.

If $V_RHO_MAG < VREL_GAIN_TAB_3$, $L > 1$, and $TDEL_ADJUST_USE > 0.0$, then:

$$S_AGT_EO = ON$$

If $S_AGT_EO = ON$ and $N_PTCHF_CYCLES < N_PTCHF_TOT$, then:

$$N_PTCHF_CYCLES = N_PTCHF_CYCLES + 1$$

$$PTCH_FAC = PTCH_FAC - PTCH_FAC \ N_PTCHF_CYCLES / N_PTCHF_TOT$$

At the beginning of load relief termination ($VREL_GAIN_TAB_4$), the pitch adjustment is ramped out with load relief.

If $V_RHO_MAG > VREL_GAIN_TAB_4$, then:

$$K_RAMP = 0$$

The pitch adjustment is made based on the time difference to obtain the reference velocity and is applied as a function of load relief.

$$THETC = THETC - PTCH_FAC \ TDEL_ADJUST_USE (1 + THETC^2) [K_RAMP - (K_RAMP - PTCH_PCT)(K_LOAD_RELIEF)]$$

For engine failure situations, after tower clear the pitch command is calculated to allow a pitch bias (DELSEL, calculated in the SSME-OUT SAF TSK) to be added to the nominal pitch table value to loft the engine out cases. In addition the pitch command is limited to protect total alpha.

If $I > 1$ and $L > 1$, then:

$$\text{DELPT_BIAS} = \text{DELSEL}$$

If $V_RHO_MAG > VREL_GAIN_TAB_4$, then

$$\text{DELPT_BIAS} = \text{DELPT_BIAS} + \text{DELPLO}_{L-1} (1.-K_LOAD_RELIEF)$$

If S_LOAD_RMP is set to ON, set

$$\text{DELPT_BIAS} = \text{DELSEL} (1.-K_LOAD_RELIEF)$$

$$\text{THETC} = .25 (\text{DELPT_BIAS}) (1. + \text{THETC THETC}) + \text{THETC}$$

After tower clear, if the current magnitude of the earth relative velocity (V_RHO_MAG) exceeds the pitch command limit (V_THET_LIM), then in late first stage the pitch command is limited to prevent a total angle of attack limit violation. This pitch command limit that incorporates the angle of attack limit protects thermal constraints defined by shuttle systems certification and the -8 degree limit in the aerodynamic database.

If ($V_RHO_MAG > V_THET_LIM$), then

$$\text{THET_LIM_EO} = \text{TAN} ((\text{ARCSIN}(-V_RHO_BR_3/V_RHO_MAG) - \text{ALPHA_EO}) / 4)$$

If ($\text{THETC} > \text{THET_LIM_EO}$), then

$$\text{THETC} = \text{THET_LIM_EO}$$

When Mission Elapsed Time (TMET) becomes greater than or equal to constant pitch rate event time ($T_CNS_PITCH_RATE$), the pitch command shall be propagated at a constant rate until an I-Loaded number of seconds, $EV25E_DELAY$ after the $NYSEP_DISABLE$ event has been set by the ascent flight control. The pitch command shall be propagated by a different rate depending on whether or not an SSME has failed. When TMET becomes greater than the time $NYSEP_DISABLE$ event occurred plus the delay time ($EV25E_DELAY$), then the pitch command shall be frozen at the last computed value.

If $\text{TMET} \geq T_CNS_PITCH_RATE$ and $EV25E_TIMER < EV25E_DELAY$, then

If $FIRST_PASS = ON$, then

$$\text{THETC_DOT} = 0.25 \text{ THETC_DOT_NOM DTGD}$$

IF $N_SSME = 2$, then

$$\text{THETC_DOT} = 0.25 \text{ THETC_DOT_EO DTGD}$$

$$\text{THET_TEMP} = \text{THETC}$$

$$\text{FIRST_PASS} = \text{OFF}$$

otherwise,

$$\text{THETC} = \text{THET_TEMP} + \text{THETC_DOT}$$

$$\text{THET_TEMP} = \text{THETC}$$

Start incrementing EV25E_TIMER once event 25E has occurred.

If NYSEP_DISABLE, then

$$\text{EV25E_TIMER} = \text{EV25E_TIMER} + \text{DTGD}$$

Once EV25E_TIMER is greater than or equal to EV25E_DELAY, THETC is held constant at the present value of THETC (i. e. THET_TEMP) until SRB separation as shown below:

If EV25E_TIMER \geq EV25E_DELAY, then

$$\text{THETC} = \text{THET_TEMP}$$

For multiple main engine failure situations after tower clear, the pitch command (THETC) is calculated.

If N_SSME > 1 or I = 1, proceed to step 6.

THETC initially depends only on the relative velocity at the time of the 2nd engine failure.

If S_LOAD_MEO = OFF, then:

$$\text{S_LOAD_MEO} = \text{ON}$$

If V_RHO_MAG \geq V_MULT_EO, then

If V_RHO_MAG \geq V_RAMP_MAX, then

$$\text{THET_MULT_EO} = \text{THETC}$$

Otherwise, THET_MULT_EO is determined as a function of the current relative velocity and pitch command.

$$\text{D_PITCH_EO} = (\text{THET_MULT_EO} - \text{THETC}) (\text{V_RAMP_MAX} - \text{V_RHO_MAG}) / (\text{V_RAMP_MAX} - \text{V_MULT_EO})$$

$$\text{THET_MULT_EO} = \text{THETC} + \text{D_PITCH_EO}$$

On all guidance passes, THETC = THET_MULT_EO

If K_ALPH_LIM = OFF or V_RHO_MAG $<$ V_MULT_EO, proceed to step 6.

If $S_{\dot{R}MP_MEO} = OFF$ and $TMET > T_{RMP_I}$, proceed to step 6.

The relative velocity is saved when V_{RHO_MAG} exceeds V_{MULT_EO} .

If $S_{\dot{R}MP_MEO} = OFF$, then:

$$\begin{aligned} S_{\dot{R}MP_MEO} &= ON \\ V_{RMP_I} &= V_{RHO_MAG} \\ THET_PREV &= THETC \end{aligned}$$

A delta alpha integration scheme is now performed to determine the final, desired value for THETC which will decrease loads while lofting the trajectory. First, the desired navigated angle-of-attack (ALPH_TGT) is determined.

If $TMET \leq T_{RMP_I}$, then:

ALPH_TGT is calculated from a table look-up as a function of navigated dynamic pressure (Q_{BAR_A}).

If $Q_{BAR_A} < Q_{TAB_ALP}(1)$, $ALPH_TGT = ALP_TAB(1)$; otherwise,

If $Q_{BAR_A} \geq Q_{TAB_ALP}(4)$, $ALPH_TGT = ALP_TAB(4)$; otherwise,

$$IX = 1$$

IX is incremented ($IX = IX + 1$) until $Q_{BAR_A} \geq Q_{TAB_ALP}(IX)$ and $Q_{BAR_A} < Q_{TAB_ALP}(IX + 1)$; then:

$$\begin{aligned} FACT_ALP &= (Q_{BAR_A} - Q_{TAB_ALP}(IX)) / (Q_{TAB_ALP}(IX+1) - Q_{TAB_ALP}(IX)) \\ ALPH_TGT &= ALP_TAB(IX) + FACT_ALP (ALP_TAB(IX+1) - ALP_TAB(IX)) \end{aligned}$$

The alpha error integration gain (D_ALP_GAIN) is now calculated as a function of Q_{BAR_A} .

If $Q_{BAR_A} < Q_{TAB_GAIN}(1)$, $D_ALP_GAIN = GAIN_TAB(1)$; otherwise,

if $Q_{BAR_A} \geq Q_{TAB_GAIN}(4)$, $D_ALP_GAIN = GAIN_TAB(4)$; otherwise,

$$IX = 1$$

IX is incremented ($IX=IX+1$) until $Q_{BAR_A} \geq Q_{TAB_GAIN}(IX)$ and $Q_{BAR_A} < Q_{TAB_GAIN}(IX+1)$; then:

$$\begin{aligned} FACT_GAIN &= (Q_{BAR_A} - Q_{TAB_GAIN}(IX)) / \\ &\quad (Q_{TAB_GAIN}(IX + 1) - Q_{TAB_GAIN}(IX)) \\ D_ALP_GAIN &= GAIN_TAB(IX) + FACT_GAIN (GAIN_TAB(IX+1) - GAIN_TAB(IX)) \end{aligned}$$

Otherwise, (TMET > T_RMP_I) the following calculation is performed for purposes of ramping ALPH_TGT to the desired SRB tail-off value (ALPH_TO).

$$\begin{aligned} &\text{If } \dot{S}_{\text{ALPH_TO}} = \text{OFF, then:} \\ &S_{\text{ALPH_TO}} = \text{ON} \\ &\text{ALPHD} = \text{ALPHA_N RAD_PER_DEG} - 4.0 \text{ DELT_ALP} / (1.0 + \text{THET_PREV} \\ &\quad \text{THET_PREV}) \\ &D_{\text{ALP_GAIN}} = \text{GAIN_TAB}(1) \end{aligned}$$

The following calculations are now made:

If TMET > T_RMP_I, then

$$\text{ALPH_TGT} = \text{ALPHD} - (\text{ALPHD} - \text{ALPH_TO}) (\text{TMET} - \text{T_RMP_I}) / (\text{T_RMP_F} - \text{T_RMP_I})$$

If TMET > T_RMP_F or V_RMP_I > V_ALPH_TO, then

$$\begin{aligned} \text{ALPH_TGT} &= \text{ALPH_TO} \\ D_{\text{ALP_GAIN}} &= \text{GAIN_TAB}(1) \end{aligned}$$

The following calculations are performed to determine DELT_ALP for the integration of THETC:

$$\begin{aligned} \text{DELT_ALP} &= 0.25 (\text{ALPHA_N RAD_PER_DEG} - \text{ALPH_TGT}) (1.0 + \text{THET_PREV} \\ &\quad \text{THET_PREV}) \\ \text{THET_CHK} &= \text{THET_PREV} - 0.25 \text{ EBF2 RAD_PER_DEG} (1.0 + \text{THET_PREV} \\ &\quad \text{THET_PREV}) \end{aligned}$$

If TMET ≤ T_RMP_I and THET_LIM - THET_CHK < DELT_ALP, then

$$\text{DELT_ALP} = \text{THET_LIM} - \text{THET_CHK}$$

If V_RHO_MAG < V_RMP_I + VRAMP, then

$$\text{DELT_ALP} = \text{DELT_ALP} (V_{\text{RHO_MAG}} - V_{\text{RMP_I}}) / \text{VRAMP}$$

Finally, the integration is performed:

$$\begin{aligned} D_{\text{ALP_INT}} &= D_{\text{ALP_INT}} + D_{\text{ALP_GAIN}} \text{ DELT_ALP} \\ \text{THETC} &= \text{THETC} + \text{DELT_ALP} + D_{\text{ALP_INT}} \\ \text{THET_PREV} &= 0.5 (\text{THETC} + \text{THET_PREV}) \end{aligned}$$

6. The desired yaw angles are evaluated.
- 6a. First the PSIC is interpolated from the PSI tables.

$$\text{PSIC} = \text{PSI}_1 + \text{PSIP} \text{ DELT}$$

7. The PSIC is adjusted for changes in yaw steering after tower clear (V_RHO_MAG ≥ PPOLY₂), otherwise go to step 8.

If $V_RHO_MAG \geq PPOLY_2$, then

- 7a. In the event of SSME failures during first stage, while the shuttle is within a prescribed velocity range, additional yaw steering is calculated based on the Shuttle's velocity at the SSME failure time. For SSME failures before the prescribed V_EO_PSI , a yaw bias is evaluated that is dependent upon the vehicle velocity at the first SSME failure. Additional steering is implemented through a bias to the yaw and roll angles, which work in concert to change the trajectory azimuth by the desired amount.

If $N_SSME = 2$ and $V_ME_OUT < V_EO_PSI$ and $DELPSI_EO \neq 0$ and $F_EARLY_PSI = OFF$, then

$$DELTA_PSI = DELTA_PSI + DELPSI_EO (V_EO_PSI - V_ME_OUT) / V_EO_PSI$$

$$F_EARLY_PSI = ON$$

If $N_SSME = 2$ and $V_RHO_MAG > V_AZ_START$ and $V_ME_OUT < V_AZ_STOP$, then

If $F_AZ_COMPUTE = OFF$, then

If $V_ME_OUT < V_PSI_SW$, then

$$DDPSI_MAX = DDPSI_MAX_EO$$

Else

$$DDPSI_MAX = DDPSI_MAX_EO2$$

If $V_ME_OUT < V_EO_PSI$, then

$$DDPSI_MAX = DDPSI_MAX (V_ME_OUT / V_EO_PSI)$$

$$DDPHI_MAX = ROLL_PSI_RATIO DDPSI_MAX$$

If $V_ME_OUT > V_PSI_RAMP1$ and $V_ME_OUT \leq V_PSI_CNST$, then

$$DDPSI_MAX = DDPSI_MAX (V_PSI_RAMP2 - V_ME_OUT) / (V_PSI_RAMP2 - V_PSI_RAMP1)$$

If $V_ME_OUT > V_PSI_CNST$, then

$$DDPSI_MAX = DDPSI_MAX (V_PSI_RAMP2 - V_PSI_CNST) / (V_PSI_RAMP2 - V_PSI_RAMP1)$$

Cutout logic is provided so that the ground track that results from the yaw steering can be limited. This provides protection for External Tank disposal.

If $(DDPSI_MAX + DELTA_PSI) > DPSI_LIM1$ and $(DDPSI_MAX + DELTA_PSI) < DPSI_LIM2$, then

If $DPSI_LIM1 > 0$, then

$$\begin{aligned} \text{RATIO_CHG} &= (\text{DPSI_LIM1} - \text{DELTA_PSI}) / \text{DDPSI_MAX} \\ \text{DDPHI_MAX} &= \text{DDPHI_MAX} \text{ RATIO_CHG} \\ \text{DDPSI_MAX} &= \text{DPSI_LIM1} - \text{DELTA_PSI} \end{aligned}$$

otherwise

$$\begin{aligned} \text{RATIO_CHG} &= (\text{DPSI_LIM2} - \text{DELTA_PSI}) / \text{DDPSI_MAX} \\ \text{DDPHI_MAX} &= \text{DDPHI_MAX} \text{ RATIO_CHG} \\ \text{DDPSI_MAX} &= \text{DPSI_LIM2} - \text{DELTA_PSI} \end{aligned}$$

$$\text{F_AZ_COMPUTE} = \text{ON}$$

Compute the rate of change for the yaw and roll to coordinate the maneuver to minimize beta perturbations. The roll induces small beta changes so the DDPHI_INC represents the desired fade in of the maneuver in roll. The DDPSI_INC represents the coordination required for yaw to prevent significant beta perturbations.

If $\text{F_AZ_COMPUTE} = \text{ON}$, then

$$\begin{aligned} \text{DDPSI} &= \text{DDPSI} + \text{DDPSI_INC} \text{ DDPHI_MAX} \\ \text{DDPHI} &= \text{DDPHI} + \text{DDPHI_INC} \text{ DDPHI_MAX} \end{aligned}$$

If $\text{ABS}(\text{DDPSI}) > \text{ABS}(\text{DDPSI_MAX})$, then

$$\text{DDPSI} = \text{DDPSI_MAX}$$

If $\text{ABS}(\text{DDPHI}) > \text{ABS}(\text{DDPHI_MAX})$, then

$$\text{DDPHI} = \text{DDPHI_MAX}$$

7b. A correction is added to reduce the crosswinds encountered when flying both the nominal or engine-out delta PSI trajectories.

$$\text{PSID} = 4 \text{ ATAN}(\text{PSIC})$$

$$\text{NORTH} = \text{NWND}(\text{SIN}(\text{PSID} + \text{DELTA_PSI} + \text{DDPSI}) - \text{SIN}(\text{PSID}))$$

$$\text{EAST} = \text{EWND}(\text{COS}(\text{PSID} + \text{DELTA_PSI} + \text{DDPSI}) - \text{COS}(\text{PSID}))$$

$$\text{DPSIW} = \text{DPSI_WIND_MULT}(\text{NORTH} - \text{EAST}) / \text{V_RHO_MAG}$$

If $\text{V_RHO_MAG} < \text{VREL_GAIN_TAB}_3$, then

$$\text{DPSIW} = \text{K_LOAD_RELIEF} \text{ DPSIW}$$

7c. The adjustments to the desired yaw attitude angle for the launch azimuth and early engine out (DELTA_PSI), engine out yaw steering (DDPSI), and wind compensation (DPSIW) are applied to the initial tangent of the yaw quarter angle interpolated from the I-Loaded yaw maneuver attitude table.

$$\text{PSIC} = \text{PSIC} + (\text{DELTA_PSI} + \text{DDPSI} + \text{DPSIW}) (1 + \text{PSIC}^2) / 4$$

- 7d. The engine out yaw steering indicator is set for both early and late yaw steering changes applied to the PSIC. This provides feedback to the crew on the course deviation indicator.

If F_EARLY_PSI or $DDPSI \neq 0$, then

$$ENGINE_OUT_YAW_STEERING = ON$$

8. The sines and cosines of the half angles of the desired pitch and yaw attitude commands are computed, which are required inputs to build elements of the M50-to-commanded body quaternion Q_GCB_I .

$$CTHET = 2./(1. + THETC^2)$$

$$STHET = CTHET THETC$$

$$CTHET = CTHET - 1.$$

$$CPSI = 2./(1. + PSIC^2)$$

$$SPSI = CPSI PSIC$$

$$CPSI = CPSI - 1.$$

9. The desired roll angles and sine and cosine are evaluated. The initial desired roll command tangent quarter angle $PHIC$ is interpolated from the I-Loaded roll attitude maneuver command table, and a side engine out roll bias is computed when applicable. Next, the side engine-out bias $DPHI$, roll increment for engine out yaw steering $DDPHI$, and the wind compensation adjustment $DPSIW$ are applied to $PHIC$. Finally, the sine and cosine of the half angle of the desired roll attitude command is computed, which are required inputs to build the elements of the M50-to-commanded-body quaternion Q_GCB_I .

If $I > 14$, set $PHIC = PHI_{15}$; otherwise ($I < 15$),

$$PHIC = PHI_I + PHIP DELT$$

For all values of I

If $ABS(DPHI) < PHID_EO$ and $I > 1$ then

$$DPHI = DPHI + PHID (INTEGER(S_EO_E3) - INTEGER(S_EO_E2))$$

$$PHIC = PHIC + DPHI + (DDPHI - 2.0 DPSIW) (1 + PHIC^2)/4$$

$$CPHI = 2./(1. + PHIC^2)$$

$$SPHI = CPHI PHIC$$

$$CPHI = CPHI - 1.$$

10. The M50-to-commanded-body quaternion Q_{GCB_I} is calculated as the product of Q_{GCB_BR} and Q_{BR_M50} . The scalar element of Q_{GCB_BR} is $CPSI \ CTHET \ CPHI + SPSI \ STHET \ SPHI$, and its vector part is $SPSI \ STHET \ CPHI - CPSI \ CTHET \ SPHI, - CPSI \ STHET \ CPHI - SPSI \ CTHET \ SPHI, CPSI \ STHET \ SPHI - SPSI \ CTHET \ CPHI$.

Then

$$Q_{GCB_I} = QUAT_MULT(Q_{GCB_BR}, Q_{BR_M50})$$

and

$$S_QUAT = ON$$

B. Interface Requirements. The input and output parameters for the boost guidance task are given in Tables 4.2.3-1 and 4.2.3-2.

During OPS-9, the I-loaded values of the boost guidance parameters can be updated via uplink. The following data sets and corresponding OPS codes can be linked: WIND TABLE (0001011), PSI_I (0001100), AND THET_I (0001101), THROTTLE LEVELS (0100111), THROTTLE VEL and TREF_ADJUST (0001110). The data sets LAUNCH TARGETING (0001111) and OMS TARGETING (0011001) can be uplinked during OPS-9 and OPS-1. The subscript I takes the value 1 to 30 for each data set. Replacement of the original I-load data with uplinked data will be transparent to the flight software.

C. Processing Requirements. Subtasks 2, 3 and 7 are performed every boost guidance cycle only when $V_RHO_MAG \geq PPOLY_2$. The remaining subtasks are performed in the order shown every boost guidance cycle.

D. Initialization Requirements. The following variables must be initialized:

$$EV25E_TIMER = 0.0$$

$$FIRST_PASS = ON$$

$$F_EARLY_PSI = OFF$$

$$F_AZ_COMPUTE = OFF$$

$$ENGINE_OUT_YAW_STEERING = OFF$$

$$THET_TEMP = 0.0$$

$$THETC_DOT = 0.0$$

$$DELT = 0.0$$

$$THETP = 0.0$$

$$PSIP = 0.0$$

$$DELSEL = 0.0$$

$$S_LOAD_RMP = OFF$$

$$S_LOAD_MEO = OFF$$

S_ṘMP_MEO = OFF
S_ḂLPH_TO = OFF
PHIP = 0.0
I = 1
LL = 1
L = 1
S_ḂQUAT = OFF
K_RAMP = 1
TDEL_ADJUST = 0.0
S_ḂHRT_INIT = OFF
SS = SSSL
DPHI = 0.0
DDPHI = 0.0
DDPSI = 0.0
DPSIW = 0.0
NF = 0
S_ḂGT_EO = OFF
N_PTCHF_CYCLES = 0
TDEL_ADJUST_USE = 0.0

ALTG = 0.0
ALTP = 0.0
IALT = 0
NWND = 0.0
EWND = 0.0
DWNDE = 0.0
DWNNDN = 0.0

E. Supplemental Information. L and LL are set to 2 or 3 in the SSME-OUT SAF TSK (Section 4.8.9) when an SSME fails.

These requirements are predicated upon a G/C STEER sampling interval of 0.16 second from Event 19 to Event 28.

During the vertical rise ($V_RHO_MAG < PPOLY_2$), the command values of THETC, PSIC, and PHIC are THET₁, PSI₁, and PHI₁. The attitude tangent interpolation (Subtasks 2 and 3) is bypassed during

vertical rise to maintain the commanded attitude at the nominal launch pad attitude until the tower is cleared.

PH, the directional sense of the uplinked/I-loaded winds, is such that positive values of WNDE TABI and WNDN TABI indicate the wind blowing from West to East and South to North, respectively.

Table 4.2.3-1. Boost Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
M50-to-boost reference quaternion	Q_{BR_M50}	ASC UPP	SP	ND
Segment start velocities for independent values of pitch and yaw polynomial	$PPOLY_I$ (I=1,30)	I-LOAD	SP	fps
Segment start values for dependent values of yaw polynomial	PSI_I (I=1,30)	I-LOAD	SP	ND
Segment start values for dependent values of pitch polynomial (Ith segment, Lth polynomial)	$THET_{L,I}$ (I=1,30) (L=1,3)	I-LOAD	SP	ND
Magnitude of vehicle relative velocity	V_RHO_MAG	ASC UPP	SP	fps
Index for nominal/engine-out pitch and yaw polynomials	L	SSME-OUT SAF TSK	I	ND
Segment values for dependent values of roll polynomial	PHI_I (I=1,15)	I-LOAD	SP	ND
Launch azimuth adjustment	DELTA_PSI	I-LOAD, ASC UPP	SP	rad
Engine out pitch bias	DELSEL	SSME-OUT SAF TSK	SP	rad
Engine out pitch bias load ramp discrete	S_LOAD_RMP	SSME-OUT SAF TSK	D	N/A
Variable load relief gain	K_LOAD_RELIEF	ASC DAP	SP	ND
Minimum throttle required to satisfy altitude constraint	KMIN_ALT	I-LOAD	I	pct
Throttle index for hot SRB's	L_THRT	I-LOAD	I	ND
Throttle index for cold SRB's	L_THRTL	I-LOAD	I	ND
Pitch adjustment factor for hot SRB's	PTCH_FAC	I-LOAD	SP	rad/sec
Pitch adjustment factor for cold SRB's	PTCH_FACL	I-LOAD	SP	rad/sec
Compensated Nav-derived angle of attack	ALPHA_N	A/E ATT PROC	SP	deg
Pitch attitude error for TVC loops	EBFB2	G/C STEER	SP	deg
Vehicles current dynamic pressure	Q_BAR_A	ASC UPP	SP	psf
Degrees to radian conversion	RAD_PER_DEG	CONSTANT	SP	rad/deg

Table 4.2.3-1. Boost Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Contingency lofting, alpha limiting on/off switch	K_ALPH_LIM	I-LOAD	I	ND
Alpha target ramp velocity	VRAMP	I-LOAD	SP	fps
Number of cycles to fade in engine out pitch table	NF_EOG	I-LOAD	I	N/A
Post load relief pitch delta for early engine out	DELPLO(i) i = 1 to 2	I-LOAD	SP	rad
Indicator, Event 25E	NYSEP_DISABLE	ASC_DAP	D	ND
Delay from event 25E to constant THETC	EV25E_DELAY	I-Loads	SP	sec
Nominal THETC_DOT	THETC_DOT_NOM	I-Loads	SP	rad/ sec
Single eng. out THETC_DOT	THETC_DOT_EO	I-Loads	SP	rad/ sec
Increment for engine out roll bias	PHID	I-LOAD	SP	N/A
Side engine out roll bias	PHID_EO	I-LOAD	SP	N/A
MPS engine out flags	\dot{S}_{EO_E1} , \dot{S}_{EO_E2} , \dot{S}_{EO_E3}	SSME OPS	D	N/A
Total number of cycles used to transition PTCH_FAC to zero for engine failure	N_PTCHF_TOT	I-LOAD	I	ND
TDEL_ADJUST deadband used to check for small SRB dispersions	TDEL_ADJUST_ DEADBAND	I-LOAD	SP	sec
Attitude hold command velocity breakpoint for contingency lofting	V_RAMP_MAX	I-LOAD	SP	fps
Contingency lofting alpha target velocity breakpoint	V_ALPH_TO	I-LOAD	SP	fps
Time to begin ramping in tail-off alpha for contingency lofting	T_RMP_I	I-LOAD	SP	sec
Time to end ramping of tail-off alpha	T_RMP_F	I-LOAD	SP	sec
Contingency lofting SRB tail-off alpha target	ALPH_TO	I-LOAD	SP	rad
Contingency lofting pitch limit	THET_LIM	I-LOAD	SP	N/A
Segment start dynamic pressures for independent values of alpha target	Q_TAB_ALP(4)	I-LOAD	SP	psf
Segment start values for dependent values of alpha target	ALP_TAB(4)	I-LOAD	SP	rad

Table 4.2.3-1. Boost Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Segment start dynamic pressures for independent values of integration gain	Q_TAB_GAIN(4)	I-LOAD	SP	psf
Segment start values for dependent values of integration gain	GAIN_TAB(4)	I-LOAD	SP	ND
Percent pitch adjustment during load relief for SRB disp	PTCH_PCT	I-LOAD	SP	ND
Tabular values of independent variable for boost throttling	QPOLY _J (J=1,4)	I-LOAD	SP	fps
Tabular values for boost throttling	THROT _J (J=1,4)	I-LOAD	I	pct
Throttle adjustment factor for hot SRB's sec	THRT_FAC	I-LOAD	SP	pct* fps/sec
Throttle adjustment factor for cold SRB's sec	THRT_FACL	I-LOAD	SP	pct* fps/sec
Previous value of time tag associated with current state(T_NAV)	T_NAV_PREV	1STG GUID INP TSK	DP	sec
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Design reference time to obtain reference velocity	TREF_ADJUST	I-LOAD	SP	sec
VREL breakpoint for beginning of maximum load relief	VREL_GAIN_TAB ₃	I-LOAD	SP	fps
VREL breakpoint for beginning of load relief termination	VREL_GAIN_TAB ₄	I-LOAD	SP	fps
Design reference velocity for SRB adaptive guidance	VREF_ADJUST	I-LOAD	SP	fps
Number of active SSME's	N_SSME	1STG GUID INP TSK	I	N/A
Reference velocity for multiple engine failures	V_MULT_EO	I-LOAD	SP	fps
Pitch command for multiple engine failures	THET_MULT_EO	I-LOAD	SP	N/A
Vehicle relative velocity	V_RHO _I (I = 1, 3)	ASC UPP	SP	fps
Altitude	ALT	ASC UPP	SP	ft
Altitude limit for speed of sound	ALTSS	I-LOAD	SP	ft
Sea level speed of sound	SSSL	I-LOAD	SP	fps
Slope for speed of sound	DSSA	I-LOAD	SP	1/sec
Guidance time delta	DTGD	1STG GUID INP TSK	SP	sec

Table 4.2.3-1. Boost Guidance Task Inputs

Definition	Symbol	Source	Prec	Units
Independent variable for wind table	ALT_WND _I (I = 1, 8)	I-LOAD	SP	ft
East component of wind	WNDE_TAB _I (I = 1, 8)	I-LOAD	SP	fps
Engine out alpha limit	ALPHA_EO	I-Load	SP	rad
Velocity to begin alpha limiting	V_THET_LIM	I-Load	SP	ft/s
Constant pitch rate time	T_CNS_PITCH_ RATE	I-Load	SP	sec
High Q engine out delta PSI	DDPSI_MAX_EO	I-Load	SP	rad
Delta PSI wind multiplier	DPSI_WIND_MULT	I-Load	SP	n/a
Delta PSI lower limit	DPSI_LIM1	I-Load	SP	rad
Delta PSI upper limit	DPSI_LIM2	I-Load	SP	rad
Velocity to begin high q engine out yaw steering	V_AZ_START	I-Load	SP	ft/s
Velocity to end high q engine out yaw steering	V_AZ_STOP	I-Load	SP	ft/s
Relative velocity magnitude at SSME failure time	V_ME_OUT	SSME OUT SAF TSK	SP	ft/s
Early engine out delta PSI velocity	V_EO_PSI	I-Load	SP	ft/s
Velocity to begin delta PSI ramp	V_PSI_RAMP1	I-Load	SP	ft/s
Velocity to end delta PSI ramp	V_PSI_RAMP2	I-Load	SP	ft/s
Velocity for constant delta PSI	V_PSI_CNST	I-Load	SP	ft/s
Late delta PSI switch velocity	V_PSI_SW	I-Load	SP	ft/s
Roll to PSI ratio	ROLL_PSI_RATIO	I-Load	SP	nd
Late high q engine out delta PSI	DDPSI_MAX_EO2	I-Load	SP	rad
Early engine out delta PSI	DELPSI_EO	I-Load	SP	rad
Incremental percent change in DDPSI per cycle	DDPSI_INC	I-Load	SP	nd
Incremental percent change in DDPHI per cycle	DDPHI_INC	I-Load	SP	nd
North component of wind	WNDN_TAB _I (I = 1, 8)	I-LOAD	SP	fps

Table 4.2.3-2. Boost Guidance Task Outputs

Definition	Symbol	Destination	Prec	Units
M50-to-commanded-body quaternion	$Q_{\dot{G}CB_I}$	G/C STEER	SP	ND
Attitude quaternion computed flag	$S_{\dot{Q}UAT}$	ASC DAP	D	N/A
Index for nominal/engine-out pitch and yaw polynomials	L	TLM	I	ND
Tabular values for boost throttling	THROT _J (J = 1,4)	BST THROT TSK	I	pct
Time difference to obtain reference velocity	TDEL_ADJUST	TLM	SP	sec
Index for selecting RTLS flight path angle target	LL	PEG TSK	I	ND
Aerodynamic reference velocity	VREL_AERO_REF	ASC DAP	SP	fps
Display indicator for engine out yaw steering active	ENGINE_ÖUT_YAW_STEERING	MEDS FC GNC XFER	D	ND

4.2.4 Boost Throttling Task (BST THROT TSK)

This task provides an open-loop SSME throttle command to limit the maximum value of dynamic pressure and to gain the desired performance. If an SSME fails ($N_{SSME} \neq 3$), then this task is not performed and the throttle command is set to the maximum allowable by the safing task if manual is not being performed.

A. Detailed Requirements. The throttle command (K_CMD) at lift-off is initialized in the LPS to 100 percent. When the relative velocity magnitude equals or exceeds one of the stored throttling-point velocities ($V_RHO_MAG \geq QPOLY_J$), K_CMD is changed to the stored value $THROT_J$ and the boost throttling segment index is incremented by one ($J = J + 1$) if manual throttling is not being performed ($S_MAN_THROT = OFF$). A maximum of four throttle changes is provided.

B. Interface Requirements. The input and output parameters for the boost throttling task are given in Tables 4.2.4-1 and 4.2.4-2.

C. Processing Requirements. This task is performed on every boost throttling task cycle while J is less than 5, unless an SSME failure has occurred.

D. Initialization Requirements. $J = 1$.

Table 4.2.4-1. Boost Throttling Task Inputs				
Definition	Symbol	Source	Prec	Units
Magnitude of vehicle relative velocity	V_RHO_MAG	ASC UPP	SP	fps
Tabular values of independent variable for boost throttling	$QPOLY_J$ ($J=1,4$)	I-LOAD	SP	fps
Tabular values for boost throttling	$THROT_J$ ($J=1,4$)	I-LOAD, BST GUID TSK	I	pct
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Number of active SSME's	N_SSME	1STG GUID INP TSK	I	N/A

Table 4.2.4-2. Boost Throttling Task Outputs				
Definition	Symbol	Destination	Prec	Units
Commanded SSME throttle setting	K_CMD	SSME SOP, 1STG GUID INP TSK, TLM, SBTC SOP, G-LIM TSK, SSME- OUT SAF TSK, THRST PRM TSK, FUL DISS TSK, ASC DAP, XXXXXX TRAJ 1 DISP	I	pct

4.2.5 Parameter Tables for First-Stage Guidance

The IDD inputs and outputs are listed in Tables 4.2.5-1 and 4.2.5-2 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 4.2.5-3. K-loads are listed in Table 4.2.5-4. Constants are listed in Table 4.2.5-5. The input variable cross-references are listed in Table 4.2.5-0

Table 4.2.5-0.AS 1STG GUID Input Variable Cross-Reference		
MSID	Local Name	Source Name
V95L0151CE	V_RHO_MAG	REL_VEL_MAG
V95W0200CD	T_NAV	T_STATE
V95U0503C, 4C, 5C, 6C	Q_ḂR_M50	Q_M50TOBR
V95X1207X	S_ḂO_E1	ME1_FAIL_SHUTDOWN
V95X1208X	S_ḂO_E2	ME2_FAIL_SHUTDOWN
V95X1209X	S_ḂO_E3	ME3_FAIL_SHUTDOWN
V95H3521C	EBFB2	EBFB(2)

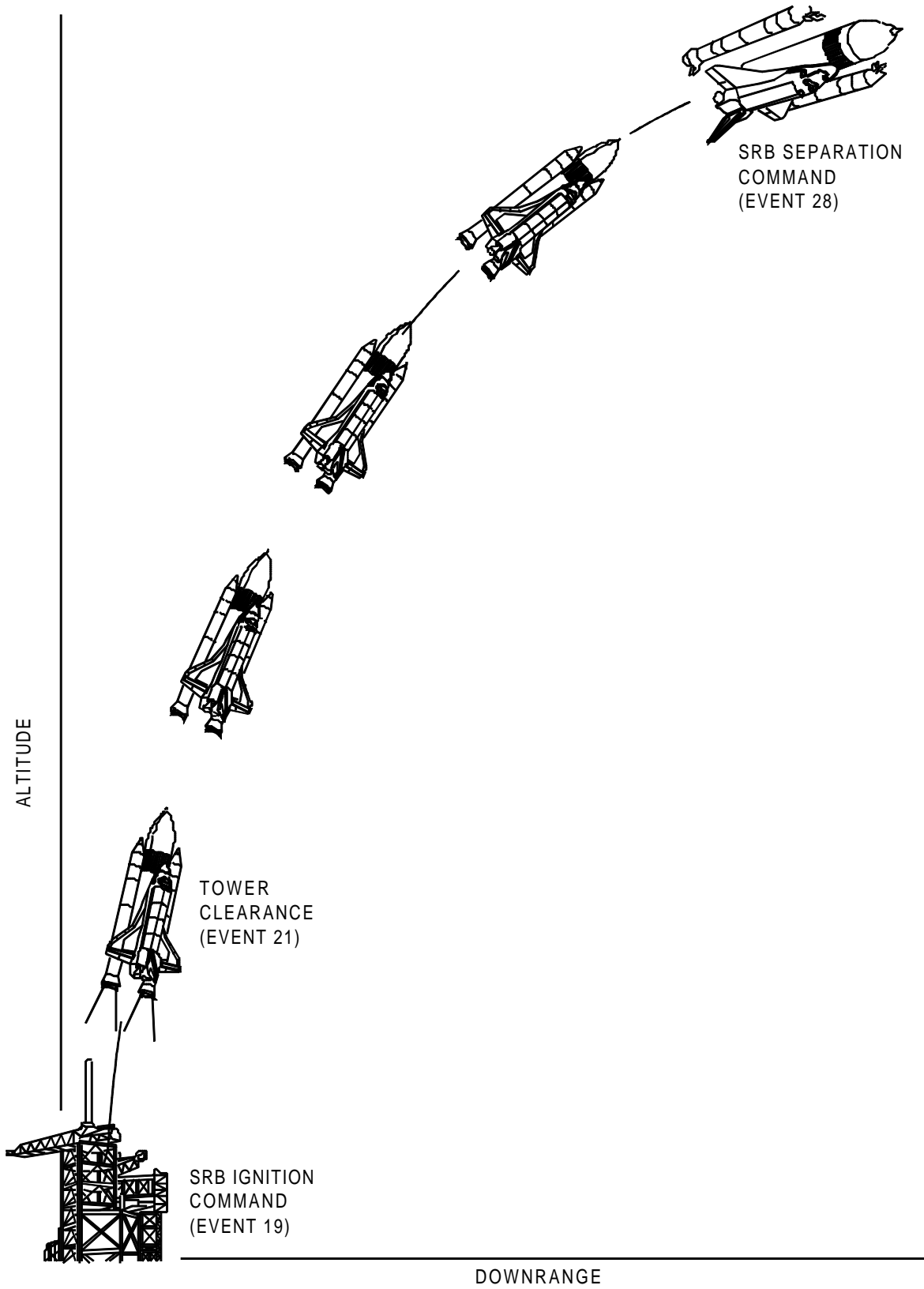


FIGURE 4.2-1. Typical Shuttle First-Stage Ascent Sequence of Events

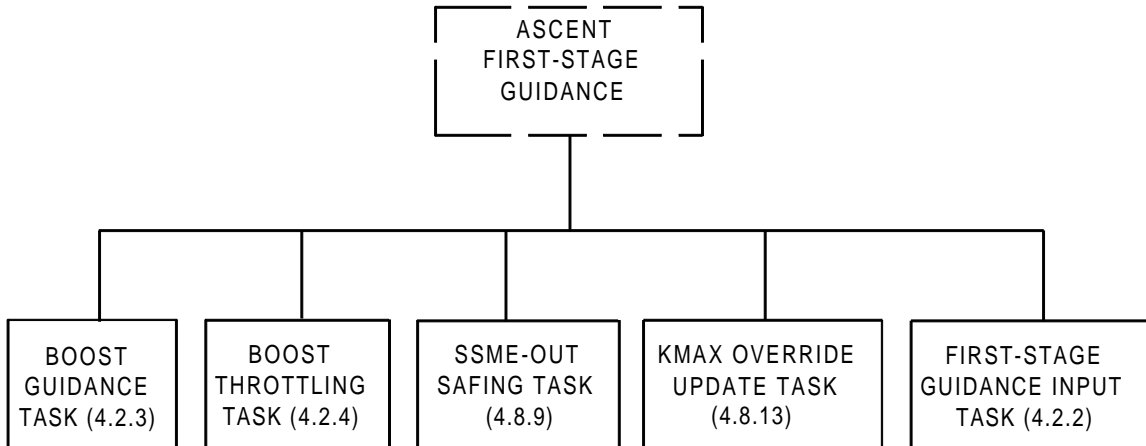


FIGURE 4.2-2. Ascent First-Stage Guidance Principal Function Task Organization

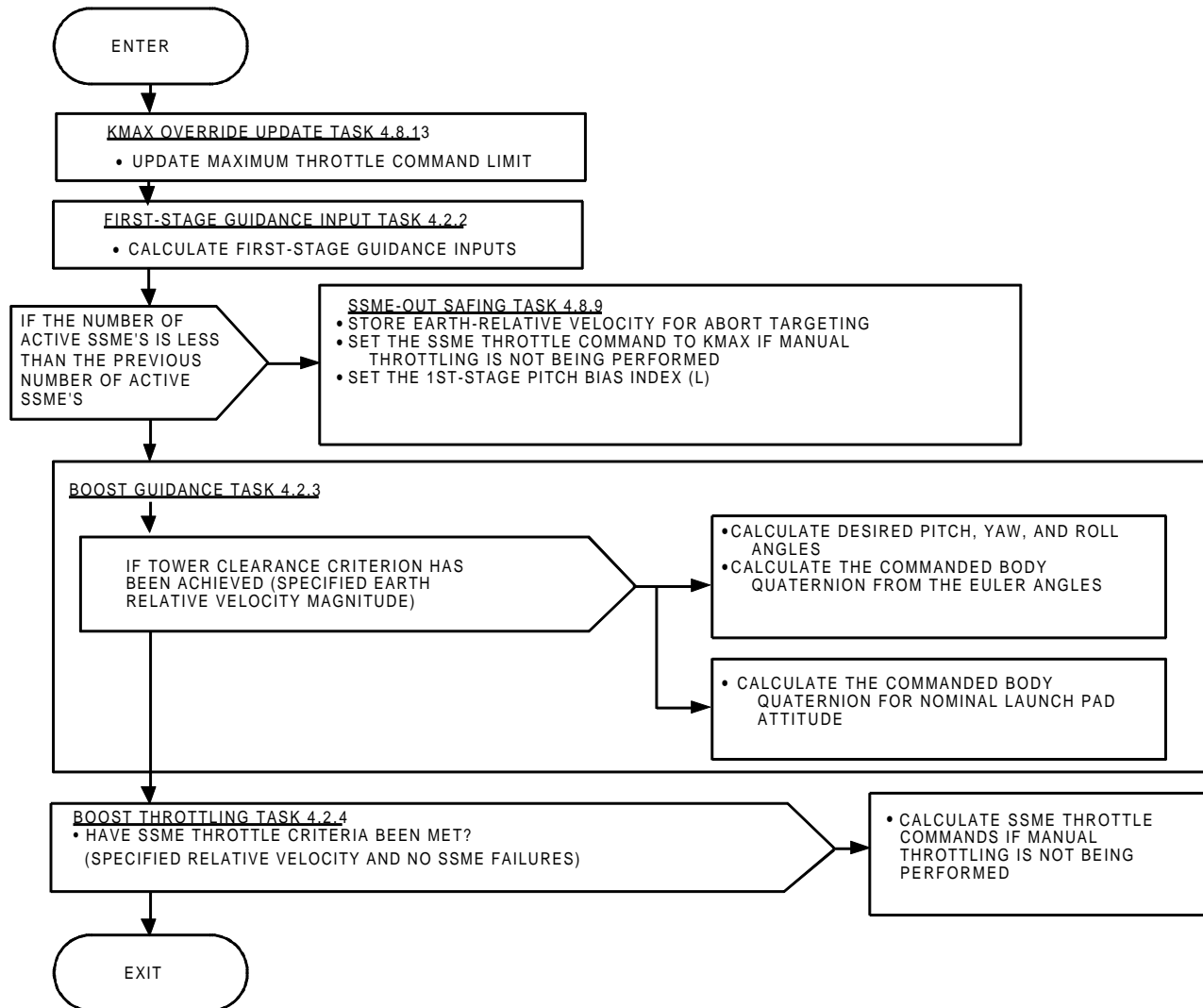


FIGURE 4.2-3. First-Stage Guidance Principal Function Logic Flow

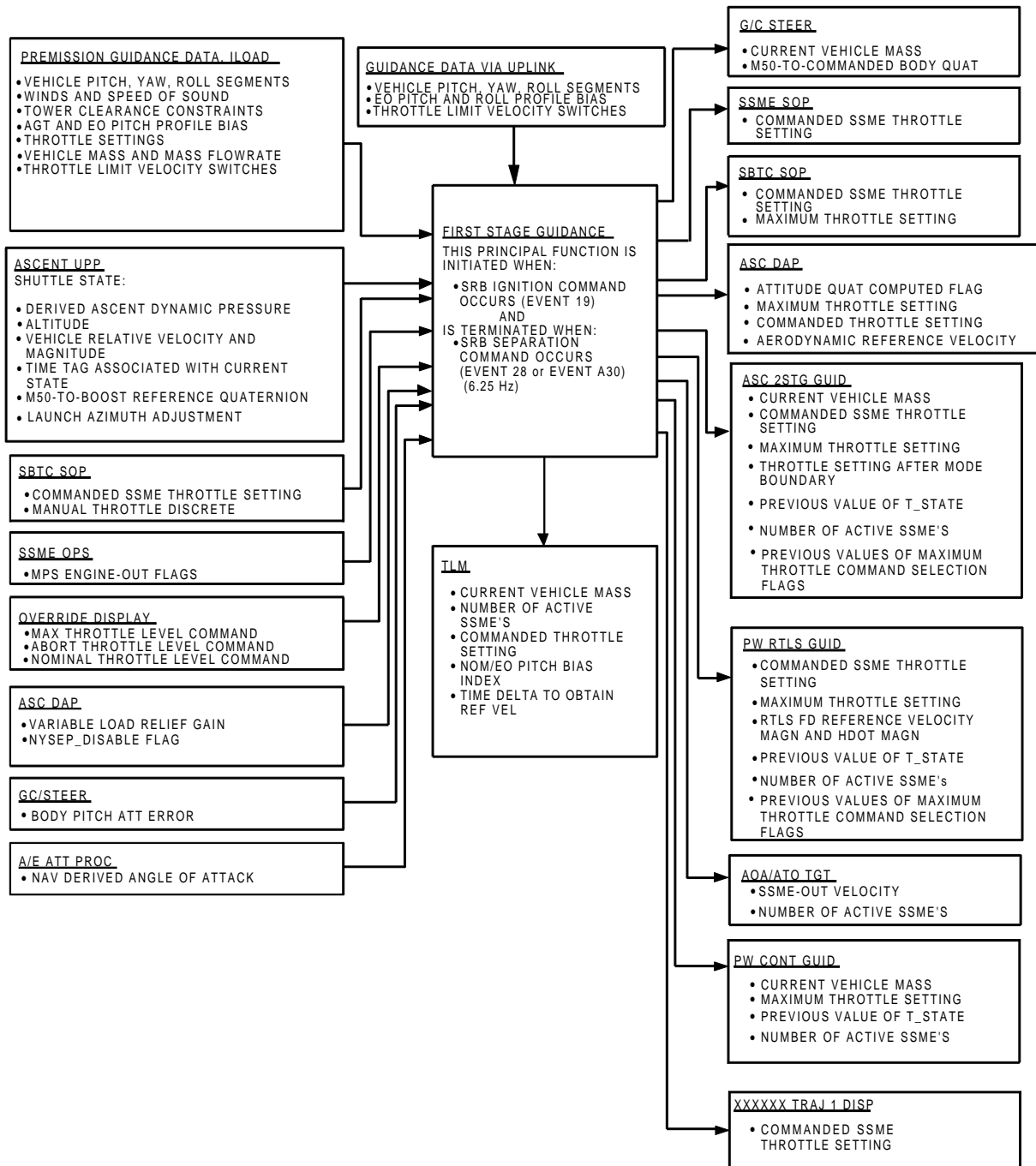


FIGURE 4.2-4. First-Stage Guidance Principal Function Data Flow

TABLE 4.2.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT FIRST STAGE GUIDANCE (G4.1)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_THROT_CMD	V93X0994X	ABORT THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
ALPHA_N	V90H2246C	NAV DERIVED ANGLE OF ATTACK	A/E ATT PROC	DEG	SPL		93017G	*
ALT	V95H0175CB	CURR ORB ALT ABOVE REF ELLIPSOID	ASC UP	FT			93017G	*
DELTA_PSI	V99U7440C	AZIMUTH BIAS	UL	RAD			90958C	
DELTA_PSI	V99U7440CA	AZIMUTH BIAS	ASC UP	RAD			90958C	
EBFB(2)	V95H3521C	BODY PITCH ATT ERROR	G/C STEER	DEG	SPL		93017G	*
H_DOT_ELLIPSOID/H_DOT	V95L0265CE	EST ALTITUDE RATE	ASC UP	FT/S			93012D	
K_CMD	V90U1948CE	COMMANDS SSME THROTTLE SETTING	SBTC SOP	PCT			93012D	
K_LOAD_RELIEF	V90J1704C	VAR LOAD RELIEF GAIN	ASC DAP					
M	V97U4429C	INITIAL MATED ORBITER/ET MASS	UL	SLUG	SPL	S	92175D	
MAX_THROT_CMD	V93X5349X	MAXIMUM THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		89990E	
ME1_FAIL_SHUTDOWN	V95X1207X	MPS E1 FAIL FLAG	SSME OPS		BD		93017G	*
ME2_FAIL_SHUTDOWN	V95X1208X	MPS E2 FAIL FLAG	SSME OPS		BD		93017G	*
ME3_FAIL_SHUTDOWN	V95X1209X	MPS E3 FAIL FLAG	SSME OPS		BD		93017G	*
MM_CODE_102/MM_102	V90X8158X	MAJOR MODE 102 FLAG	MSC				93012D	
NOM_THROT_CMD	V93X0995X	NOMINAL THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
NYSEP_DISABLE	V90X0373X	NYSEP DISABLE INDICATOR	ASC DAP		BD		91015C	
PHI(01)	V97U4451C	SEGMT BNDRY TAN ROLL ANG/4 (01)	UL					
PHI(02)	V97U4452C	SEGMT BNDRY TAN ROLL ANG/4 (02)	UL					
PHI(03)	V97U4453C	SEGMT BNDRY TAN ROLL ANG/4 (03)	UL					
PHI(04)	V97U4454C	SEGMT BNDRY TAN ROLL ANG/4 (04)	UL					
PHI(05)	V97U4455C	SEGMT BNDRY TAN ROLL ANG/4 (05)	UL					
PHI(06)	V97U4456C	SEGMT BNDRY TAN ROLL ANG/4 (06)	UL					
PHI(07)	V97U4457C	SEGMT BNDRY TAN ROLL ANG/4 (07)	UL					
PHI(08)	V97U4458C	SEGMT BNDRY TAN ROLL ANG/4 (08)	UL					
PHI(09)	V97U4459C	SEGMT BNDRY TAN ROLL ANG/4 (09)	UL					
PHI(10)	V97U4460C	SEGMT BNDRY TAN ROLL ANG/4 (10)	UL					
PHI(11)	V97U4461C	SEGMT BNDRY TAN ROLL ANG/4 (11)	UL					
PHI(12)	V97U4462C	SEGMT BNDRY TAN ROLL ANG/4 (12)	UL					
PHI(13)	V97U4463C	SEGMT BNDRY TAN ROLL ANG/4 (13)	UL					
PHI(14)	V97U4464C	SEGMT BNDRY TAN ROLL ANG/4 (14)	UL					
PHI(15)	V97U4465C	SEGMT BNDRY TAN ROLL ANG/4 (15)	UL					
PSI(01)	V97U4516C	SEGMT BNDRY TAN YAW ANG/4 (01)	UL					
PSI(02)	V97U4520C	SEGMT BNDRY TAN YAW ANG/4 (02)	UL					
PSI(03)	V97U4524C	SEGMT BNDRY TAN YAW ANG/4 (03)	UL					
PSI(04)	V97U4528C	SEGMT BNDRY TAN YAW ANG/4 (04)	UL					
PSI(05)	V97U4532C	SEGMT BNDRY TAN YAW ANG/4 (05)	UL					
PSI(06)	V97U4536C	SEGMT BNDRY TAN YAW ANG/4 (06)	UL					
PSI(07)	V97U4540C	SEGMT BNDRY TAN YAW ANG/4 (07)	UL					
PSI(08)	V97U4544C	SEGMT BNDRY TAN YAW ANG/4 (08)	UL					
PSI(09)	V97U4548C	SEGMT BNDRY TAN YAW ANG/4 (09)	UL					
PSI(10)	V97U4552C	SEGMT BNDRY TAN YAW ANG/4 (10)	UL					
PSI(11)	V97U4556C	SEGMT BNDRY TAN YAW ANG/4 (11)	UL					
PSI(12)	V97U4560C	SEGMT BNDRY TAN YAW ANG/4 (12)	UL					
PSI(13)	V97U4564C	SEGMT BNDRY TAN YAW ANG/4 (13)	UL					
PSI(14)	V97U4568C	SEGMT BNDRY TAN YAW ANG/4 (14)	UL					

TABLE 4.2.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT FIRST STAGE GUIDANCE (G4.1)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
PSI(15)	V97U4572C	SEGMT BNDRY TAN YAW ANG/4 (15)	UL					
PSI(16)	V97U4576C	SEGMT BNDRY TAN YAW ANG/4 (16)	UL					
PSI(17)	V97U4580C	SEGMT BNDRY TAN YAW ANG/4 (17)	UL					
PSI(18)	V97U4584C	SEGMT BNDRY TAN YAW ANG/4 (18)	UL					
PSI(19)	V97U4588C	SEGMT BNDRY TAN YAW ANG/4 (19)	UL					
PSI(20)	V97U4592C	SEGMT BNDRY TAN YAW ANG/4 (20)	UL					
PSI(21)	V97U4596C	SEGMT BNDRY TAN YAW ANG/4 (21)	UL					
PSI(22)	V97U4600C	SEGMT BNDRY TAN YAW ANG/4 (22)	UL					
PSI(23)	V97U4604C	SEGMT BNDRY TAN YAW ANG/4 (23)	UL					
PSI(24)	V97U4608C	SEGMT BNDRY TAN YAW ANG/4 (24)	UL					
PSI(25)	V97U4612C	SEGMT BNDRY TAN YAW ANG/4 (25)	UL					
PSI(26)	V97U4616C	SEGMT BNDRY TAN YAW ANG/4 (26)	UL					
PSI(27)	V97U4620C	SEGMT BNDRY TAN YAW ANG/4 (27)	UL					
PSI(28)	V97U4624C	SEGMT BNDRY TAN YAW ANG/4 (28)	UL					
PSI(29)	V97U4628C	SEGMT BNDRY TAN YAW ANG/4 (29)	UL					
PSI(30)	V97U4632C	SEGMT BNDRY TAN YAW ANG/4 (30)	UL					
QPOLY(1)	V97U4640C	IND VAR FOR THROTTLE CMD(1)	UL	FT/S		S	90256D	
QPOLY(2)	V97U4641C	IND VAR FOR THROTTLE CMD(2)	UL	FT/S		S	90256D	
QPOLY(3)	V97U4642C	IND VAR FOR THROTTLE CMD(3)	UL	FT/S		S	90256D	
QPOLY(4)	V97U4643C	IND VAR FOR THROTTLE CMD(4)	UL			S	90256D	
Q_BAR_A	V95P0500C	DERIVED ASCENT DYNAMIC PRESS	ASC UPP	LB/FT2		SPL	93017G	*
Q_M50TOBR(1)	V95U0503C	M50-TO BOOST REF QUATERNION ELE 1	ASC UPP				89461	
Q_M50TOBR(2)	V95U0504C	M50-TO BOOST REF QUATERNION ELE 2	ASC UPP				89461	
Q_M50TOBR(3)	V95U0505C	M50-TO BOOST REF QUATERNION ELE 3	ASC UPP				89461	
Q_M50TOBR(4)	V95U0506C	M50-TO BOOST REF QUATERNION ELE 4	ASC UPP				89461	
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S			93017G	*
S_MAN_THROT	V96X0006X	MANUAL THROTTLE DISCRETE	SBTC SOP			BD	93017G	*
THET(1,01)	V97U4667C	SEGMT BNDRY TAN PITCH ANG/4 (1,01)	UL	ND			89942	
THET(1,02)	V97U4671C	SEGMT BNDRY TAN PITCH ANG/4 (1,02)	UL	ND			89942	
THET(1,03)	V97U4675C	SEGMT BNDRY TAN PITCH ANG/4 (1,03)	UL	ND			89942	
THET(1,04)	V97U4679C	SEGMT BNDRY TAN PITCH ANG/4 (1,04)	UL	ND			89942	
THET(1,05)	V97U4683C	SEGMT BNDRY TAN PITCH ANG/4 (1,05)	UL	ND			89942	
THET(1,06)	V97U4687C	SEGMT BNDRY TAN PITCH ANG/4 (1,06)	UL	ND			89942	
THET(1,07)	V97U4691C	SEGMT BNDRY TAN PITCH ANG/4 (1,07)	UL	ND			89942	
THET(1,08)	V97U4695C	SEGMT BNDRY TAN PITCH ANG/4 (1,08)	UL	ND			89942	
THET(1,09)	V97U4699C	SEGMT BNDRY TAN PITCH ANG/4 (1,09)	UL	ND			89942	
THET(1,10)	V97U4703C	SEGMT BNDRY TAN PITCH ANG/4 (1,10)	UL	ND			89942	
THET(1,11)	V97U4707C	SEGMT BNDRY TAN PITCH ANG/4 (1,11)	UL	ND			89942	
THET(1,12)	V97U4711C	SEGMT BNDRY TAN PITCH ANG/4 (1,12)	UL	ND			89942	
THET(1,13)	V97U4715C	SEGMT BNDRY TAN PITCH ANG/4 (1,13)	UL	ND			89942	
THET(1,14)	V97U4719C	SEGMT BNDRY TAN PITCH ANG/4 (1,14)	UL	ND			89942	
THET(1,15)	V97U4723C	SEGMT BNDRY TAN PITCH ANG/4 (1,15)	UL	ND			89942	
THET(1,16)	V97U4727C	SEGMT BNDRY TAN PITCH ANG/4 (1,16)	UL	ND			89942	
THET(1,17)	V97U4731C	SEGMT BNDRY TAN PITCH ANG/4 (1,17)	UL	ND			89942	
THET(1,18)	V97U4735C	SEGMT BNDRY TAN PITCH ANG/4 (1,18)	UL	ND			89942	
THET(1,19)	V97U4739C	SEGMT BNDRY TAN PITCH ANG/4 (1,19)	UL	ND			89942	

TABLE 4.2.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT FIRST STAGE GUIDANCE (G4.1)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
THET(1,20)	V97U4743C	SEGMT BNDRY TAN PITCH ANG/4 (1,20)	UL	ND			89942	
THET(1,21)	V97U4747C	SEGMT BNDRY TAN PITCH ANG/4 (1,21)	UL	ND			89942	
THET(1,22)	V97U4751C	SEGMT BNDRY TAN PITCH ANG/4 (1,22)	UL	ND			89942	
THET(1,23)	V97U4755C	SEGMT BNDRY TAN PITCH ANG/4 (1,23)	UL	ND			89942	
THET(1,24)	V97U4759C	SEGMT BNDRY TAN PITCH ANG/4 (1,24)	UL	ND			89942	
THET(1,25)	V97U4763C	SEGMT BNDRY TAN PITCH ANG/4 (1,25)	UL	ND			89942	
THET(1,26)	V97U4767C	SEGMT BNDRY TAN PITCH ANG/4 (1,26)	UL	ND			89942	
THET(1,27)	V97U4771C	SEGMT BNDRY TAN PITCH ANG/4 (1,27)	UL	ND			89942	
THET(1,28)	V97U4775C	SEGMT BNDRY TAN PITCH ANG/4 (1,28)	UL	ND			89942	
THET(1,29)	V97U4779C	SEGMT BNDRY TAN PITCH ANG/4 (1,29)	UL	ND			89942	
THET(1,30)	V97U4783C	SEGMT BNDRY TAN PITCH ANG/4 (1,30)	UL	ND			89942	
THROT(1)	V97U4808C	THROTTLE COMMAND TABLE(1)	UL	PCT			90256D	
THROT(2)	V97U4809C	THROTTLE COMMAND TABLE(2)	UL	PCT			90256D	
THROT(3)	V97U4810C	THROTTLE COMMAND TABLE(3)	UL	PCT			90256D	
THROT(4)	V97U4811C	THROTTLE COMMAND TABLE(4)	UL	PCT			90256D	
TREF_ADJUST	V99U7566C	REFERENCE VELOCITY TIME	UL	SEC		S	90256D	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
V_KMAX_DOWN	V97U0603C	THROTTLE LIMIT DECREASE VEL SW	UL	FT/S	SPL	S	92232B	
V_KMAX_UP	V97U0604C	THROTTLE LIMIT INCREASE VEL SW	UL	FT/S	SPL	S	92232B	
V_RHO(1)	V95L0215CE	X-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(2)	V95L0216CE	Y-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(3)	V95L0217CE	Z-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
WNDE_TAB(1)	V99U6349C	EAST COMPONENT OF WIND(1)	UL	FT/S		S	90256D	
WNDE_TAB(2)	V99U6350C	EAST COMPONENT OF WIND(2)	UL	FT/S		S	90256D	
WNDE_TAB(3)	V99U6351C	EAST COMPONENT OF WIND(3)	UL	FT/S		S	90256D	
WNDE_TAB(4)	V99U6352C	EAST COMPONENT OF WIND(4)	UL	FT/S		S	90256D	
WNDE_TAB(5)	V99U6353C	EAST COMPONENT OF WIND(5)	UL	FT/S		S	90256D	
WNDE_TAB(6)	V99U6354C	EAST COMPONENT OF WIND(6)	UL	FT/S		S	90256D	
WNDE_TAB(7)	V99U6355C	EAST COMPONENT OF WIND(7)	UL	FT/S		S	90256D	
WNDE_TAB(8)	V99U6356C	EAST COMPONENT OF WIND(8)	UL	FT/S		S	90256D	
WNDN_TAB(1)	V99U6357C	NORTH COMPONENT OF WIND(1)	UL	FT/S		S	90256D	
WNDN_TAB(2)	V99U6358C	NORTH COMPONENT OF WIND(2)	UL	FT/S		S	90256D	
WNDN_TAB(3)	V99U6359C	NORTH COMPONENT OF WIND(3)	UL	FT/S		S	90256D	
WNDN_TAB(4)	V99U6360C	NORTH COMPONENT OF WIND(4)	UL	FT/S		S	90256D	
WNDN_TAB(5)	V99U6361C	NORTH COMPONENT OF WIND(5)	UL	FT/S		S	90256D	
WNDN_TAB(6)	V99U6362C	NORTH COMPONENT OF WIND(6)	UL	FT/S		S	90256D	
WNDN_TAB(7)	V99U6363C	NORTH COMPONENT OF WIND(7)	UL	FT/S		S	90256D	
WNDN_TAB(8)	V99U6364C	NORTH COMPONENT OF WIND(8)	UL	FT/S		S	90256D	

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

TABLE 4.2.5-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT FIRST STAGE GUIDANCE (G4.1)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_CMD_PREV	V93X1031XA	PREV KMAX CMD TO ABT	ASC 2STG GUID PW RTLS GUID		BD		92608C	
ENGINE_OUT_YAW_STEERING	V90X0431X	ENGINE OUT YAW STEERING	MEDS FC GNC XFER	ND	BD		92670D	
H_DOT_FD	V90R2098CA	RTLS FUEL DISSP REF HDOT	PW RTLS GUID	FT/S				
KMAX	V97U4424CA	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 2STG GUID ASC DAP PW CONT GUID PW RTLS GUID SBTC SOP	PCT			90608D	
K_CMD	V90U1948CB	COMMANDED SSME THROTTLE SETTING	ASC 2STG GUID ASC DAP DL FMT 21/A PW RTLS GUID SBTC SOP SSME OPS SSME SOP XXXXXX TRAJ 1 DISP	PCT			93017G	*
K_CMD_MODE_BNDRY	V97U4420C	NOM SSME THROT SET-RTLS/AOA BNDRY	ASC 2STG GUID	PCT			89461	
L	V90J1943C	1ST STG ATTITUDE PROFILE SELECTOR	DL FMT 21/1		HXS		93017G	*
LL	V90J2007CA	RTLS FLIGHT PATH ANG TARGET INDEX	PW RTLS GUID				89461	
M/CURR_ORB_MASS/WEIGHT	V90U1961CF	CURRENT VEHICLE MASS	ASC 2STG GUID ASC DAP DL FMT 21/1 G/C STEER OMS RM PW CONT GUID PW RTLS GUID	SLUGS			93017G	*
MAX_CMD_PREV	V93X1032XA	PREV KMAX CMD TO MAX	ASC 2STG GUID PW RTLS GUID		BD		92608C	
NOM_CMD_PREV	V93X1033XA	PREV KMAX CMD TO NOM	ASC 2STG GUID PW RTLS GUID		BD		92608C	
N_SSME	V90U1962CA	NUMBER OF ACTIVE SSME'S	AOA/ATO TGT ASC 2STG GUID DL FMT 21/1 PW CONT GUID PW RTLS GUID				93017G	*
Q_CB_M50(1)/Q_GCB_1	V90U1949CA	M50-TO-CMD BODY QUATERNION ELE 1	G/C STEER					
Q_CB_M50(2)/Q_GCB_2	V90U1950CA	M50-TO-CMD BODY QUATERNION ELE 2	G/C STEER					
Q_CB_M50(3)/Q_GCB_3	V90U1951CA	M50-TO-CMD BODY QUATERNION ELE 3	G/C STEER					
Q_CB_M50(4)/Q_GCB_4	V90U1952CA	M50-TO-CMD BODY QUATERNION ELE 4	G/C STEER					
S_QUAT	V90X1987X	ATTITUDE QUATERNION COMPUTED FLAG	ASC DAP					
TDEL_ADJUST	V90W2003C	REL VEL TIME DIFFERENCE FRM DESIGN	DL FMT 21/A	S	SPL		93017G	*
T_NAV_PREV	V90W0151C	PREVIOUS VALUE OF T_STATE	ASC 2STG GUID PW CONT GUID PW RTLS GUID	S	DPL		90608D	
VREL_AERO_REF	V90L2018C	AERODYNAMIC REFERNCE VEL	ASC DAP	FT/S	SPL	S	90256D	

TABLE 4.2.5-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT FIRST STAGE GUIDANCE (G4.1)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
V_ME_OUT	V90L1947CA	SSME ENGINE-OUT VELOCITY	AOA/ATO TGT	FT/S			93017G	*
V_RTLS_FD	V90U1967CA	RTLS FUEL DISSIPATION REF VEL MAG	DL FMT 21/A PW RTLS GUID	FT/S				

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 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALPHA_EO	V97U0786C	RAD	F	S	D	C	G4.1	00	A1P	92670D	
ALPH_TO	V99U9873C	RAD	F	S	M	P	G4.1	00	A1C	DC0829	
ALP_TAB(1)	V99U9879C	RAD	F	S	M	P	G4.1	00	A1C	DC0829	
ALP_TAB(2)	V99U9880C	RAD	F	S	M	P	G4.1	00	A1C	DC0829	
ALP_TAB(3)	V99U9881C	RAD	F	S	M	P	G4.1	00	A1C	DC0829	
ALP_TAB(4)	V99U9882C	RAD	F	S	M	P	G4.1	00	A1C	DC0829	
ALTSS	V99U6346C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(1)	V99U6338C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(2)	V99U6339C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(3)	V99U6340C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(4)	V99U6341C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(5)	V99U6342C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(6)	V99U6343C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(7)	V99U6344C	FT	F	S	D	C	G4.1	00	A1S	92227	
ALT_WND(8)	V99U6345C	FT	F	S	D	C	G4.1	00	A1S	92227	
DDPHI_INC	V97U0631C	ND	F	S	D	C	G4.1	00	PSJ	92670D	
DDPSI_INC	V97U0630C	ND	F	S	D	C	G4.1	00	PSI	92670D	
DDPSI_MAX_EO	V97U0787C	RAD	F	S	D	C	G4.1	00	PSI	92670D	
DDPSI_MAX_EO2	V97U0622C	RAD	F	S	D	C	G4.1	00	PSI	92670D	
DELPLO(1)	V99U6461C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
DELPLO(2)	V99U6462C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
DELPSI_EO	V97U0794C	RAD	F	S	D	C	G4.1	00	PSI	92670D	
DELTA_PSI	V99U7440C	RAD	F	S	M	C	G4.1	00	ARC	90958C	
							G4.19				
DEL_CST(1)	V99U7540C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
DEL_CST(2)	V99U7541C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
DPSI_LIM1	V97U0790C	RAD	F	S	D	C	G4.1	00	PSI	92670D	
DPSI_LIM2	V97U0791C	RAD	F	S	D	C	G4.1	00	PSI	92670D	
DPSI_WIND_MULT	V97U0789C	ND	F	S	D	C	G4.1	00	PSJ	92670D	
DSSA	V99U6347C	SEC**-1	F	S	D	C	G4.1	00	A1S	92227	
EV25E_DELAY	V97U1838C	SEC	F	S	D	C	G4.1	00	A1S	92227	
GAIN_TAB(1)	V99U9887C	ND	F	S	M	P	G4.1	00	A1C	DC0829	
GAIN_TAB(2)	V99U9888C	ND	F	S	M	P	G4.1	00	A1C	DC0829	
GAIN_TAB(3)	V99U9889C	ND	F	S	M	P	G4.1	00	A1C	DC0829	
GAIN_TAB(4)	V99U9890C	ND	F	S	M	P	G4.1	00	A1C	DC0829	
KMAX	V97U4424C	PCT	I	S	M	C	G4.1	00	A2P	89990E	
							G4.2				
							G4.4				
							G4.5				
							G4.55				
KMAX_ABT	V97U0601C	PCT	I	S	M	C	G4.1	00	A2P	92232B	
							G4.2				
							G4.4				
							G4.5				

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
KMAX_NOM	V97U0602C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5	00	A2P	92232B	
KMAX_SECONDARY	V99U7107C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5	00	A2P	89990E	
KMIN_ALT	V99U7558C	PCT	I	S	D	C	G4.1	00	A1T	92243A	
K_ALPH_LIM	V99U9867C	NONE	I	S	M	P	G4.1	00	A1C	DC0829	
L_THRT	V99U7559C	ND	I	S	D	C	G4.1	00	A1T	92243A	
L_THRTL	V99U7560C	ND	I	S	D	C	G4.1	00	A1T	92243A	
M	V97U4429C	SLUGS	F	S	M	X	G4.1 G4.158 G4.211	01 02 03	AMC	DC2248	
								08	ZF2		
								09	AMC		
MDOT_SSME	V97U4442C	SLUGS/SEC	F	S	D	C	G4.1 G4.2 G4.4 G4.5	00	ZF1	90243C	
NF_EOG	V99U6466C	ND	I	S	M	C	G4.1	00	A1P	DC2726	
N_PTCHF_TOT	V99U7674C	ND	I	S	D	C	G4.1	00	A1T	92243A	
PHI (01)	V97U4451C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (02)	V97U4452C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (03)	V97U4453C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (04)	V97U4454C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (05)	V97U4455C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (06)	V97U4456C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (07)	V97U4457C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (08)	V97U4458C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (09)	V97U4459C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (10)	V97U4460C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (11)	V97U4461C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (12)	V97U4462C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (13)	V97U4463C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (14)	V97U4464C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHI (15)	V97U4465C	ND	F	S	M	C	G4.1	00	YD1	90243C	
PHID	V99U6464C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
PHID_EO	V99U6465C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
PPOLY(01)	V97U4486C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(02)	V97U4487C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(03)	V97U4488C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(04)	V97U4489C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(05)	V97U4490C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(06)	V97U4491C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(07)	V97U4492C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
PPOLY(08)	V97U4493C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(09)	V97U4494C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(10)	V97U4495C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(11)	V97U4496C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(12)	V97U4497C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(13)	V97U4498C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(14)	V97U4499C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(15)	V97U4500C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(16)	V97U4501C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(17)	V97U4502C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(18)	V97U4503C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(19)	V97U4504C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(20)	V97U4505C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(21)	V97U4506C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(22)	V97U4507C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(23)	V97U4508C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(24)	V97U4509C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(25)	V97U4510C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(26)	V97U4511C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(27)	V97U4512C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(28)	V97U4513C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(29)	V97U4514C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PPOLY(30)	V97U4515C	FT/SEC	F	S	D	C	G4.1	00	A1S	92243A	
PSI(01)	V97U4516C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(02)	V97U4520C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(03)	V97U4524C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(04)	V97U4528C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(05)	V97U4532C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(06)	V97U4536C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(07)	V97U4540C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(08)	V97U4544C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(09)	V97U4548C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(10)	V97U4552C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(11)	V97U4556C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(12)	V97U4560C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(13)	V97U4564C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(14)	V97U4568C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(15)	V97U4572C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(16)	V97U4576C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(17)	V97U4580C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(18)	V97U4584C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(19)	V97U4588C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(20)	V97U4592C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(21)	V97U4596C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(22)	V97U4600C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(23)	V97U4604C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI(24)	V97U4608C	ND	F	S	M	C	G4.1	00	A1N	DC2726	

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
PSI (25)	V97U4612C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI (26)	V97U4616C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI (27)	V97U4620C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI (28)	V97U4624C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI (29)	V97U4628C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PSI (30)	V97U4632C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
PTCH_FAC	V99U7561C	RAD/SEC	F	S	D	C	G4.1	00	A1T	92243A	
PTCH_FACL	V99U7562C	RAD/SEC	F	S	D	C	G4.1	00	A1T	92243A	
PTCH_PCT	V99U7563C	ND	F	S	D	C	G4.1	00	A1T	89676C	
P_INT(1)	V99U7538C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
P_INT(2)	V99U7539C	RAD	F	S	M	C	G4.1	00	A1P	DC2726	
P_SLP(1)	V99U7536C	RAD*SEC/FT	F	S	M	C	G4.1	00	A1P	DC2726	
P_SLP(2)	V99U7537C	RAD*SEC/FT	F	S	M	C	G4.1	00	A1P	DC2726	
QPOLY(1)	V97U4640C	FT/SEC	F	S	M	C	G4.1	00	A1N	92227	
QPOLY(2)	V97U4641C	FT/SEC	F	S	M	C	G4.1	00	A1N	92227	
QPOLY(3)	V97U4642C	FT/SEC	F	S	M	C	G4.1	00	A1N	92227	
QPOLY(4)	V97U4643C	FT/SEC	F	S	M	C	G4.1	00	A1N	92227	
Q_TAB_ALP(1)	V99U9875C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_ALP(2)	V99U9876C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_ALP(3)	V99U9877C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_ALP(4)	V99U9878C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_GAIN(1)	V99U9883C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_GAIN(2)	V99U9884C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_GAIN(3)	V99U9885C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
Q_TAB_GAIN(4)	V99U9886C	LBS/FT**2	F	S	M	P	G4.1	00	A1C	DC0829	
ROLL_PSI_RATIO	V97U0621C	ND	F	S	D	C	G4.1	00	PSJ	92670D	
SSSL	V99U6348C	FT/SEC	F	S	D	C	G4.1	00	A1S	92227	
TDEL_ADJUST_DEADBAND	V99U7675C	SEC	F	S	D	C	G4.1	00	A1T	92243A	
THET(1,01)	V97U4667C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,02)	V97U4671C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,03)	V97U4675C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,04)	V97U4679C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,05)	V97U4683C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,06)	V97U4687C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,07)	V97U4691C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,08)	V97U4695C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,09)	V97U4699C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,10)	V97U4703C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,11)	V97U4707C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,12)	V97U4711C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,13)	V97U4715C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,14)	V97U4719C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,15)	V97U4723C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,16)	V97U4727C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,17)	V97U4731C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,18)	V97U4735C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,19)	V97U4739C	ND	F	S	M	C	G4.1	00	A1N	DC2726	

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
THET(1,20)	V97U4743C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,21)	V97U4747C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,22)	V97U4751C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,23)	V97U4755C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,24)	V97U4759C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,25)	V97U4763C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,26)	V97U4767C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,27)	V97U4771C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,28)	V97U4775C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,29)	V97U4779C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(1,30)	V97U4783C	ND	F	S	M	C	G4.1	00	A1N	DC2726	
THET(2,1)	V99U6401C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,10)	V99U6410C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,11)	V99U6411C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,12)	V99U6412C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,13)	V99U6413C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,14)	V99U6414C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,15)	V99U6415C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,16)	V99U6416C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,17)	V99U6417C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,18)	V99U6418C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,19)	V99U6419C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,2)	V99U6402C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,20)	V99U6420C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,21)	V99U6421C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,22)	V99U6422C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,23)	V99U6423C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,24)	V99U6424C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,25)	V99U6425C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,26)	V99U6426C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,27)	V99U6427C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,28)	V99U6428C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,29)	V99U6429C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,3)	V99U6403C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,30)	V99U6430C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,4)	V99U6404C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,5)	V99U6405C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,6)	V99U6406C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,7)	V99U6407C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,8)	V99U6408C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(2,9)	V99U6409C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,1)	V99U6431C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,10)	V99U6440C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,11)	V99U6441C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,12)	V99U6442C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,13)	V99U6443C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,14)	V99U6444C	ND	F	S	M	C	G4.1	00	A1P	DC2726	

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
THET(3,15)	V99U6445C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,16)	V99U6446C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,17)	V99U6447C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,18)	V99U6448C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,19)	V99U6449C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,2)	V99U6432C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,20)	V99U6450C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,21)	V99U6451C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,22)	V99U6452C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,23)	V99U6453C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,24)	V99U6454C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,25)	V99U6455C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,26)	V99U6456C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,27)	V99U6457C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,28)	V99U6458C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,29)	V99U6459C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,3)	V99U6433C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,30)	V99U6460C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,4)	V99U6434C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,5)	V99U6435C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,6)	V99U6436C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,7)	V99U6437C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,8)	V99U6438C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THET(3,9)	V99U6439C	ND	F	S	M	C	G4.1	00	A1P	DC2726	
THETC_DOT_EO	V97U1837C	RAD/SEC	F	S	D	C	G4.1	00	A1P	91015C	
THETC_DOT_NOM	V97U1836C	RAD/SEC	F	S	D	C	G4.1	00	A1S	92227	
THET_LIM	V99U9874C	NONE	F	S	M	P	G4.1	00	A1C	DC0829	
THET_MULT_EO	V99U9803C	NONE	F	S	M	P	G4.1	00	A1C	DC0829	
THROT(1)	V97U4808C	PCT	I	S	M	C	G4.1	00	A1N	92227	
THROT(2)	V97U4809C	PCT	I	S	M	C	G4.1	00	A1N	92227	
THROT(3)	V97U4810C	PCT	I	S	M	C	G4.1	00	A1N	92227	
THROT(4)	V97U4811C	PCT	I	S	M	C	G4.1	00	A1N	92227	
THRT_FAC	V99U7564C	PCT*(FT/SEC)/SEC	F	S	D	C	G4.1	00	A1T	92243A	
THRT_FACL	V99U7565C	PCT*(FT/SEC)/SEC	F	S	D	C	G4.1	00	A1T	92243A	
TREF_ADJUST	V99U7566C	SEC	F	S	M	C	G4.1	00	A1N	92227	
T_CNS_PITCH_RATE	V97U0784C	SEC	F	S	D	C	G4.1	00	A1S	92740D	
T_RMP_F	V99U9872C	SEC	F	S	M	P	G4.1	00	A1C	DC0829	
T_RMP_I	V99U9871C	SEC	F	S	M	P	G4.1	00	A1C	DC0829	
VRAMP	V99U9868C	FT/SEC	F	S	M	P	G4.1	00	A1C	DC0829	
VREF_ADJUST	V99U7567C	FT/SEC	F	S	D	C	G4.1	00	A1T	92243A	
VREL_GAIN_TAB(03)	V97U2287C	FT/SEC	F	S	D	C	G4.1	00	ADG	DC2593	
VREL_GAIN_TAB(04)	V97U2288C	FT/SEC	F	S	D	C	G4.176	00	ADG	DC2593	
V_ALPHA_TO	V99U9870C	FT/SEC	F	S	M	P	G4.1	00	A1C	DC0829	
V_AZ_START	V97U0795C	FT/SEC	F	S	D	C	G4.1	00	PSI	92670D	
V_AZ_STOP	V97U0796C	FT/SEC	F	S	D	C	G4.1	00	PSI	92670D	

TABLE 4.2.5-3. ASCENT FIRST STAGE GUIDANCE (G4.1) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
V_EO_PSI	V97U0788C	FT/SEC	F	S	D	C	G4.1	00	PSI	92670D	
V_EO_SW	V99U7542C	FT/SEC	F	S	M	C	G4.1	00	A1P	DC2726	
V_KMAX_DOWN	V97U0603C	FT/SEC	F	S	M	C	G4.1	00	ATV	92232B	
							G4.2				
							G4.4				
V_KMAX_UP	V97U0604C	FT/SEC	F	S	M	C	G4.1	00	ATV	92232B	
							G4.2				
							G4.4				
V_MULT_EO	V99U9802C	FT/SEC	F	S	M	P	G4.1	00	A1C	DC0829	
V_PSI_CNST	V97U0619C	FT/SEC	F	S	D	C	G4.1	00	PSJ	92670D	
V_PSI_RAMP1	V97U0617C	FT/SEC	F	S	D	C	G4.1	00	PSJ	92670D	
V_PSI_RAMP2	V97U0618C	FT/SEC	F	S	D	C	G4.1	00	PSJ	92670D	
V_PSI_SW	V97U0620C	FT/SEC	F	S	D	C	G4.1	00	PSI	92670D	
V_PYR_SW	V97U4821C	FT/SEC	F	S	M	C	G4.1	00	A1P	DC2726	
V_RAMP_MAX	V99U9869C	FT/SEC	F	S	M	P	G4.1	00	A1C	DC0829	
V_THET_LIM	V97U0785C	FT/SEC	F	S	D	C	G4.1	00	A1P	92670D	
WNDE_TAB(1)	V99U6349C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(2)	V99U6350C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(3)	V99U6351C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(4)	V99U6352C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(5)	V99U6353C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(6)	V99U6354C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(7)	V99U6355C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDE_TAB(8)	V99U6356C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(1)	V99U6357C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(2)	V99U6358C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(3)	V99U6359C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(4)	V99U6360C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(5)	V99U6361C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(6)	V99U6362C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(7)	V99U6363C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	
WNDN_TAB(8)	V99U6364C	FT/SEC	F	S	M	C	G4.1	00	A1N	DC2726	

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

TABLE 4.2.5-4. ASCENT FIRST STAGE GUIDANCE (G4.1) 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 4.2.5-5. ASCENT FIRST STAGE GUIDANCE (G4.1) 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.

4.3 SECOND-STAGE REQUIREMENTS (MM 103)

Principal function AS 2STG GUID (CPDS, Level B, principal function 4.2). Execution of this principal function requires the general guidance and targeting tasks PFG-Input (Section 4.8.8), G-Limiting (Section 4.8.3), MPS Guidance Cutoff (Section 4.8.5), SSME-Out Safing (Section 4.8.9), Powered Explicit Guidance (Section 4.8.1), Acceleration-Mass Update (Section 4.8.2), Thrust Parameters (Section 4.8.7), and RTLS/TAL Target Selection (4.8.11).

The second-stage major mode begins at the separation command of the SRB's from the SRB/orbiter/external tank (ET) vehicle configuration and normally terminates after separation of the ET from the orbiter/ET configuration as either an automatic transition upon completion of the -Z translation maneuver (Event 35) or a crew-initiated transition (PRO) to the OMS-1 insertion MM 104 (Figure 4.3-1). The trajectory conditions at which ET separation occurs are chosen preflight to allow the ET to impact the earth on a free-fall trajectory while sufficient orbital propellant is provided to allow the OMS engines to insert the Orbiter into orbit. If an RTLS abort is initiated during this major mode, the second-stage MM 103 will be terminated, and transition to abort MM 601 will occur. If an ATO or TAL is selected, no transition occurs. In the event of two SSME failures, $N_{SSME} < 2$ (a contingency abort), the ET low level sensor arm command will be issued by AS 2STG GUID.

The SSME's are used to boost the orbiter/ET vehicle along an ascending powered flight trajectory until the desired trajectory conditions (altitude, velocity, flight path angle, and orbital plane) are achieved. The SSME thrust is then terminated by the SSME OPS principal function using a desired cutoff time supplied by the ascent second-stage guidance principal function.

The second-stage major mode is characterized by two flight phases. The powered flight phase begins at SRB separation command (Event 28) and terminates at MECO confirmed (Event 33). The coasting flight phase begins at Event 33 and terminates at transition to MM 104 (Event 36).

The mission-shaping techniques used for abort-critical missions, those in which a gap would normally occur between latest RTLS capability and earliest AOA capability, may require that the ATO MECO target set and the SSME full power level be used until the abort gap is eliminated. From the RTLS/AOA mode boundary until MECO, the nominal mission MECO target set and the SSME rated power level are used, unless a transatlantic abort landing (TAL) has been selected. If a TAL is in progress, TAL targets override the nominal targets.

The minimum "droop" altitude the vehicle would reach during single engine flight is predicted during second stage. This prediction is used to define the early press to TAL boundary; below a given critical altitude, a contingency abort must be performed. This critical minimum altitude is defined primarily by External Tank heating constraints. In the event of a significant performance loss, the vehicle may initially be targeted to remain above this critical altitude.

Prior to MECO, the thrust acceleration will normally reach 3 g's. The time at which this occurs is variable and depends upon thrust performance and vehicle weight. After a 3-g acceleration is achieved, the SSME's are throttled to maintain the average acceleration at 3 g's until a few seconds prior to MECO, at which time the SSME's will be throttled to minimum thrust for cutoff preparation. For one or two SSME failure TAL aborts the acceleration limit can be less than 3 g's, and depends on the number of remaining active SSME's. The lower acceleration limit for TAL aborts improves TAL performance by lengthening the powered flight phase and reducing the downrange distance from the landing site at MECO.

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During the second stage, an ATO may be initiated by the crew by setting the abort-mode rotary switch to the ATO position and pressing the ABORT pushbutton. Selecting ATO will cause the guidance to interrogate the AOA/ATO targeting logic, which may change the desired MECO targets to the appropriate abort MECO targets. If an SSME failed in first stage prior to the first stage engine-out yaw steering end velocity (V_AZ_STOP) the MECO target orbit insertion plane is set to the current inertial plane at Second Stage Guidance Initialization. This planar target is maintained until abort selection resets the second stage MECO targets. Freezing the target plane under these conditions prevents large attitude transients when second stage steering begins.

If an SSME failure occurs during second-stage ascent, the two remaining SSME's are set to the maximum allowable power level to obtain maximum performance, unless manual throttling or fine countdown is being performed. This maximum allowable throttle level is either a function of abort mode regions defined by velocity switch breakpoints, or is a function of crew display selection.

To increase mission manifesting and design flexibility closer to launch when required, the second stage inertial velocity and inertial flightpath angle pseudo targets can be updated via pre-mission uplink.

The ascent second-stage guidance principal function will be initiated at Event 28A (Second Stage Guidance Activation) and will be terminated at Event 33 (MECO Confirmed) or Event A30E (Powered RTLS Guidance Activation When An RTLS Abort Is Declared In MM 103) or Event 28B (Powered Contingency Abort Request During MM 103). The tasks to be performed by the ascent second-stage guidance principal function are:

1. PFG input task (PFG INP TSK)
2. KMAX override update task (KMAX UPDT TSK)
3. Acceleration-mass update task (ACC-MASS UPD TSK)
4. ET low-level sensor arm command task (ET LLS ARM TSK)
5. Single engine MECO preparation task (SE MECO PREP TSK)
6. TVC retrim task (TVC RT TSK)
7. G-limiting task (G-LIM TSK)
8. SSME-out safing task (SSME-OUT SAF TSK)
9. Guidance parameter reinitialization task (GUID PRMT RINT TSK)
10. RTLS/TAL target selection task (RTLS/TAL TGT SEL TSK)
11. Second-stage ascent guidance task (ASC GUID TSK)
12. MPS guidance cutoff task (MPS GUID C/O TSK)
13. MECO time display task (T MECO DISP TSK)
14. MECO preparation task (MECO PREP TSK)

Figures 4.3–2, 4.3–3, and 4.3–4 illustrate the ascent second–stage guidance task organization, functional flow, and data flow for the MM 103. The principal function interfaces are given in Section 4.3.4.

During manual guidance, the G/C STEER principal function ignores automatic guidance inputs and accepts manual inputs. During manual throttling, the manual throttle command replaces the auto command and auto throttling is inhibited.

Certain I–loads supporting this principal function are required to be in contiguous areas of memory in a specific sequence. Section 4.11 describes this requirement.

4.3.1 Second-Stage Guidance Sequencing (2STG SEQ)

Several tasks that support the ascent second-stage guidance must be performed periodically, or on specific events identified in the CPDS, Level B GN&C, Volume V, Book 1. These tasks are as follows:

1. PFG input task (PFG INP TSK)
2. KMAX override update task (KMAX UPDT TSK)
3. Acceleration-mass update task (ACC-MASS UPD TSK)
4. ET low-level sensor arm command task (ET LLS ARM TSK)
5. Single engine MECO preparation task (SE MECO PREP TSK)
6. TVC retrim task (TVC RT TSK)
7. G-limiting task (G-LIM TSK)
8. SSME-out safing task (SSME-OUT SAF TSK)
9. Guidance parameters reinitialization task (GUID PRMT RINT TSK)
10. RTLS/TAL target selection task (RTLS/TAL TGT SEL TSK)
11. Ascent guidance task (ASC GUID TSK)
12. MPS guidance cutoff task (MPS GUID C/O TSK)
13. MECO time display task (T MECO DISP TSK)
14. MECO preparation task (MECO PREP TSK)

A. Detailed Requirements.

- Task 1. The PFG input task must be performed repetitively from Event 28A until the SSME cutoff confirmation (Event 33). The detailed requirements for this task are given in Section 4.8.8.
- Task 2. The KMAX override update task (Section 4.8.13) is performed on demand from Event 28A to the SSME cutoff confirmation (Event 33) when either item 4, 50, or 51 is entered on the Override Display (SPEC 51). The detailed requirements for this task are given in Section 4.8.13.
- Task 3. The acceleration-mass update task must be performed repetitively from Event 28A until MECO confirmed (Event 33). The detailed requirements of this task are given in Section 4.8.2.
- Task 4. The ET low-level sensor arm command task must be performed during the guidance cycle in which current mass (M) first becomes less than a premission load or uplinked value (MASS_LOW_LEVEL) or in the event of two SSME failures ($N_{SSME} < 2$). The

requirement of this task is to send the ET low-level sensor arm command (Event 30) discrete (S_LOW_LEVEL) to the SSME OPS.

- Task 5. The single engine MECO preparation task must be performed once between Event 28A and Event 31 (S_MECO = ON) when the following condition occurs:

(N_SSME = 1 or CONT_SERC = ON) and guidance mass (M) is less than $MASS_LOW_LEVEL - (2MDOT_OMS (T1-ASSIST_OMS_DT))$ and S_MAN_THROT is off.

The detailed requirement is to set the throttle command (K_CMD) equal to I-Load (KMIN) and set the discrete SE_MECO_PREP_K to ON.

- Task 6. The TVC retrim task must be performed during the guidance cycle in which current mass (M) first becomes less than a premission load (MASS_SSME_TRIM), during second stage, or less than TAL_MASS_SSME_TRIM during a TAL abort (TAL_ABORT_DECLARED = ON). The requirement of this task is to send the FCS TVC retrim discrete (S_SSME_TRIM) to the ASC DAP. The TVC retrim task shall not be performed if the MECO time flag is set (S_TMECO = ON).

- Task 7. The g-limiting task must be performed repetitively from Event 28A until the SSME's are commanded to K_CO in preparation for MECO or to Event 33 during manual throttling. The detailed requirements for this task are given in Section 4.8.3.

- Task 8. The SSME-out safing task must be performed during the first guidance cycle after an SSME-out occurs (SSME_FAIL = ON) from Event 28A until the discrete S_MECO is set to ON (Event 31). The detailed requirements for this task are given in Section 4.8.9.

- Task 9. The guidance parameter reinitialization task must be performed between Event 28A and Event 31 when the following condition occurs:

During the guidance cycle in which the navigation time (T_NAV) first becomes greater than or equal to the RTLS/AOA mode boundary time ($T_RTLS_AOA + T_GMTLO$), if AOA/ATO targeting has not been executed (S_ABORT_CONTROL = OFF) and a TAL has not been selected (TAL_ABORT_DECLARED = OFF). The detailed requirements of this task are given in Section 4.3.2.

- Task 10. The RTLS/TAL target selection task must be performed on the first guidance pass after a TAL abort has been declared (TAL_ABORT_DECLARED = ON) and then repetitively until fine countdown (S_MECO = ON). The detailed requirements of this task are given in Section 4.8.11.

- Task 11. The ascent guidance task must be performed repetitively from Event 28A until Event 31. The detailed requirements of this task are given in Section 4.3.3.

- Task 12. The MPS guidance cutoff task must be performed from Event 31 until the SSME cutoff time discrete (S_TMECO) has been set (internal to this task) or to Event 33 during manual throttling. The detailed requirements for this task are given in Section 4.8.5.

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Task 13. The MECO time display task must be performed repetitively from Event 28A until S_TṀECO has been set or to Event 33 during manual throttling. The detailed requirement for this task is to compute the predicted mission elapsed time of MECO as follows:

$$TMET_MECO = T_NAV + TGO - T_GMTLO$$

Task 14. The MECO PREP TASK must be performed from Event 28A until the MECO preparation discrete (GUID_MECO_PREP_FLAG) is set. The detailed requirement for this task is to set the discrete (GUID_MECO_PREP_FLAG) when the time to MECO (TGO) is less than ABORT_MECO_PREP_TIME.

B. Interface Requirements.

The input and output parameters for second-stage guidance task sequencing are given in Tables 4.3.1-1 and 4.3.1-2.

C. Processing Requirements.

The recommended execution rates for each task are given as follows:

- Task 1: 1.92 seconds from Event 28A until Event 31, 0.32 second from Event 31 until Event 33
- Task 2: Prior to fine count down, one time only within 1.92 seconds of the event for each item entry event; thereafter, within 0.32 second.
- Task 3: 1.92 seconds from Event 28A until Event 31, 0.32 second from Event 31 until Event 33
- Task 4: One time only within 1.92 seconds of event
- Task 5: One time only within 1.92 seconds of event from Event 28A to Event 31
- Task 6: One time only within 1.92 seconds of event
- Task 7: 1.92 seconds from Event 28A until Event 31, 0.32 second from Event 31 until the SSME's are commanded to K_CO or during manual throttling until Event 33
- Task 8: Each time within 1.92 seconds of event
- Task 9: One time only within 1.92 seconds of event
- Task 10: Every 1.92 seconds from first guidance pass after TAL abort has been declared until S_ṀECO is set ON
- Task 11: 1.92 seconds from Event 28A until Event 31
- Task 12: 0.32 second from Event 31 until S_TṀECO is set or during manual throttling to Event 33
- Task 13: 1.92 seconds from Event 28A until Event 31, 0.32 second from Event 31 until S_TṀECO is set or during manual throttling to Event 33
- Task 14: 1.92 seconds from Event 28A until GUID_ṀECO_PREP_FLAG is set

The execution of these tasks should occur in the order in which they are listed.

D. Initialization Requirements. The following variables must be initialized upon transition to OPS 101.

$S_{\dot{L}}LOW_LEVEL = OFF$

$S_{\dot{S}}SME_TRIM = OFF$

$G_{\dot{U}}ID_MECO_PREP_FLAG = OFF$

$SE_{\dot{M}}ECHO_PREP_K = OFF$

On the first pass of second stage guidance the throttle command will be set to the second stage throttle I-Load when ever manual throttling is not engaged and an engine failure has not occurred. This must be done before the estimate of thrust (FT) and exhaust velocity (VEX) are calculated for PEG and the execution of the SSME Safing Task.

if $S_{\dot{M}}AN_THROT = OFF$ and $N_{\dot{S}}SME = 3$; then

$K_CMD = K_CMD_STG2$

E. Supplemental Information. Operationally, the ability to change KMAX after Fine Countdown (Event 31) prior to MECO Confirmed (Event 33) is acceptable since no procedures or trajectory design criteria exist that would require a change in KMAX after Fine Countdown (reference DR 109232).

Table 4.3.1-1. Second-Stage Guidance Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Fine countdown discrete	S_MECO	ASC GUID TSK	D	N/A
Time tag associated with current state	T_NAV	ASC UPP	DP	sec
Mission elapsed time defining RTLS/AOA mode boundary	T_RTLS_AOA	I-LOAD	SP	sec
Value of mass for enabling MPS low-level sensing	MASS_LOW_LEVEL	I-LOAD, UPLINK	SP	slugs
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Value of mass for TVC retrim	MASS_SSME_TRIM	I-LOAD	SP	slugs
Time-to-go	TGO	PEG TSK, MPS GUID C/O TSK	SP	sec
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Discrete to indicate pre-MECO throttle-down complete	S_KCO	MPS GUID C/O TSK	D	N/A
Cont single eng roll cntl flag	CONT_SERC	ASC DAP XXXXXX TRAJ 1 DISP XXXXXX TRAJ 2 DISP	D	N/A
TGO for MECO preparation	ABORT_MECO_PREP_TIME	K-LOAD	SP	sec
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Discrete to indicate that pre-MECO/ATO targeting is completed	S_ABORT_CONTROL	ATO OMS PRE-MECO BRN DET TSK	D	N/A
Discrete to indicate that a TAL abort is in progress	TAL_ABORT_DECLARED	MSC	D	N/A
TVC retrim mass for a TAL abort	TAL_MASS_SSME_TRIM	I-LOAD	SP	slugs
Discrete indicating T_MECO has been set	S_TMECO	MPS GUID C/O TSK	D	N/A
Main engine failure flag	SSME_FAIL	PFG INP TSK, SSME-OUT SAF TSK	D	N/A
Second Stage Nominal Throttle Setting	K_CMD_STG2	I-LOAD	I	pct
Minimum throttle setting for SSME	KMIN	I-Load	I	pct
OMS mass flow rate	MDOT_OMS	K-Load	SP	slugs/sec
OMS equivalent on time	T1	ABT CNTL SEQ	SP	sec
OMS assist timer	ASSIST_OMS_DT	I-Load, Uplink	SP	sec

Table 4.3.1-2. Second-Stage Guidance Sequencing Outputs

Definition	Symbol	Destination	Prec	Units
ET level sensor arm CMD	S_ĠLOW_LEVEL	SSME OPS, TLM	D	N/A
FCS TVC retrim discrete	S_ĠSME_TRIM	ASC DAP, TLM	D	N/A
Predicted SSME C/O time in MET	TMET_MECO	XXXXXX TRAJ 2 DISP, TLM	SP	sec
MECO preparation discrete	GUID_MECO_PREP_FLAG	ABT CNTL SEQ	D	N/A
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, MPS GUID C/O TSK G-LIM TSK, SSME-OUT SAF TSK, TLM, SBTC SOP, PEG TSK, DRP CTL TSK, FUL DISS TSK, XXXXXX TRAJ 2 DISP	I	pct
Single engine MECO prep throttle discrete	SE_ĠMECO_PREP_K	SSME-OUT SAF TSK, GUID PRMT RINT TSK, G-LIM TSK	D	N/A

4.3.2 Second-Stage Guidance Parameter Reinitialization Task (GUID PRMT RINT TSK)

The subtasks to be performed for the guidance parameter reinitialization tasks are:

1. Reinitialize the MECO targets for the guidance calculations.
2. Reset the SSME throttle command.
3. Reset the number of PEG thrust phases for optimum nominal ascent guidance and reset the guidance phase counter.
4. Compute the unit vector normal to the desired trajectory plane for nominal second stage.

A. Detailed Requirements.

1. Replace the previous abort main engine cutoff targets with the actual mission MECO targets.

$$\text{RDMAG} = \text{RD_NOM}$$

$$\text{VDMAG} = \text{VD_NOM}$$

$$\text{GAMD} = \text{GAMD_NOM}$$

2. Set the SSME throttle command to K_CMD_MODE_BNDRY , provided that an SSME failure has not occurred previously ($\text{N_SSME} = 3$), SE_MECO_PREP_K is OFF, and manual throttling is not being performed ($\text{S_MAN_THROT} = \text{OFF}$).

$$\text{K_CMD} = \text{K_CMD_MODE_BNDRY}$$

3. Set the number of thrust phases in PEG to two: $\text{N} = 2$ and set the guidance phase counter to one: $\text{KPHASE} = 1$.
4. If the plane constraint is earth-fixed ($\text{EF_PLANE_SW} = \text{ON}$), compute the unit vector normal to the desired trajectory plane, $\bar{\text{IY}}$, by converting $\bar{\text{IYD_NOM}}$ from earth-fixed to M50 coordinates.

$$\bar{\text{IY}} = \text{EARTH_FIXED_TO_M50_COORD}(\text{T_GMTLO}) \bar{\text{IYD_NOM}},$$

Otherwise, compute $\bar{\text{IY}}$ by rotating $\bar{\text{IYD_NOM}}$ to adjust for nodal regression.

$$\bar{\text{IY}} = \text{M_NODE_ADJ}^* \bar{\text{IYD_NOM}}$$

B. Interface Requirements. The input and output parameters and functional interfaces for the guidance parameter reinitialization task are given in Tables 4.3.2-1 and 4.3.2-2.

C. Processing Requirements. None.

D. Initialization Requirements. Prior to the earliest time of AOA capability, guidance targets and throttle setting are specified by preflight load.

E. Supplemental Information. Prior to execution of this task (if manual throttling has not been performed), K_CMD has the last value set in first-stage guidance, either THROT₄ (nominal) or KMAX (one SSME out).

Table 4.3.2-1. Second-Stage Guidance Parameter Reinitialization Task Inputs				
Definition	Symbol	Destination	Prec	Units
Nominal ascent terminal flightpath angle constraint	GAMD_NOM	I-LOAD	SP	rad
Nominal ascent terminal radial constraint	RD_NOM	I-LOAD	DP	ft
Desired inertial velocity magnitude at nominal MECO	VD_NOM	I-LOAD	SP	fps
Nominal SSME throttle setting after RTLS/AOA mode boundary	K_CMD_MODE_BNDRY	I-LOAD, 1STG GUID INP TSK, ASC GUID TSK	I	pct
Manual throttle discrete	S _{MAN} THROT	SBTC SOP	D	N/A
Single engine MECO prep throttle discrete	SE _{MECO} PREP_K	SE MECO PREP TSK	D	N/A
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Nominal second-stage unit vector normal to desired trajectory plane in earth-fixed or M50 coordinates	$\bar{I}YD_NOM$	I-LOAD	DP	ND
Earth-fixed plane switch	E \dot{F} _PLANE_SW	I-LOAD	D	N/A
Node adjustment matrix	\dot{M} _NODE_ADJ	ASC UPP	DP	ND
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A

Table 4.3.2-2. Second-Stage Guidance Parameter Reinitialization Task Outputs				
Definition	Symbol	Destination	Prec	Units
Desired MECO flightpath angle	GAMD	PEG TSK	SP	rad
Desired MECO radius	RDMAG	PEG TSK	DP	ft
Desired MECO velocity	VDMAG	PEG TSK, MPS GUID C/O TSK, TLM, AOA ONORB TGT SEL TSK, XXXXXX TRAJ DIP	SP	fps
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, MPS GUID C/O TSK, G-LIM TSK, SSME- OUT SAF TSK, TLM, SBTC SOP, PEG TSK, FUL DISS TSK, DRP CTL TSK, XXXXXX TRAJ 2 DISP	I	pct
Unit vector normal to desired trajectory plane in M50 coordinates	$\bar{I}Y$	PEG TSK, AOA ONORB TGT SEL TSK	DP	ND
Number of thrust phases	N	PEG TSK	I	ND
Guidance phase counter	KPHASE	PEG TSK	I	ND

4.3.3 Second-Stage Ascent Guidance Task (ASC GUID TSK)

The following subtasks are necessary to support the ascent guidance calculation:

1. Obtain an estimate of acceleration and exhaust velocity.
2. Execute the powered explicit guidance (PEG) calculations and ensure convergence.
3. Command desired vehicle roll angle.
4. Set the fine countdown discrete (Event 31).

A. Detailed Requirements. On each cycle during which one of the three mutually exclusive display throttle level commands is actuated ($\dot{N}OM_THROT_CMD = ON$ and $\dot{N}OM_CMD_PREV = OFF$) or ($\dot{A}BT_THROT_CMD = ON$ and $\dot{A}BT_CMD_PREV = OFF$) or ($\dot{M}AX_THROT_CMD = ON$ and $\dot{M}AX_CMD_PREV = OFF$), the following must occur:

- (1) $K_CMD_MODE_BNDRY = KMAX$
- (2) If manual throttling is not being performed ($\dot{S}_MAN_THROT = OFF$), and the g-limiting task has not been executed ($\dot{S}_GLIMIT = OFF$), then execute the following:

$$K_CMD = KMAX$$

Set the previous throttle command indicators to the current values.

$$\dot{N}OM_CMD_PREV = \dot{N}OM_THROT_CMD$$

$$\dot{A}BT_CMD_PREV = \dot{A}BT_THROT_CMD$$

$$\dot{M}AX_CMD_PREV = \dot{M}AX_THROT_CMD$$

Estimates of acceleration and exhaust velocity are computed for use in the PEG calculations. The thrust parameters task (which was previously called by the acceleration–mass update task) is reexecuted to obtain estimates of thrust (FT) and exhaust velocity (VEX) based on the current throttle command (K_CMD). Acceleration is then computed as follows:

$$ATR = FT_FACTOR FT/M$$

The ascent guidance task must execute the PEG calculations (Section 4.8.1) until the PEG is either converged, or the number of cycles has reached the maximum allowed each guidance computation cycle. The convergence criterion is determined internal to the PEG task.

If the guidance ready flag has been set ($\dot{S}_GDRDY = ON$), then the Droop Control task (DRP_CTL_TSK, 4.3.4) must be executed to predict the single engine minimum droop altitude and, if necessary, target to remain above a given minimum altitude.

In addition, the ascent guidance task must specify the commanded roll angle input to G/C STEER. When the magnitude of vehicle relative velocity (V_RHO_MAG) first exceeds V_RHO_PHI and $TAL_ABORT_DECLARED = OFF$, the commanded roll angle is set as

$$\text{PHI_CMD} = \text{PHI_2STG}$$

If $\dot{\text{T}}\text{AL_ABORT_DECLARED} = \text{ON}$ and $\text{V_RHO_MAG} > \text{V_RHO_TAL}$, and $\text{S_}\dot{\text{T}}\text{AL_ROLL_INH} = \text{OFF}$, then $\text{PHI_CMD} = 0$.

The ascent guidance task commands a throttle down to KMIN ($\text{K_CMD} = \text{KMIN}$) and sets a flag ($\text{S_}\dot{\text{G}}\text{IMB_RELIEF} = \text{ON}$) if (1) through (4) below are all true, or if (1) and (5) below are both true:

- (1) $\text{S_}\dot{\text{M}}\text{AN_THROT} = \text{OFF}$
- (2) $\text{M} < \text{M_}\dot{\text{G}}\text{IMB_RELIEF}$
- (3) $\text{S_}\dot{\text{E}}\text{O_E1} = \text{ON}$
- (4) ($\text{DYC2} > \text{DYC_}\dot{\text{G}}\text{IMB_RELIEF}$ or $\text{DYC3_}\dot{\text{G}}\text{IMB_RELIEF}$)
- (5) $\text{S_}\dot{\text{G}}\text{IMB_RELIEF} = \text{ON}$

The above throttle down is performed to provide pitch gimbal relief by reducing the deformation of the thrust structure

The ascent guidance task must monitor time-to-go for the purpose of initiating the MPS guidance cutoff calculations before thrust termination. This shall be accomplished by comparing the time-to-go (TGO) computed by the PEG equations with an input (TGO_FCD) for initiating the MPS guidance cutoff calculations. If manual guidance is active ($\text{A}\dot{\text{U}}\text{T} = \text{OFF}$), TGO is compared with a different I-load parameter (TGO_MAN). Whenever TGO becomes less than or equal to TGO_FCD or less than or equal to TGO_MAN during manual guidance, a discrete ($\text{S_}\dot{\text{M}}\text{E}(\text{CO})$) is set that terminates the ascent guidance task and initiates the MPS guidance cutoff task, Event 31.

B. Interface Requirements. The input and output parameters for the ascent guidance task are given in Tables 4.3.3-1 and 4.3.3-2.

C. Processing Requirements. The thrust parameters task must be executed once in each guidance interval prior to executing PEG. The subtask to determine initiation of MPS guidance cutoff task should follow the execution of PEG.

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters:

$$\text{SMODE} = 1$$

$$\text{S_}\dot{\text{G}}\text{DRDY} = \text{OFF}$$

$$\text{S_}\dot{\text{I}}\text{NIT} = \text{ON (PEG INITIALIZATION FLAG)}$$

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

$$\text{P}\dot{\text{E}}\text{G_STEERING_UPD} = \text{OFF}$$

$$\text{S_}\dot{\text{G}}\text{IMB_RELIEF} = \text{OFF}$$

Table 4.3.3-1. Second-Stage Ascent Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Maximum number of PEG iterations	N_MAX	K-LOAD	I	N/A
Discrete indicating convergence	S \dot{C} ONV	PEG TSK	D	N/A
Time-to-go	TGO	PEG TSK	SP	sec
Value of TGO to initiate fine countdown for second stage	TGO_FCD	I-LOAD	SP	sec
Total vehicle thrust force	FT	THRST PRM TSK	SP	lbs
Thrust scaling factor	FT_FACTOR	ACC-MASS UPD TSK, SSME-OUT SAF TSK	SP	ND
Current vehicle MASS	M	ACC-MASS UPD TSK	SP	slugs
Commanded roll angle	PHI_CMD	K-LOAD	SP	rad
Desired roll command for second stage	PHI_2STG	I-LOAD	SP	rad
Magnitude of vehicle relative velocity	V_RHO_MAG	ASC UPP	SP	fps
Switch velocity for roll command	V_RHO_PHI	I-LOAD	SP	fps
Value of TGO to initiate fine countdown during manual guidance	TGO_MAN	I-LOAD	SP	sec
Auto guidance discrete	A \dot{U} T0	ASC DAP	D	N/A
Maximum throttle level command	M \dot{A} X_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	ABT \dot{T} HROT_CMD	OVERRIDE DISPLAY	D	N/A
Nominal throttle level command	NOM \dot{T} HROT_CMD	OVERRIDE DISPLAY	D	N/A
G Limit discrete	S \dot{G} LIMIT	G-LIM TSK	D	N/A
Manual throttle discrete	S \dot{M} AN_THROT	SBTC SOP	D	N/A
Discrete to indicate that a TAL abort is in progress	T \dot{A} L_ABORT_DECLARED	MSC	D	N/A
TAL switch velocity for roll command	V_RHO_TAL	I-LOAD	SP	ft/s
TAL rollover inhibit discrete	S \dot{T} AL_ROLL_INH	RTLS/TAL TGT SEL TSK	D	N/A
Guidance ready flag	S \dot{G} DRDY	PEG TSK	D	N/A
MPS E1 engine-out flag	S \dot{E} O_E1	SSME OPS	D	N/A
SSME 2 pitch gimbal cmd	DYC2	ASC DAP	SP	deg
SSME 3 pitch gimbal cmd	DYC3	ASC DAP	SP	deg
Pitch gimbal threshold for gimbal relief throttle logic	DYC_GIMB_RELIEF	I-LOAD	SP	deg
Mass threshold for gimbal relief throttle logic	M_GIMB_RELIEF	I-LOAD	SP	slugs
Minimum throttle setting of SSME	KMIN	I-LOAD	I	pct
Previous value of nominal throttle level command	N \dot{O} M_CMD_PREV	1STG GUID INP TSK	D	N/A
Previous value of abort throttle level command	A \dot{B} T_CMD_PREV	1STG GUID INP TSK	D	N/A

Table 4.3.3-1. Second-Stage Ascent Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Previous value of maximum throttle level command	M \dot{A} X_CMD_PREV	1STG GUID INP TSK	D	N/A
Maximum throttle setting for SSME	KMAX	KMAX UPDT TSK, SSME-OUT SAF TSK, I-LOAD	I	pct

Table 4.3.3-2. Second-Stage Ascent Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
Fine countdown discrete (Event 31)	S_MECO	2STG SEQ, MSC, ASC UPP SEQ, ACC-MASS UPD TSK, TLM, AOA/ATO TGT SEQ, PW RTLS SEQ, XXXXXX TRAJ 2 DISP	D	N/A
PEG initialization discrete	S \dot{I} NIT	PEG TSK	D	N/A
PEG maneuver mode flag	SMODE	PEG TSK, CONT MODE SEL TSK, CONT LVLH TSK, CONT 3EO MODE SEL TASK	I	N/A
Steering enable flag	S \dot{S} TEER	PEG TSK	D	N/A
Thrust acceleration estimate input to PEG	ATR	PEG TSK	SP	fps ²
Commanded roll angle	PHI_CMD	G/C STEER	SP	rad
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, FLYBK TSK, FUL DISS TSK, G-LIM TSK, SSME-OUT SAF TSK, SBTC SOP, PEG TSK, DRP CTL TSK, XXXXXX TRAJ 2 DISP	I	pct
Nominal SSME throttle setting after RTLS/AOA mode boundary	K_CMD_MODE_BNDRY	GUID PRMT RINT TSK	I	pct
PEG steering updated flag	P \dot{E} G_STEERING_UPD	MSC	D	N/A
Gimbal relief throttle down flag	S_G \dot{I} MB_RELIEF	MPS GUID C/O TSK	D	N/A
Previous value of nominal throttle level command	N \dot{O} M_CMD_PREV	FUL DISS TSK	D	N/A
Previous value of abort throttle level command	A \dot{B} T_CMD_PREV	FUL DISS TSK	D	N/A

Table 4.3.3-2. Second-Stage Ascent Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
Previous value of maximum throttle level command	M \dot{A} X_CMD_PREV	FUL DISS TSK	D	N/A

4.3.4 Second Stage Droop Control Task (DRP CTL TSK)

The Droop Control Task is executed during second stage to continuously predict the minimum droop altitude assuming single engine flight. If the predicted altitude, PRED_DROOP_ALT, is above the minimum droop altitude, MIN_DROOP_ALT, a press to TAL may be considered. This prediction is made available for display to the crew. In the event of a significant performance loss such as an engine failure, this task will re-compute the PEG output steering parameters if necessary to keep the vehicle above the critical target altitude. The minimum droop altitude target is defined primarily by External Tank heating constraints, and is an I-Load to this task.

A. Detailed Requirements. This task is divided into six subtasks. The first five are executed in the order given. The sixth is executed as required by subtasks 2 and 4.

If FT_S is less than 260,000 lb, the droop control task must be exited without any action.

1. State Parameters Subtask. This subtask determines the various state parameters and engine performance parameters required by the Droop Predictor Subtask (subtask 6). This subtask is only executed if the minimum altitude reached indicator (S_MIN_ALT) has not been set.
 - a. Calculate the magnitude of the position vector (RINIT), the local horizontal and vertical unit vectors, the PEG commanded thrust attitude, and the horizontal and vertical components of velocity:

$$RINIT = ABVAL (\overline{RGD})$$

$$\overline{IX_DRP} = \overline{RGD} / RINIT$$

The unit vector normal to the commanded thrust plane and the downrange unit vector are calculated as follows:

$$\overline{IY_DRP} = UNIT (\overline{LAM_DRP} \times \overline{IX_DRP})$$

$$\overline{IZ_DRP} = \overline{IX_DRP} \times \overline{IY_DRP}$$

The PEG commanded thrust direction is:

$$\overline{PEG_CMD} = UNIT (\overline{LAM_DRP} + (TGD - TLAM_DRP) \overline{LAM_DRP})$$

The LVLH PEG thrust pitch attitude is:

$$PEG_ATT = PI/2 - ARCCOS (\overline{PEG_CMD} \cdot \overline{IX_DRP})$$

Determine the horizontal, vertical, and out-of-plane components of the velocity.

$$VGDIX = \overline{VGD} \cdot \overline{IX_DRP}$$

$$VGDYI = \overline{VGD} \cdot \overline{IY_DRP}$$

$$VGDIZ = \overline{VGD} \cdot \overline{IZ_DRP}$$

- b. Determine the current acceleration due to gravity:

$$GE = EARTH_MU / (RINIT^2)$$

Determine the effective acceleration due to gravity by subtracting the centripetal acceleration from the current gravitational acceleration:

$$GACC = GE - (VGDIY^2 + VGDIZ^2) / RINIT$$

- c. Decrement the time to reach the minimum altitude:

$$TNEW = T1NEW - DTGD$$

- d. If this task is not commanding the droop attitude (if $S_{\dot{C}DROOP} = OFF$), then set the thrust TV_MAX equal to the input sensed thrust, determine the flow rate based on this thrust, and set the thrust attitude to the minimum threshold attitude:

$$\begin{aligned} TV_MAX &= FT_S \\ MDT &= FT_S / VEX \\ THR_ATT &= THRESH_ATT \end{aligned}$$

- e. If this task is commanding the droop attitude (if $S_{\dot{C}DROOP}$ is ON), then the input sensed thrust must be adjusted to account for the OMS dump and then rate limited as follows:

- (1) Initialize the average thrust and exhaust velocity to the input values:

$$\begin{aligned} FTS_AVE &= FT_S \\ VEX_AVE &= VEX \end{aligned}$$

- (2) If an OMS dump is in progress ($N_OMS > 0$), and if $TNEW > 0$, then modify the average exhaust velocity (VEX_AVE) and the average thrust (FTS_AVE) as follows to account for the OMS dump cutoff during the droop trajectory:

$$\begin{aligned} OMS_FT &= N_OMS FT_OMS + N_RCS FT_RCS \\ FTSSO &= FTS_AVE - OMS_FT \\ DUMP_ON_PCT &= MINIMUM (1, TB_OMS/TNEW) \\ DUMP_OFF_PCT &= 1 - DUMP_ON_PCT \end{aligned}$$

$$\begin{aligned} VEX_AVE &= VEX_AVE DUMP_ON_PCT + VEXSO DUMP_OFF_PCT \\ FTS_AVE &= FTS_AVE DUMP_ON_PCT + FTSSO DUMP_OFF_PCT \end{aligned}$$

- (3) Limit the rate of change in sensed thrust. On the first pass through this logic, prevent rate limiting by setting TV_MAX to FTS_AVE.

$$TV_MAX = FTS_AVE$$

Otherwise, if not the first pass, limit the rate of change of thrust to be within the positive rate limit FT_PLIM and the negative rate limit FT_NLIM:

$$RATE = MIDVAL (FT_NLIM, (FTS_AVE - TV_MAX) / DTGD, FT_PLIM)$$

Then apply this rate to calculate TV_MAX:

$$TV_MAX = TV_MAX + RATE\ DTGD + FT_SSME (K_CMD - K_CMD_PREV) 0.01$$

- (4) Calculate the mass flow rate:

$$MDT = TV_MAX / VEX_AVE$$

- f. Calculate approximate time to low level cutoff:

$$TMMAX = (M - MASS_LOW_LEVEL) / MDT$$

- g. Save the current value of K_CMD:

$$K_CMD_PREV = K_CMD$$

- h. Set and latch the local contingency mode 2 indicator:

$$S_MODE_2 = (S_MODE_2 = ON) \text{ or } (CONT_2EO_MODE = 2)$$

2. Control Determination Subtask. This subtask determines the predicted minimum droop altitude for the current thrust attitude, then determines if the minimum altitude has been reached, and if this task should change the vehicle's thrust attitude. This task is only executed if the minimum altitude/droop off indicator (S_MIN_ALT) has not previously been set.

- a. Determine the vertical and horizontal components of the thrust:

$$\begin{aligned} TV_VERT &= TV_MAX \sin(THR_ATT) \\ TV_HORIZ &= TV_MAX \cos(THR_ATT) \end{aligned}$$

- b. Execute the Droop Predictor Subtask (subtask 6). This subtask determines the minimum droop altitude (ROUT) and time to reach that altitude (TNEW) given the vehicle state and engine parameters (the inputs are: M, TV_VERT, TV_HORIZ, GACC, MDT, VGDYI, TMMAX, VGDIX, VGDIZ, RINIT, TNEW, GE, ALT_GD, VMISS_DRP). The Droop Predictor Subtask also outputs a discrete indicating if a solution was found (S_FFOUND), a solution range indicator (S_MIN_RANGE) and the time to go to reach the minimum droop altitude (TNEW).

- c. If a solution was found (S_FFOUND = ON) then:

- (1) Set the time to droop equal to the droop predictor output, and turn off the display flash discrete.

$$\begin{aligned} T1NEW &= TNEW \\ S_DRP_FLASH &= OFF \end{aligned}$$

- (2) If the predicted minimum droop altitude ROUT is less than the target altitude MIN_DROOP_ALT, and the S_MIN_RANGE flag was set, then turn on S_ATT_CMD. Otherwise S_ATT_CMD is turned off. Note S_MIN_RANGE is true when a minimum altitude was found TMMIN. If false, a high performance condition is indicated, and S_ATT_CMD should not be turned on.

$$S_ATT_CMD = (ROUT < MIN_DROOP_ALT) \text{ and} \\ (S_MIN_RANGE = ON)$$

- (3) Determine if the current PEG solution is acceptable for returning control to PEG. The PEG solution must not be elevation limited, must be converged, and the attitude commanded must be less than the droop solution.

$$S_PEG_OK = (S_LOW_TW = OFF) \text{ and } (S_CONV = ON) \\ \text{and } (PEG_ATT < THR_ATT)$$

- (4) S_MIN_ALT is used to determine if the minimum altitude has been reached and if this task should stop commanding the droop thrust altitude. S_MIN_ALT is determined as follows:

$$S_MIN_ALT = (S_CDROOP = ON) \text{ and } [(T1NEW \leq 0) \text{ or} \\ \{ (S_PEG_OK = ON) \text{ and } (ROUT > \\ MIN_DROOP_ALT + ALT_PEG_LOSS T1NEW) \}]$$

- (5) If true, S_CDROOP indicates the steering parameters will be changed by this task. This discrete must be turned on if the minimum altitude/droop off discrete has not yet been set (S_MIN_ALT = OFF), and if either S_ATT_CMD is ON or S_CDROOP is ON, and if the number of active engines is less than DRP_NSSME or the number of active engines is less than 3 and the Droop guidance enable flag (DRP_ENA) is ON:

$$S_CDROOP = (S_MIN_ALT = OFF) \text{ and } \{ (S_ATT_CMD = ON) \text{ or} \\ (S_CDROOP = ON) \} \text{ and } \{ (N_SSME < DRP_NSSME) \text{ or} \\ (N_SSME < 3 \text{ and } DRP_ENA = ON) \}$$

- d. Otherwise, if a solution was not found (S_FOUND = OFF), then turn off S_CDROOP and turn on the display flash discrete S_DRP_FLASH:

$$S_CDROOP = OFF \\ S_DRP_FLASH = ON$$

3. Steering Parameters Subtask. This subtask is performed only if the Command Droop flag (S_ĈDROOP) is ON. This subtask changes the PEG steering parameters as required to reach or remain above the desired altitude:

- a. Turn on S_ĎRP_LATCH to indicate S_ĈDROOP has been turned on:

$$S_{\dot{D}R P_L A T C H} = O N$$

- b. If the predicted altitude is less than the target altitude, then the thrust attitude must be increased:

$$\begin{aligned} & \text{If } (R O U T < M I N_D R O O P_A L T) \text{ then} \\ & \quad T H R_A T T = T H R_A T T + A T T_I N C R \end{aligned}$$

Otherwise, if the predicted altitude is greater than the target plus the altitude deadband, then the thrust attitude must be decreased:

$$\begin{aligned} & \text{If } R O U T > (M I N_D R O O P_A L T + A L T_D B N D) \text{ then} \\ & \quad T H R_A T T = T H R_A T T - A T T_I N C R \end{aligned}$$

Limit THR_ATT to be between the maximum and minimum:

$$T H R_A T T = M I D V A L (T H R_M I N, T H R_A T T, T H R_M A X)$$

- c. This logic determines if this task should output steering commands before the stand-on-tail contingency maneuver region (when S_ĎMODE_2 = OFF). Prior to the stand-on-tail region, this task will maneuver the vehicle only if the droop altitude target can be reached, signaled by the S_ĎRP_EARLY flag. This logic is performed if both S_ĎMODE_2 and S_ĎRP_EARLY are OFF:

$$\text{If } (S_{\dot{M}O D E_2} = O F F) \text{ and } (S_{\dot{D}R P_E A R L Y} = O F F), \text{ then}$$

Set the thrust attitude to the maximum:

$$T H R_A T T = T H R_M A X$$

Then, if the predicted altitude is above the target altitude, turn on the S_ĎRP_EARLY flag and reset the thrust attitude to the minimum:

If (ROUT > MIN_DROOP_ALT), then:

$$\begin{aligned} & S_{\dot{D}R P_E A R L Y} = O N \\ & T H R_A T T = T H R_M I N \end{aligned}$$

- d. Update the steering parameters, turn off the S_ĎUNCONV flag to assure the ADI error needles are unstowed, and if a TAL has been declared, set the S_ĎDROOP_TARGETS flag to reset the TAL MECO targets to their low energy values:

- (1) If (S_ĎRP_EARLY = ON) or (S_ĎMODE_2 = ON), then:

$$\bar{L}A M C = \bar{I}X_{\dot{D}R P} \sin (T H R_A T T) + \bar{I}Z_{\dot{D}R P} \cos (T H R_A T T)$$

$$\overline{L}AMDC = 0$$

$$TLAMC = 0$$

$$\overline{I}ZC = \overline{I}Z_DRP$$

$$S_UNCONV = OFF$$

- (2) If a TAL has been declared, the discrete to switch the PEG MECO targets to the low energy TAL targets is set one time only:

If ($\dot{T}AL_ABORT_DECLARED = ON$) and ($S_DROOP_TARGETS = OFF$), then:

$$S_DROOP_TARGETS = ON$$

- e. If ROUT is less than the droop target altitude (MIN_DROOP_ALT), then turn on the display flash discrete ($S_DRP_FLASH = ON$).
4. Hypothetical Droop Prediction Subtask. This subtask is performed only if S_CDROOP is off and S_MIN_ALT is off. The droop altitude is predicted assuming the remainder of the trajectory will be flown with only one active engine at the current throttle setting K_CMD and the maximum thrust attitude defined by MAXV and MINH.
- a. Determine the vehicle thrust and mass flow assuming only one SSME is burning, then set the other input parameters required by the Droop Predictor Subtask.

$$\begin{aligned} TV_MAX &= FT_SSME K_CMD 0.01 \\ MDT &= MDOT_SSME K_CMD 0.01 \\ TNEW &= T2NEW \\ TMMAX &= (M - MASS_LOW_LEVEL) / MDT \\ TV_VERT &= MAXV TV_MAX \\ TV_HORIZ &= MINH TV_MAX \end{aligned}$$

- b. Execute the Droop Predictor Subtask (subtask 6) to determine the droop altitude (ROUT) and the time to reach it (TNEW).
- c. Reset the hypothetical time to droop:
- $$T2NEW = TNEW$$
5. Display Output Subtask. This subtask outputs the predicted droop altitude and time for display. This task is only executed if the minimum altitude reached indicator (S_MIN_ALT) has not been set.

If S_FOUND is ON, then:

If (S_DRP_LATCH = ON) and (ROUT > MIN_DROOP_ALT), then:

$$\text{PRED_DROOP_ALT} = \text{MAX}(\text{MIN_DROOP_ALT}, (\text{ROUT} - \text{ALT_PEG_LOSS T1NEW}))$$

Otherwise,

$$\text{PRED_DROOP_ALT} = \text{MAX}(\text{ROUT}, 0)$$

Otherwise,

$$\text{PRED_DROOP_ALT} = 0$$

6. Droop Predictor Subtask. The purpose of this subtask is to predict the minimum altitude and the time when it will be reached given a pre-determined thrust, thrust attitude and vehicle state. This subtask is executed as required by the Control Determination Subtask (Subtask 2) and the Hypothetical Droop Prediction Subtask (Subtask 4).

a. Set up the various initial parameters required by the Newton-Raphson loop in part b. below.

(1) First turn off the found discrete (S_FFOUND) and turn on S_MIN_RANGE:

$$\text{S_FFOUND} = \text{OFF}$$

$$\text{S_MIN_RANGE} = \text{ON}$$

(2) The minimum time (TMMIN) is approximated as the time the vertical acceleration first becomes positive:

$$\begin{aligned} \text{TMMIN} &= (M - \text{TV_VERT} / \text{GACC}) / \text{MDT} \\ \text{TMMIN} &= \text{MIDVAL}(0.0, \text{TMMIN}, \text{TMMAX}-10.0) \end{aligned}$$

(3) The constants of the equations of motion that are not time dependent are:

$$\text{XK1} = \text{GACC} - 2 \text{VGDIZ TV_HORIZ} / (\text{RINIT MDT}) - 2 \text{TV_HORIZ}^2 / (\text{RINIT MDT}^2)$$

$$\text{XK3} = \text{TV_HORIZ}^2 \text{M} / (\text{RINIT MDT}^3)$$

$$\text{XK2} = 2 \text{VGDIZ TV_HORIZ M} / (\text{RINIT MDT}^2) + 2 \text{XK3}$$

$$\text{XK4} = (\text{XK2} + \text{XK3}) / 2$$

b. Part b. is a Newton-Raphson iteration loop used to determine the time the minimum altitude will be reached. This loop should be executed until the maximum number of iterations (PASS_MAX) has been reached or until one of the other exit conditions is reached as described below.

(1) The time to reach minimum droop (TNEW) is set up and limited to maximum and minimum values:

$$TNEW = MIDVAL (TMMIN, TNEW, TMMAX)$$

- (2) The time dependent constants and velocity change due to gravity are:

$$TVAL = 1 - MDT TNEW / M$$

$$TVALLN = LOG (TVAL)$$

$$VGRAV = XK1 TNEW - TVAL TVALLN (XK2 - XK3 TVALLN)$$

Where LOG is a functional representation of the natural logarithm of the expression within the parentheses.

- (3) The vertical velocity at time TNEW is:

$$VOUT = VGDIX - (TV_VERT/MDT) TVALLN - VGRAV$$

- (4) If the absolute value of VOUT is within the VMISS_DRP criteria, then a correct solution for the time has been found. S_FFOUND is turned on and the iteration loop is exited. That is:

If (ABS (VOUT) ≤ VMISS_DRP) then

S_FFOUND = ON
exit this loop.

- (5) If the loop was not exited, then determine the new time as follows:

$$AGRAV = GE - (VGDIZ - (TV_HORIZ/MDT) TVALLN)^2 / RINIT - VGDY^2 / RINIT$$

The derivative of VOUT is:

$$VDOT = TV_VERT / (M TVAL) - AGRAV$$

The new time to reach the droop altitude is:

$$TNEXT = TNEW - VOUT/VDOT$$

- (6) If (TNEW = TMMIN) and (TNEXT < TMMIN), then:

S_MIN_RANGE = OFF

S_FFOUND = ON
exit this loop

- (7) Otherwise if (TNEW = TMMAX) and (TNEXT > TMMAX), then:

S_FFOUND = ON
exit this loop

(8) Set $T_{NEW} = T_{NEXT}$ and repeat this loop.

c. Determine the final droop altitude in feet, as follows:

(1) The position change due to gravity (RGRAV) is:

$$XK5 = T_{NEW} - MDT T_{NEW}^2 / (2 M) - M / (2 MDT)$$

$$RGRAV = TVALLN^2 XK3 XK5 - 2 TVALLN XK4 XK5 + XK4 T_{NEW} + (T_{NEW}^2 / 2) (XK1 - MDT XK4 / M)$$

(2) The altitude (ROUT) at time T_{NEW} is:

$$ROUT = ALT_GD + VGDIX T_{NEW} + TV_VERT T_{NEW}/MDT + (M/MDT - T_{NEW}) (TV_VERT/MDT) TVALLN - RGRAV$$

- B. Interface Requirements. The input and output parameters and functional interface for the Second Stage Droop Control Task are given in Tables 4.3.4-1 and 4.3.4-2.
- C. Processing Requirements. This task is divided into six subtasks. The first five are executed in the order given. The sixth, the Droop Predictor Subtask, is executed as required by subtasks 2 and 4.
- D. Initialization Requirements. The following parameters must be initialized as indicated, upon transition to Major Mode 101:

$$T1_{NEW} = 0.0$$

$$T2_{NEW} = 1000.0$$

$$S_{\dot{MIN_ALT}} = OFF$$

$$S_{\dot{DRP_EARLY}} = OFF$$

$$S_{\dot{DROOP_TARGETS}} = OFF$$

$$S_{\dot{CDROOP}} = OFF$$

$$S_{\dot{MODE_2}} = OFF$$

$$S_{\dot{DRP_FLASH}} = OFF$$

$$S_{\dot{DRP_LATCH}} = OFF$$

$$MINH = \cos(THR_MAX)$$

$$MAXV = \sin(THR_MAX)$$

$$VEXSO = FT_SSME / MDOT_SSME$$

$$PRED_DROOP_ALT = 0$$

Table 4.3.4-1. Second Stage Droop Control Task Inputs				
Definition	Symbol	Source	Prec	Units
Altitude deadband for decrementing attitude	ALT_DBND	I-LOAD	SP	ft/rad
Current altitude above the Fisher ellipsoid	ALT_GD	PFG INP TSK	SP	ft
Altitude loss of PEG thrust attitude vs. optimal droop	ALT_PEG_LOSS	I-LOAD	SP	fps
Droop attitude increment	ATT_INCR	I-LOAD	SP	rad
Contingency 2 engine out mode indicator	CONT_2EO_MODE	CONT MODE SEL TSK	I	N/A
Guidance cycle time	DTGD	PFG INP TSK	SP	sec
Earth gravitational constant	EARTH_MU	CONSTANT	DP	ft ³ /sec ²
Negative rate limit for FT_S	FT_NLIM	I-LOAD	SP	lbf/sec
Nominal OMS thrust level	FT_OMS	K-LOAD	SP	lbf
Positive rate limit for FT_S	FT_PLIM	I-LOAD	SP	lbf/sec
Nominal RCS thrust level	FT_RCS	K-LOAD	SP	lbf
Estimated total thrust	FT_S	ACC-MASS UPD TSK	SP	lbf
Nominal SSME thrust level	FT_SSME	I-LOAD	SP	lbf
Commanded SSME throttle setting	K_CMD	SSME-OUT SAF TSK, GUID PRMT RINT TSK, ASC GUID TSK, RTLS/TAL TGT SEL TSK	I	pct
M50 desired thrust vector for Droop Control Task	$\bar{L}\bar{A}M_{DRP}$	PEG TSK	SP	ND
M50 desired thrust turning rate vector for Droop Control Task	$\bar{L}\bar{A}M\dot{D}_{DRP}$	PEG TSK	SP	sec ⁻¹
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Value of mass for enabling MPS low-level sensing	MASS_LOW_LEVEL	I-LOAD, UPLINK	SP	slugs
Nominal SSME mass flow rate	MDOT_SSME	I-LOAD	SP	slug/sec
Droop altitude target	MIN_DROOP_ALT	I-LOAD	SP	ft
Number of active OMS engines	N_OMS	PFG INP TSK	I	N/A
Number of active +X RCS engines	N_RCS	PFG INP TSK	I	N/A
OMS time to burn	TB_OMS	PFG INP TSK	SP	sec
Maximum passes for Droop solution loop	PASS_MAX	I-LOAD	I	ND
Ratio of circumference to diameter	PI	CONSTANT	DP	N/A
Vehicle position vector	$\bar{R}\bar{G}\bar{D}$	PFG INP TSK	DP	ft
PEG convergence flag	$\dot{S}CONV$	PEG TSK	D	N/A
PEG low thrust to weight indicator	S_{LOW_TW}	PEG TSK	D	N/A
Discrete to indicate that a TAL abort is in progress	TAL_ABORT_DECLARED	MSC	D	N/A
Time associated with RGD and VGD	TGD	PFG INP TSK	DP	sec

Table 4.3.4-1. Second Stage Droop Control Task Inputs				
Definition	Symbol	Source	Prec	Units
Droop thrust attitude sensitivity threshold	THRESH_ATT	I-LOAD	SP	rad
Maximum thrust attitude	THR_MAX	I-LOAD	SP	rad
Minimum thrust attitude	THR_MIN	I-LOAD	SP	rad
Time associated with desired thrust vector expressed in GMT for Droop Control Task	TLAM_DRP	PEG TSK	DP	sec
Equivalent exhaust velocity	VEX	THRST PRM TSK	SP	fps
Vehicle velocity vector	\vec{VGD}	PFG INP TSK	DP	fps
H DOT velocity miss criteria	VMISS_DRP	I-LOAD	SP	fps
Minimum number of recognized engines to trigger the Droop Control Task	DRP_NSSME	I-LOAD	I	ND
Number of active SSME engines	N_SSME	PFG INP TSK	I	N/A
Droop guidance enable flag	DRP_ENA	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP	D	N/A

Table 4.3.4-2. Second Stage Droop Control Task Outputs				
Definition	Symbol	Destination	Prec	Units
M50 desired thrust vector	$\vec{L}AMC$	G/C STEER	SP	ND
M50 desired thrust turning rate vector	$\vec{L}AMDC$	G/C STEER	SP	sec ⁻¹
Predicted minimum droop altitude	PRED_DROOP_ALT	XXXXXX TRAJ 2 DISP	SP	ft
Commanded droop attitude indicator	$S_{\dot{C}DROOP}$	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, TLM, PEG TSK	D	N/A
Minimum droop violation flag	$S_{\dot{D}RP_FLASH}$	XXXXXX TRAJ 2 DISP	D	N/A
Low energy TAL droop targets desired indicator	$S_{\dot{D}ROOP_TARGETS}$	RTLS/TAL TGT SEL TSK	D	N/A
Time associated with desired thrust vector expressed in GMT	TLAMC	G/C STEER	DP	sec
Guidance convergence status indicator	$S_{\dot{U}NCONV}$	ASC ADI PROC	D	N/A
Unit vector to landing site	$\vec{I}ZC$	G/C STEER	DP	ND
Droop altitude solution	ROUT	TLM	SP	ft
Droop commanded thrust attitude	THR_ATT	TLM	SP	rad

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4.3.5 Parameter Tables for Second-Stage Guidance

The IDD inputs and outputs are listed in Table 4.3.5-1 and Table 4.3.5-2 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 4.3.5-3. K-loads are listed in Table 4.3.5-4. Constants are listed in Table 4.3.5-5. The input variable cross-references are listed in Table 4.3.5-0.

Table 4.3.5-0.ASC 2STG GUID Input Variable Cross-Reference		
MSID	Local Name	Source Name
V95L0151CE	V_RHO_MAG	REL_VEL_MAG
V95H0185CB, 6CB, 7CB	R_NAV	R_AVGG
V95L0190CB, 1CB, 2CB	V_NAV	V_AVGG
V95W0200CD	T_NAV	T_STATE
V95L0210CB, 1CB, 2CB	V_S	V_IMU_OLD
V95X1207X	S_EO_E1	ME1_FAIL_SHUTDOWN
V95X1208X	S_EO_E2	ME2_FAIL_SHUTDOWN
V95X1209X	S_EO_E3	ME3_FAIL_SHUTDOWN
V90X8156X	MM103	MM_CODE_103
V90X8152X	MM104	MM_CODE_104
V90X8623X	MM105	MM_CODE_105
V90X8194X	MM601	MM_CODE_601

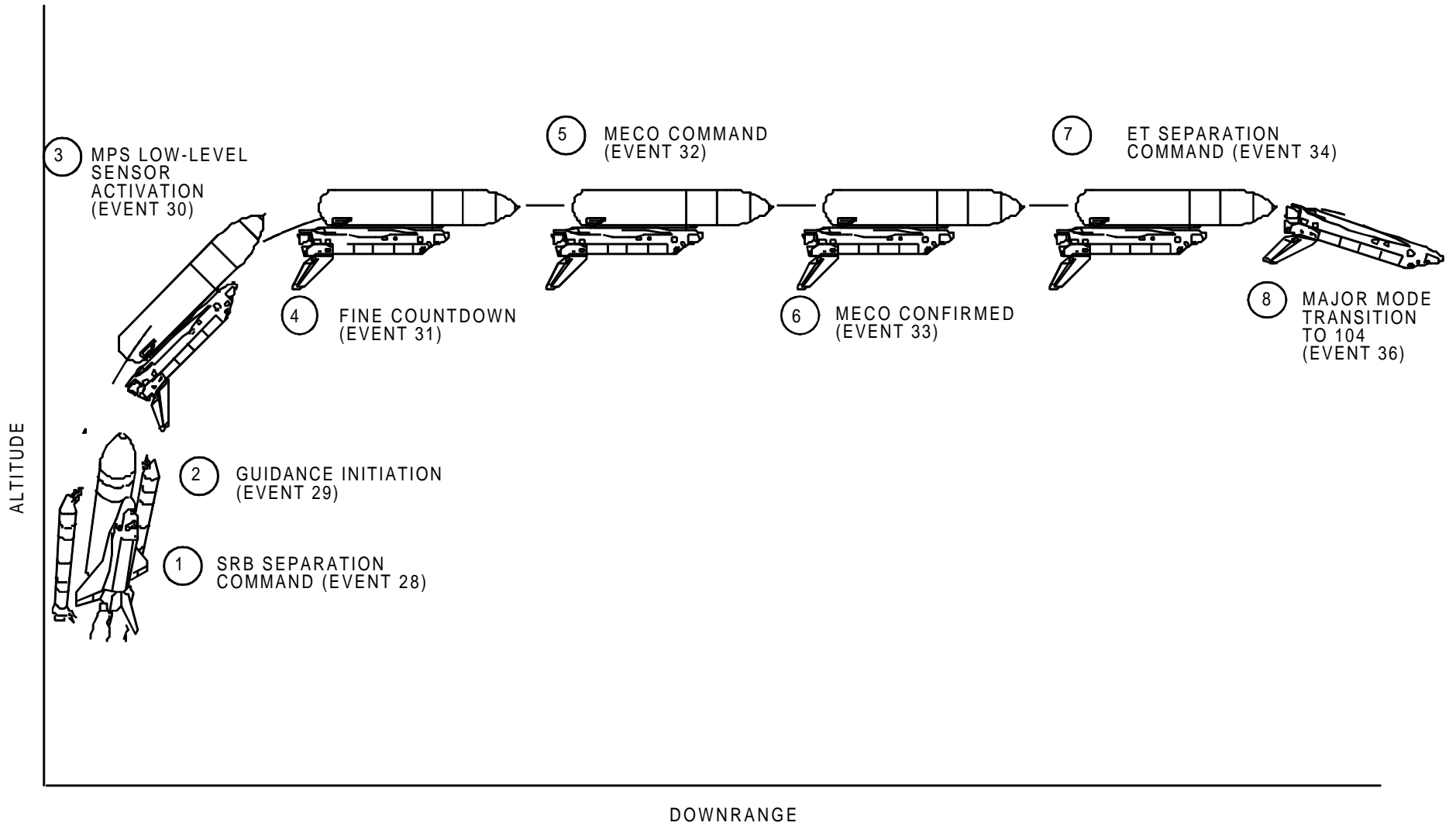


FIGURE 4.3-1. Typical Ascent Second-Stage Sequence of Events

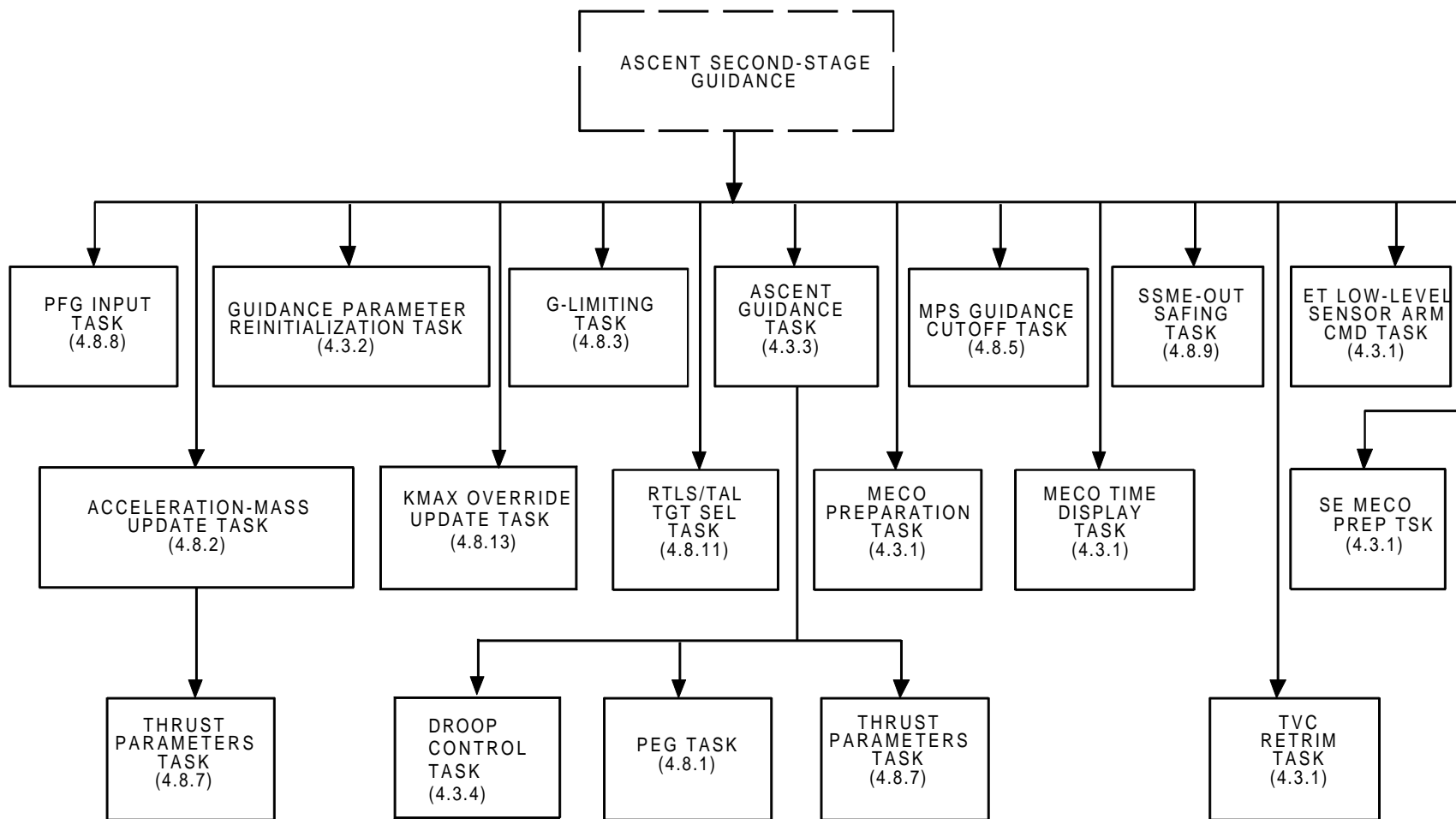


FIGURE 4.3-2. Ascent Second-Stage Guidance Principal Function Task Organization

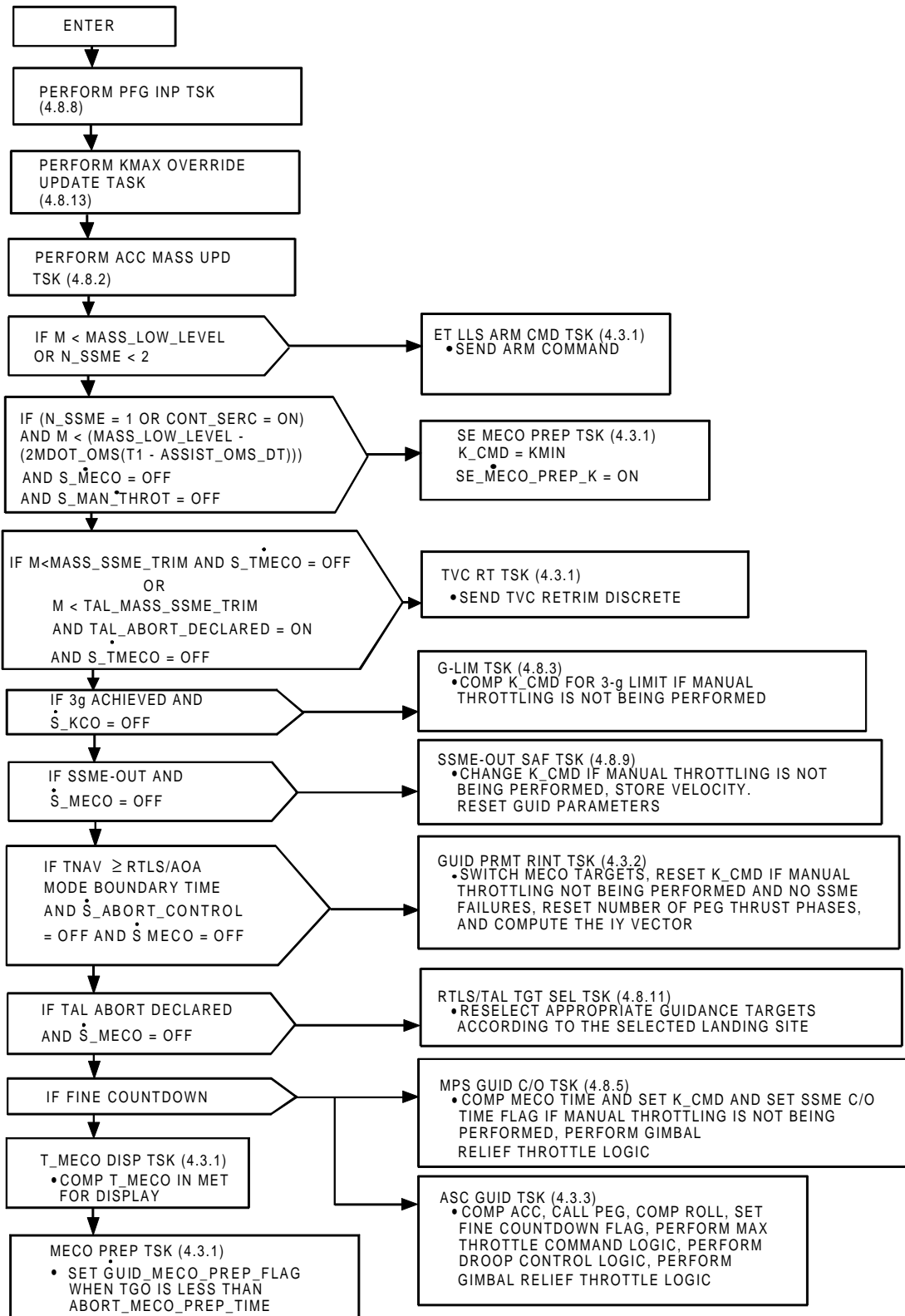


FIGURE 4.3-3. Ascent Second-Stage Guidance Functional Flow

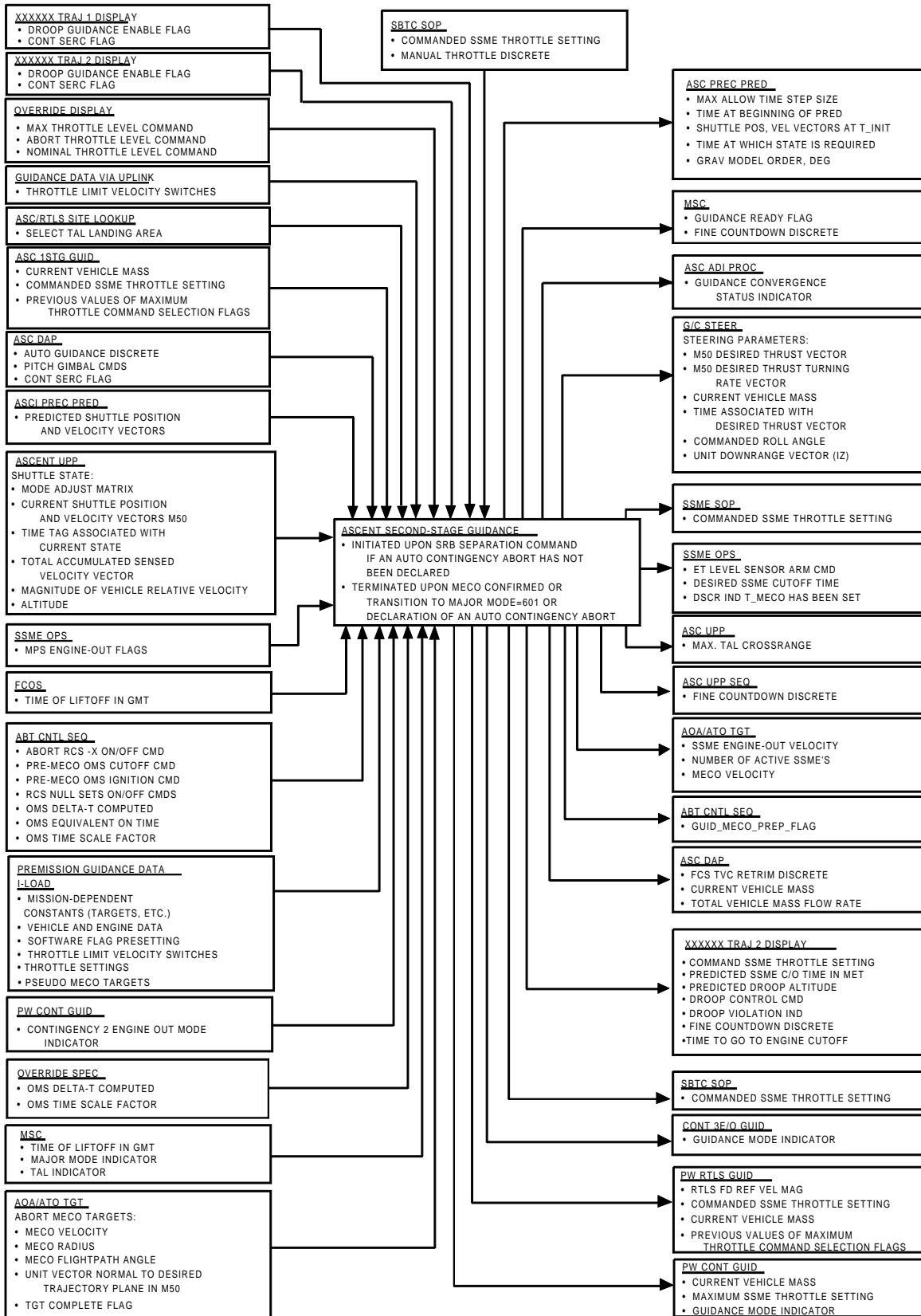


FIGURE 4.3-4. Ascent Second-Stage Guidance Principal Function (Major Mode 103) Data Flow

TABLE 4.3.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_CMD_PREV	V93X1031XA	PREV KMAX CMD TO ABT	ASC 1STG GUID		BD		92608C	
ABT_THROT_CMD	V93X0994X	ABORT THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
ALT	V95H0175CB	CURR ORB ALT ABOVE REF ELLIPSOID	ASC UPP	FT			93017G	*
AREA_SEL	V93J4392CB	SELECTED AREA	ASC SITE LOOKUP				93017G	*
ASSIST_OMS_DT	V97U1248C	SECOND STAGE OMS ASSIST DUMP TIMER	UL	S			93025B	
AUTO	V90X1710X	AUTO GUIDANCE MODE FLAG	ASC DAP		BD		93017G	*
CONT_2EO_MODE	V90J2077C	CONTINGENCY 2-ENG OUT MODE INDEX	PW CONT GUID		HXS		93017G	*
CONT_SERC	V93X6682X	CONT SINGLE ENG ROLL CNTL FLAG	XXXXXX TRAJ 1 DISP		BD		93017G	*
CONT_SERC	V93X6682XA	CONT SINGLE ENG ROLL CNTL FLAG	ASC DAP		BD		93017G	*
CONT_SERC	V93X6682XB	CONT SINGLE ENG ROLL CNTL FLAG	XXXXXX TRAJ 2 DISP		BD		93017G	*
DRP_ENA	V93X2932X	DROOP GUIDANCE ENABLE FLAG	XXXXXX TRAJ 1 DISP		BD		93017G	*
DRP_ENA	V93X2932XA	DROOP GUIDANCE ENABLE FLAG	XXXXXX TRAJ 2 DISP		BD		93017G	*
DYC2	V90H1719C	MPS 2 PITCH ACTR DEFLECTION CMD	ASC DAP	DEG			91042A	
DYC3	V90H1720C	MPS 3 PITCH ACTR DEFLECTION CMD	ASC DAP	DEG			91042A	
GAMD	V90U8497C	DESIRED MECO FLIGHT PATH ANGLE	AOA/ATO TGT	RAD				
GAMD	V97U4394C	DESIRED MECO FLIGHT PATH ANGLE	UL	RAD			92364D	
H_DOT_ELLIPSOID/H_DOT	V95L0265CE	EST ALTITUDE RATE	ASC UPP	FT/S			93012D	
IY(X)	V90U1976CD	X-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93090E	
IY(Y)	V90U1977CD	Y-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93090E	
IY(Z)	V90U1978CD	Z-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93090E	
IYD(X)	V97U4413CB	UNIT VEC NORM TRAJ PLANE X COMP	UL				93090E	
IYD(Y)	V97U4414CB	UNIT VEC NORM TRAJ PLANE Y COMP	UL				93090E	
IYD(Z)	V97U4415CB	UNIT VEC NORM TRAJ PLANE Z COMP	UL				93090E	
IYD_NOM(1)	V96U9385C	X-EF/M50 UN VEC NORM TO ORB PLN	UL				92237	
IYD_NOM(2)	V96U9386C	Y-EF/M50 UN VEC NORM TO ORB PLN	UL				92237	
IYD_NOM(3)	V96U9387C	Z-EF/M50 UN VEC NORM TO ORB PLN	UL				92237	
KMAX	V97U4424CA	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 1STG GUID	PCT			90608D	
K_CMD	V90U1948CB	COMMANDED SSME THROTTLE SETTING	ASC 1STG GUID	PCT			93017G	*
K_CMD	V90U1948CE	COMMANDED SSME THROTTLE SETTING	SBTC SOP	PCT			93012D	
K_CMD_MODE_BNDRY	V97U4420C	NOM SSME THROT SET-RTLS/AOA BNDRY	ASC 1STG GUID	PCT			89461	
M/CURR_ORB_MASS/WEIGHT	V90U1961CF	CURRENT VEHICLE MASS	ASC 1STG GUID	SLUGS			93017G	*
MASS_LOW_LEVEL	V97U4432C	MASS TO ARM MPS LOW LEVEL SENSORS	UL	SLUG	SPL	S	92175D	
MAX_CMD_PREV	V93X1032XA	PREV KMAX CMD TO MAX	ASC 1STG GUID		BD		92608C	
MAX_THROT_CMD	V93X5349X	MAXIMUM THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		89990E	
ME1_FAIL_SHUTDOWN	V95X1207X	MPS E1 FAIL FLAG	SSME OPS		BD		93017G	*
ME2_FAIL_SHUTDOWN	V95X1208X	MPS E2 FAIL FLAG	SSME OPS		BD		93017G	*
ME3_FAIL_SHUTDOWN	V95X1209X	MPS E3 FAIL FLAG	SSME OPS		BD		93017G	*
MM_CODE_102/MM_102	V90X8158X	MAJOR MODE 102 FLAG	MSC				93012D	
MM_CODE_103/MM_103	V90X8156X	MAJOR MODE 103 FLAG	MSC				93012D	
MM_CODE_104/MM_104	V90X8152X	MAJOR MODE 104 FLAG	MSC				92355B	
MM_CODE_105/MM_105	V90X8623X	MAJOR MODE 105 FLAG	MSC				92355B	
MM_CODE_601/MM_601	V90X8194X	MAJOR MODE 601 FLAG	MSC		BD		93012D	
M_NODE_ADJ	V95U0512C	NODAL ADJUSTMENT MATRIX	ASC UPP				89461	
NOM_CMD_PREV	V93X1033XA	PREV KMAX CMD TO NOM	ASC 1STG GUID		BD		92608C	
NOM_THROT_CMD	V93X0995X	NOMINAL THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
N_SSME	V90U1962CA	NUMBER OF ACTIVE SSME'S	ASC 1STG GUID				93017G	*

TABLE 4.3.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
RDMAG	V90U8498C	DESIRED MECO RADIUS	AOA/ATO TGT	FT				
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S			93017G	*
R_AVGG(1)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CB	X-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(2)	V90H0882CB	Y-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(3)	V90H0883CB	Z-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_LS_EF(1)	V90H1900CB	X-COMP LDG SITE POS VCT-EF COORD	ASC SITE LOOKUP	FT			93090E	
R_LS_EF(2)	V90H1901CB	Y-COMP LDG SITE POS VCT-EF COORD	ASC SITE LOOKUP	FT			93090E	
R_LS_EF(3)	V90H1902CB	Z-COMP LDG SITE POS VCT-EF COORD	ASC SITE LOOKUP	FT			93090E	
S_ABORT_CONTROL	V90X8504X	TGT COMPLETE FLAG	AOA/ATO TGT					
S_ATO	V90X8635X	ATO ABORT DECLARED	MSC				93012D	
S_MAN_THROT	V96X0006X	MANUAL THROTTLE DISCRETE	SBTC SOP		BD		93017G	*
S_OMS_CUTOFF	V90X8318XA	OMS CUTOFF CMD	ABT CNTL SEQ				93064D	
S_OMS_IGN	V90X8319X	ABORT OMS IGNITION CMD	ABT CNTL SEQ				89990E	
S_RCS_IGN	V90X8314X	ABORT RCS +X ON CMD	ABT CNTL SEQ		BD		93017G	*
S_RCS_NULL20	V90X8317X	20 RCS NULL JETS ON CMD	ABT CNTL SEQ		BD		93017G	*
T1	V90W8320C	OMS EQUIVALENT ON TIME	ABT CNTL SEQ	S	SPL		93017G	*
TAL_ABORT_DECLARED	V90X8658X	TAL ABORT DECLARED	MSC				93090E	
TARGET10(1)	V99U8910C	RTLS/TAL GUID TARGET 10 - AREA 1	UL	RAD			92392C	
TARGET11(1)	V99U8911C	RTLS/TAL GUID TARGET 11 - AREA 1	UL	RAD			92392C	
TARGET12(1)	V99U8912C	RTLS/TAL GUID TARGET 12 - AREA 1	UL	FT			92392C	
TARGET14(1)	V98U8497C	RTLS/TAL GUID TARGET 14 - AREA 1	UL	FT/S			92392C	
TARGET2(1)	V99U8902C	RTLS/TAL GUID TARGET 2 - AREA 1	UL	FT/S			92392C	
TARGET4(1)	V99U8904C	RTLS/TAL GUID TARGET 4 - AREA 1	UL	FT/S			92392C	
TARGET6(1)	V99U8906C	RTLS/TAL GUID TARGET 6 - AREA 1	UL	FT/S			92392C	
TARGET9(1)	V99U8909C	RTLS/TAL GUID TARGET 9 - AREA 1	UL	RAD			92392C	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_NAV_PREV	V90W0151C	PREVIOUS VALUE OF T_STATE	ASC 1STG GUID	S	DPL		90608D	
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
VDMAG	V90U8499CB	DESIRED MECO VELOCITY	AOA/ATO TGT	FT/S			93012D	
VDMAG	V97U4828C	DESIRED MECO VELOCITY	UL	FT/S			92364D	
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CB	X-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(2)	V90L0886CB	Y-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(3)	V90L0887CB	Z-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CB	X-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CB	Y-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CB	Z-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_KMAX_DOWN	V97U0603C	THROTTLE LIMIT DECREASE VEL SW	UL	FT/S	SPL	S	92232B	
V_KMAX_UP	V97U0604C	THROTTLE LIMIT INCREASE VEL SW	UL	FT/S	SPL	S	92232B	
	V90W8325CA	OMS DELTA T COMPUTED	ABT CNTL SEQ	S	SPL		93017G	*
	V90W8325CB	OMS DELTA T COMPUTED	OVERRIDE SPEC	S	SPL		90122E	

TABLE 4.3.5-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
	V94J3755CA	OMS TIME SCALE FACTOR	ABT CNTL SEQ				90122E	
	V94J3755CB	OMS TIME SCALE FACTOR	VERRIDE SPEC				90122E	

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

TABLE 4.3.5-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_CMD_PREV	V93X1031XB	PREV KMAX CMD TO ABT	PW RTLS GUID		BD		92608C	
AD	V90A1973CA	DESIRED THRUST ACCELERATION	DL FMT 21/1	FT/S2			93017G	*
CR_MAX	V90H3892C	MAXIMUM TAL MECO CROSSRANGE	ASC BRG SPEC ASC UPP	FT			93090E	
DT_MAX	V90U8500CA	MAX ALLOW TIME STEP SIZE	ASC PREC PRED	S				
FT_FACTOR	V90U1979CA	THRUST SCALING FACTOR	DL FMT 21/1				93017G	*
FT_S	V90U8120CE	ESTIMATED TOTAL THRUST	DL FMT 21/1	LBF	SPL		93017G	*
GMD_PRED	V90U8501CA	GRAVITY MODEL DEGREE	ASC PREC PRED					
GMO_PRED	V90U8502CA	GRAVITY MODEL ORDER	ASC PREC PRED					
GUID_MECO_PREP_FLAG	V90X1989XA	MECO PREPARATION DISCRETE	ABT CNTL SEQ					
H_DOT_FD	V90R2098CB	RTLS FUEL DISSP REF HDOT	PW RTLS GUID	FT/S				
IY(X)	V90U1976CA	X-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT ASC BRG SPEC DL FMT 21/1				93017G	*
IY(Y)	V90U1977CA	Y-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT ASC BRG SPEC DL FMT 21/1				93017G	*
IY(Z)	V90U1978CA	Z-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT ASC BRG SPEC DL FMT 21/1				93017G	*
IZC(X)	V90U2095CA	X-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
IZC(Y)	V90U2096CA	Y-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
IZC(Z)	V90U2097CA	Z-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
KMAX	V97U4424CB	MAXIMUM THROTTLE SETTING OF SSME'S	PW CONT GUID PW RTLS GUID SBTC SOP	PCT			90608D	
K_CMD	V90U1948CA	COMMANDED SSME THROTTLE SETTING	DL FMT 21/A PW RTLS GUID SBTC SOP SSME SOP XXXXXX TRAJ 2 DISP	PCT			93017G	*
LAMC(X)	V90U1954CA	X-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMC(Y)	V90U1955CA	Y-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMC(Z)	V90U1956CA	Z-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMDC(X)	V90U1957CA	X-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
LAMDC(Y)	V90U1958CA	Y-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
LAMDC(Z)	V90U1959CA	Z-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
LAMD MAG	V90U1968CA	MAGNITUDE OF LAMDC	DL FMT 21/1	RAD/S			93017G	*
LL	V90J2007CB	RTLS FLIGHT PATH ANG TARGET INDEX	PW RTLS GUID				89461	

TABLE 4.3.5-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
M/CURR_ORB_MASS/WEIGHT	V90U1961CG	CURRENT VEHICLE MASS	ASC DAP DL FMT 21/1 G/C STEER OMS RM PW CONT GUID PW RTLS GUID XXXXXX TRAJ DIP	SLUGS			93017G	*
MAX_CMD_PREV	V93X1032XB	PREV KMAX CMD TO MAX	PW RTLS GUID		BD		92608C	
MDOT	V90R1993CA	TOTAL VEHICLE MASS FLOW RATE	ASC DAP TLM	SLUGS/S				
NOM_CMD_PREV	V93X1033XB	PREV KMAX CMD TO NOM	PW RTLS GUID		BD		92608C	
N_OMS	V90J2031CA	NUMBER OF ACTIVE OMS ENGINES	TLM					
N_RCS	V90J1974CA	NUMBER OF ACTIVE RCS ENGINES	TLM					
N_RCS_NULL	V90J1975CA	NUMBER OF ACTIVE RCS NULL ENGINES	TLM					
OTREQ	V90X0893XH	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
PEG_STEERING_UPD	V90X5410X	PEG STEERING UPDATED FLAG	MSC				90828A	
PHI_CMD	V90H1969CA	COMMANDED ROLL ANGLE	G/C STEER	RAD			89461	
PRED_DROOP_ALT	V90H8086C	PREDICTED MINIMUM DROOP ALTITUDE	XXXXXX TRAJ 2 DISP	FT			93012D	
ROUT	V90H8118C	DROOP ALTITUDE SOLUTION	DL FMT 21/1	FT	SPL		93017G	*
R_INIT(X)	V90H8508CA	X-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Y)	V90H8509CA	Y-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Z)	V90H8510CA	Z-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
SCONV	V90X1971XA	PEG CONVERGENCE DISCRETE	DL FMT 21/1				93017G	*
SMODE	V94J3779CA	GUIDANCE MODE INDICATOR	CONT 3E/O GUID PW CONT GUID		HXS		93012D	
S_CDROOP	V90X8087X	DROOP CONTROL CMD	DL FMT 21/A XXXXXX TRAJ 2 DISP		BD		93017G	*
S_DRP_FLASH	V90X8088X	DROOP VIOLATION IND	XXXXXX TRAJ 2 DISP		BD		93012D	
S_LOW_LEVEL	V90X1942XA	ET LEVEL SENSOR ARM CMD	DL FMT 21/A SSME OPS				93017G	*
S_MECO	V90X1963XB	FINE COUNT DOWN DISCRETE	AOA/ATO TGT ASC UPP SEQ DL FMT 21/1 MSC PW RTLS GUID XXXXXX TRAJ 2 DISP				93017G	*
S_SSME_TRIM	V90X1960XA	FCS TVC RETRIM DISCRETE	ASC DAP DL FMT 21/A				93017G	*
S_TMECO	V90X1944XA	SSME C/O TIMING REQUEST FLAG	SSME OPS				89461	
S_UNCONV	V90X2084XA	PEG UNCONVERGED DSCR IND	ASC ADI PROC		BD		90964	
TGD	V90W1994CB	GUIDANCE TIME TAG	DL FMT 21/1				93017G	*
TGO	V90W1941CA	TIME TO GO TO VELOCITY CUTOFF	DL FMT 21/A XXXXXX TRAJ 2 DISP	S			93017G	*
THR_ATT	V90U8119C	DROOP COMMANDED THRUST ATTITUDE	DL FMT 21/1	RAD	SPL		93017G	*
TLAMC	V90W1953CA	TIME ASSOC W REF THR VECTOR	DL FMT 21/1 G/C STEER	S			93017G	*

TABLE 4.3.5-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT SECOND STAGE GUIDANCE (G4.2)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
TMET_MECO	V90W1970CA	PREDICTED SSME C/O TIME IN MET	DL FMT 21/1 XXXXXX TRAJ 2 DISP				93017G	*
TP	V90W1946CA	PREDICTED TIME OF THRUST C/O	DL FMT 21/1	S			93017G	*
T_FINAL	V90W8506CA	TIME AT WHICH STATE IS DESIRED	ASC PREC PRED	S				
T_INIT	V90W8512CA	TIME AT BEGINNING OF PRED	ASC PREC PRED	S				
T_MECO	V90W1945CA	DESIRED SSME C/O TIME	SSME OPS	S				
VDMAG	V90U8499CA	DESIRED MECO VELOCITY	AOA/ATO TGT TLM XXXXXX TRAJ DIP	FT/S			93012D	
VGOMAG	V90U1966CA	MAGNITUDE OF VGO VECTOR	DL FMT 21/1	FT/S			93017G	*
V_INIT(X)	V90L8513CA	X-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Y)	V90L8514CA	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Z)	V90L8515CA	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_ME_OUT	V90L1947CB	SSME ENGINE-OUT VELOCITY	AOA/ATO TGT DL FMT 21/A	FT/S			93017G	*
V_RTLS_FD	V90U1967CB	RTLS FUEL DISSIPATION REF VEL MAG	PW RTLS GUID	FT/S				
	V90M2938PA	CGGB_CGG_CO1_FLAG_HALFWORD_1	DL FMT 21/A				93017G	*
	V90M2963P	CGEB_MC1_LG1_FLAG1_MFE	DL FMT 21/A				93017G	*
	V90M2965PC	CGGB_CGG_CO1_FLAG_HALFWORD_2	DL FMT 21/A				93017G	*
	V90M3141PB	CGGB_CO1_MFE_FLGWD	DL FMT 21/1				93017G	*
	V90M3142PA	CGGB_MC16_GUID_TGT_FLAG	DL FMT 21/1				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 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALT_DBND	V97U9470C	FT/RAD	F	S	D	P	G4.2	00	A2D	90122E	
ALT_PEG_LOSS	V97U9471C	FT/SEC	F	S	D	P	G4.2	00	A2D	90122E	
ASSIST_OMS_DT	V97U1248C	SEC	F	S	M	C	G4.192	00	QOD	93025B	
							G4.2				
ATT_INCR	V97U9472C	RAD	F	S	D	P	G4.2	00	A2D	90122E	
CR_MAX_LOW	V97U9473C	FT	F	S	M	P	G4.2	00	A2D	90122E	
DRP_NSSME	V97U9482C	ND	I	S	D	P	G4.2	00	A2D	90122E	
DT_MIN_K	V97U4350C	SEC	F	S	D	C	G4.2	00	ZF1	92670D	
DT_TAILOFF(1)	V96U8335C	SEC	F	S	D	C	G4.2	00	ZF1	90243C	
DT_TAILOFF(2)	V96U8334C	SEC	F	S	D	C	G4.2	00	ZF1	90243C	
DYC_GIMB_RELIEF	V97U0090C	DEG	F	S	D	C	G4.2	00	ZF1	91042A	
EF_PLANE_SW	V99U7441C	ND	D		M	C	G4.19	00	A2N	93090E	
							G4.2				
							G4.20				
							G4.210				
							G4.226				
							G4.3				
							G5.26				
FT_NLIM	V97U9474C	LBF/SEC	F	S	D	P	G4.2	00	A2D	90122E	
FT_PLIM	V97U9475C	LBF/SEC	F	S	D	P	G4.2	00	A2D	90122E	
FT_SSME	V97U4392C	LBF	F	S	D	C	G4.176	00	ZF1	90243C	
							G4.2				
							G4.4				
							G4.5				
GAMD	V97U4394C	RAD	F	S	M	C	G4.2	00	APS	DC0860	
GAMD_LOW	V97U9493C	RAD	F	S	M	P	G4.2	00	A2D	90122E	
GAMD_NOM	V97U4396C	RAD	F	S	M	C	G4.13	00	A2M	DC0599	
							G4.2				
IYD(1)	V97U4413C	ND	F	D	M	C	G4.19	00	A2N	93090E	
							G4.2				
							G4.210				
							G4.226				
							G4.3				
							G5.26				
IYD(2)	V97U4414C	ND	F	D	M	C	G4.19	00	A2N	93090E	
							G4.2				
							G4.210				
							G4.226				
							G4.3				
							G5.26				
IYD(3)	V97U4415C	ND	F	D	M	C	G4.19	00	A2N	93090E	
							G4.2				
							G4.210				
							G4.226				
							G4.3				
							G5.26				
IYD_NOM(1)	V96U9385C	ND	F	D	M	C	G4.2	00	A2N	DC0860	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
IYD_NOM(2)	V96U9386C	ND	F	D	M	C	G4.2	00	A2N	DC0860	
IYD_NOM(3)	V96U9387C	ND	F	D	M	C	G4.2	00	A2N	DC0860	
KMAX	V97U4424C	PCT	I	S	M	C	G4.1	00	A2P	89990E	
							G4.2				
							G4.4				
							G4.5				
							G4.55				
KMAX_ABT	V97U0601C	PCT	I	S	M	C	G4.1	00	A2P	92232B	
							G4.2				
							G4.4				
							G4.5				
KMAX_NOM	V97U0602C	PCT	I	S	M	C	G4.1	00	A2P	92232B	
							G4.2				
							G4.4				
							G4.5				
KMAX_SECONDARY	V99U7107C	PCT	I	S	M	C	G4.1	00	A2P	89990E	
							G4.2				
							G4.4				
							G4.5				
KMIN	V97U4425C	PCT	I	S	D	C	G4.2	00	A2P	89990E	
							G4.4				
							G4.55				
K_CMD_MODE_BNDRY	V97U4420C	PCT	F	S	M	X	G4.2	00	A2P	89990E	
K_CMD_STG2	V97U9355C	PCT	I	S	D	C	G4.2	00	A2P	91086A	
K_CO_MAX	V96U9261C	PCT	I	S	M	C	G4.2	00	A2P	89990E	
							G4.4				
MASS_LOW_LEVEL	V97U4432C	SLUGS	F	S	M	C	G4.2	00	AMC	DC2248	
							G4.4				
MASS_MIN	V97U9004C	SLUGS	F	S	D	C	G4.2	00	ZF1	90243C	
MASS_SSME_TRIM	V97U4436C	SLUGS	F	S	M	C	G4.2	00	AMC	DC2248	
							G4.4				
MDOT_SSME	V97U4442C	SLUGS/SEC	F	S	D	C	G4.1	00	ZF1	90243C	
							G4.2				
							G4.4				
							G4.5				
MIN_DROOP_ALT	V97U9476C	FT	F	S	D	P	G4.2	00	A2D	90122E	
M_GIMB_RELIEF	V97U0089C	SLUGS	F	S	D	C	G4.2	00	ZF1	91042A	
PASS_MAX	V97U9477C	ND	I	S	D	P	G4.2	00	A2D	90122E	
PHI_2STG	V97U4482C	RAD	F	S	D	C	G4.2	00	YD1	91019A	
							G4.4				
RDMAG	V97U4647C	FT	F	D	M	C	G4.2	00	APS	DC0860	
RD_LOW	V97U9478C	FT	F	D	M	P	G4.2	00	A2D	90122E	
RD_NOM	V97U4645C	FT	F	D	M	C	G4.13	00	A2M	DC0599	
							G4.2				
RTLS_PRIME_AREA	V99U8961C	ND	I	S	M	C	G4.2	00	AAP	DC0599	
							G4.238				
							G4.4				

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
S_IY	V96U9391C	ND	D		M	C	G4.13 G4.2	00	AVI	89998A	
TAL_1ENG_GLIMIT	V97U0793C	ND	F	S	D	P	G4.2	00	ZF1	92670D	
TAL_2ENG_GLIMIT	V97U0792C	ND	F	S	D	C	G4.2	00	ZF1	92670D	
TAL_MASS_SSME_TRIM	V99U7556C	SLUGS	F	S	M	C	G4.2	00	AMC	DC2248	
TAL_PRIME_AREA	V99U8962C	ND	I	S	M	C	G4.2 G4.4 G6.21	00	AAP	91047C	
TARGET10(1)	V99U8910C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET10(10)	V98U8477C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET10(2)	V99U8922C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET10(3)	V99U8934C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET10(4)	V99U8946C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET10(5)	V99U8958C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET10(6)	V98U8473C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET10(7)	V98U8474C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET10(8)	V98U8475C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET10(9)	V98U8476C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET11(1)	V99U8911C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET11(10)	V98U8482C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET11(2)	V99U8923C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET11(3)	V99U8935C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET11(4)	V99U8947C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET11(5)	V99U8959C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET11(6)	V98U8478C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET11(7)	V98U8479C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET11(8)	V98U8480C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET11(9)	V98U8481C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET12(1)	V99U8912C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET12(10)	V98U8491C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET12(2)	V99U8924C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET12(3)	V99U8936C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET12(4)	V99U8948C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET12(5)	V99U8960C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET12(6)	V98U8483C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET12(7)	V98U8484C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET12(8)	V98U8485C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET12(9)	V98U8490C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET13(1)	V99U8963C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET13(10)	V98U8496C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET13(2)	V99U8964C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET13(3)	V99U8965C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET13(4)	V99U8966C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET13(5)	V99U8967C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET13(6)	V98U8492C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET13(7)	V98U8493C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET13(8)	V98U8494C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET13(9)	V98U8495C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET2(1)	V99U8902C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET2(10)	V98U8285C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET2 (2)	V99U8914C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET2 (3)	V99U8926C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET2 (4)	V99U8938C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET2 (5)	V99U8950C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET2 (6)	V98U8277C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET2 (7)	V98U8278C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET2 (8)	V98U8279C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET2 (9)	V98U8284C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET3 (1)	V99U8903C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET3 (10)	V98U8290C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET3 (2)	V99U8915C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET3 (3)	V99U8927C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET3 (4)	V99U8939C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET3 (5)	V99U8951C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET3 (6)	V98U8286C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET3 (7)	V98U8287C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET3 (8)	V98U8288C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET3 (9)	V98U8289C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET4 (1)	V99U8904C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET4 (10)	V98U8299C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET4 (2)	V99U8916C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET4 (3)	V99U8928C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET4 (4)	V99U8940C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET4 (5)	V99U8952C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET4 (6)	V98U8291C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET4 (7)	V98U8296C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET4 (8)	V98U8297C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET4 (9)	V98U8298C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET5 (1)	V99U8905C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET5 (10)	V98U8439C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET5 (2)	V99U8917C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET5 (3)	V99U8929C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET5 (4)	V99U8941C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET5 (5)	V99U8953C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET5 (6)	V98U8300C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET5 (7)	V98U8436C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET5 (8)	V98U8437C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET5 (9)	V98U8438C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET6 (1)	V99U8906C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET6 (10)	V98U8450C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET6 (2)	V99U8918C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET6 (3)	V99U8930C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET6 (4)	V99U8942C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET6 (5)	V99U8954C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET6 (6)	V98U8440C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET6 (7)	V98U8447C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET6 (8)	V98U8448C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET6 (9)	V98U8449C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET7 (1)	V99U8907C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET7 (10)	V98U8455C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET7 (2)	V99U8919C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET7 (3)	V99U8931C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET7 (4)	V99U8943C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET7 (5)	V99U8955C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET7 (6)	V98U8451C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET7 (7)	V98U8452C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET7 (8)	V98U8453C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET7 (9)	V98U8454C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET8 (1)	V99U8908C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET8 (10)	V98U8467C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET8 (2)	V99U8920C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET8 (3)	V99U8932C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET8 (4)	V99U8944C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET8 (5)	V99U8956C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET8 (6)	V98U8456C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET8 (7)	V98U8457C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET8 (8)	V98U8458C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET8 (9)	V98U8459C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET9 (1)	V99U8909C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET9 (10)	V98U8472C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET9 (2)	V99U8921C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET9 (3)	V99U8933C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET9 (4)	V99U8945C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET9 (5)	V99U8957C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET9 (6)	V98U8468C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET9 (7)	V98U8469C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET9 (8)	V98U8470C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET9 (9)	V98U8471C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET_INDEX (1)	V99U8901C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (10)	V98U8276C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (11)	V98U8567C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (12)	V98U8568C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (13)	V98U8569C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (14)	V98U8570C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX (15)	V98U8571C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(16)	V98U8572C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(17)	V98U8573C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(18)	V98U8574C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(19)	V98U8575C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(2)	V99U8913C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(20)	V98U8576C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(21)	V98U8577C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(22)	V98U8578C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(23)	V98U8579C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(24)	V98U8580C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(25)	V98U8581C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(26)	V97U9927C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(27)	V97U9928C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(28)	V97U9929C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(29)	V97U9930C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(3)	V99U8925C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(30)	V97U9931C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(31)	V97U9932C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(32)	V97U9933C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(33)	V97U9934C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(34)	V97U9935C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(35)	V97U9936C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(36)	V97U9937C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(37)	V97U9938C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(38)	V97U9939C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(39)	V97U9940C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(4)	V99U8937C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(40)	V97U9941C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(41)	V97U9942C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(42)	V97U9943C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(43)	V97U9944C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(44)	V97U9945C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(45)	V97U9946C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.3.5-3. ASCENT SECOND STAGE GUIDANCE (G4.2) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(5)	V99U8949C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(6)	V98U8272C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(7)	V98U8273C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(8)	V98U8274C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(9)	V98U8275C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TFAIL	V96U9384C	SEC	F	S	M	C	G4.2	00	APS	DC0860	
TGO_FCD	V97U4663C	SEC	F	S	D	C	G4.2	00	ZF1	92670D	
TGO_MAN	V97U9002C	SEC	F	S	D	P	G4.2 G4.4	00	ZF1	90243C	
THRESH_ATT	V97U9479C	RAD	F	S	D	P	G4.2	00	A2D	90122E	
THR_MAX	V97U9480C	RAD	F	S	D	P	G4.2	00	A2D	90122E	
THR_MIN	V97U9481C	RAD	F	S	D	P	G4.2	00	A2D	90122E	
T_RTLS_AOA	V97U4661C	SEC	F	S	M	C	G4.2	00	APS	DC0860	
VDMAG	V97U4828C	FT/SEC	F	S	M	C	G4.2	00	APS	DC0860	
VD_NOM	V97U4827C	FT/SEC	F	S	M	C	G4.13 G4.2	00	A2M	DC0599	
VMISS_DRP	V97U9483C	FT/SEC	F	S	D	P	G4.2	00	A2D	90122E	
V_KMAX_DOWN	V97U0603C	FT/SEC	F	S	M	C	G4.1 G4.2 G4.4	00	ATV	92232B	
V_KMAX_UP	V97U0604C	FT/SEC	F	S	M	C	G4.1 G4.2 G4.4	00	ATV	92232B	
V_RHO_PHI	V97U4823C	FT/SEC	F	S	D	C	G4.2 G4.4	00	YD1	91019A	
V_RHO_TAL	V97U9693C	FT/SEC	F	S	M	C	G4.2	00	ZF1	90243C	

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

TABLE 4.3.5-4. ASCENT SECOND STAGE GUIDANCE (G4.2) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
ABORT_MECO_PREP_TIME	V98U7961C	01	+1.0	E+01 SEC	F		S C	G4.2 G4.4	59955	
AD_INIT INITIAL VALUE OF DESIRED ACCELERATION	V97U4306C	00	+9.42	E+01 FT/SEC**2	F		S C	G4.2 G4.4	90329C	
AL ACCELERATION LIMIT	V97U4307C	00	+9.5500000	E+01 FT/SEC**2	F		S C	G4.2 G4.4	90329C	
ALIM_1 LOWER LIMIT FOR TERMINATING G- LIMITING	V97U4308C	00	+9.2000000	E+01 FT/SEC**2	F		S C	G4.2 G4.4	90329C	
ALIM_2 LOWER LIMIT FOR INITIATING G- LIMITING	V97U4309C	00	+9.47	E+01 FT/SEC**2	F		S C	G4.2 G4.4	90329C	
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 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	
DTRD TGO REMAINING WHEN POSITION CONSTRAINTS RELEASED	V97U4371C	00	+4.0000000	E+01 SEC	F		S C	G4.2 G4.4	90329C	
DT_FCD	V97U4347C	00	+3.200	E-01 SEC	F		S C	G4.2	92740D	
EPS-X CRIT REJ THRUST SCALING FACTOR	V97U4380C	00	+2.0	E-02 ND	F		S C	G4.2 G4.4 G4.5	89990E	
EPSTGO PEG INHIBIT STEERING OUTPUT	V97U4381C	00	+4.0	E-02 ND	F		S C	G4.2 G4.210 G4.3 G4.4	59955	
ETB MIN TBN-1 COMPUTATION OF TGO	V97U4382C	00	+5.0000000	E+00 SEC	F		S C	G4.2 G4.4	59955	
FTF_MIN	V97U4838C	00	+5.0	E-01 ND	F		S C	G4.2 G4.4 G4.5	90451	
FT_FACTOR THRUST SCALING FACTOR	V97U4389C	00	+9.98	E-01 ND	F		S C	G4.2 G4.4 G4.5	90329C	

TABLE 4.3.5-4. ASCENT SECOND STAGE GUIDANCE (G4.2) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03 LBF	F		S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02 LBF	F		S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
KDOT MAX THROTTLE CHG RATE	V97U4422C	00	+1.0000000	E+01 PCT/SEC	F		S	C G4.2	89541	
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	
K_INT G-LIMITING INTEGRAL GAIN	V97U4418C	00	+1.0	E-02 SEC**-2	F		S	C G4.2 G4.4	59955	
K_PROP PROPORTIONAL GAIN	V97U4419C	00	+1.5	E-01 SEC**-1	F		S	C G4.2 G4.4	59955	
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01 SLUGS/SEC	F		S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01 SLUGS/SEC	F		S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
MUP_TH MINIMUM CHANGE IN MASS REQUIRED FOR MASS TO BE UPDATED	V97U6150C	00	+3.0	E-01 SLUGS	F		S	P G4.13 G4.2 G4.3 G4.4 G4.5	90608D	
NMAX_CYCLES_UNCONV NO. OF UNCONVERGED PEG CYCLES TO STOW ERROR NEEDLES	V96U7796C	00	+5	ND	I		S	C G4.2 G4.4	90329C	

TABLE 4.3.5-4. ASCENT SECOND STAGE GUIDANCE (G4.2) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
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	
N_MAX MAXIMUM NUMBER OF PEG ITERATION	V97U4445C	00	+1	ND	I	S	P	G4.2 G4.209 G4.3 G4.4	90329C	
PHIDOT_MAX MAXIMUM TURNING RATE	V97U9003C	00	+3.5	E-02 RAD/SEC	F	S	C	G4.2 G4.210 G4.3 G4.4	90329C	
PHI_CMD COMMANDED ROLL ANGLE	V97U4481C	00	+3.141593	E+00 RAD	F	S	C	G4.2	90329C	
RHOMAG SCALAR DAMPING FACTOR APPLIED TO VMISS TO CORRECT V	V97U4650C	00	+1.0000000	E+00 ND	F	S	C	G4.2	90329C	
STG2_MECO_INIT_TGO MAXIMUM TGO AT WHICH S_TMECO IS SET IN MM 103	V97U2653C	00	+9.6	E-01 SEC	F	S	P	G4.2	90608D	
TLAG THROTTLE LAG TIME	V97U4834C	00	+5.0000000	E-01 SEC	F	S	C	G4.2 G4.4	59955	

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

TABLE 4.3.5-5. ASCENT SECOND STAGE GUIDANCE (G4.2) 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 4.3.5-5. ASCENT SECOND STAGE GUIDANCE (G4.2) 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.

4.4 ORBIT INSERTION REQUIREMENTS (MM's 104 AND 105)

Principal function ORB INS GUID (CPDS, Level B, principal function 4.3). Execution of this principal function requires the general guidance and targeting tasks: PFG Input (Section 4.8.8), Acceleration–Mass Update (Section 4.8.2), Powered Explicit Guidance (Section 4.8.1), Linear Terminal Velocity Constraint (Section 4.8.4), Thrust Parameters (Section 4.8.7), and Commanded Body Attitude Task (Section 4.8.10).

4.4.1 Overview

The orbit insertion guidance principal function supplies the guidance and related support requirements for the post–MECO MM's 104 and 105. The powered maneuvers during these major modes will be performed with the OMS engines or the four +X acceleration translational RCS jets. The crew will have the capability to select the thrust system for the maneuver, change guidance targets, delay the maneuver, etc., via the XXXXX MNVR YYYYY display. Since the requirements of this section are interrelated with the requirements of the ascent maneuver display processing (AS MNVR DIP) principal function, a complete understanding is difficult without first reading the AS MNVR DIP (Section 4.7). It is recommended that the reader refer to Section 4.7 prior to reading the following guidance requirements section.

The guidance requirements discussed in the following two subsections (4.4.1.1 and 4.4.1.2) span MM's 104 and 105 and support nominal OMS–1/OMS–2 maneuvers, ATO OMS–1/OMS–2 maneuvers, and the AOA OMS–1 maneuver. The AOA OMS–2 maneuver is supported by OPS–3 guidance requirements and will not be discussed in this FSSR document. The guidance requirements do not change as a function of the major mode; however, conditions for entry into the major mode change. Each major mode, therefore, will be discussed independently; the guidance requirements section will follow and will apply to both major modes.

A general overview of the ORB INS GUID principal function task requirements, sequence of events, and related data requirements is discussed in Subsection 4.4.1.3.

4.4.1.1 MM 104

After the SSME burn has been completed (MECO), a short coast period (approximately 18 seconds) follows until the external tank separation command is issued. The first OMS burn (OMS–1) begins at a fixed interval of time from the separation command (this interval is approximately 102 seconds). The purpose of the OMS–1 burn is to raise the orbiter energy to premission selected apogee altitude. Normally, this burn will be performed with the OMS engines to the premission selected targets which are I–loaded. The apogee direction is constrained during the burn to lie in the target orbit plane. However, for abort burns (both AOA and ATO), the target lies in the current orbit plane. The burn in either case (plane constrained or unconstrained) is near fuel optimal leading to a thrust direction very nearly along the current inertial velocity vector. In the event of a single OMS engine failure (if the burn was initiated with the two OMS engines), the guidance will automatically transition across the failure (given knowledge by the OMS FIRE SEQ of the failure) and will complete the burn with the remaining OMS engine. Additionally, if the remaining OMS engine (or selected single OMS) fails or nominal OMS cutoff occurs, then guidance will continue to solve the guidance equations by assuming the thrust level of the 4 +X RCS jets. In the event of a propulsion system failure, the guidance targets remain unchanged throughout the burn.

However, as has been stated, the parameters of the OMS–1 burn may be a crew input. Optionally, the crew may choose to alter the guidance targets or the propulsion system configuration. There are other

inputs that can be altered, but these two are of primary importance to the guidance function. A general discussion of the handling of these inputs will follow.

The crewman can enter a set of guidance targets in the form of an altitude and range angle relative to the launch site. It should be noted that these targets are not true targets, but are biased to compensate for the non-Keplerian force effects on the orbit. A set of external ΔV targets (ΔV_X , ΔV_Y , ΔV_Z) also can be entered. The guidance mode switch will automatically be set by the AS MNVR DIP to be consistent with the most recent target values entered from the display or initialized by I-load or uplink. While this option is available, it is not the planned mode for performing the burn (the external ΔV mode is not closed-loop and would produce target misses in the event of propulsion system failures). The orbit insertion guidance principal function will accept either set of inputs if the PEG mode switch is set properly and will complete the automatic burn sequence. It should be noted, when reading the orbit insertion guidance principal function requirements, that an action based upon the guidance mode switch is not necessary at this requirements level. The action based upon the guidance mode switch is necessary only at the PEG level where routing changes are made.

The engine configuration is also selectable by the crewman. The nominal engine configuration for both OMS-1 and OMS-2 would be two OMS engines, but right OMS, left OMS, both OMS, or 4 +X translational RCS jets can be selected. Once the desired configuration is selected, the AS MNVR DIP sets the number of OMS engines or 4 +X RCS jets for input to orbit insertion guidance. The selected engine configuration will be used to converge guidance throughout the burn unless a failure occurs. If the 4 +X translation RCS jets are selected for the maneuver, guidance will perform essentially the same function as performed for the OMS maneuver with one exception. Guidance does not provide an automatic cutoff flag for the RCS engines. It is assumed that the crewman performs cutoff manually from display information.

For a complete discussion of the crewman input capability and its effect upon the guidance principal function, the reader should refer to Section 4.7.

MM 104 begins (Event 36) upon completion of the ET separation burn (-Z translation) or upon an OPS 104 PRO (Figure 4.4-1). (See CPDS, Level B, GN&C, Vol. 5, Book 1.) When the major mode transition occurs, the XXXXX MNVR YYYYY display is forced onto the CRT and AS MNVR DIP begins to perform prethrust calculations. The OMS-1 planned time of ignition (TIG) is calculated by the AS MNVR DIP referenced to the actual ET separation time.

The vehicle is aligned to the prethrust determined attitude and orbit insertion guidance becomes active at the planned time of ignition (Event 37) minus 15 seconds. The MSC sets the Time Base 1 (TB1), and when TB1 becomes zero, if certain criteria from the AS MNVR DIP (i.e., maneuver proceed) have been met, then OMS ignition will be initiated (Event 37) by the software if the crewman has set the proper hardware configuration. The orbit insertion guidance becomes active at the planned time of ignition minus 15 seconds and is deactivated at the major mode transition (Event 44) or at a crew entry of new target data or a LOAD entry on the maneuver display (Event 45B). The guidance transitions smoothly from the pre-ignition to post-ignition phases.

4.4.1.2 MM 105

The OMS-2 burn is again an energy-raising burn. The burn normally occurs near the apogee of the orbit established by the OMS-1 burn. Normally the purpose of the burn is to circularize the orbit. All burn requirements and constraints are the same as OMS-1.

The orbit insertion guidance becomes active at the planned time of ignition minus 15 seconds and is deactivated at the major mode transition (Event 49) or at a crew entry of new target data or a LOAD entry on the maneuver display (Event 45B). The OMS-2 insertion major mode begins upon an OPS 105 PRO (Event 44). The occurrence of a zero Time Base 2 initiates the OMS-2 ignition sequence (Event 46). OMS cutoff (Event 42) and transition to MM 106 (Event 49) are similar to the MM 104 events (Figure 4.4-1).

4.4.1.3 Orbit Insertion Guidance Tasks and Time Line

The orbit insertion guidance principal function is composed of the following tasks for both MM's 104 and 105.

1. PFG input task (PFG INP TSK)
2. Acceleration-mass update task (ACC-MASS UPD TSK)
3. Thrust parameters task (THRST PRM TSK)
4. OMS guidance task (OMS GUID TSK)
5. Powered explicit guidance task (PEG TSK)
6. Linear terminal velocity constraint task (LTVCON TSK)
7. Commanded body attitude task (CMD BDY ATT TSK)

A typical time line of guidance-related events for either major mode is as follows:

1. AS MNVR DIP load solution
2. Maneuver to burn attitude
3. Guidance calculations are initiated.
4. Engine ignition occurs and the transition DAP begins removing the attitude errors, using the guidance commands.
5. If an OMS engine failure occurs, guidance updates input parameters to achieve the same target.
6. Time of engine cutoff is computed for the OMS/RCS maneuver
7. Engine cutoff occurs.
8. Velocity residuals are trimmed.
9. The current major mode is exited by crew action.

Figures 4.4-2, 4.4-3, and 4.4-4 illustrate the orbit insertion guidance task organization, functional flow, and data flow for MM's 104 and 105. The principal function interfaces are given in Section 4.4.4.

Certain I-loads supporting this principal function are required to be in contiguous areas of memory in a specific sequence. Section 4.11 describes this requirement.

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4.4.2 Orbit Insertion Sequencing (ORB INS SEQ)

Several tasks that support the orbit insertion guidance principal function are initiated and terminated on specific events. (These events are identified in the CPDS, GN&C, Level B, Vol. 5, Book 1.) These tasks are:

1. PFG input task (PFG INP TSK)
2. Acceleration–mass update task (ACC–MASS UPD TSK)
3. OMS guidance task (OMS GUID TSK)

If an abort (AOA or ATO) is declared or “LOAD” becomes a dynamic flashing character set (LOAD_ FLASH = ON), subsequent to guidance initiation and prior to engine ignition authorization (BURN_ ENABLE = ON), then guidance must be terminated.

A. Detailed Requirements.

The tasks that support the orbit insertion guidance must be sequenced as follows:

1. PFG input task (PFG INP TSK)
2. Acceleration–mass update task (ACC–MASS UPD TSK)
3. OMS guidance task (OMS GUID TSK)

B. Interface Requirements. The input parameters for the orbit insertion sequencing are given in Table 4.4.2–1.

C. Processing Requirements.

- Task 1. The PFG input task (see Section 4.8.8) is performed repetitively every 0.96 second from the time that cyclic guidance is initiated until the major mode termination point (Event 44 or 49).
- Task 2. The acceleration–mass update task (see Section 4.8.2) is performed repetitively every 0.96 second from TIG until the major mode termination point (Event 44 or 49).
- Task 3. The OMS guidance task is performed repetitively every 0.96 second from TIG minus 15 seconds until the major mode termination point (Event 44 or 49)

D. Initialization Requirements. None.

Table 4.4.2-1.Orbit Insertion Sequencing Inputs

Definition	Symbol	Source	Prec	Units
Time associated with \overline{RGD} and \overline{VGD}	TGD	PFG INP TSK	DP	sec
OMS/RCS ignition time	TIG	PRE–MAN DISP SUPT TSK	DP	sec

4.4.3 OMS Guidance Task (OMS GUID TSK)

The OMS guidance task performs the following activities:

- Computes an estimated thrust acceleration (ATR) for PEG.
- Calls PEG to compute reference thrust orientation parameters and time-to-go (TGO) until engine cutoff.
- Calls CMD BDY ATT TSK to compute the M50 to commanded body attitude quaternion.
- Computes the engine cutoff time (T_CUTOFF) and alerts the MSC to establish an engine cutoff timebase.

A. Detailed Requirements.

1. An estimate of the thrust acceleration is computed for PEG.

$$ATR = FT/M$$

2. The PEG task (PEG TSK, Section 4.8.1) is performed repetitively until PEG is either converged (SCONV=ON) or has been executed a maximum number (NMAX) of times.
3. If current time (T_GMT) is greater than the time of ignition (TIG), then perform the following:
 - a. Set the time to compute the commanded body attitude quaternion (Q_{CBM50}^+) equal to current time ($T_{CA} = T_{GMT}$) and perform the commanded body attitude task (CMD BDY ATT TSK, Section 4.8.10).
 - b. The following computations are executed if $\dot{OMS_L_ON_CMD_IND}$ is ON or $\dot{OMS_R_ON_CND_IND}$ is ON or any SEL FWD THC (e.g., $\dot{THC_NEG_X_CMD}$) output is ON and the cutoff flag (\dot{SCO}) is OFF:
 - I. 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 \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: $\overline{THRUST_M50}$

$$TGO_CUTOFF = TGO (\overline{THRUST_M50} \cdot \overline{VGO})/ABVAL(\overline{VGO})$$

- II. If the 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 $TGO_CUTOFF \leq TGO_MIN$, then do the following:

$$T_CUTOFF = TGD + TGO_CUTOFF - TCO_BIAS$$

$$S_OMSCO = ON$$

$$SSTEER = OFF$$

$$SCO = ON$$

B. Interface Requirements. The input and output parameters for the OMS guidance task are given in Tables 4.4.3-1 and 4.4.3-2.

C. Processing Requirements. Subtasks 1, 2, and 3 are performed every guidance cycle. Subtasks 3.a and 3.b are performed only if current time (T_GMT) is greater than the time of ignition (TIG). The subtasks must be performed in the order shown.

D. Initialization Requirements. The following initialization is performed each time cyclic guidance is initialized.

$$NMAX = N_MAX$$

$$T_CUTOFF = 0$$

$$S_OMSCO = OFF$$

$$SSTEER = ON$$

$$SCO = OFF$$

E. Supplemental Information. The PEG initialization is done by the AS MNVR DIP.

Table 4.4.3-1.OMS Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Time associated with \overline{RGD} and \overline{VGD}	TGD	PGF INP TSK	DP	sec
OMS/RCS ignition time	TIG	PRE MAN DISP SUPT TSK	DP	sec
Discrete indicating convergence	$\dot{S}CONV$	PEG TSK	D	N/A
Time-to-go to thrust cutoff	TGO	PEG TSK	SP	sec
Value of TGO_CUTOFF when steering output is inhibited during maneuvers	TGO_MIN	K-LOAD	SP	sec
Cutoff time bias	TCO_BIAS	K-LOAD	SP	sec
Maximum number of PEG iterations	N_MAX	K-LOAD	I	N/A
Total vehicle thrust force	FT	THRST PRM TSK	SP	lbf
Current vehicle mass	M	ACC-MASS UPD TSK, PRE-MAN DISP SUPT TSK	SP	slugs
Clock-computer (GMT)	T_GMT	FCOS	DP	sec
Left OMS ON indicator	$\dot{O}MS_L_ON_CMD_IND$	OMS FIRE SEQ	D	N/A
Right OMS ON indicator	$\dot{O}MS_R_ON_CMD_IND$	OMS FIRE SEQ	D	N/A
THC +X RCS command	$\dot{THC}_POS_X_CMD$	GN&C SW RM	D	N/A
THC -X RCS command	$\dot{THC}_NEG_X_CMD$	GN&C SW RM	D	N/A
THC +Y RCS command	$\dot{THC}_POS_Y_CMD$	GN&C SW RM	D	N/A
THC -Y RCS command	$\dot{THC}_NEG_Y_CMD$	GN&C SW RM	D	N/A
THC +Z RCS command	$\dot{THC}_POS_Z_CMD$	GN&C SW RM	D	N/A
THC -Z RCS command	$\dot{THC}_NEG_Z_CMD$	GN&C SW RM	D	N/A
M50 to measured body quaternion	$Q_B_I_S, Q_B_I_V$	A/E ATT PROC	SP	ND
Unit engine thrust direction in body coordinates	$\overline{THRUST_BODY}$	CMD BDY ATT TSK	SP	ND
M50 velocity-to-be-gained vector	\overline{VGO}	PEG TSK	SP	fps
PEG steering enable flag	$\dot{S}STEER$	PRE-MAN DISP SUPT TSK	D	N/A

Table 4.4.3-2.OMS Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
OMS/RCS maneuver cutoff time	T_CUTOFF	MSC	DP	sec
OMS cutoff alert discrete	$\dot{S}OMSCO$	MSC, TLM	D	N/A
Thrust acceleration estimate	ATR	PEG TSK	SP	fps ²
Commanded body attitude time	T_CA	CMD BDY ATT TSK	DP	sec
PEG steering enable flag	$\dot{S}STEER$	PEG TSK	D	N/A
Desired vehicle burn attitude in ADI coordinates	VEH_PITCH, VEH_ROLL, VEH_YAW	MNVR DISP, TLM	SP	deg
Valid angle comp flag	$\dot{X_FLAG}$	MNVR DISP	D	N/A

4.4.4 Parameter Tables for Orbit Insertion Guidance

The IDD inputs and outputs are listed in Tables 4.4.4-1 and Table 4.4.4-2 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 4.4.4-3. K-loads are listed in Table 4.4.4-4. Constants are listed in Table 4.4.4-5. The input variable cross-references are listed in Table 4.4.4-0.

Table 4.4.4-0.ORB INS GUID Variable Cross-Reference		
MSID	Local Name	Source Name
V95H0185CB, 6CB, 7CB	R_NAV	R_AVGG
V95W0200CD	T_NAV	T_STATE
V95L0190CB, 1CB, 2CB	V_NAV	V_AVGG
V95U0512C	M_NODE_ADJ	N_NODE_ADJ
V91W5000CZ	T_GMT	CLOCK
V90X8152X	MM104	MM_CODE_104
V90X8623X	MM105	MM_CODE_105
V90X8153X	MM106	MM_CODE_106

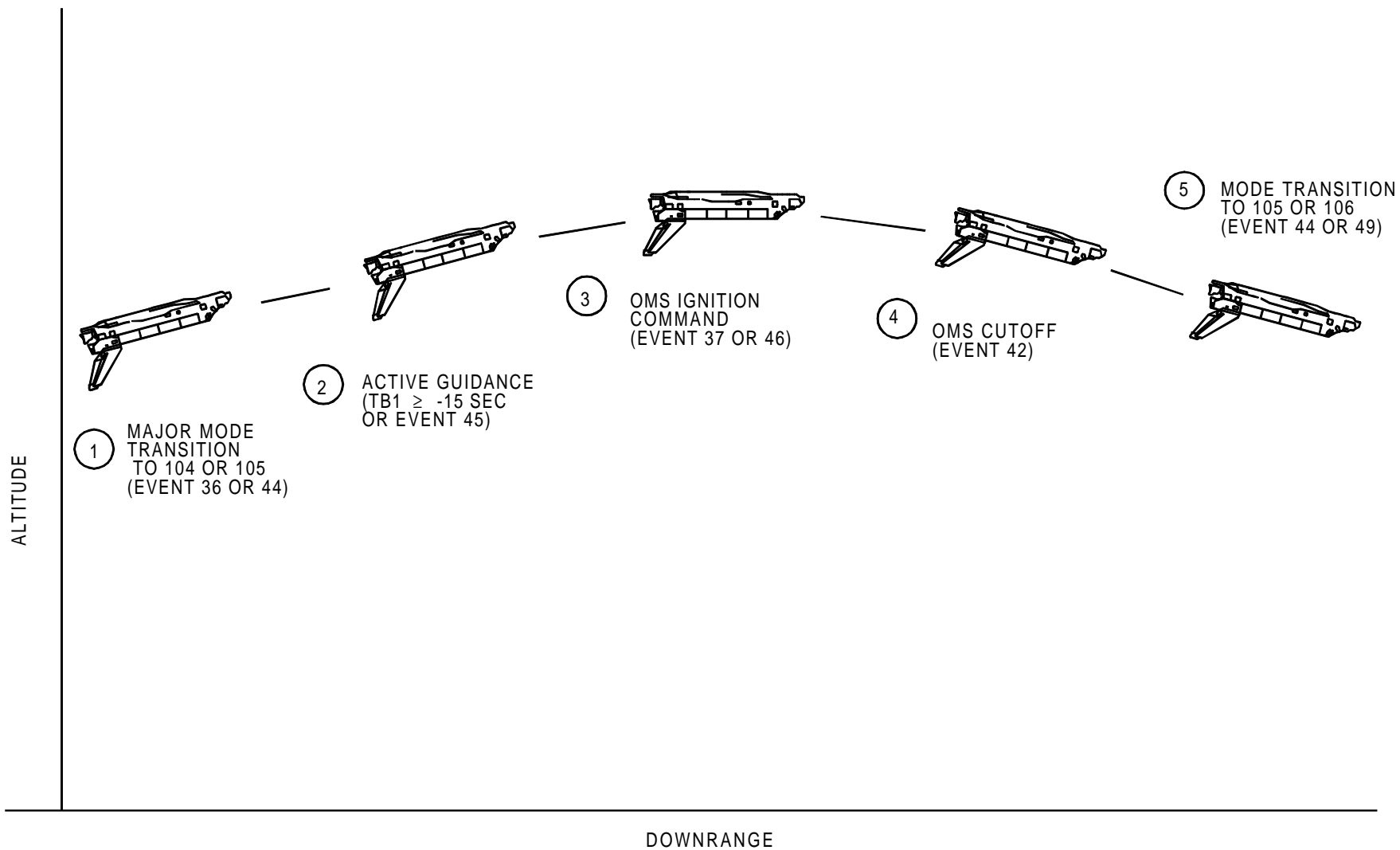


FIGURE 4.4-1. Typical OMS-1 and OMS-2 Ascent Sequence of Events

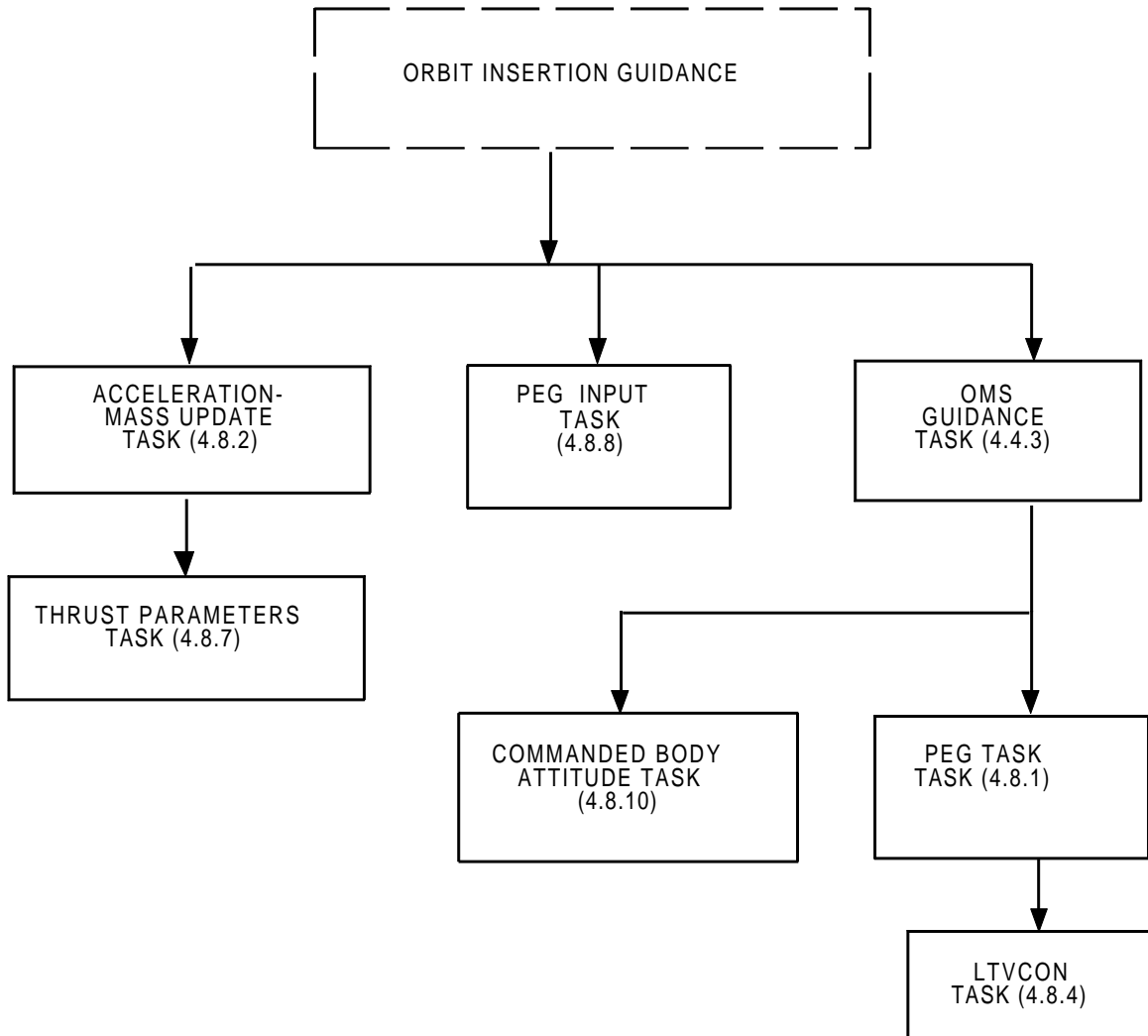


FIGURE 4.4-2. Orbit Insertion Guidance Principal Function Task Organization

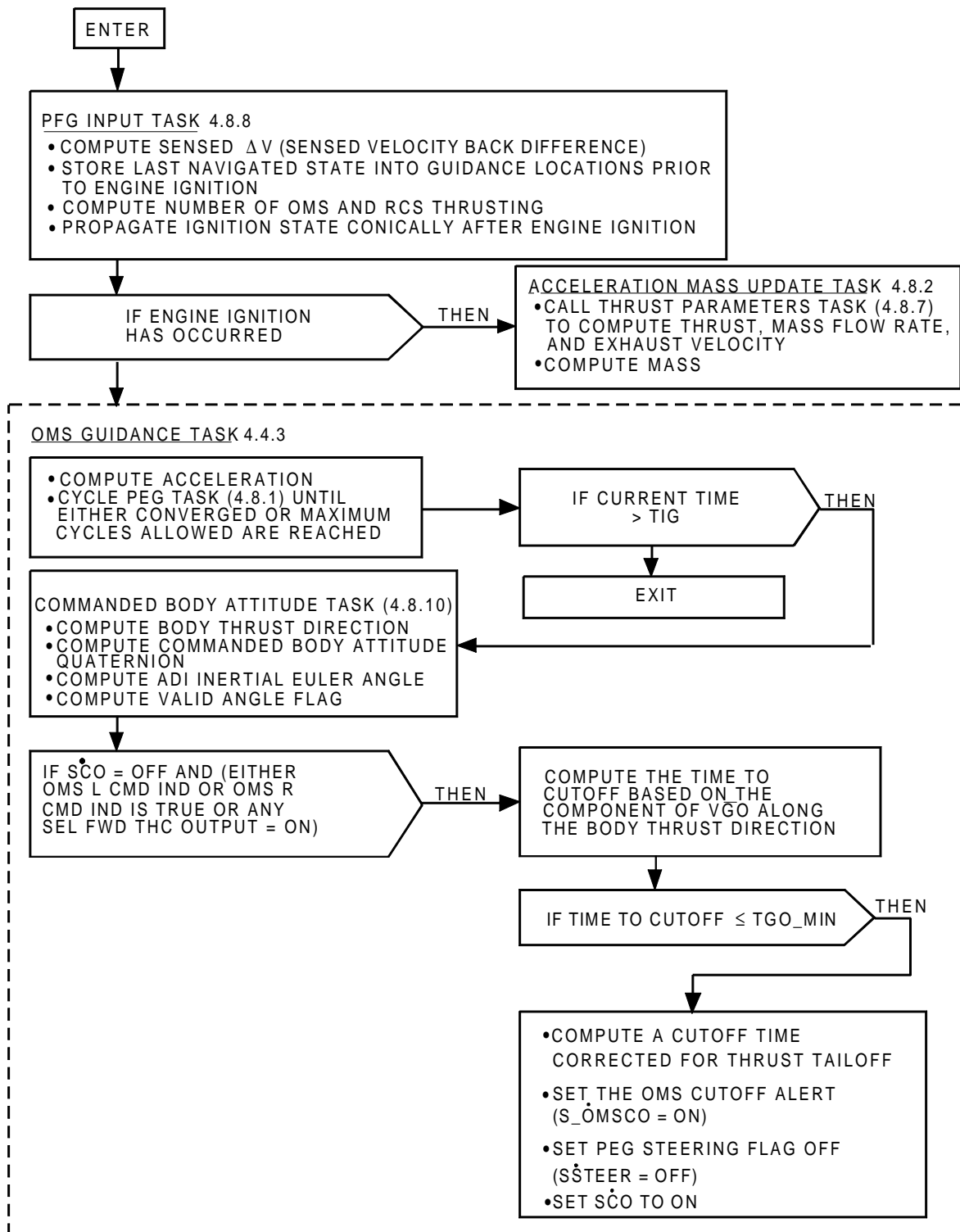


FIGURE 4.4-3. Orbit Insertion Guidance Functional Flow

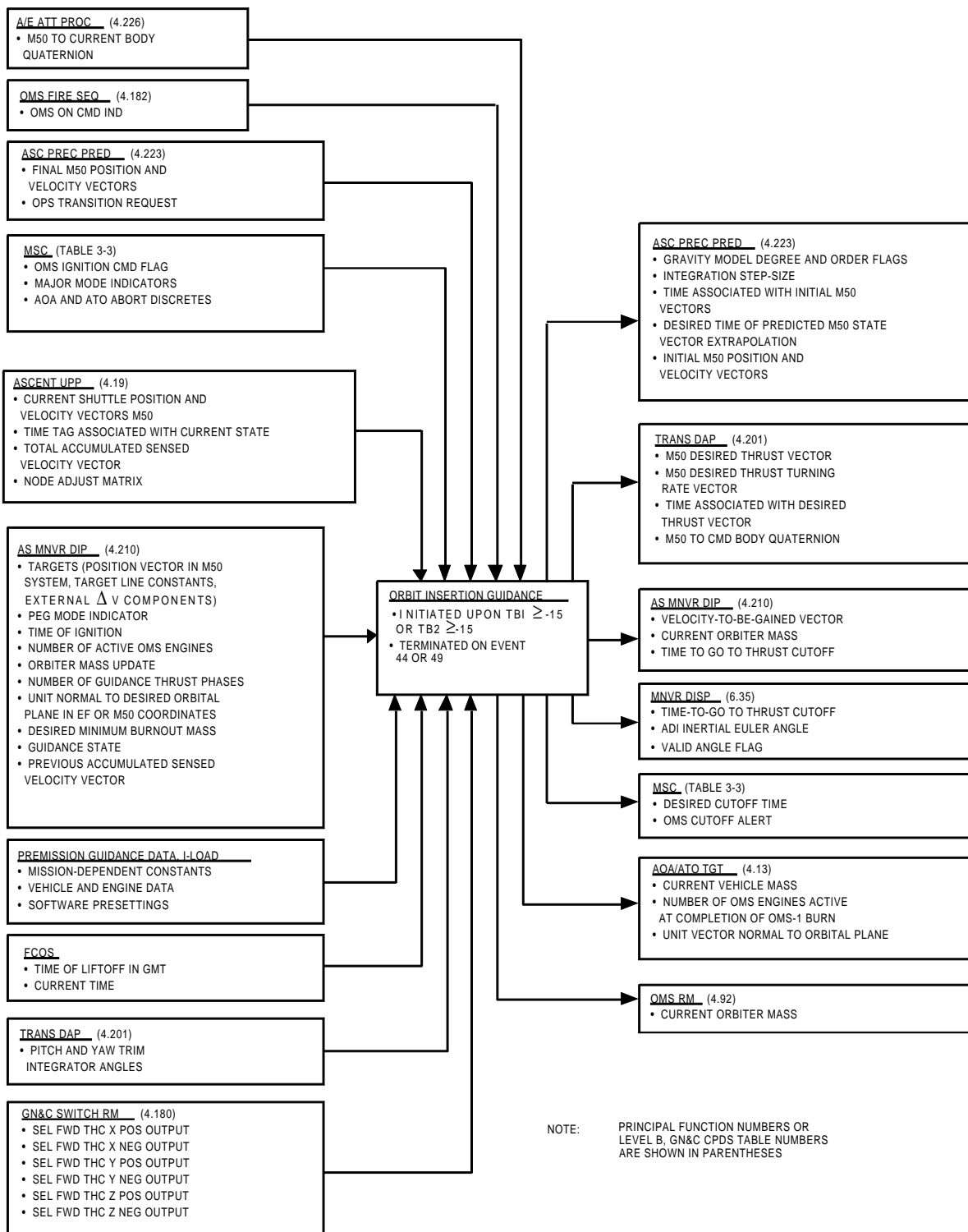


FIGURE 4.4-4. Orbit Insertion Guidance Data Flow

TABLE 4.4.4-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT INSERTION GUIDANCE (G4.3)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
C1	V94H3773CB	INTERCEPT OF TARGET LINE-GUID	ASC MNVR DIP	FT/S				
C2	V94H3774CB	SLOPE OF TARGET LINE-GUID	ASC MNVR DIP					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
IYD(X)	V97U4413CA	UNIT VEC NORM TRAJ PLN X COMP	ASC MNVR DIP					
IYD(X)	V97U4413CB	UNIT VEC NORM TRAJ PLANE X COMP	UL				93090E	
IYD(Y)	V97U4414CA	UNIT VEC NORM TRAJ PLN Y COMP	ASC MNVR DIP					
IYD(Y)	V97U4414CB	UNIT VEC NORM TRAJ PLANE Y COMP	UL				93090E	
IYD(Z)	V97U4415CA	UNIT VEC NORM TRAJ PLN Z COMP	ASC MNVR DIP					
IYD(Z)	V97U4415CB	UNIT VEC NORM TRAJ PLANE Z COMP	UL				93090E	
M/CURR_ORB_MASS/WEIGHT	V90U1961CI	CURRENT VEHICLE MASS	ASC MNVR DIP	SLUGS			93017G	*
MBO	V94U3838C	DESIRED MINIMUM BURNOUT MASS	ASC MNVR DIP	SLUGS				
MM_CODE_104/MM_104	V90X8152X	MAJOR MODE 104 FLAG	MSC				92355B	
MM_CODE_105/MM_105	V90X8623X	MAJOR MODE 105 FLAG	MSC				92355B	
MM_CODE_106/MM_106	V90X8153X	MAJOR MODE 106 FLAG	MSC				92355B	
M_NODE_ADJ	V95U0512C	NODAL ADJUSTMENT MATRIX	ASC UPP				89461	
N	V94U3823C	NUMBER OF GUIDANCE THRUST PHASES	ASC MNVR DIP					
N_OMS	V90J2031CD	NUMBER OF ACTIVE OMS ENGINES	ASC MNVR DIP				90120B	
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_OFS	V94J3791CA	PRIME PROP SYS INDICATOR FLAG	ASC MNVR DIP				93017G	*
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)	V94H3930CA	X-COMP OF GUIDANCE POS VEC AT TGD	ASC MNVR DIP	FT			89461	
RGD(Y)	V94H3931CA	Y-COMP OF GUIDANCE POS VEC AT TGD	ASC MNVR DIP	FT			89461	
RGD(Z)	V94H3932CA	Z-COMP OF GUIDANCE POS VEC AT TGD	ASC MNVR DIP	FT			89461	
RT(X)	V90H3781CA	X-M50 OF POSITION TARGET VECTOR	ASC MNVR DIP	FT				
RT(Y)	V90H3782CA	Y-M50 OF POSITION TARGET VECTOR	ASC MNVR DIP	FT				
RT(Z)	V90H3783CA	Z-M50 OF POSITION TARGET VECTOR	ASC MNVR DIP	FT				
R_AVGG(1)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CB	X-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(2)	V90H0882CB	Y-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(3)	V90H0883CB	Z-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
SMODE	V94J3779C	GUIDANCE MODE INDICATOR	ASC MNVR DIP		HXS		93017G	*
S_AOA	V90X8636X	AOA ABORT DECLARED	MSC		BD		92355B	
S_ATO	V90X8635X	ATO ABORT DECLARED	MSC				93012D	
TB_TIME	V90W8625C	ENGINE IGNITION TIME BASE TIME	MSC	S			89599C	
TGD	V94W3938CA	TIME ASSOCIATED WITH RGD,VGD	ASC MNVR DIP	S				
THC_FSN(1)	V90X7694X	SEL FWD THC NEG X OUTPUT	GN&C SW RM		BD		93017G	*

TABLE 4.4.4-1. INPUT FUNCTIONAL PARAMETERS FOR ORBIT INSERTION GUIDANCE (G4.3)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
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	V94W3790CA	TIME OF IGNITION	ASC MNVR DIP	S			93017G	*
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
VGD(X)	V94H3935CA	X-COMP OF GUIDANCE VEL VEC AT TGD	ASC MNVR DIP	FT/S			89461	
VGD(Y)	V94H3936CA	Y-COMP OF GUIDANCE VEL VEC AT TGD	ASC MNVR DIP	FT/S			89461	
VGD(Z)	V94H3937CA	Z-COMP OF GUIDANCE VEL VEC AT TGD	ASC MNVR DIP	FT/S			89461	
VGO(X)	V94L3804CA	X-EXTERNAL DEL V TARGET VECTOR	ASC MNVR DIP	FT/S				
VGO(Y)	V94L3805CA	Y-EXTERNAL DEL V TARGET VECTOR	ASC MNVR DIP	FT/S				
VGO(Z)	V94L3806CA	Z-EXTERNAL DEL V TARGET VECTOR	ASC MNVR DIP	FT/S				
VSP(X)	V94H3940CA	X-COMP OF PREV ACCUM IMU VEL	ASC MNVR DIP	FT/S				
VSP(Y)	V94H3941CA	Y-COMP OF PREV ACCUM IMU VEL	ASC MNVR DIP	FT/S				
VSP(Z)	V94H3942CA	Z-COMP OF PREV ACCUM IMU VEL	ASC MNVR DIP	FT/S				
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CB	X-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(2)	V90L0886CB	Y-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(3)	V90L0887CB	Z-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CB	X-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CB	Y-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CB	Z-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	

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

TABLE 4.4.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT INSERTION GUIDANCE (G4.3)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
DT_MAX	V90U8500CB	MAX ALLOW TIME STEP SIZE	ASC PREC PRED	S				
FT_S	V90U8120CC	ESTIMATED TOTAL THRUST	DL FMT 21/1	LBF	SPL		93017G	*
GMD_PRED	V90U8501CB	GRAVITY MODEL DEGREE	ASC PREC PRED					
GMO_PRED	V90U8502CB	GRAVITY MODEL ORDER	ASC PREC PRED					
IY(X)	V90U1976CB	X-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93017G	*
			DL FMT 21/1					
IY(Y)	V90U1977CB	Y-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93017G	*
			DL FMT 21/1					
IY(Z)	V90U1978CB	Z-M50 UNIT VEC NORMAL TO ORB PLANE	AOA/ATO TGT				93017G	*
			DL FMT 21/1					
LAMC(X)	V90U1954CC	X-COMP OF M50 REF THR VECTOR	DL FMT 21/1				93017G	*
			TRANS DAP					
LAMC(Y)	V90U1955CC	Y-COMP OF M50 REF THR VECTOR	DL FMT 21/1				93017G	*
			TRANS DAP					
LAMC(Z)	V90U1956CC	Z-COMP OF M50 REF THR VECTOR	DL FMT 21/1				93017G	*
			TRANS DAP					
LAMDC(X)	V90U1957CC	X-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1	RAD/S			93017G	*
			TRANS DAP					
LAMDC(Y)	V90U1958CC	Y-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1	RAD/S			93017G	*
			TRANS DAP					
LAMDC(Z)	V90U1959CC	Z-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1	RAD/S			93017G	*
			TRANS DAP					
LAMD MAG	V90U1968CB	MAGNITUDE OF LAMDC	DL FMT 21/1	FT/S			93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CA	CURRENT VEHICLE MASS	AOA/ATO TGT	SLUGS			93017G	*
			ASC MNVR DIP					
			DL FMT 21/1					
			OMS RM					
N_OMS	V90J2031CB	NUMBER OF ACTIVE OMS ENGINES	AOA/ATO TGT					
			TLM					
N_RCS	V90J1974CB	NUMBER OF ACTIVE RCS ENGINES	TLM					
N_RCS_NULL	V90J1975CB	NUMBER OF ACTIVE RCS NULL ENGINES	TLM					
OTREQ	V90X0893XI	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
PROP_FLAG_OFS	V94J3791CD	PRIME PROP SYS INDICATOR FLAG	DL FMT 21/A				93017G	*
Q_CB_M50_S	V94U3980CC	M50 TO BODY QUAT ELEM 1	TLM					
			TRANS DAP					
Q_CB_M50_V(1)	V94U3981CC	M50 TO BODY QUAT ELEM 2	TLM					
			TRANS DAP					
Q_CB_M50_V(2)	V94U3982CC	M50 TO BODY QUAT ELEM 3	TLM					
			TRANS DAP					
Q_CB_M50_V(3)	V94U3983CC	M50 TO BODY QUAT ELEM 4	TLM					
			TRANS DAP					
R_INIT(X)	V90H8508CB	X-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Y)	V90H8509CB	Y-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Z)	V90H8510CB	Z-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
SCONV	V90X1971XB	PEG CONVERGENCE DISCRETE	DL FMT 21/1				93017G	*

TABLE 4.4.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM ORBIT INSERTION GUIDANCE (G4.3)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
S_OMSCO	V90X2035XA	OMS CUTOFF ALERT DISCRETE	DL FMT 21/A MSC				93017G	*
TGD	V90W1994CC	GUIDANCE TIME TAG	DL FMT 21/1				93017G	*
TGO	V90W1941CB	TIME TO GO TO VELOCITY CUTOFF	ASC MNVR DIP DL FMT 21/A DL FMT 22/1 XXXXX MNVR DISP	S			93017G	*
TLAMC	V90W1953CC	TIME ASSOC W REF THR VECTOR	DL FMT 21/1 TRANS DAP	S			93017G	*
TP	V90W1946CB	PREDICTED TIME OF THRUST C/O	DL FMT 21/1	S			93017G	*
T_CUTOFF	V90W2034CA	DESIRED CUTOFF TIME	DL FMT 21/1 MSC	S			93017G	*
T_FINAL	V90W8506CB	TIME AT WHICH STATE IS DESIRED	ASC PREC PRED	S				
T_INIT	V90W8512CB	TIME AT BEGINNING OF PRED	ASC PREC PRED	S				
VEH_PITCH	V93U6909CF	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 21/A XXXXX MNVR DISP	DEG			93017G	*
VEH_ROLL	V93U6910CF	ROLL ANGLE IN ADI INERTIAL COORD	DL FMT 21/A XXXXX MNVR DISP	DEG			93017G	*
VEH_YAW	V93U6911CF	YAW ANGLE IN ADI INERTIAL COORD	DL FMT 21/A XXXXX MNVR DISP	DEG			93017G	*
VGO(X)	V90L2026C	X VEL TO BE GAINED VECTOR IN M50	ASC MNVR DIP	FT/S			89461	
VGO(Y)	V90L2027C	Y VEL TO BE GAINED VECTOR IN M50	ASC MNVR DIP	FT/S			89461	
VGO(Z)	V90L2028C	Z VEL TO BE GAINED VECTOR IN M50	ASC MNVR DIP	FT/S			89461	
VGOMAG	V90U1966CB	MAGNITUDE OF VGO VECTOR	DL FMT 21/1	RAD/S			93017G	*
V_INIT(X)	V90L8513CB	X-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Y)	V90L8514CB	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Z)	V90L8515CB	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
X_FLAG	V90X0414XA	VALID ANGLE COMP FLAG	XXXXX MNVR DISP			BD	90763E	
	V90M2926PA	CGEB_FLT_LG1_FLAG2_MFE	DL FMT 21/A				93017G	*
	V90M3142PB	CGGB_MC16_GUID_TGT_FLAG	DL FMT 21/1				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

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TABLE 4.4.4-3. ORBIT INSERTION GUIDANCE (G4.3) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
EF_PLANE_SW	V99U7441C	ND	D		M	C	G4.19 G4.2 G4.20 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
EP_TRANSFER	V96U7514C	ND	F	S	D	P	G4.209 G4.3 G5.10	00	ZFW	93182B	*
IYD(1)	V97U4413C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
IYD(2)	V97U4414C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
IYD(3)	V97U4415C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
KLAMDZX	V97U4423C	ND	F	S	D	C	G4.13 G4.209 G4.210 G4.211 G4.3 G5.26	00	ZF1	90243C	
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 4.4.4-4. ORBIT INSERTION GUIDANCE (G4.3) 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	
EPSTGO PEG INHIBIT STEERING OUTPUT	V97U4381C	00	+4.0	E-02	ND	F	S	C G4.2 G4.210 G4.3 G4.4	59955	
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03	LBF	F	S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02	LBF	F	S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
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	

TABLE 4.4.4-4. ORBIT INSERTION GUIDANCE (G4.3) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE		ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01	SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01	SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
MUP_TH MINIMUM CHANGE IN MASS REQUIRED FOR MASS TO BE UPDATED	V97U6150C	00	+3.0	E-01	SLUGS	F	S	P	G4.13 G4.2 G4.3 G4.4 G4.5	90608D	
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	
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	

TABLE 4.4.4-4. ORBIT INSERTION GUIDANCE (G4.3) 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(2)	V97U2369C	01	-5.2100000	E+00	DEG	F	S	C G4.158	90353G	
OMS ENG YAW TRIM ANG THRUST - CG		02	-5.2100000	E+00				G4.201		
		03	-5.2100000	E+00				G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.35		
								G4.7		
PHIDOT_MAX	V97U9003C	00	+3.5	E-02	RAD/SEC	F	S	C G4.2	90329C	
MAXIMUM TURNING RATE								G4.210		
								G4.3		
								G4.4		
PITCH_BIAS	V97U4485C	00	+2.7605300	E-01	RAD	F	S	C G4.158	59955	
CONST OMS ENG ELEC PITCH TRIM ANG								G4.209		
								G4.210		
								G4.211		
								G4.3		
								G4.7		
Q_M50_INRTL_ASCENT(1)	V97U2214CA	00	+1.0	E+00	ND	F	S	C G4.210	89688B	
								G4.226		
								G4.3		
Q_M50_INRTL_ASCENT(2)	V97U2215CA	00	+0.0	E+00	ND	F	S	C G4.210	89688B	
								G4.226		
								G4.3		
Q_M50_INRTL_ASCENT(3)	V97U2216CA	00	+0.0	E+00	ND	F	S	C G4.210	89688B	
								G4.226		
								G4.3		
Q_M50_INRTL_ASCENT(4)	V97U2217CA	00	+0.0	E+00	ND	F	S	C G4.210	89688B	
								G4.226		
								G4.3		
TCO_BIAS	V97U4662C	00	+3.98	E-01	SEC	F	S	C G4.209	90329C	
OMS CUTOFF TIME BIAS								G4.3		
								G4.7		
TGO_MIN	V97U4665C	00	+6.0000000	E+00	SEC	F	S	C G4.209	89542A	
MIN TIME-TO-GO THRUST TERMINATE								G4.3		
								G4.7		
THRUST_BODY_RCS_X(1)	V97U4812C	00	+9.8480780	E-01	ND	F	S	C G4.158	90329C	
X-COMPONENT OF RCS THRUST								G4.209		
DIRECTION								G4.210		
								G4.211		
								G4.3		
								G4.7		

TABLE 4.4.4-4. ORBIT INSERTION GUIDANCE (G4.3) 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	
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 4.4.4-5. ORBIT INSERTION GUIDANCE (G4.3) 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 4.4.4-5. ORBIT INSERTION GUIDANCE (G4.3) 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 4.4.4-5. ORBIT INSERTION GUIDANCE (G4.3) 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 AOA/ATO TARGETING REQUIREMENTS (MM's 103, 104, AND 105)

This section addresses the requirements for the principal function AOA/ATO TGT (CPDS, Level B, GN&C principal function 4.13). Execution of this principal function requires the general guidance and targeting tasks Acceleration–Mass Update (Section 4.8.2), H– θ –to–M50 Target (Section 4.8.6), Powered Explicit Guidance (Section 4.8.1), Linear Terminal Velocity Constraint (Section 4.8.4), and Thrust Parameters (4.8.7).

This principal function performs the targeting, both pre–MECO and post MECO, required for AOA/ATO and sets flags that are used by the ABT CNTL SEQ principal function to control the pre–MECO OMS burns. This principal function will be performed if the crew has selected an AOA or ATO at any time up to crew proceed command for ignition of the OMS–2 burn. AOA/ATO TGT is common to several major modes (103, 104, 105) and performs appropriate tasks in each major mode as discussed in Section 4.5.1.

Continuous ATO capability exists from lift–off to a short time (mission dependent) before OMS–2 ignition for intact abort situations other than an SSME failure. For the failure of an SSME, AOA capability extends as late as possible (a short time before OMS–2 ignition) to support time–critical abort situations. ATO capability is desired as early as possible, since it is the preferred abort mode for all non–time–critical abort situations. Thus, the AOA/ATO TGT principal function must support an AOA or ATO request at any time up to the crew proceed command for OMS–2 ignition. However, for an abort situation other than an SSME failure, it is recommended that the crew not select an abort mode until the capability exists (based on velocity) to perform the abort with one SSME failed.

The pre–MECO ATO TGT logic is basically designed for the one–SSME failure abort situation, the most severe case designed for; but it readily handles other abort situations as well. To achieve ATO capability for early SSME failures, a more favorable MECO target may be used. Also, to achieve earliest abort capability, a variable IY option is available which changes the orbital plane target (unit vector normal to the orbital plane at MECO) from the nominal value to a current, in–plane performance optimum value. In addition, the available OMS propellant may be burned pre–MECO, leaving only enough propellant for on–orbit and deorbit usage. When possible, the ATO software conserves ΔV to allow mission continuation from the ATO orbit. In the one–SSME failure ATO situation, this is achieved by reducing the pre–MECO OMS burn as performance improves with later SSME failure times. For an ATO without an SSME failure, the pre–MECO OMS burn may be made to allow for aborts due to a partial SSME thrust loss.

To increase mission manifesting and design flexibility closer to launch when required, the second stage inertial velocity and inertial flightpath angle ATO targets can be updated via pre-mission uplink.

The on–orbit objective for AOA targeting is to select stored targets that achieve a compatible set of acceptable entry interface (EI) conditions. The targets are premission–computed to minimize on–orbit ΔV usage. This minimization of ΔV results in the selection of a two–burn rather than a one–burn AOA sequence. The targets are stored on board in the form of earth–fixed, in–plane scalar parameters (altitude and downrange angle) and in terms of a velocity–flight path angle relationship. However, if the variable IY targeting option is employed, the AOA OMS–2 targets must be a function of inclination in order to achieve the desired EI conditions. The software contains minimum ΔV target sets for two EI target lines: a shallow and a nominal line. The shallow EI target set is used for early aborts where performance is critical, since it requires less on–orbit ΔV to achieve. A nominal EI target set is selected as soon as adequate performance is available since it results in a nominal entry trajectory. A nominal entry trajectory is much more desirable for several reasons, including lower thermal protection system backface temperatures and less sensitivity to dispersions. If a nominal EI target set is selected and a subsequent

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MECO or OMS-1 burn dispersion results in inadequate performance, targets for shallow EI are selected in an effort to reduce the deorbit OMS ΔV requirement to an acceptable level.

The on-orbit objective for ATO targeting is to retrieve stored targets that achieve an orbit from which a deorbit can be performed. The ATO targets are selected to minimize the total ΔV required to perform the ATO and deorbit maneuvers.

The AOA/ATO OMS-1 and OMS-2 targeting is performed in OPS-1. The AOA OMS-1, ATO OMS-1, and ATO OMS-2 burns are executed during OPS-1; however, the AOA OMS-2 burn, a deorbit burn, is executed during OPS-3. Thus, a transfer from OPS-1 to OPS-3 is necessary prior to an AOA OMS-2 burn, and the AOA OMS-2 target parameters selected in OPS-1 must be part of the OPS-1 to OPS-3 data transfer.

All data sets transferred from the AOA/ATO TGT principal function to other principal functions (listed in Figure 4.5-2) are assumed to be time homogeneous.

If an ATO abort is selected via the abort-mode rotary switch or the override display, the automatically selected target set parameters and ID will be displayed to the crew upon entering MM 104 or MM 105. Any automatically selected target set may be overridden by the crew via an item number control (I_TGT) execute display. This item entry control will also allow the crew to select an AOA or ATO abort and the respective target sets desired. I_TGT is initially zero upon entering MM 104 and thereafter may be set equal to 1 through 12 by crew entry or automatically by AOA/ATO targeting when an abort is selected.

Tasks performed by the AOA/ATO TGT principal function include:

1. ATO MECO target selection task (ATO MECO TGT SEL TSK, 4.5.2)
2. ATO OMS pre-MECO burn determination task (ATO OMS PRE-MECO BRN DET TSK, 4.5.3)
3. AOA on-orbit target selection task (AOA ONORB TGT SEL TSK, 4.5.4)
4. ATO on-orbit target selection task (ATO ONORB TGT SEL TSK, 4.5.5)

In addition, five general guidance and targeting tasks are performed:

1. Ascent powered explicit guidance (4.8.1)
2. Linear terminal velocity constraint (4.8.4)
3. Acceleration-mass update (4.8.2)
4. Thrust parameters (4.8.7)
5. H- θ -to-M50 target (4.8.6)

Figure 4.5-1 presents a diagram of the task organization within the AOA/ATO TGT principal function.

An AOA/ATO targeting principal function task organization is shown in Figure 4.5-1, and data flow diagram between other principal functions is shown in Figure 4.5-2. The input/output interfaces are listed in Section 4.5.6.

Certain I-loads supporting this principal function are required to be in contiguous areas of memory in a specific sequence. Section 4.11 describes this requirement.

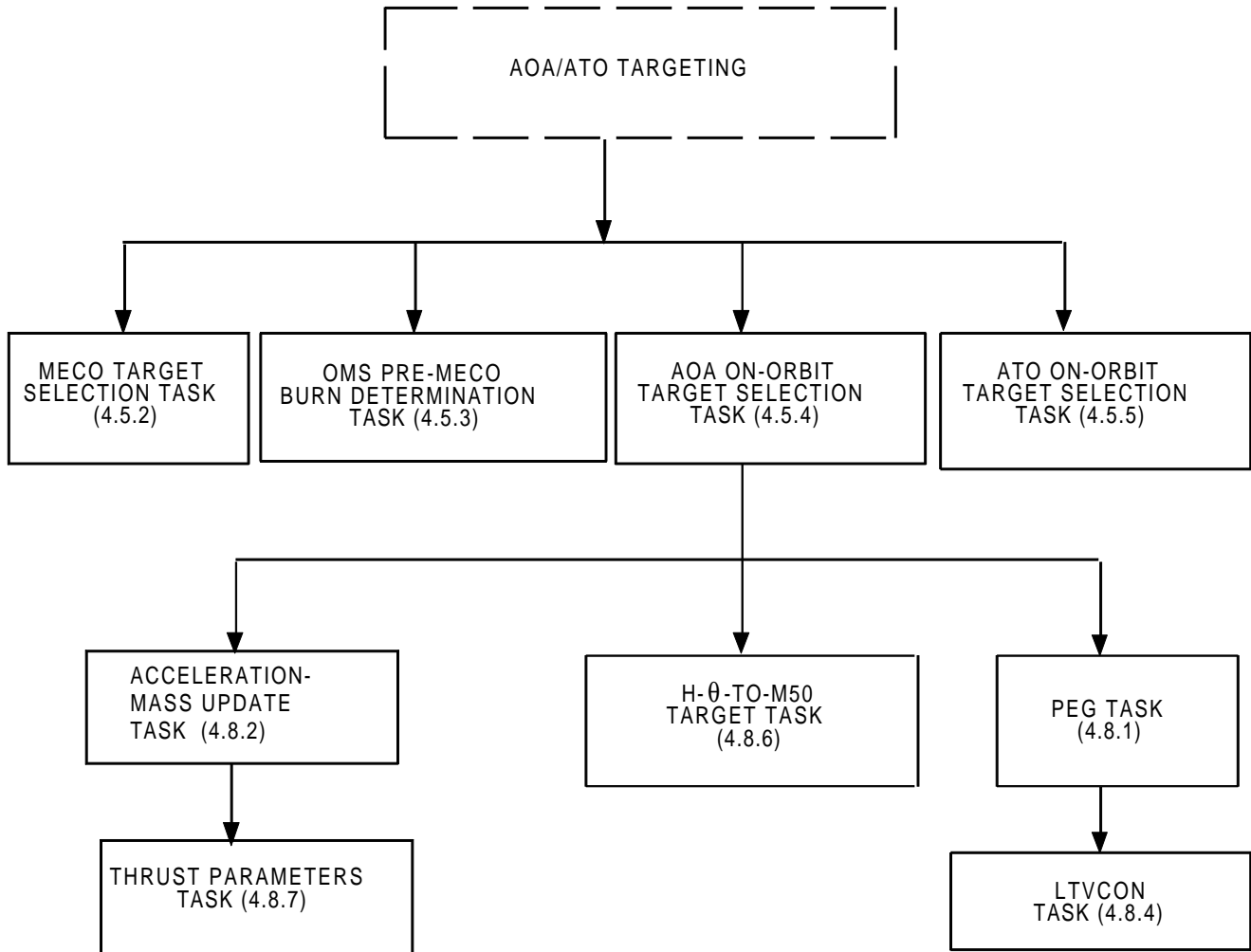


FIGURE 4.5-1. AOA/ATO Targeting Principal Function Task Organization

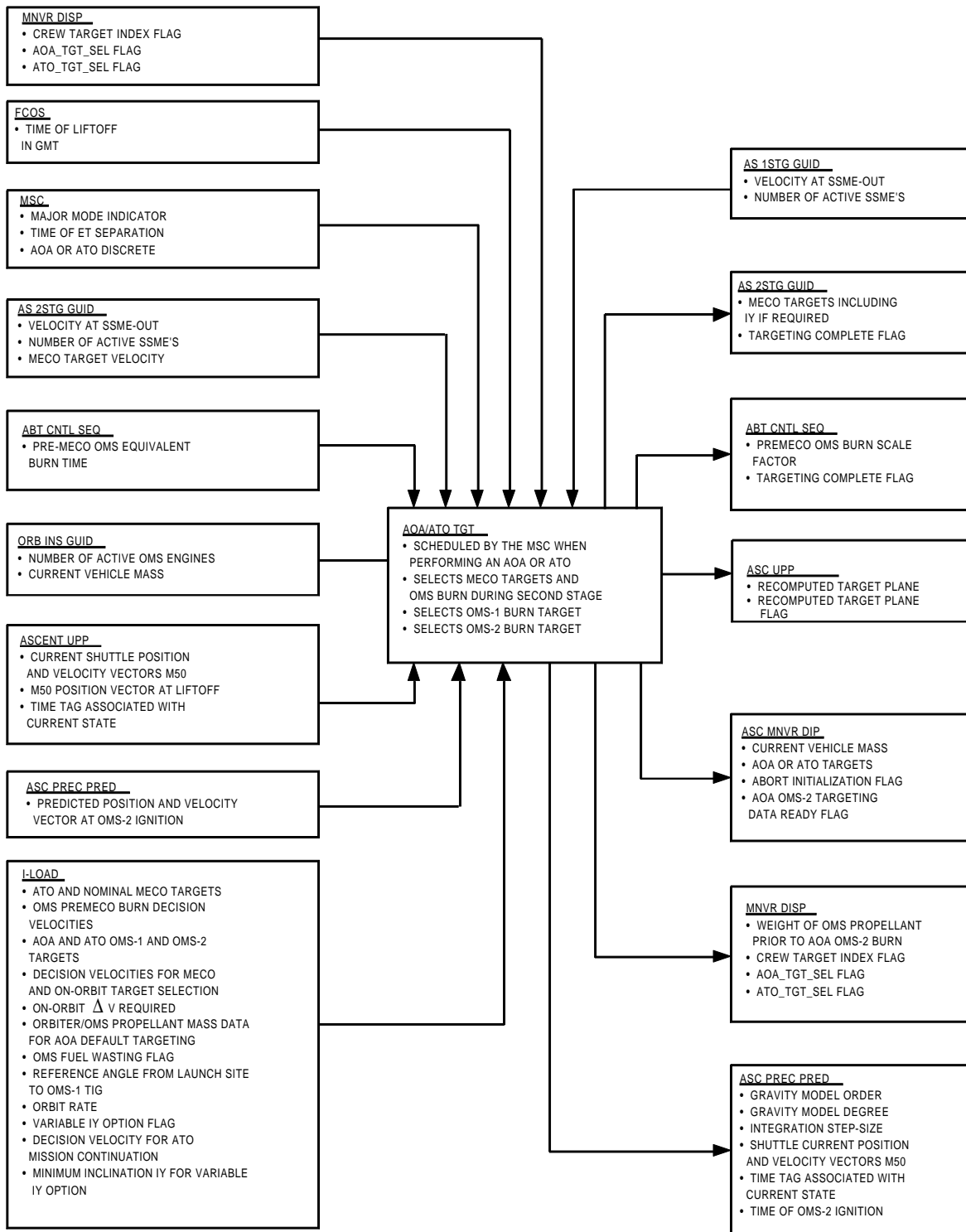


FIGURE 4.5-2. AOA/ATO Targeting Data Flow

4.5.1 AOA/ATO Targeting Sequencing (AOA/ATO TGT SEQ)

Scheduling of AOA/ATO TGT. The crew can request an ATO by (1) setting the abort-mode rotary switch to the ATO position and pressing the abort pushbutton indicator (PBI) or (2) by item entries on the override display or (3) by item entries on the ascent maneuver display. The crew can request an AOA only by item entries on the ascent maneuver display. This crew action instructs the MSC to declare the appropriate abort and to schedule the AOA/ATO TGT principal function at the proper time. All Level B events that authorize the scheduling of AOA/ATO TGT are given in parenthesis in the appropriate places. The AOA/ATO TGT is scheduled (Event A5A) upon transition to ascent second stage (MM 103) if an ATO was selected during ascent first stage (MM 102), or is scheduled (Event A9.1) immediately if an ATO is selected during ascent second stage prior to FCD. An AOA cannot be requested during ascent prior to transition to MM104 (Event 36). If an SSME has failed prior to ATO selection, then V_ME_OUT must be set equal to the earth relative velocity at SSME failure (within two seconds) before AOA/ATO TGT is executed. AOA/ATO TGT should only be executed once during MM 103 irrespective of the number of subsequent SSME failures. During ascent second stage, AOA/ATO TGT selects MECO targets and sets flags and scaling factors used by the ABT CNTL SEQ to control the pre-MECO OMS burn.

An AOA or ATO may be selected up to a short time before ignition of the OMS-2 burn. If an ATO is in progress when transition to MM 104 occurs, AOA/ATO TGT is scheduled (Event A13) immediately to select the targets for the OMS-1 burn. If an AOA or ATO is selected after transition to MM 104, but before the OMS-1 execute command, AOA/ATO TGT is scheduled (Events A16, A16A) immediately to select the targets for the OMS-1 burn. Then, upon transition to MM 105, AOA/ATO TGT is again scheduled (Events A17, A17A) immediately to select targets for the OMS-2 burn. If an ATO is selected via the abort-mode rotary switch after the OMS-1 execute command, the nominal OMS-1 burn is performed and then upon transition to MM 105, AOA/ATO TGT is scheduled to select targets for the OMS-2 burn. If an AOA or ATO is selected via item entry after the OMS-1 execute command, an "illegal entry" message will be generated. The item entry may be re-entered after OMS-1 cutoff. If an AOA or ATO is selected during MM 105 before nominal OMS-2 execute command, AOA/ATO TGT is scheduled (Events A19, A19A) immediately to select targets for the OMS-2 burn. Scheduling of the proper tasks is performed by sequencing logic within AOA/ATO TGT.

A downmode from ATO to AOA is possible in MM 104 prior to the OMS-1 execute command. To perform this downmode the crew must select an AOA I_TGT on the ascent maneuver display. When this occurs the MSC must reschedule (Event A16A) AOA/ATO TGT to select AOA OMS-1 burn targets. At the transition to MM 105, a normal scheduling of AOA/ATO TGT is made to select AOA OMS-2 burn targets.

If an AOA or ATO abort is selected, the automatically or manually selected target set and ID (I_TGT) will be displayed to the crew during MM 104 or MM 105.

If the crew is not satisfied with the planned OMS burn targets based on their evaluation or on ground advice, then they can select another target from the stored matrix of targets in AOA/ATO TGT (Table 4.5.4-1). The crew makes this target selection by item entry of a target index (I_TGT) through the maneuver display using a lap pad reference key that relates the target index flag to the particular target set. This target selection capability is available in MM 104 and MM 105 for OMS-1 and OMS-2 targeting, respectively. Upon crew selection of a target set in this manner, the AOA or ATO target select flag is set ON, which causes MSC to schedule (or reschedule) AOA/ATO TGT immediately. At this point, AOA/ATO TGT must lock out the automatic onboard target selection logic normally used and simply select the target set from the proper stored table based on the value of the target index flag. In the event of

an OMS–1 target selection via item entry index by the crew, AOA/ATO TGT will automatically select the associated OMS–2 target when scheduled by the MSC at transition to MM 105. However, full capability exists for the crew to change this OMS–2 target through an item entry of a new target index value.

A. Detailed Requirements.

Sequencing within AOA/ATO TGT. Sequencing of tasks within AOA/ATO TGT is described in the AOA/ATO TGT functional flow, Figure 4.5.1–1. If AOA/ATO TGT is scheduled in MM 103, the AOA/ATO TGT sequencing executes the MECO target selection task and the OMS pre–MECO burn determination task. If AOA/ATO TGT is scheduled during MM 104, AOA/ATO TGT sequencing executes the AOA on–orbit target selection task or the ATO on–orbit target selection task to obtain OMS–1 burn target parameters. If AOA/ATO TGT is scheduled during MM 105, AOA/ATO TGT sequencing executes the AOA on–orbit target selection task or the ATO on–orbit target selection task to obtain OMS–2 burn target parameters.

B. Interface Requirements. The input parameters for AOA/ATO Targeting Sequencing are given in Table 4.5.1–1.

C. Processing Requirements. The AOA/ATO Targeting Sequencing is performed once each time AOA/ATO Targeting is scheduled.

D. Initialization Requirements. None.

Table 4.5.1-1. AOA/ATO Targeting Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Major mode 103 flag	MM $\dot{1}$ 03	MSC	D	N/A
Major mode 104 flag	MM $\dot{1}$ 04	MSC	D	N/A
Major mode 105 flag	MM $\dot{1}$ 05	MSC	D	N/A
Discrete to indicate AOA abort declared	S_ \dot{A} OA	MSC	D	N/A
Discrete to indicate ATO abort declared	S_ \dot{A} TO	MSC	D	N/A
Fine countdown discrete	S_ \dot{M} ECO	ASC GUID TSK	D	N/A

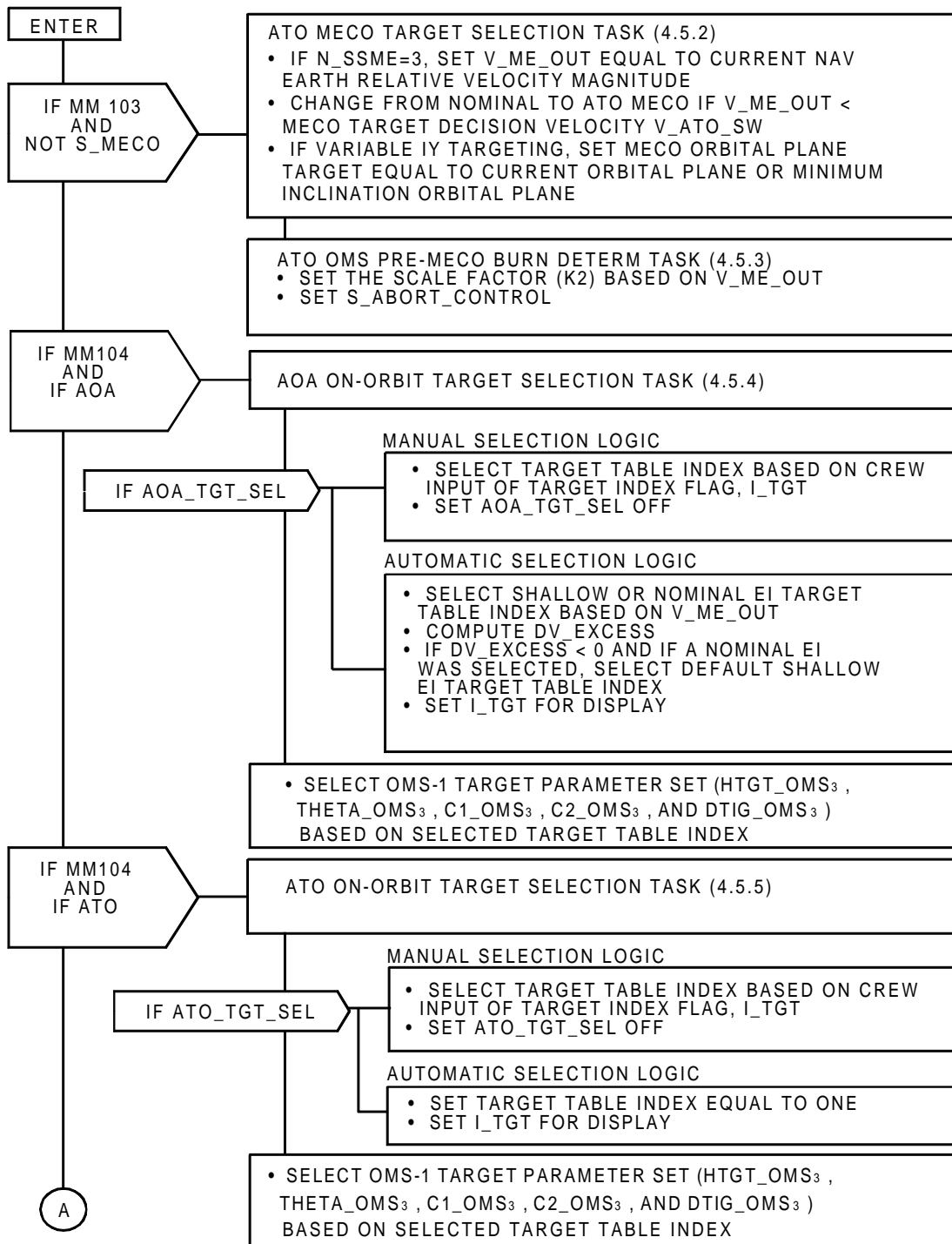


FIGURE 4.5.1-1.(1) AOA/ATO Targeting Functional Flow (Sheet 1 of 2)

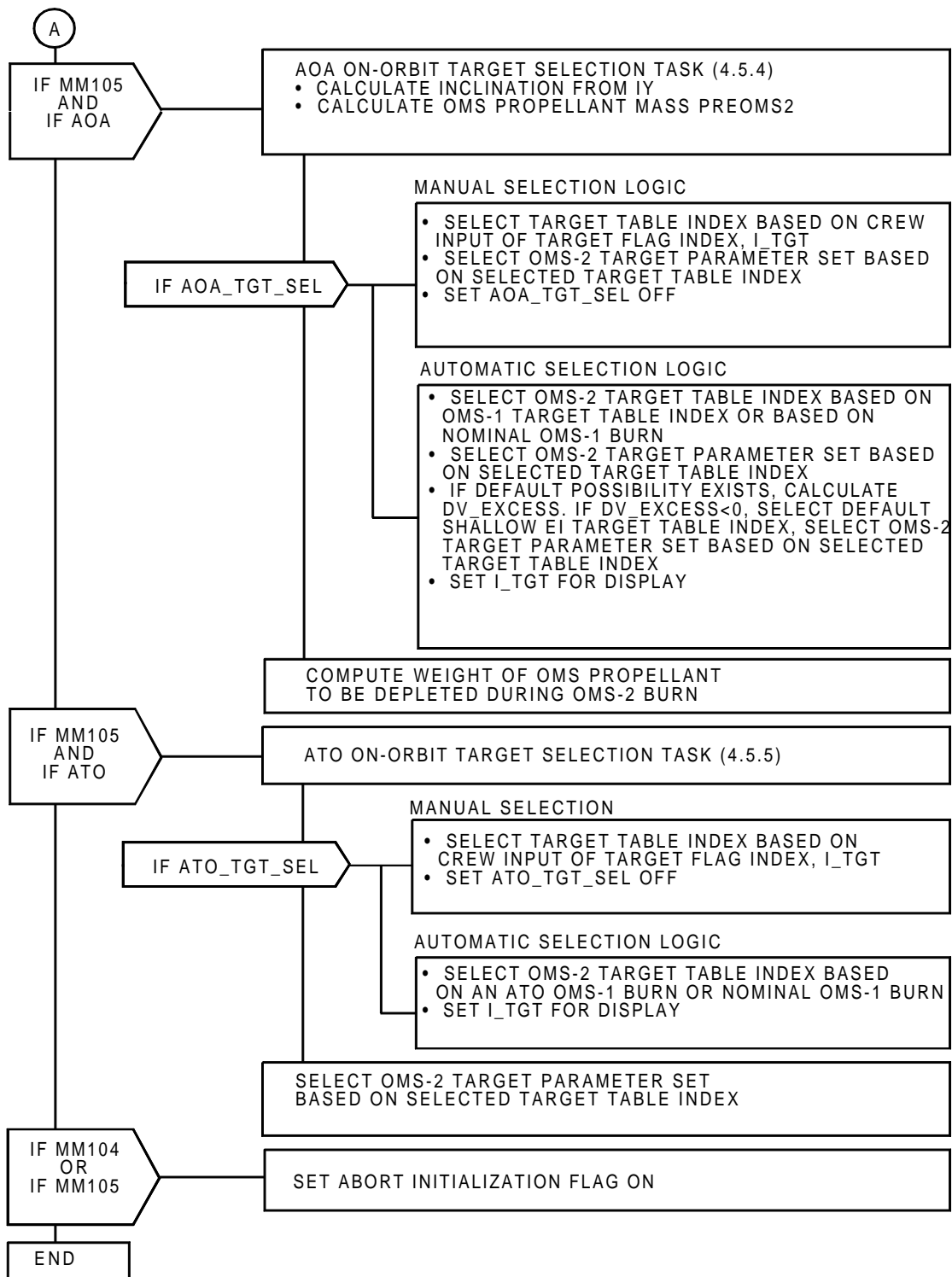


FIGURE 4.5.1-1.(2) AOA/ATO Targeting Functional Flow (Sheet 2 of 2)

4.5.2 ATO MECO Target Selection Task (ATO MECO TGT SEL TSK)

The ATO MECO target selection task determines whether the nominal or ATO MECO target will be used by the ascent second-stage guidance in the event of an ATO. Also, if the variable IY option has been selected permission, this task calculates the unit vector normal to the desired orbit plane at ATO MECO target set.

A. Detailed Requirements. An ATO MECO target set consisting of a velocity magnitude, radius magnitude, and flight path angle are permission loaded into this software. If an ATO has been requested, the software must decide whether the guidance should remain targeted for nominal MECO or be retargeted for the ATO MECO. This decision is based on the velocity at SSME-out; if V_ME_OUT is less than the stored, permission computed switch velocity V_ATO_SW, then the guidance will be targeted for the ATO MECO; e.g.,

$$VDMAG = VD_ATO$$

$$RDMAG = RD_ATO$$

$$GAMD = GAMD_ATO$$

The nominal MECO target is maintained if V_ME_OUT is greater than or equal to the switch velocity; e.g., VDMAG = VD_NOM, RDMAG = RD_NOM, GAMD = GAMD_NOM. If an ATO is performed with no SSME failures (e.g., partial thrust loss of an SSME), then V_ME_OUT is set to the current navigated relative velocity magnitude, V_ME_OUT = V_RHO_MAG.

For an ATO with variable IY targeting option selected ($\dot{S}_{IY} = ON$), the unit vector normal to the desired orbit plane used by AS 2STG GUID (\bar{IY}) is calculated as follows:

$$\bar{IY} = \text{UNIT}(V_NAV \times R_NAV)$$

Also, set on a flag to indicate a new target plane has been calculated:

$$S_ATO_IY = ON$$

However, if the orbit inclination associated with \bar{IY} is less than a minimum acceptable inclination defined permission, then \bar{IY} is set equal to the minimum \bar{IY} . This inclination test is made by comparing the Z components of the \bar{IY} vectors in the M50 coordinate system. \bar{IY} minimum in M50 is calculated by:

$$\bar{IY_MIN_M50} = EARTH_FIXED_TO_M50_COORD(T_GMTLO) \bar{IY_MIN_EF}$$

If $IY(3) < IY_MIN_M50(3)$,

then $\bar{IY} = \bar{IY_MIN_M50}$

where

$\bar{IY_MIN_M50}$ = minimum inclination \bar{IY} in the M50 coordinate system

$\bar{IY_MIN_EF}$ = permission stored minimum \bar{IY} in earth-fixed coordinates

$EARTH_FIXED_TO_M50_COORD(t) \bar{X}$ = earth-fixed to M50 coordinate transformation of vector \bar{X} at time t

T_GMTLO = Greenwich mean time at lift-off

When V_ME_OUT is greater than or equal to a premission stored or uplinked mission continuation velocity criterion (V_MSSN_CNTN), the variable \overline{IY} flag ($S_{\dot{IY}}$) is set to OFF so that nominal MECO \overline{IY} target is maintained, allowing mission continuation. This task makes no change to \overline{IY} when $S_{\dot{IY}} = \text{OFF}$.

B. Interface Requirements. The ATO MECO target selection input and output parameters are given in Tables 4.5.2-1 and 4.5.2-2.

C. Processing Requirements. The ATO MECO target selection task is performed once if an ATO is initiated before FCD (Event 31).

D. Initialization Requirements. The parameter $S_{\dot{A}TO_IY}$ shall be initialized OFF.

Table 4.5.2-1. ATO MECO Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Variable IY targeting option flag	S_ĪY	I-LOAD	D	N/A
Relative velocity magnitude at SSME failure time	V_ME_OUT	SSME-OUT SAF TSK	SP	fps
Earth-fixed unit vector normal to minimum inclination orbit plane	ĪȲ_MIN_EF	I-LOAD	DP	ND
ATO MECO terminal radius constraint	RD_ATO	I-LOAD	DP	ft
ATO MECO terminal velocity constraint	VD_ATO	I-LOAD, UPLINK	SP	fps
ATO MECO terminal flightpath angle constraint	GAMD_ATO	I-LOAD, UPLINK	SP	rad
ATO mission continuation velocity criterion	V_MSSN_CNTN	I-LOAD, UPLINK	SP	fps
ATO velocity criterion for switching MECO/EI constraints	V_ATO_SW	I-LOAD	SP	fps
Current Shuttle position vector in M50	R_ĪNAV	ASC UPP	SP	ft
Current navigated earth relative velocity magnitude	V_RHO_MAG	ASC UPP	SP	fps
Current Shuttle velocity vector in M50	V_ĪNAV	ASC UPP	SP	fps
Number of active SSME's	N_SSME	1STG GUID INP TSK, PFG INP TSK	I	N/A
Nominal MECO terminal radius constraint	RD_NOM	I-LOAD	DP	ft
Nominal MECO terminal velocity constraint	VD_NOM	I-LOAD	SP	fps
Nominal MECO terminal flightpath angle constraint	GAMD_NOM	I-LOAD	SP	rad

Table 4.5.2-2. AOA/ATO MECO Target Selection Task Outputs				
Definition	Symbol	Destination	Prec	Units
MECO flight path angle	GAMD	PEG TSK	SP	rad
MECO radius	RDMAG	PEG TSK	DP	ft
MECO velocity	VDMAG	PEG TSK, AOA ONORB TGT SEL TSK, XXXXXX TRAJ DIP	SP	fps
Unit vector normal to the desired orbit plane	ĪȲ	PEG TSK, AOA ONORB TGT SEL TSK, ASC UPP	DP	ND
ATO target plane recomputed flag	S_ĀTO_IY	ASC UPP	D	N/A

4.5.3 ATO OMS Pre-MECO Burn Determination Task (ATO OMS PRE-MECO BRN DET TSK)

The ATO OMS pre-MECO burn determination task sets the burn time flag and scaling factor used by the ABT CNTL SEQ principal function to execute the pre-MECO OMS burn. A burn duration table is premission loaded into the ABT CNTL SEQ. This table includes the burn durations for OMS propellant through the OMS and RCS engines.

A. Detailed Requirements.

This subtask sets the necessary scaling factor (K2) used by the ABT CNTL SEQ to regulate the pre-MECO OMS burn duration for ATO, as shown in Figure 4.5.3-1. This scaling factor is applied to an ATO burn duration table, premission loaded into the ABT CNTL SEQ. Scaling factor K2 governs the OMS propellant burned through the OMS and RCS engines. For early ATO's (V_ME_OUT less than or equal to a premission stored velocity, V_LIN), a constant burn duration sequence is specified by setting K2 equal to unity. The OMS propellant burn (through both the OMS and RCS engines) is decreased linearly as V_ME_OUT increases if V_ME_OUT is greater than V_LIN and less than or equal to V_ZERO in an effort to conserve OMS propellant for on-orbit usage. This is achieved by decreasing the K2 scaling factor linearly as a function of V_ME_OUT to a point (V_ZERO) where K2 is decreased to zero.

$$K2 = \frac{V_ZERO - V_ME_OUT}{V_ZERO - V_LIN}$$

K2 is set to zero if it is less than a small value (EPS_K2) to preclude commanding a very short burn. V_MSSN_CNTN described in Task 4.5.2 is always greater than V_ZERO for a mission using variable IY, since a full mission continuation capability does not exist until the nominal mission orbit plane (IY) can be achieved with zero pre-MECO OMS burn.

The discrete, S_ĀBORT_CONTROL, is set to indicate that the pre-MECO OMS burn parameter has been set. This enables the ABT CNTL SEQ to start the burn. This flag is also output to second stage guidance to indicate that pre-MECO ATO TGT has been executed.

B. Interface Requirements. The ATO OMS pre-MECO burn determination input and output parameters are presented in Tables 4.5.3-1 and 4.5.3-2.

During OPS-9 exclusively, the I-loaded value for the defining parameters for the scaling factor (K2) can be updated via uplink. These parameters are the following: EPS_K2 (V97U4837C), V_LIN (V97U4819C), and V_ZERO (V97U4825C). Replacement of the original I-load data with uplinked data will be transparent to the flight software.

C. Processing Requirements. The ATO OMS pre-MECO burn determination task is performed once if an ATO is initiated before FCD (Event 31).

D. Initialization Requirements. The following variables must be initialized:

K2 = 0.0

S_ĀBORT_CONTROL = OFF

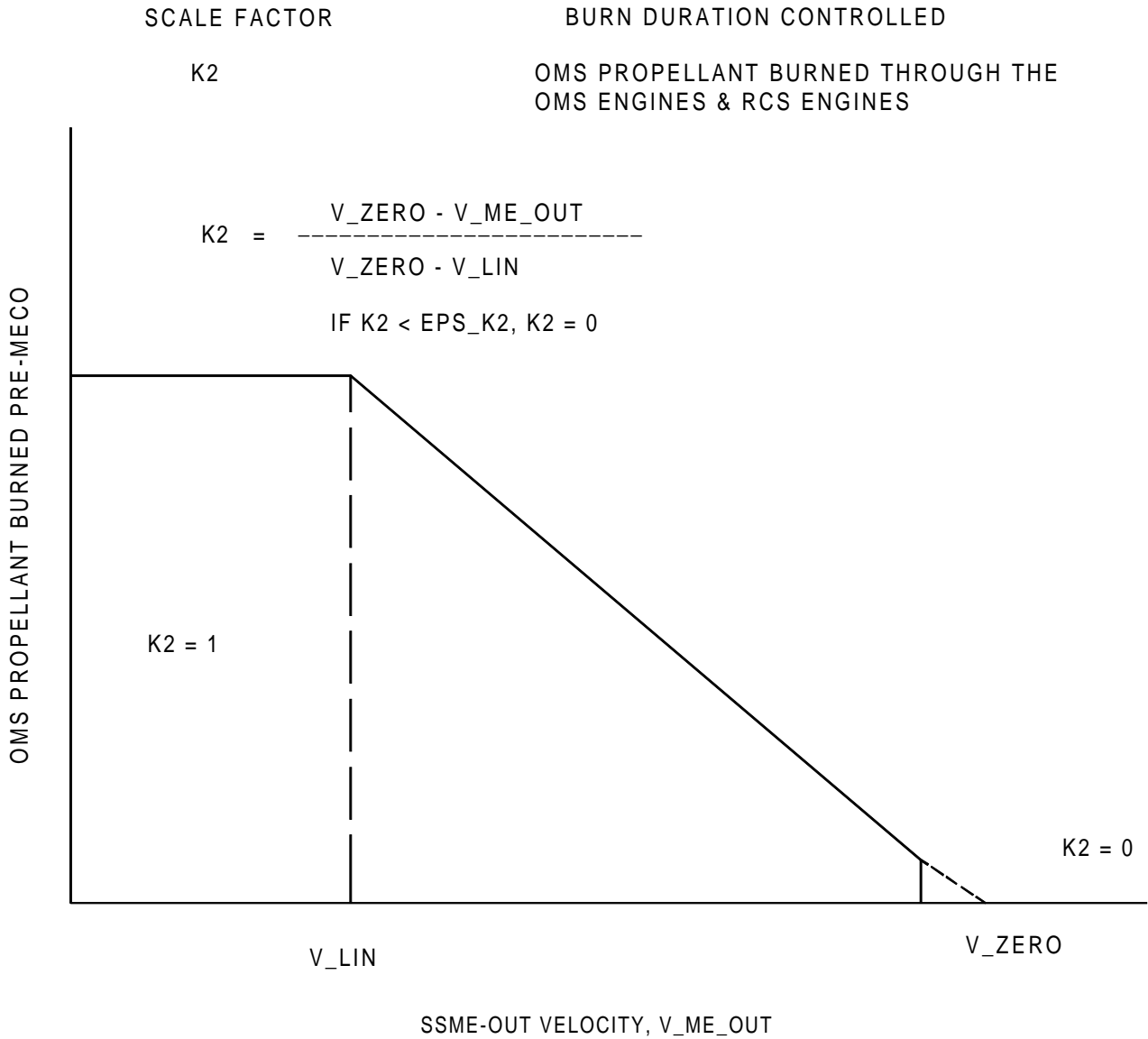


FIGURE 4.5.3-1. Pre-MECO OMS Burn Duration Scaling Factor for ATO

Table 4.5.3-1. ATO OMS Pre-MECO Burn Determination Task Inputs				
Definition	Symbol	Source	Prec	Units
Relative velocity magnitude at SSME failure time	V_ME_OUT	SSME-OUT SAF TSK	SP	fps
ATO velocity criterion for defining pre-MECO OMS and RCS burn requirements	V_LIN	I-LOAD, UPLINK	SP	fps
ATO velocity criterion for defining pre-MECO OMS and RCS burn requirements	V_ZERO	I-LOAD, UPLINK	SP	fps
Minimum tolerance value of K2	EPS_K2	I-LOAD, UPLINK	SP	ND

Table 4.5.3-2. ATO OMS Pre-MECO Burn Determination Task Outputs				
Definition	Symbol	Destination	Prec	Units
ATO pre-MECO burn time scaling factor for OMS propellant through OMS	K2	ABT CNTL SEQ	SP	ND
Discrete to indicate that pre-MECO ATO targeting is completed	S_ABORT_CONTROL	ABT CNTL SEQ, AS 2STG GUID	D	N/A

4.5.4 AOA On-Orbit Target Selection Task (AOA ONORB TGT SEL TSK)

The AOA on-orbit target selection task selects an intermediate orbit in-plane apogee target for an OMS-1 burn or an entry interface target for an OMS-2 burn from a set of targets computed and stored on board premission. Target selection must be consistent with the MECO target and the entry interface target line selected earlier. If the variable IY option is being used, then the OMS-2 target must be considered with the orbit inclination. In addition, the excess OMS delta velocity (DV_EXCESS) is calculated prior to the OMS-1 and OMS-2 burns. A negative value of DV_EXCESS prior to either the OMS-1 or OMS-2 burn will result in a default to targets stored for the shallow entry interface target line. The automatic target selection logic can be overridden by crew item entry of the target index (I_TGT) through the MANEUVER display, which sets AOA_TGT_SEL = ON. The following four subtasks are performed in the AOA on-orbit target selection task:

1. Excess OMS-1 ΔV
2. AOA OMS-1 target
3. Excess OMS-2 ΔV
4. AOA OMS-2 target

A. Detailed Requirements.

1. Excess OMS-1 ΔV . This subtask computes the excess OMS ΔV prior to the OMS-1 burn and is used by the automatic target selection logic, AOA_TGT_SEL = OFF, in order to determine if the shallow EI default target set is required (see subtask 3). If AOA_TGT_SEL = ON this subtask is not executed. The excess OMS ΔV requirement from the ΔV available pre-OMS-1 is obtained by subtracting the pre-MECO OMS burned and the OMS required for post-MECO c.g. control from the initial OMS loaded. Also, an OMS ΔV default tolerance is added into the excess OMS ΔV calculation to prevent a default for small ΔV deficiencies. The required computations are:

$$\text{MASS_OMS_PREOMS1} = \text{MASS_OMS_INIT} - \text{DM_PREMECO} - \text{MASS_CG_CNTL}$$

$$\text{DV_OMS} = \frac{\text{FT_OMS}}{\text{MDOT_OMS}} \text{LOG} \left(\frac{M}{M - \text{MASS_OMS_PREOMS1}} \right)$$

$$\text{DV_EXCESS} = \text{DV_OMS} - \text{DV_RQD} + \text{ABVAL}(\text{V_NAV}) - \text{VDMAG} + \text{DV_TOL}$$

where

DV_EXCESS = excess OMS ΔV

DV_OMS = remaining usable OMS ΔV

DV_RQD = the sum of OMS-1 and OMS-2 ΔV required from the OMS engines

DV_TOL = OMS ΔV default tolerance

FT_OMS = nominal thrust of an OMS engine

MASS_CG_CNTL = mass of OMS propellant which must remain at EI for c.g. control

MASS_OMS_INIT = mass of usable OMS propellant loaded minus the OMS propellant set aside for DV_TOL

MASS_OMS_PREOMS1 = mass of usable OMS propellant prior to OMS-1 burn

VDMAG = MECO target velocity magnitude

$V_{\overline{NAV}}$ = current navigated velocity

M = current orbiter mass

DM_PREMECO = mass of OMS burned pre-MECO

MDOT_OMS = mass flow rate of an OMS engine

The MECO velocity dispersion is the difference between the current velocity and the MECO target velocity. The expected on-orbit delta velocity requirement, the initial usable OMS propellant mass, the OMS propellant mass needed for c.g. control, and the OMS ΔV default tolerance are loaded premission. The mass of the orbiter prior to the OMS-1 burn (calculated above as M) is output to the ASC MNVR DIP for use in initializing the acceleration mass update task (4.8.2).

2. AOA OMS-1 Target. This subtask selects an intermediate orbit target set for the OMS-1 burn. The apogee altitude (HTGT) referenced to the earth equatorial radius, in-plane downrange angle from the launch site (THETA), velocity target parameters (C1 and C2), and a time of ignition after ET separation (DTIG) are the parameters that require computed values. These parameters are premission computed and I-loaded on-board in the AOA OMS-1 target table containing three target sets. The HTGT and THETA target I-loads are designed to account for J2 and drag effects over the arc between OMS-1 ignition and the target apogee. (Note: OMS-1 targets are not a function of inclination for the variable IY targeting option.)

If automatic target selection is desired, AOA_TGT_SEL = OFF, then the following AOA target sets (HTGT, THETA, C1, C2, AND DTIG) are available as described by the following targeting situations: (1) ATO MECO target conditions, shallow entry interface (EI) target line (I_TGT = 3); (2) nominal MECO target conditions, nominal EI target line (I_TGT = 4); and (3) off-nominal MECO conditions, shallow EI target line (I_TGT = 5). The AOA TARGET SET (1) will be selected automatically if ATO is declared pre-MECO and ATO MECO targets are chosen ($V_{ME_OUT} < V_{ATO_SW}$). The AOA TARGET SET (2) will be selected automatically if ATO is declared pre-MECO and nominal MECO targets are chosen ($V_{ME_OUT} > V_{ATO_SW}$), or if AOA is initiated after MECO but before the OMS-1 proceed command. The third AOA target set (3) will be automatically defaulted to FROM TARGET SET (2) if a delta velocity deficiency exists prior to OMS-1 ignition (negative excess delta V computed in the previous subtask). This default AOA target set reduces the delta V required to perform the OMS-1 and OMS-2 burns as compared to the targets for the nominal EI target line which are normally selected.

In addition to the above target parameters, the target index flag (I_TGT) is set for display.

In the event of a downmode from ATO to AOA, the AOA OMS-1 target set must be selected consistent with the MECO targets used by second-stage guidance following the initiation of ATO. The selection between the ATO MECO targets and the nominal MECO targets for ATO was based on the SSME failure velocity as described in Section 4.5.2.

If selection is manual, AOA_TGT_SEL = ON, meaning that the crew has selected a target set via item entry of the target index flag (I_TGT), then the above automatic target selection logic is locked out, the previously selected OMS-1 targets are neglected, and a target set defined by the value of the index flag is selected from the I-loaded AOA OMS-1 target table. Since ATO targets are selected when I_TGT = 1 or 2, the first AOA target set is selected from the AOA OMS-1 table when I_TGT equals 3. If I_TGT equals 4, then the second AOA target set is selected, etc. Refer to Table 4.5.4-1 for a definition of the relationship between the target index flag and the target table sets. The AOA_TGT_SEL flag is set to OFF to allow MSC to recognize a future target index item entry by the crew.

Every pass through this subtask, the abort initialization flag, ABORT_INIT, is set to ON to indicate to the AS MNVR DIP that new targets have been selected.

3. Excess OMS-2 ΔV. This subtask computes the excess OMS ΔV prior to the OMS-2 burn and is used by the automatic target selection logic, AOA_TGT_SEL = OFF, in order to determine if the shallow EI default target set is required (see subtask 5). If target selection is manual, AOA_TGT_SEL = ON, then DV_OMS, DV_EXCESS, and the PEG call to obtain VGOMAG are not required. However, MASS_OMS_PREOMS2 and TIG_OPS3 must still be calculated and H-θ-TO-M50 called to transform THETA. The excess OMS ΔV is obtained by computing the OMS propellant mass available prior to the OMS-2 burn, converting it to a ΔV, and then subtracting the projected OMS-2 ΔV required. An OMS ΔV default tolerance is added into the excess OMS delta velocity calculation to prevent a default for small ΔV deficiencies.

$$\text{MASS_OMS_PREOMS2} = \text{MASS_OMS_INIT} - \text{DM_PREMECO} - \text{MASS_CG_CNTL} - \text{DM_OMS1}$$

$$\text{DV_OMS} = \frac{\text{FT_OMS}}{\text{MDOT_OMS}} \text{LOG} \left(\frac{\text{M}}{\text{M} - \text{MASS_OMS_PREOMS2}} \right)$$

$$\text{DV_EXCESS} = \text{DV_OMS} - \text{VGOMAG} + \text{DV_TOL}$$

where

MASS_OMS_INIT = mass of usable OMS propellant loaded minus the OMS propellant set aside for DV_TOL

DM_OMS1 = OMS propellant burned during OMS-1 (see below)

MASS_OMS_PREOMS2 = OMS propellant mass remaining prior to the OMS-2 burn

DM_PREMECO = mass of OMS propellant burned pre-MECO

M = current vehicle mass

MASS_CG_CNTL = mass of OMS propellant which must remain at EI for c.g. control

FT_OMS = nominal thrust of an OMS engine

MDOT_OMS = mass flow rate of an OMS engine

DV_OMS = remaining OMS ΔV

VGOMAG = projected OMS-2 ΔV required

DV_TOL = OMS ΔV default tolerance

DV_EXCESS = excess OMS ΔV

The OMS propellant mass available prior to the OMS-2 burn is equal to the OMS propellant mass initially available minus the OMS propellant burned pre-MECO, the OMS propellant required for c.g. control, and the OMS propellant mass burned during OMS-1. The OMS propellant mass burned during OMS-1 is equal to the change in orbiter mass during OMS-1.

$$\text{MASS_PREOMS1} = \text{MASS_ORB} - \text{DM_PREMECO}$$

$$\text{DM_OMS1} = \text{MASS_PREOMS1} - M$$

where

MASS_PREOMS1 = mass of orbiter prior to OMS-1 burn

M = current vehicle mass

MASS_ORB = mass of orbiter at lift-off (should not include any SSME propellant or ET structural mass)

DM_PREMECO = mass of OMS propellant burned pre-MECO

The mass of the orbiter prior to the OMS-1 burn is given by the mass of the orbiter at lift-off minus the OMS mass burned pre-MECO. The mass of the orbiter prior to the OMS-2 burn is saved by ORB INS GUID principal function at the end of the OMS-1 burn. (An adjustment for the SSME propellant dumped during OMS-1 is not necessary, since it is not accounted for in computing the mass burned during OMS-1 nor included in the mass of the orbiter prior to OMS-1.)

The time of ignition of the OMS-2 burn is calculated by adding the stored delta TIG (selected below in Subtask 5) to the time of ET separation and subtracting an adjustment for MECO downrange dispersions:

$$\text{TIG_OPS3} = \text{DTIG_OMS} + \text{T_ET_SEP}$$

where

$$\text{DTIG_OMS} = \text{DTIG} - \text{TIG_ADJ},$$

$$\text{TIG_ADJ} = (\text{THETA_LSS} - \text{THETA_LS_REF})/\text{ORB_RATE}$$

The projected OMS-2 delta V is then computed by first propagating the current state ahead to TIG_OPS3, with use of the ASC PREC PRED principal function. Inputs to ASC PREC PRED are:

- a. \bar{R}_{NAV} , \bar{V}_{NAV} , T_{NAV} —the current state vector and time tag
- b. GMD and GMO—gravity degree (4) and order (4)
- c. DELTA_T—integration step size (DELTA_T = DT_AOA_PRED)
- d. T_{FINAL} —the predicted state time ($T_{FINAL} = TIG_OPS3$)

Next, the H- θ -to-M50 task is called with arguments of the AOA OMS-2 target altitude (HTGT) (Subtask 5) and central angle (THETA), the OMS-2 TIG position vector (\bar{R}_{GD}), and an AOA OMS-2 burn discrete ($S_{AOA_OMS2} = ON$). From these arguments the target position vector, \bar{R}_T , and the down-range angle from OMS-2 TIG to the target, THETA, are calculated. Then, if the default possibility exists (automatic selection logic in Subtask 5 selected $I = 2$ for the target table index), the ACC-MASS UPD TSK is called which in turn calls THRST PRM TSK to furnish thrust (FT), mass (M), equivalent exhaust velocity (VEX), and mass flow rate (MDOT). Acceleration is calculated for PEG from FT and M, $ATR = FT/M$. Necessary inputs to ACC-MASS UPD TSK are number of active OMS engines ($N_{OMS} = 2$) and number of RCS jets ($N_{RCS} = 0$).

Finally, unless an OPS transition has been requested ($OTREQ = ON$), PEG is called iteratively until convergence is achieved ($SCONV = ON$) or until the maximum number of calls ($NMAX_DIP$) is exceeded to obtain the magnitude of the velocity to be gained, VGOMAG. Inputs to PEG are:

- a. \bar{R}_{GD} , \bar{V}_{GD} , TGD—the guidance state (equal to TIG state)
- b. \bar{R}_T —the target position vector
- c. C1, C2—the target line constants
- d. N—number of thrust phases (N=1)
- e. S_{INIT} —PEG initialization switch ($S_{INIT} = ON$)
- f. SMODE—PEG mode indicator (SMODE=4)
- g. ATR—thrust acceleration
- h. VEX—equivalent exhaust velocity
- i. MDOT—mass flow rate
- j. Integration step size (DT_limit = DTMAX)

The projected OMS-2 delta V will be too small if both OMS are failed, but will be valid for a single OMS failure because the OMS-2 targets are designed for equal delta V for one or two OMS.

4. AOA OMS-2 Target. This subtask selects the desired set of entry interface target parameters for the OMS-2 burn. Target parameters are HTGT, THETA, C1, C2, and DTIG. These parameters are premission-computed and are I-loaded on board in the AOA OMS-2 target table containing ten target sets. The THETA and C1 I-loads are designed to account for the J2 effect over the arc between OMS-2 ignition and the entry interface. The altitude (HTGT) is referenced to the Fischer ellipsoid as required for an EI target and is set equal to a constant value, H_EI, for all target sets. The downrange angle (THETA), I-loaded referenced to the launch site, must be converted to a down-range angle referenced to time of AOA OMS-2 ignition to be consistent with the OPS-3 target parameter format (THETA_OMS₃ = THETA from H-θ-to-M50 task). This conversion of the downrange angle is performed in the H-θ-to-M50 target task. These target parameters (HTGT, THETA, C1, C2, and DTIG) are output to the AS MNVR DIP for conversion to display format and transferred to the OPS-3 maneuver display.

If selection is automatic, AOA_TGT_SEL = OFF, then five sets of OMS-2 burn target parameters are available for selection, three for shallow EI and two for nominal EI. The decision logic for OMS-2 target selection is the value of the target index (I) as follows, where I = I_TGT - 2:

- a. Select shallow EI target set (I = 1) corresponding to AOA OMS-1 target set I_TGT = 3.
- b. Select nominal EI target set (I = 2) if executing an AOA from nominal MECO to nominal EI and an AOA was initiated between MECO and the OMS-1 proceed command and if a default has not occurred (DV_EXCESS > 0).
- c. Select shallow EI target set (I = 3) if default occurs prior to OMS-1 from the nominal MECO, nominal EI targeting situation.
- d. Select shallow EI target set (I = 6) if default occurs after OMS-1 (prior to OMS-2) from the nominal MECO, nominal EI targeting situation; that is, if the possibility exists for a default (I = 2) and DV_EXCESS < 0, then set I = 6.
- e. Select nominal EI target set (I = 10) if the decision to perform an AOA was made after the crew proceed for the OMS-1 maneuver, i.e., nominal OMS-1 burn performed.

Note the target set (I = 3) built for ATO MECO conditions can no longer be accessed automatically prior to OMS-1 since an AOA abort cannot be selected pre-MECO.

For a default case (I = 6), the delta time and time of OMS-2 ignition must be recomputed

$$DTIG_OMS_3 = DTIG - TIG_ADJ$$

$$TIG_OPS3 = DTIG_OMS_3 + T_ET_SEP$$

ASC PREC PRED must be called once again to obtain the projected state vector at TIG. The OPS transition flag (OTREQ) is set to OFF before the call. Exit this task if an OPS transition has been requested (OTREQ = ON); otherwise, the H-θ-to-M50 target task must be called once again to obtain THETA referenced to OMS-2 time of ignition (OPS-3 target format). For non-default cases, the TIG and THETA computed in the OMS-2 ΔV subtask are retained. The first three AOA OMS-2 target sets are compatible pairs with the three AOA

OMS-1 target sets and are selected automatically based on OMS-1 target selection unless an OMS-2 default has occurred or a nominal OMS-1 burn has occurred. The target index flag, I_TGT, is set for display.

If selection is manual, AOA_TGT_SEL = ON, the crew has item entered a target request and the target set defined by the value of the target index flag (I_TGT) is selected from the I-loaded AOA OMS-2 target table. The manual target selection of ten OMS-2 target sets is available via the target index flag; five of the target sets are described above in the automatic OMS-2 target selection logic. The remaining five target sets can only be accessed by crew key-in of I_TGT equal to 6, 7, 9, 10, or 11. (NOTE: I_TGT = 1 or 2 selects ATO targets, so I_TGT = 6, 7, 9, 10, or 11 results in selection of the fourth, fifth, seventh, eighth, or ninth sets from the AOA OMS-2 target table. See Table 4.5.4-1.) The AOA_TGT_SEL flag is set to OFF to allow MSC to recognize a future target index item entry by the crew.

The OMS-2 target parameters THETA, C1, C2, and DTIG are functions of the orbit inclination. The HTGT target parameter will remain a constant altitude, H_EI, above the Fischer ellipsoid for all cases. The orbit inclination is calculated by

$$\text{INCL} = \text{ARCCOS}(-\text{IY}(3))$$

The functionalized target parameters are expressed as quadratic functions of inclination.

$$\text{THETA} = \text{THETA_AOA_OMS2}(I,1) + \text{THETA_AOA_OMS2}(I,2) \text{INCL} + \text{THETA_AOA_OMS2}(I,3) \text{INCL}^2$$

$$\text{C1} = \text{C1_AOA_OMS2}(I,1) + \text{C1_AOA_OMS2}(I,2) \text{INCL} + \text{C1_AOA_OMS2}(I,3) \text{INCL}^2$$

$$\text{C2} = \text{C2_AOA_OMS2}(I,1) + \text{C2_AOA_OMS2}(I,2) \text{INCL} + \text{C2_AOA_OMS2}(I,3) \text{INCL}^2$$

$$\text{DTIG} = \text{DTIG_AOA_OMS2}(I,1) + \text{DTIG_AOA_OMS2}(I,2) \text{INCL} + \text{DTIG_AOA_OMS2}(I,3) \text{INCL}^2$$

For target sets with indices 1 through 9, the parameters are functionalized; but for target set I = 10 (AOA after nominal OMS-1), the parameters are constants rather than functions of inclinations, since only the nominal mission inclination is possible.

If it is determined prelaunch that the variable IY option is not to be used, then all linear and quadratic terms are I-loaded to zero with only nonzero constant terms remaining.

The weight of the OMS propellant to be burned during OMS-2(WT_PROP_DEP) is output to the maneuver display in OPS-3. Guidance will deplete this OMS propellant during the OMS-2 burn by thrusting out of plane. WT_PROP_DEP is prefixed by either a plus or minus to indicate right or left out-of-plane thrusting. A mission-dependent parameter (SFUELD) is premission-stored in AOA/ATO TGT to either +1 or -1 for this purpose. The necessary computation is

$$\text{WT_PROP_DEP} = \text{SFUELD G}_2\text{FPS2 MASS_OMS_PREOMS2}$$

The MASS_OMS_PREOMS2 was computed above in the excess OMS-2 ΔV sub-task. If MASS_OMS_PREOMS2 is negative, then WT_PROP_DEP is set to zero to avoid OMS propellant wasting. G_2_FPS2 is the gravitational constant.

Every pass through this subtask, the abort initialization flag, ABORT_INIT, is set to ON to indicate to the AS MNVR DIP that new targets have been selected.

B. Interface Requirements. The input and output parameters for the AOA on-orbit target selection task are presented in Tables 4.5.4-2 and 4.5.4-3.

C. Processing Requirements. The excess OMS-1 ΔV and the AOA OMS-1 target subtasks are executed if the AOA/ATO TGT principal function is scheduled during MM 104 before the OMS-1 proceed command (BURN_ENABLE). The excess OMS-2 ΔV and the AOA OMS-2 target subtasks are executed if AOA/ATO TGT is scheduled after transition to MM 105.

D. Initialization Requirements. ABORT_INIT must be initialized to OFF.

Table 4.5.4-1. Target Index Flag/Target Table Relationship

Target Index Flag I_TGT	Table (Index)		Accessed by	
	OMS-1	OMS-2	Automatic Logic	Key-In of I_TGT*
1	ATO_OMS1(1)	ATO_OMS2(1)	yes	yes
2		ATO_OMS2(2)	yes	yes
3	AOA_OMS1(1)	AOA_OMS2(1)	yes	yes
4	AOA_OMS1(2)	AOA_OMS2(2)	yes	yes
5	AOA_OMS1(3)	AOA_OMS2(3)	yes	yes
6		AOA_OMS2(4)		yes
7		AOA_OMS2(5)		yes
8		AOA_OMS2(6)	yes	yes
9		AOA_OMS2(7)		yes
10		AOA_OMS2(8)		yes
11		AOA_OMS2(9)		yes
12		AOA_OMS2(10)	yes	yes

*If the crew selects this OMS-1 target by key-in of the target index flag (I_TGT), the associated OMS-2 target is automatically selected by the software upon transitioning to MM 105. The crew may override this automatic OMS-2 target selection by key-in of a new value for I_TGT in MM 105 prior to the OMS-2 burn for ATO or prior to OPS-3 transition for AOA.

Table 4.5.4-2. AOA On-Orbit Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Mass of orbiter at lift-off (not to include MPS vent mass)	MASS_ORB	I-LOAD, UPLINK	SP	slug
Mass of usable OMS propellant loaded minus the OMS propellant set aside for DV_TOL	MASS_OMS_INIT	I-LOAD, UPLINK	SP	slug
Mass of OMS propellant to be reserved for c.g. control	MASS_CG_CNTL	I-LOAD	SP	slug
Sum of OMS-1 and OMS-2 ΔV expected	DV_RQD	I-LOAD	SP	fps
ΔV tolerance for OMS-1 and OMS-2 default targeting decision	DV_TOL	I-LOAD	SP	fps
Desired MECO velocity magnitude	VDMAG	GUID PRMT RINT TSK, I-LOAD, ATO MECO TGT SEL TSK, UPLINK	SP	fps
Target altitude referenced to earth equatorial radius for OMS-1 (3)*	HTGT_AOA_OMS1	I-LOAD	SP	ft
Target altitude referenced to Fischer ellipsoid for OMS-2 (1)*	H_EI	K-LOAD	SP	ft
Target in-plane downrange angle from launch site for OMS-1 (3)*	THETA_AOA_OMS1	I-LOAD	SP	rad
Polynomial coefficients for target in-plane downrange angle from the launch site for OMS-2:				
Constant (10)*	THETA_AOA_OMS2(I,1)	I-LOAD	SP	rad
Linear (9)*	THETA_AOA_OMS2(I,2)	I-LOAD	SP	ND
Quadratic (9)*	THETA_AOA_OMS2(I,3)	I-LOAD	SP	rad ⁻¹
Mass to weight conversion factor	G_2_FPS2	CONSTANT	SP	lb/slug
Time tag associated with current state	T_NAV	ASCENT UPP	DP	sec
Target intercept of the vertical velocity vs. horizontal velocity relationship for OMS-1 (3)*	C1_AOA_OMS1	I-LOAD	SP	fps
Polynomial coefficients for target intercept of the vertical velocity vs. horizontal velocity relationship for OMS-2:				
Constant (10)*	C1_AOA_OMS2(I,1)	I-LOAD	SP	fps
Linear (9)*	C1_AOA_OMS2(I,2)	I-LOAD	SP	fps/rad
Quadratic (9)*	C1_AOA_OMS2(I,3)	I-LOAD	SP	fps/rad ²

Table 4.5.4-2. AOA On-Orbit Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Target slope of the vertical velocity vs. horizontal velocity relationship for OMS-1 (3)*	C2_AOA_OMS1	I-LOAD	SP	ND
Polynomial coefficients for target slope of the vertical velocity vs. horizontal velocity relationship for OMS-2:				
Constant (10)*	C2_AOA_OMS2(I,1)	I-LOAD	SP	ND
Linear (9)*	C2_AOA_OMS2(I,2)	I-LOAD	SP	rad ⁻¹
Quadratic (9)*	C2_AOA_OMS2(I,3)	I-LOAD	SP	rad ⁻²
Time of ignition referenced to ET separation for OMS-1 (3)*	DTIG_AOA_OMS1	I-LOAD	SP	sec
Polynomial coefficient for time of ignition referenced to ET separation for OMS 2:				
Constant (10)*	DTIG_AOA_OMS2(I,1)	I-LOAD	SP	sec
Linear (9)*	DTIG_AOA_OMS2(I,2)	I-LOAD	SP	sec/rad
Quadratic (9)*	DTIG_AOA_OMS2(I,3)	I-LOAD	SP	sec/rad ²
Time of ET separation	T_ET_SEP	FCOS	DP	sec
Magnitude of VGO vector	VGOMAG	PEG TSK	SP	fps
Assumed number of active OMS engines	N_OMS	PFM INP TSK	I	N/A
Position vector at OMS-2 time of ignition	\overline{RGD}	A/E PREC PRED	DP	ft
Velocity vector at OMS-2 time of ignition	\overline{VGD}	A/E PREC PRED	DP	fps
Current position vector	\overline{R}_{NAV}	ASCENT UPF	DP	ft
Current velocity vector	\overline{V}_{NAV}	ASCENT UPF	SP	fps
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slug
Fuel wasting flag: 0 – no fuel wasting ± – left/right thrusting to use excess propellant	SFUELD	I-LOAD	I	N/A
Nominal OMS thrust	FT_OMS	K-LOAD	SP	lbf
Nominal OMS mass flow rate	MDOT_OMS	K-LOAD	SP	slug/sec
Total vehicle thrust force	FT	THRST PRM TSK	SP	lb
Maximum PEG cycles	NMAX_DIP	K-LOAD	I	N/A
Discrete indicating convergence	S \dot{C} ONV	PEG TSK	D	N/A

Table 4.5.4-2. AOA On-Orbit Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Central angle between OMS-2 ignition and the target position vector at entry interface	THETA	H-θ-TO-M50 TSK	SP	rad
Desired A/E PREC PRED step size	DT_AOA_PRED	K-LOAD	SP	sec
Central angle between launch site reference and OMS-1 TIG	THETA_LSS	H-θ-TO-M50 TSK	SP	rad
Reference central angle between launch site reference and OMS-1 TIG	THETA_LS_REF	I-LOAD	SP	rad
Circular orbit rate	ORB_RATE	K-LOAD	SP	rad/sec
Maximum integration step size	DTMAX	K-LOAD	SP	sec
Crew target index flag	I_TGT	MNVR DISP	I	N/A
AOA target selection	$\dot{A}O\dot{A}_TGT_SEL$	MNVR DISP	D	N/A
Abort initialization flag	$\dot{A}BORT_INIT$	DISP INIT TSK	D	N/A
Unit vector normal to desired plane in M50 coordinates	$\bar{I}Y$	PEG TSK, ATO MECO TGT SEL TSK, GUID PRMT RINT TSK	DP	ND
OPS transition request flag	$\dot{O}TREQ$	ASC PREC PRED	D	N/A
Mass of OMS burned Pre-MECO	DM_PREMECO	DISP INIT TSK	SP	slugs
* Number of parameters				

Table 4.5.4-3. AOA On-Orbit Target Selection Task Outputs

Definition	Symbol	Destination	Prec	Units
Target altitude	HTGT_OMS ₃	DISP INIT TSK	SP	ft
	HTGT	H-θ-M50 TGT TSK	SP	ft
Target in-plane downrange angle (from launch site for OMS-1, from TIG for OMS-2)	THETA_OMS ₃	DISP INIT TSK	SP	rad
Angle from launch site to OMS-2 target position vector	THETA	H-θ-M50 TGT TSK	SP	rad
Target intercept of the vertical velocity vs. horizontal velocity relationship	C1_OMS ₃	DISP INIT TSK, TLM	SP	fps
	C1	PEG TSK	SP	fps
Target slope of the vertical velocity vs. horizontal velocity relationship	C2_OMS ₂	DISP INIT TSK, TLM	SP	ND
	C2	PEG TSK	SP	ND
Time of ignition referenced to ET separation	DTIG_OMS ₃	DISP INIT TSK	SP	sec
Time of ignition of the OMS-2 burn	T_FINAL	ASC PREC PRED	DP	sec
PEG initialization discrete	S [•] INIT	PEG TSK	D	N/A
Number of thrust phases	N	PEG TSK	I	N/A
AOA OMS-2 targeting data ready flag	S_ĀOA_OMS2	H-θ-TO-M50 TSK, DISP INIT TSK	D	N/A
Number of active OMS engines	N_OMS	THRST PRM TSK	I	N/A
Number of active RCS engines	N_RCS	THRST PRM TSK	I	N/A
OPS transition request flag	OTREQ	ASC PREC PRED	D	N/A
Weight of OMS propellant prior to the AOA OMS-2 burn	WT_PROP_DEP	MNVR DISP (OPS-3) ¹	SP	lb
Current position vector	R _{NAV}	ASC PREC PRED	DP	ft
Current velocity vector	V _{NAV}	ASC PREC PRED	SP	fps
Time tag associated with current state	T_NAV	ASC PREC PRED	DP	sec
Gravity model degree	GMD_PRED	ASC PREC PRED	I	N/A
Gravity model order	GMO_PRED	ASC PREC PRED	I	N/A
Integration step size	DELTA_T	ASC PREC PRED	SP	sec
Vehicle position vector input to PEG	R _{GD}	PEG TSK, H-θ-TO-M50 TSK	DP	ft
Vehicle velocity vector input to PEG	V _{GD}	PEG TSK, H-θ-TO-M50 TSK	DP	fps
Time associated with R _{GD} and V _{GD}	TGD	PEG TSK	DP	sec

Table 4.5.4-3.AOA On-Orbit Target Selection Task Outputs				
Definition	Symbol	Destination	Prec	Units
Target position in inertial coordinates	$\overline{R_T}$	PEG TSK	DP	ft
Abort initialization flag	$\dot{A}BORT_INIT$	DISP INIT TSK, ASC MNVR DIP SEQ	D	N/A
Thrust acceleration estimate input to PEG	ATR	PEG TSK	SP	fps ²
PEG mode indicator	SMODE	PEG TSK	I	N/A
Excess OMS delta V	DV_EXCESS	TLM	SP	ft/sec
Maximum integration step size for gravity prediction	DT_LIMIT	PEG TSK	SP	sec
Crew target index flag	I_TGT	MNVR DISP	I	N/A
AOA target selection	$\dot{A}OA_TGT_SEL$	MNVR DISP	D	N/A
¹ Data transferred to OPS-3.				

4.5.5 ATO On-Orbit Target Selection Task (ATO ONORB TGT SEL TSK)

The ATO on-orbit target selection task obtains the ATO OMS-1 and OMS-2 target parameters. The target parameters are computed and stored on board permission. The automatic target selection logic can be overridden by crew item entry of the target index flag (I_TGT) through the maneuver display, which sets ATO_TGT_SEL = ON. Neither the OMS-1 nor OMS-2 ATO target is a function of the inclination for the variable IY targeting option. The following two subtasks are performed in the ATO on-orbit target selection task.

1. ATO OMS-1 target
2. ATO OMS-2 target

A. Detailed Requirements.

1. ATO OMS-1 Target. This subtask obtains the ATO OMS-1 apogee target parameters. These target parameters are a permission stored apogee altitude (HTGT) referenced to the earth equatorial radius, in-plane downrange angle from the launch site (THETA), velocity target parameters (C₁ and C₂), and a time of ignition referenced to ET separation (DTIG). The HTGT and THETA I-loads are designed to account for J₂ and drag effects over the arc between OMS-1 ignition and the target apogee. Even though an ATO is performed from either the ATO or the nominal MECO, target parameters are a single HTGT, THETA, C₁, C₂, DTIG set. The target index flag, I_TGT, is set to 1.

If the crew has selected a target set via item entry of the target index flag (I_TGT), then ATO_TGT_SEL is set ON and the above automatic target selection logic is locked out, the previously selected OMS-1 targets are neglected, and the target set defined by the value of the index flag is selected from the I-loaded ATO OMS-1 target table. One OMS-1 target set is available via the target index flag (I_TGT), I_TGT = 1. Table 4.5.4-1 shows the relationship between the target index flag and the ATO OMS-1 target table. The ATO_TGT_SEL flag is set to OFF to allow the MSC to recognize a future target index item entry by the crew. If a parallel RCS burn is required, the crew must command it through the translational hand controller. Guidance will be less than optimum since it has not planned on this parallel burn.

Every pass through this subtask, the abort initialization flag, ABORT_INIT, is set to ON to indicate to the AS MNVR DIP that new targets have been selected.

2. ATO OMS-2 Target. This subtask obtains the ATO OMS-2 perigee target parameters. For most missions, this target will result in orbit circularization. The target parameters selected are an HTGT, THETA, C₁, C₂, DTIG set. Two ATO OMS-2 target parameter sets are required; one to be used if a nominal OMS-1 burn was performed, the other to be used if an ATO OMS-1 burn was performed. These target parameters are permission computed and I-loaded on-board and are offset for J₂ in the same manner as the ATO OMS-1 target parameters. The target index flag, I_TGT, is set to the selected target table index.

If the crew has item entered a target request (ATO_TGT_SEL=ON), the target set defined by the value of the target index flag (I_TGT) is selected from the I-loaded ATO OMS-2 target table. The automatic target selection logic and any previously selected OMS-2 target must be ignored. Two OMS-2 target sets are available via the index flag; the first one (I_TGT = 1) is compatible with the OMS-1 target set. The second (I_TGT = 2) target set is the one described

above for use following a nominal OMS-1 burn. The $\dot{A}TO_TGT_SEL$ flag is set to OFF to allow the MSC to recognize a future target index item entry by the crew.

Every pass through this subtask, the abort initialization flag, $\dot{A}BORT_INIT$, is set to ON to indicate to the AS MNVR DIP that new targets have been selected.

B. Interface Requirements. The input and output parameters for the ATO on-orbit target selection task are given in Tables 4.5.5-1 and 4.5.5-2.

C. Processing Requirements. The ATO OMS-1 target subtask is executed if AOA/ATO TGT principal function is scheduled before OMS-1 proceed command ($\dot{B}URN_ENABLE$). The ATO OMS-2 target subtask is executed in MM 105 if AOA/ATO TGT is scheduled.

D. Initialization Requirements. None.

Table 4.5.5-1. ATO On-Orbit Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Target altitude referenced to earth equatorial radius (3)*:				
– OMS-1 (1)*	HTGT_ATO_OMS1	I-LOAD	SP	ft
– OMS-2 (2)*	HTGT_ATO_OMS2	I-LOAD	SP	ft
Target inplane downrange angle from launch site:				
– OMS-1 (1)*	THETA_ATO_OMS1	I-LOAD	SP	rad
– OMS-2 (2)*	THETA_ATO_OMS2	I-LOAD	SP	rad
Time of ignition referenced to ET separation:				
– OMS-1 (1)*	DTIG_ATO_OMS1	I-LOAD	SP	sec
– OMS-2 (2)*	DTIG_ATO_OMS2	I-LOAD	SP	sec
Target intercept of the vertical velocity vs. horizontal velocity relationship:				
– OMS-1 (1)*	C1_ATO_OMS1	I-LOAD	SP	fps
– OMS-2 (2)*	C1_ATO_OMS2	I-LOAD	SP	fps
Target slope of the vertical velocity vs. horizontal velocity relationship:				
– OMS-1 (1)*	C2_ATO_OMS1	I-LOAD	SP	ND
– OMS-2 (2)*	C2_ATO_OMS2	I-LOAD	SP	ND
Crew target index flag	I_TGT	MNVR DISP	I	N/A
ATO target selection flag	$\dot{A}TO_TGT_SEL$	MNVR DISP	D	N/A
Abort initialization flag	$\dot{A}BORT_INIT$	DISP INIT TSK	D	N/A
*Number of parameters				

Table 4.5.5-2. ATO On-Orbit Target Selection Task Outputs

Definition	Symbol	Destination	Prec	Units
Target altitude	HTGT_OMS ₃	DISP INIT TSK	SP	ft
Target in-plane downrange angle from launch site	THETA_OMS ₃	DISP INIT TSK	SP	rad
Target intercept of the vertical velocity vs. horizontal velocity relationship	C1_OMS ₃	DISP INIT TSK, TLM	SP	fps
Target slope of the vertical velocity vs. horizontal velocity relationship	C2_OMS ₃	DISP INIT TSK, TLM	SP	ND
Time of ignition referenced to ET separation	DTIG_OMS ₃	DISP INIT TSK	SP	sec
Abort initialization flag	ĀBORT_INIT	DISP INIT TSK, ASC MNVR DIP SEQ	D	N/A
ATO target selection	ĀTO_TGT_SEL	MNVR DISP	D	N/A
Crew target index flag	I_TGT	MNVR DISP	I	N/A

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4.5.6 Parameter Tables for AOA/ATO Targeting

The IDD inputs and outputs are listed in Table 4.5.6-1 and Table 4.5.6-2 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 4.5.6-3. K-loads are listed in Table 4.5.6-4. Constants are listed in Table 4.5.6-5. The input variable cross-references are listed in Table 4.5.6-0.

Table 4.5.6-0. AOA/ATO TGT Input Variable Cross-Reference		
MSID	Local Name	Source Name
V95H0185CB, 6CB, 7CB	$R_{\bar{N}AV}$	R_AVGG
V95L0190CB, 1CB, 2CB	$V_{\bar{N}AV}$	V_AVGG
V95L0151CE	$V_{\bar{RHO_MAG}}$	REL_VEL_MAG
V95W0200CD	$T_{\bar{N}AV}$	T_STATE
V90H0881CB, 2CB, 3CB	$R_{\bar{G}D}$	R_FINAL
V90L0885CB, 6CB, 7CB	$V_{\bar{G}D}$	V_FINAL

TABLE 4.5.6-1. INPUT FUNCTIONAL PARAMETERS FOR ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABORT_INIT	V90X8489XB	ABORT INITIALIZATION FLAG	ASC MNVR DIP					
AOA_TGT_SEL	V93X6963XA	AOA TARGET SELECTION	XXXXX MNVR DISP					
ATO_TGT_SEL	V93X6964XA	ATO TARGET SELECTION	XXXXX MNVR DISP					
DM_PREMECO	V90U1924C	MASS OF OMS BURNED PRE-MECO	ASC MNVR DIP	SLUG			92235B	
EPS_K2	V97U4837C	MINIMUM TOLERANCE VALUE OF K2	UL	ND			91014E	
GAMD_ATO	V97U4395C	ATO MECO TERM FLIGHT PATH ANGLE	UL	RAD			92364D	
IY(X)	V90U1976CA	X-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93017G	*
IY(X)	V90U1976CB	X-M50 UNIT VEC NORMAL TO ORB PLANE	ORB INS GUID				93017G	*
IY(Y)	V90U1977CA	Y-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93017G	*
IY(Y)	V90U1977CB	Y-M50 UNIT VEC NORMAL TO ORB PLANE	ORB INS GUID				93017G	*
IY(Z)	V90U1978CA	Z-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93017G	*
IY(Z)	V90U1978CB	Z-M50 UNIT VEC NORMAL TO ORB PLANE	ORB INS GUID				93017G	*
IY_MIN_EF(1)	V96U9388C	X-EF UN VEC NORM TO MIN INCL	UL				89461	
IY_MIN_EF(2)	V96U9389C	Y-EF UN VEC NORM TO MIN INCL	UL				89461	
IY_MIN_EF(3)	V96U9390C	Z-EF UN VEC NORM TO MIN INCL	UL				89461	
I_TGT	V93J6962CA	CREW TARGET INDEX FLAG	XXXXX MNVR DISP				93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CA	CURRENT VEHICLE MASS	ORB INS GUID	SLUGS			93017G	*
MASS_OMS_INIT	V97U4434C	USABLE OMS PROPELLANT MASS	UL	SLUG	SPL	S	92175D	
MASS_ORB	V97U4435C	INITIAL ORBITER ONLY MASS	UL	SLUG	SPL	S	92175D	
MM_CODE_103/MM_103	V90X8156X	MAJOR MODE 103 FLAG	MSC				93012D	
MM_CODE_104/MM_104	V90X8152X	MAJOR MODE 104 FLAG	MSC				92355B	
MM_CODE_105/MM_105	V90X8623X	MAJOR MODE 105 FLAG	MSC				92355B	
N_OMS	V90J2031CB	NUMBER OF ACTIVE OMS ENGINES	ORB INS GUID					
N_SSME	V90U1962CA	NUMBER OF ACTIVE SSME'S	ASC 1STG GUID				93017G	*
OTREQ	V90X0893XB	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S			93017G	*
R_AVGG(1)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CB	X-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(2)	V90H0882CB	Y-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(3)	V90H0883CB	Z-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_M50_AT_LIFTOFF(1)	V95U0507C	X-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(2)	V95U0508C	Y-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(3)	V95U0509C	Z-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
S_AOA	V90X8636X	AOA ABORT DECLARED	MSC		BD		92355B	
S_ATO	V90X8635X	ATO ABORT DECLARED	MSC				93012D	
S_MECO	V90X1963XB	FINE COUNT DOWN DISCRETE	ASC 2STG GUID				93017G	*
THETA_LSS	V94U3808C	LNCH SITE TO OMS1 TIG CNTRL ANGLE	ASC MNVR DIP	RAD				
T_ET_SEP	V90W8621C	TIME OF ET SEPARATION	MSC	S			90705H	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
VDMAG	V90U8499CA	DESIRED MECO VELOCITY	ASC 2STG GUID	FT/S			93012D	
VDMAG	V97U4828C	DESIRED MECO VELOCITY	UL	FT/S			92364D	
VD_ATO	V97U4826C	ATO MECO TERM VELOCITY	UL	FT/S			92364D	
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*

TABLE 4.5.6-1. INPUT FUNCTIONAL PARAMETERS FOR ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CB	X-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(2)	V90L0886CB	Y-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(3)	V90L0887CB	Z-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_LIN	V97U4819C	PRE-MECO ATO VEL CRIT-OMS/RCS BURN	UL	FT/S			91014E	
V_ME_OUT	V90L1947CA	SSME ENGINE-OUT VELOCITY	ASC 1STG GUID	FT/S			93017G	*
V_ME_OUT	V90L1947CB	SSME ENGINE-OUT VELOCITY	ASC 2STG GUID	FT/S			93017G	*
V_MSSN_CNTN	V96U9392C	VEL FOR ATO MISSION CONTINUATION	UL	FT/S			92201C	
V_ZERO	V97U4825C	PRE-MECO ATO ZERO VEL-OMS/RCS BURN	UL	FT/S			91014E	

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

TABLE 4.5.6-2. OUTPUT FUNCTIONAL PARAMETERS FROM ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABORT_INIT	V90X8489XA	ABORT INITIALIZATION FLAG	ASC MNVR DIP					
AOA_TGT_SEL	V93X6963XB	AOA TARGET SELECTION	XXXXX MNVR DISP					
ATO_TGT_SEL	V93X6964XB	ATO TARGET SELECTION	XXXXX MNVR DISP					
C1_OMS(3)	V90L8487C	INTERCEPT OF TARGET LINE-DIP	ASC MNVR DIP	FT/S				
			TLM					
C2_OMS(3)	V90U8488C	SLOPE OF TARGET LINE-DIP	ASC MNVR DIP					
			TLM					
DTIG_OMS(3)	V90W8485C	TIME OF OMS 1/2 IGN AFTER ET SEP	ASC MNVR DIP	S				
			TLM					
DT_MAX	V90U8500CC	MAX ALLOW TIME STEP SIZE	ASC PREC PRED	S				
DV_EXCESS	V90U8511C	EXCESS OMS DELTA V	TLM	FT/S	SPL			
FT_S	V90U8120CA	ESTIMATED TOTAL THRUST	DL FMT 21/1	LBF	SPL		93017G	*
GAMD	V90U8497C	DESIRED MECO FLIGHT PATH ANGLE	ASC 2STG GUID	RAD				
GMD_PRED	V90U8501CC	GRAVITY MODEL DEGREE	ASC PREC PRED					
GMO_PRED	V90U8502CC	GRAVITY MODEL ORDER	ASC PREC PRED					
HTGT_OMS(3)	V90H8481C	TGT ALTITUDE AT END OF COAST PHASE	ASC MNVR DIP	FT				
			TLM					
IY(X)	V90U1976CD	X-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93090E	
			ASC BRG SPEC					
			ASC UPP					
IY(Y)	V90U1977CD	Y-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93090E	
			ASC BRG SPEC					
			ASC UPP					
IY(Z)	V90U1978CD	Z-M50 UNIT VEC NORMAL TO ORB PLANE	ASC 2STG GUID				93090E	
			ASC BRG SPEC					
			ASC UPP					
I_TGT	V93J6962CB	CREW TARGET INDEX FLAG	DL FMT 21/1				93017G	*
			XXXXX MNVR DISP					
K2	V90J8517C	SCALE FACTOR 2	ABT CNTL SEQ					
OTREQ	V90X0893XJ	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
RDMAG	V90U8498C	DESIRED MECO RADIUS	ASC 2STG GUID	FT				
R_INIT(X)	V90H8508CD	X-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Y)	V90H8509CD	Y-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Z)	V90H8510CD	Z-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
S_ABORT_CONTROL	V90X8504X	TGT COMPLETE FLAG	ABT CNTL SEQ					
			ASC 2STG GUID					
S_AOA_OMS2	V90X8486X	AOA OMS-2 TGT DATA READY FLAG	ASC MNVR DIP					
S_ATO_IY	V90X3905X	ATO TARGET PLANE RECOMPUTED FLAG	ASC UPP		BD		92522D	
THETA_OMS(3)	V90H8482C	TGT INPLN DNRNG ANG FROM LANH SITE	ASC MNVR DIP	RAD				
			TLM					
T_FINAL	V90W8506CD	TIME AT WHICH STATE IS DESIRED	ASC PREC PRED	S				
T_INIT	V90W8512CD	TIME AT BEGINNING OF PRED	ASC PREC PRED	S				
VDMAG	V90U8499CB	DESIRED MECO VELOCITY	ASC 2STG GUID	FT/S			93012D	
			XXXXXX TRAJ DIP					
V_INIT(X)	V90L8513CD	X-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Y)	V90L8514CD	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				

TABLE 4.5.6-2. OUTPUT FUNCTIONAL PARAMETERS FROM ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
V_INIT(Z)	V90L8515CD	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
WT_PROP_DEP	V90U8491C	WT OF OMS PROP PRIOR AOA/OMS2 BURN	TLM	LBS				

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 4.5.6-3. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
C1_AOA_OMS1(1)	V97U4312C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C1_AOA_OMS1(2)	V97U4313C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C1_AOA_OMS1(3)	V97U4314C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C1_AOA_OMS2(1,1)	V97U4316C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(1,2)	V96U9393C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(1,3)	V96U9397C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(10,1)	V96U9462C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(2,1)	V97U4317C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(2,2)	V96U9394C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(2,3)	V96U9398C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(3,1)	V97U4318C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(3,2)	V96U9395C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(3,3)	V96U9399C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(4,1)	V97U4319C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(4,2)	V96U9396C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(4,3)	V96U9400C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(5,1)	V97U4320C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(5,2)	V96U9463C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(5,3)	V96U9468C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(6,1)	V96U9458C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(6,2)	V96U9464C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(6,3)	V96U9469C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(7,1)	V96U9459C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(7,2)	V96U9465C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(7,3)	V96U9470C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(8,1)	V96U9460C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(8,2)	V96U9466C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(8,3)	V96U9471C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(9,1)	V96U9461C	FT/SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(9,2)	V96U9467C	(FT/SEC)/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_AOA_OMS2(9,3)	V96U9472C	(FT/SEC)/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
C1_ATO_OMS1	V97U4323C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C1_ATO_OMS2(1)	V97U4324C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C1_ATO_OMS2(2)	V97U4325C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
C2_AOA_OMS1(1)	V97U4328C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
C2_AOA_OMS1(2)	V97U4329C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
C2_AOA_OMS1(3)	V97U4330C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
C2_AOA_OMS2(1,1)	V97U4332C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(1,2)	V96U9401C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(1,3)	V96U9405C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(10,1)	V96U9477C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(2,1)	V97U4333C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(2,2)	V96U9402C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(2,3)	V96U9406C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(3,1)	V97U4334C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(3,2)	V96U9403C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(3,3)	V96U9407C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	

TABLE 4.5.6-3. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
C2_AOA_OMS2(4,1)	V97U4335C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(4,2)	V96U9404C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(4,3)	V96U9408C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(5,1)	V97U4336C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(5,2)	V96U9478C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(5,3)	V96U9483C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(6,1)	V96U9473C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(6,2)	V96U9479C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(6,3)	V96U9484C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(7,1)	V96U9474C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(7,2)	V96U9480C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(7,3)	V96U9485C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(8,1)	V96U9475C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(8,2)	V96U9481C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(8,3)	V96U9486C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(9,1)	V96U9476C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(9,2)	V96U9482C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_AOA_OMS2(9,3)	V96U9487C	RAD**-2	F	S	M	C	G4.13	00	A3A	DC1033A	
C2_ATO_OMS1	V97U4339C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
C2_ATO_OMS2(1)	V97U4340C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
C2_ATO_OMS2(2)	V97U4341C	ND	F	S	M	C	G4.13	00	ZF2	90243C	
DTIG_AOA_OMS1(1)	V97U4356C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS1(2)	V96U9488C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS1(3)	V96U9489C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(1,1)	V97U4357C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(1,2)	V96U9409C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(1,3)	V96U9413C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(10,1)	V96U9447C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(2,1)	V97U4358C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(2,2)	V96U9410C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(2,3)	V96U9414C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(3,1)	V97U4359C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(3,2)	V96U9411C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(3,3)	V96U9415C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(4,1)	V97U4360C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(4,2)	V96U9412C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(4,3)	V96U9416C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(5,1)	V97U4361C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(5,2)	V96U9448C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(5,3)	V96U9453C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(6,1)	V96U9443C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(6,2)	V96U9449C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(6,3)	V96U9454C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(7,1)	V96U9444C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(7,2)	V96U9450C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(7,3)	V96U9455C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(8,1)	V96U9445C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	

TABLE 4.5.6-3. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
DTIG_AOA_OMS2(8,2)	V96U9451C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(8,3)	V96U9456C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(9,1)	V96U9446C	SEC	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(9,2)	V96U9452C	SEC/RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_AOA_OMS2(9,3)	V96U9457C	SEC/RAD**2	F	S	M	C	G4.13	00	A3A	DC1033A	
DTIG_ATO_OMS1	V97U4364C	SEC	F	S	M	C	G4.13	00	A3T	DC1527	
DTIG_ATO_OMS2(1)	V97U4365C	SEC	F	S	M	C	G4.13	00	A3T	DC1527	
DTIG_ATO_OMS2(2)	V97U4366C	SEC	F	S	M	C	G4.13	00	A3T	DC1527	
DV_RQD	V97U4373C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
DV_TOL	V97U4377C	FT/SEC	F	S	M	C	G4.13	00	ZF2	90243C	
EPS_K2	V97U4837C	ND	F	S	M	C	G4.13	00	AAD	90655	
GAMD_ATO	V97U4395C	RAD	F	S	M	C	G4.13	00	A2A	DC0759	
GAMD_NOM	V97U4396C	RAD	F	S	M	C	G4.13	00	A2M	DC0599	
							G4.2				
HTGT_AOA_OMS1(1)	V97U4397C	FT	F	S	M	C	G4.13	00	A3A	DC1033A	
HTGT_AOA_OMS1(2)	V97U4398C	FT	F	S	M	C	G4.13	00	A3A	DC1033A	
HTGT_AOA_OMS1(3)	V97U4399C	FT	F	S	M	C	G4.13	00	A3A	DC1033A	
HTGT_ATO_OMS1	V97U4408C	FT	F	S	M	C	G4.13	00	A3T	DC1527	
HTGT_ATO_OMS2(1)	V97U4409C	FT	F	S	M	C	G4.13	00	A3T	DC1527	
HTGT_ATO_OMS2(2)	V97U4410C	FT	F	S	M	C	G4.13	00	A3T	DC1527	
IY_MIN_EF(1)	V96U9388C	ND	F	D	M	C	G4.13	00	A2N	DC0860	
IY_MIN_EF(2)	V96U9389C	ND	F	D	M	C	G4.13	00	A2N	DC0860	
IY_MIN_EF(3)	V96U9390C	ND	F	D	M	C	G4.13	00	A2N	DC0860	
KLAMDXX	V97U4423C	ND	F	S	D	C	G4.13	00	ZF1	90243C	
							G4.209				
							G4.210				
							G4.211				
							G4.3				
MASS_CG_CNTL	V97U4431C	SLUGS	F	S	M	C	G4.13	00	AMC	DC2248	
MASS_OMS_INIT	V97U4434C	SLUGS	F	S	M	C	G4.13	00	AMC	DC2248	
MASS_ORB	V97U4435C	SLUGS	F	S	M	C	G4.13	00	AMC	DC2248	
							G4.210				
RD_ATO	V97U4644C	FT	F	D	M	C	G4.13	00	A2A	DC0759	
RD_NOM	V97U4645C	FT	F	D	M	C	G4.13	00	A2M	DC0599	
							G4.2				
SFUELD	V97U4658C	ND	I	S	M	C	G4.13	00	A3A	DC1033A	
S_IY	V96U9391C	ND	D		M	C	G4.13	00	AVI	89998A	
							G4.2				
THETA_AOA_OMS1(1)	V97U4787C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS1(2)	V97U4788C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS1(3)	V97U4789C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(1,1)	V97U4791C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(1,2)	V96U9417C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(1,3)	V96U9421C	RAD** -1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(10,1)	V96U9432C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(2,1)	V97U4792C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(2,2)	V96U9418C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	

TABLE 4.5.6-3. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
THETA_AOA_OMS2(2,3)	V96U9422C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(3,1)	V97U4793C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(3,2)	V96U9419C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(3,3)	V96U9423C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(4,1)	V97U4794C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(4,2)	V96U9420C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(4,3)	V96U9424C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(5,1)	V97U4795C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(5,2)	V96U9433C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(5,3)	V96U9438C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(6,1)	V96U9428C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(6,2)	V96U9434C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(6,3)	V96U9439C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(7,1)	V96U9429C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(7,2)	V96U9435C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(7,3)	V96U9440C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(8,1)	V96U9430C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(8,2)	V96U9436C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(8,3)	V96U9441C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(9,1)	V96U9431C	RAD	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(9,2)	V96U9437C	ND	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_AOA_OMS2(9,3)	V96U9442C	RAD**-1	F	S	M	C	G4.13	00	A3A	DC1033A	
THETA_ATO_OMS1	V97U4798C	RAD	F	S	M	C	G4.13	00	A3T	DC1527	
THETA_ATO_OMS2(1)	V97U4799C	RAD	F	S	M	C	G4.13	00	A3T	DC1527	
THETA_ATO_OMS2(2)	V97U4800C	RAD	F	S	M	C	G4.13	00	A3T	DC1527	
THETA_LS_REF	V97U4802C	RAD	F	S	M	C	G4.13	00	ZF2	90243C	
VD_ATO	V97U4826C	FT/SEC	F	S	M	C	G4.13	00	A2A	DC0759	
VD_NOM	V97U4827C	FT/SEC	F	S	M	C	G4.13	00	A2M	DC0599	
							G4.2				
V_ATO_SW	V97U4816C	FT/SEC	F	S	M	C	G4.13	00	A2A	DC0759	
V_LIN	V97U4819C	FT/SEC	F	S	M	C	G4.13	00	AAD	90655	
V_MSSN_CNTN	V96U9392C	FT/SEC	F	S	M	C	G4.13	00	AVI	89998A	
V_ZERO	V97U4825C	FT/SEC	F	S	M	C	G4.13	00	AAD	90655	

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

TABLE 4.5.6-4. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
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	
DT_AOA_PRED	V97U4830C	00	+1.00	E+01 SEC	F	S	C	G4.13	29602A	
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
H_EI ENTRY INTERFACE ATTITUDE	V97U4401C	00	+4.0	E+05 FT	F	S	C	G4.13	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	
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	

TABLE 4.5.6-4. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
MUP_TH MINIMUM CHANGE IN MASS REQUIRED FOR MASS TO BE UPDATED	V97U6150C	00	+3.0	E-01 SLUGS	F	S	P	G4.13 G4.2 G4.3 G4.4 G4.5	90608D	
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	
ORB_RATE	V97U4450C	00	+1.195301	E-03 RAD/SEC	F	S	C	G4.13	39323	

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

TABLE 4.5.6-5. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) 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 4.5.6-5. ABORT-ONCE-AROUND/ABORT-TO-ORBIT TARGETING (G4.13) 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	
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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4.6 POWERED RTLS REQUIREMENTS (MM 601)

Powered RTLS guidance is performed by the PW RTLS GUID principal function (CPDS, Level B, GN&C, principal function 4.4). MM 601 extends from the RTLS abort initiation during second stage to the completion of the $-Z$ translation. The general guidance and targeting tasks required for the powered RTLS principal function are PFG Input (Section 4.8.8), SSME-Out Safing (Section 4.8.9), G-Limiting (Section 4.8.3), MPS Guidance Cutoff (Section 4.8.5), PEG (Section 4.8.1), Acceleration-Mass Update (Section 4.8.2), Thrust Parameters (Section 4.8.7), RTLS Contingency Abort (Section 4.8.12), and RTLS/TAL Target Selection (Section 4.8.11) tasks.

In second-stage flight the RTLS major mode is initiated by the crew setting the abort mode rotary switch to the RTLS position and pressing the abort button. If an RTLS is selected during first stage, the major mode begins at the SRB separation command. Termination occurs either as an automatic transition upon completion of the $-Z$ translation maneuver (Event A39) or a crew-initiated transition (PRO) to MM 602. In the event of a second SSME failure, PW RTLS GUID will set the ET low-level sensor arm command and a special contingency abort calculation will be performed by PW RTLS GUID to determine if glide RTLS guidance should be scheduled in MM 602. (Guidance is not normally scheduled in MM 602 for contingency aborts.)

The powered RTLS major mode is normally composed of three flight phases. The fuel dissipation phase continues the downrange flight at a fixed inertial thrust direction while cyclical computations are performed to determine the proper time to initiate the turnaround. This phase is not executed in aborts near the limit of the RTLS capability since the turnaround is begun immediately.

The flyback phase, which includes the turnaround, guides the vehicle to targets designated at the beginning of powered pitchdown (MECO minus 20 seconds). Throttling for fuel depletion control is also performed during the flyback phase.

The powered pitchdown phase serves two functions. Each cycle, it commands the orbiter/ET to the angle of attack required for separation and simultaneously computes the SSME cutoff time. The SSME thrust is then terminated at this time by the SSME OPS principal function.

After the first SSME failure occurs and while in MM601, the two remaining SSME's are set to the maximum allowable power lever to obtain maximum performance, unless manual throttling is being performed. This maximum allowable throttle level is either a function of abort mode regions defined by velocity switch breakpoints, or is a function of crew display selection.

To increase mission manifesting and design flexibility closer to launch when required, a subset of the available I-Loads required by Powered RTLS Guidance can be updated via pre-mission uplink. The uplink parameters include the PPD one engine-out and systems RTLS range-velocity target line intercepts and flightpath angle targets, the PPD altitude target, the common MECO range-velocity target line intercept, and the late RTLS turnaround velocity switch.

The powered RTLS guidance principal function will be initiated at Event A30D (Powered RTLS Guidance Activation) or Event A30E (Powered RTLS Guidance Activation When An RTLS Abort is Declared in MM 103). It will be terminated at Event A39 (Transition From MM 601 to MM 602) or Event A30F (Powered Contingency Abort Request in MM 601). The tasks to be performed by the powered RTLS (Figure 4.6-1) guidance principal function for MM 601 are as follows:

1. KMAX override update task (KMAX UPDT TSK)

2. PFG input task (PFG INP TSK)
3. RTLS contingency abort task (RTLS CONT ABT TSK)
4. Acceleration–mass update task (ACC–MASS UPD TSK)
5. ET low–level sensor arm command task (ET LLS ARM TSK)
6. TVC retrim task (TVC RT TSK)
7. G–limiting task (G–LIM TSK)
8. SSME–out safing task (SSME–OUT SAF TSK)
9. RTLS initialization task (RTLS INIT TSK)
10. RTLS/TAL target selection task (RTLS/TAL TGT SEL TSK)
11. Fuel dissipation task (FUL DISS TSK)
12. Flyback task (FLYBK TSK)
13. Powered pitchdown task (PPD TSK)
14. MPS guidance cutoff task (MPS GUID C/O TSK)
15. Pitch command task (PITCH CMD TSK)
16. MECO preparation task (MECO PREP TSK)

The PEG and thrust parameters general guidance tasks are called by the fuel dissipation and flyback tasks.

Figures 4.6–2, 4.6–3, and 4.6–4 illustrate the RTLS powered flight guidance task organization functional flow, and data flow. The principal function interfaces are given in Section 4.6.7.

4.6.1 Powered RTLS Guidance Sequencing (PRTLS SEQ)

A. Detailed Requirements.

The tasks that support the RTLS second-stage guidance must be sequenced as follows:

1. The KMAX override update task is performed on demand from the first guidance pass after MM601 = ON to entry to MM602 (Event A39) when either item 4, 50, or 51 is entered on the Override Display (SPEC 51). The detailed requirements for this task are given in Section 4.8.13.
2. The PFG input task (PFG INP TSK) must be performed on the first guidance pass after MM601 = ON until SSME cutoff confirmation (Event A36, MECO_CONFIRM = ON). The detailed requirements for this task are given in Section 4.8.8.
3. The RTLS contingency abort task (RTLS CONT ABT TSK) must be performed once when a second SSME has failed ($N_{SSME} < 2$) if the SSME cutoff timing request flag S_TMECO has not been set, and once when the MECO confirmed flag is set to ON. When the RTLS CONT ABT TSK is performed after a second SSME failure, the MPS low-level sensors are armed (see Task 4). The detailed requirements for this task are given in Section 4.8.12.
4. The acceleration-mass update task (Section 4.8.2) must be performed on the first guidance pass after MM601 = ON until SSME cutoff confirmation (Event A36).
5. The RTLS second-stage guidance principal function is also required to send a signal (S_LOW_LEVEL = ON) to the SSME operations principal function to activate the MPS low-level sensor. This will be done when current vehicle mass (M) becomes less than an I-load or uplinked value (MASS_LOW_LEVEL), or after a second SSME failure.
6. The RTLS second-stage guidance principal function must send a signal (S_SSME_TRIM = ON) to the ASC DAP to retrim the TVC when M becomes less than an I-load value (MASS_SSME_TRIM).
7. The G-limiting task must be performed on the first guidance pass after MM601 = ON until the engines are commanded (S_KCO = ON), to an I-load value KMIN, or during manual throttling until MECO confirmed, or until S_TMECO is set to ON during manual guidance (AUTO = OFF). The detailed requirements for this task are given in Section 4.8.3.
8. The SSME-out safing task (Section 4.8.9) must be performed upon notification of an SSME failure (SSME_FAIL = ON) from SRB separation or transition from MM 103 until SSME cutoff confirmation (Event A36).
9. The RTLS initialization task must be performed only once during the first cycle after MM601 = ON. Detailed requirements for this task are presented in Section 4.6.2.
10. The RTLS/TAL target selection task must be performed on the first guidance pass after MM601 equals ON and then repetitively until fine countdown (S_MECO = ON). The detailed requirements for this task are presented in Section 4.8.11.

11. The RTLS flyback and pitch command discretely are set for immediate turnaround if the earth relative velocity is greater than an input value. The RTLS mass display parameter is also set to indicate that an immediate turnaround has been commanded. This check must be made cyclically from RTLS select until $S_{\dot{M}E C O}$ is set ON. If $S_{\dot{R}T L S_F B} = OFF$ and $V_{R H O_M A G} > V_{L A T E_R T L S}$, then $S_{\dot{R}T L S_F B} = ON$, $S_{\dot{P}I T C H_C M D} = ON$, and $M F_D I S P L A Y = +777$.
12. The fuel dissipation task must be performed from the initiation of MM 601 until the discrete marking the beginning of the turnaround ($S_{\dot{R}T L S_F B}$) is set to ON. If the velocity at SSME-out is near the boundary of RTLS opportunity, the $S_{\dot{R}T L S_F B}$ discrete is set to ON by PRTLS SEQ and the fuel dissipation task is not performed. The detailed requirements for this task are presented in Section 4.6.3.
13. The flyback task is performed from the time the flyback discrete is set to ON until the fine countdown discrete ($S_{\dot{M}E C O}$) is set to ON. This includes the turnaround and flyback to the beginning of the fine countdown prior to the powered pitchdown. The flyback task is not called during the guidance cycle in which $S_{\dot{R}T L S_F B}$ is set to ON by the fuel dissipation task. The detailed requirements for this task are presented in Section 4.6.4.
14. At the initiation of fine countdown ($S_{\dot{M}E C O} = ON$), the powered RTLS sequencer will begin to compare the current time ($T_{N A V}$) to the last computed MECO time ($T P$). On each guidance cycle prior to PPD, PRTLS sequencing will set $S_{\dot{F}C D}$ to ON to cue the crew that fine countdown is in progress. When the value of $T P - T_{N A V}$ is less than .08 seconds, the flag $S_{\dot{F}C D}$ is set to OFF.

Also, at the initiation of fine countdown, the PRTLS sequencer will decrement $C O N T_M E C O_P R E P_T I M E$ by .16 seconds each cycle until the $C O N T_M E C O_P R E P_T I M E$ has expired. Once the $C O N T_M E C O_P R E P_T I M E$ has expired, the $C O N T_M E C O_P R E P_F L A G$ is set ON.

If the $A \dot{U} T O$ guidance discrete is OFF, then on each guidance cycle during fine countdown, PRTLS sequencing will set $L A M C$ equal to the unit of the sensed M50 velocity increment ($D \dot{V} S_R T L S$), the time derivative of $L A M C$ ($L A M D C$) and the associated time tag ($T L A M C$) equal to zero, and the guidance convergence indicator ($S_{\dot{U} N C O N V}$) to OFF.

15. The powered pitchdown task must be performed when the difference between the PEG predicted time, $T P$, and navigation state time, $T_{N A V}$, becomes less than .08 seconds. The detailed requirements for this task are given in Section 4.6.5.
16. The MPS guidance cutoff task (Section 4.8.5) must be performed from the beginning of the powered pitchdown until the MECO discrete $S_{\dot{T}M E C O}$ is set to ON or until MECO confirmed during manual throttling.

17. The MECO PREP TASK must be performed from the time the flyback discrete (S_R \dot{R} TL \dot{S} _FB) is set ON until the discrete (G \dot{U} ID_MECO_PREP_FLAG) is set. The detailed requirement for this task is to set the discrete (G \dot{U} ID_MECO_PREP_FLAG) when the time to MECO is less than a K-loaded value ABORT_MECO_PREP_TIME; that is:

If $T_{MET_MECO} + T_{GMTLO} - TGD < ABORT_MECO_PREP_TIME$, then:

$$G\dot{U}ID_MECO_PREP_FLAG = ON$$

The RTLS pitch command task (PITCH CMD TSK) is performed within 160 milliseconds of the previous RTLS guidance cycle when the discrete S_P \dot{I} TCH_CMD is set to ON. The detailed requirements for this task are given in Section 4.6.6.

Manual Guidance Sequencing

1. Fuel Dissipation Phase: If manual guidance (A \dot{U} T \dot{O} = OFF) is selected in fuel dissipation and an early turnaround is initiated by the crew, then the flyback discrete (S_R \dot{R} TL \dot{S} _FB) is set to ON, the pitch command discrete (S_P \dot{I} TCH_CMD) is set to ON, and the commanded throttle setting (K_CMD) is set to the nearest integral value to the PEG throttle setting (K), provided that automatic throttling is selected (S_M \dot{A} N_THROT = OFF).
2. Flyback Phase: If manual guidance is selected during the flyback phase, the throttling for fuel depletion is stopped and the PEG throttle is set to the engine commanded throttle setting (K_CMD). The crew can return to auto guidance, but fuel depletion throttling is not resumed.
3. Powered Pitchdown Phase: If manual guidance is selected during the powered pitchdown, the powered pitchdown task and the MPS guidance cutoff task will be executed normally. Commanding the engines to KMIN will not be done if manual guidance is selected before the start of powered pitchdown and the crew does not return to auto guidance. PPD TSK will be executed cyclically after MECO confirmed is set ON.

If manual throttling is activated during flyback, the throttling for fuel depletion is terminated (S_THROT = OFF) and the PEG throttle command, K, is set to the current commanded throttle setting, K_CMD. Fuel depletion throttling cannot be resumed after this occurrence.

B. Interface Requirements.

The input and output parameters for the PRTLS guidance sequencing are given in Tables 4.6.1–1 and 4.6.1–2.

C. Processing Requirements.

The recommended execution rates for the tasks are as follows:

Task 1 – Prior to fine count down, one time only within 1.92 seconds of the event for each item entry event; thereafter, within 0.16 second.

Tasks 2 and 4 – 1.92 seconds from initiation until the fine count down begins, then 0.16 second until M \dot{E} CO_CONFIRM = ON

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- Task 3 – One time only when $N_{SSME} < 2$ and $S_{\dot{T}MECO} = OFF$, and one time when $M\dot{E}CO_CONFIRM = ON$
- Task 5 – One time only*
- Task 6 – One time only*
- Task 7 – 1.92 seconds from initiation until the fine countdown begins, then 0.16 second until the task is terminated by PRTLS sequencing
- Task 8 – Each time an SSME has failed*
- Task 9 – One time only*
- Task 10 – 1.92 seconds from initiation until $S_{\dot{M}E}CO$ is set ON
- Task 11 – 1.92 seconds
- Task 12 – 1.92 seconds from initiation until $S_{\dot{R}T}LS_FB$ or $S_{\dot{M}E}CO$ is set ON
- Task 13 – 1.92 seconds from the time $S_{\dot{R}T}LS_FB$ is set ON until $S_{\dot{M}E}CO$ is set ON
- Task 14 – 0.16 second from the time $S_{\dot{M}E}CO$ is set ON until $S_{\dot{F}CD}$ is set OFF
- Task 15 – 0.16 second from the time $S_{\dot{F}CD}$ is set OFF until Event A39
- Task 16 – 0.16 second from the beginning of PPD until $S_{\dot{T}MECO}$ is set ON
- Task 17 – 1.92 seconds from the time $S_{\dot{R}T}LS_FB$ is set ON until $G\dot{U}ID_MECO_PREP_FLAG = ON$

These tasks should be executed in the order listed.

* The tests for performing these tasks should be made every guidance cycle until the tasks are executed.

D. Initialization Requirements. The following variables must be initialized:

$S_{\dot{P}ITCH_CMD} = OFF$

$C\dot{O}NT_MECO_PREP_FLAG = OFF$

E. Supplemental Information. The ability to change KMAX after Fine Countdown ($S_{\dot{M}E}CO = ON$) is acceptable because no procedures are in place to change KMAX after Fine Countdown. The ability to modify KMAX after Fine Countdown is a feature originally defined in DR 109232.

Table 4.6.1-1.PRTL5 Guidance Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
TGO for MECO preparation	ABORT_MECO_PREP_TIME	K-LOAD	SP	sec
Predicted time to achieve PEG targets	TP	PEG TSK	DP	sec
Value of mass for TVC retrim	MASS_SSME_TRIM	I-LOAD	SP	slugs
Value of mass in enabling MPS low-level sensing	MASS_LOW_LEVEL	I-LOAD, UPLINK	SP	slugs
Fine countdown discrete	S_MECO	FLYBK TSK, ASC GUID TSK	D	N/A
Flyback task discrete	S_RTLS_FB	FUL DISS TSK	D	N/A
MECO confirmation discrete	MECO_CONFIRM	SSME OPS	D	N/A
Time tag associated with current state	T_NAV	RTLS UPP	DP	sec
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
AUTO guidance mode flag	AUTO	ASC DAP	D	N/A
Discrete indicating T_MECO has been set	S_TMECO	MPS GUID C/O TSK	D	N/A
Pitch command task discrete	S_PITCH_CMD	FUL DISS TSK, PITCH CMD TSK	D	N/A
Magnitude of vehicle relative velocity	V_RHO_MAG	RTLS UPP	SP	fps
Relative velocity magnitude for latest RTLS	V_LATE_RTLS	RTLS/TAL TGT SEL TSK	SP	fps
GMT time of lift-off	T_GMTLO	FCOS	DP	sec
Predicted MECO time in MET seconds	TMET_MECO	FUL DISS TSK, FLYBK TSK	SP	sec
Current guidance time	TGD	PFG INP TSK	DP	sec
Change in sensed velocity	DVS_RTLS	PFG INP TSK	SP	fps
Discrete to indicate pre-MECO throttle down complete	S_KCO	PPD TSK, MPS GUID C/O TSK	D	N/A
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Delta Time from Fine Countdown to Contingency MECO preparation	CONT_MECO_PREP_TIME	I-LOAD	SP	sec
Main engine failure flag	SSME_FAIL	PFG INP TSK, SSME-OUT SAF TSK	D	N/A

Table 4.6.1-2. PRTLs Guidance Sequencing Outputs				
Definition	Symbol	Destination	Prec	Units
Discrete to activate MPS low-level sensor	$S_{\dot{L}OW_LEVEL}$	SSME OPS	D	N/A
FCD TVC retrim discrete	$S_{\dot{S}ME_TRIM}$	ASC DAP	D	N/A
MECO preparation discrete	$G_{\dot{U}ID_MECO_PREP_FLAG}$	ABORT CNTL SEQ	D	N/A
Flyback discrete	$S_{\dot{R}TLS_FB}$	PITCH CMD TASK	D	N/A
Guidance convergence status indicator	$S_{\dot{U}NCONV}$	ASC ADI PROC, XXXXXX TRAJ DIP	D	N/A
Fine countdown indicator	$S_{\dot{F}CD}$	RTLS TRAJ 2 DISP	D	N/A
M50 desired thrust direction	$\bar{L}AMC$	G/C STEER	SP	ND
M50 desired thrust turning rate vector	$\bar{L}AMDC$	G/C STEER	SP	sec ⁻¹
GMT time associated with desired thrust direction	TLAMC	G/C STEER, TLM	DP	sec
RTLS mass display parameter	MF_DISPLAY	XXXXXX TRAJ DIP, TLM	I	ND
Contingency MECO preparation discrete	$C_{\dot{O}NT_MECO_PREP_FLAG}$	ABORT CNTL SEQ	D	N/A

4.6.2 RTLS Initialization Task (RTLS INIT TSK)

The subtasks to be performed for initializing the guidance and targets are as follows:

1. Reinitialize guidance parameters in the RTLS mode.
2. Set guidance parameters dependent on the number of active SSME's.

A. Detailed Requirements. The following subtasks must be performed to initialize the RTLS guidance and targets

1. Set the correct guidance mode, number of phases, and initialization discrete. Set the discrete enabling guidance steering commands to OFF. Set the fine countdown indicator to OFF. Set the flyback discrete to OFF and set the RTLS mass display parameter to its initial value.

$$SMODE = 5$$

$$S\dot{N}IT = ON$$

$$N = 2$$

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

$$S\dot{F}CD = OFF$$

$$S\dot{R}TLS_FB = OFF$$

$$MF_DISPLAY = -999$$

2. Determine if this is a three SSME RTLS case. If so ($N_{SSME} = 3$), set the values for the current and flyback throttles and store the present relative velocity and altitude rate:

$$K_CMD = MAX(ROUND(2 KMAX/3), KMIN)$$

The current throttle value, K_CMD , is set only if manual throttling is not being performed ($S_MAN_THROT = OFF$).

$$K = K_3ENG$$

$$V_RTLS_FD = V_RHO_MAG$$

$$H_DOT_FD = H_DOT_ELLIPSOID$$

Otherwise ($N_{SSME} < 3$), set the values for the flyback throttle.

$$K = K_2ENG$$

B. Interface Requirements. The input and output parameters for the RTLS initialization task are given in Tables 4.6.2-1 and 4.6.2-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.6.2-1. RTLS Initialization Task Inputs				
Definition	Symbol	Source	Prec	Units
Minimum throttle setting	KMIN	I-LOAD	I	pct
Magnitude of vehicle relative velocity	V_RHO_MAG	RTLS UPP	SP	fps
Maximum throttle setting for SSME	KMAX	I-LOAD, ASC GUID TSK, 1STG GUID INP TSK, SSME-OUT SAF TSK	I	pct
Number of active SSME's	N_SSME	PGF INP TSK	I	N/A
Initial value of K for three-engine RTLS	K_3ENG	I-LOAD	SP	pct
Initial value of K for two-engine RTLS	K_2ENG	I-LOAD	SP	pct
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Est altitude rate	H_DOT_ELLIPSOID	RTLS UPP	SP	fps

Table 4.6.2-2. RTLS Initialization Task Outputs				
Definition	Symbol	Destination	Prec	Units
PEG maneuver mode flag	SMODE	PEG TSK, CONT MODE SEL TSK, CONT LVLH TSK, RTLS TRAJ 2 DISP, CONT 3EO MODE SEL TSK	I	N/A
PEG initialization discrete	S_INIT	PEG TSK	D	N/A
Number of thrust phases	N	PEG TSK	I	N/A
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, FLYBK TSK, FUL DISS TSK, G-LIM TSK, SSME-OUT SAF TSK, SBTC SOP, RTLS TRAJ 2 DISP	I	pct
Desired throttle setting	K	PEG TSK, FUL DISS TSK, FLYBK TSK, TLM	SP	pct
Steering enable flag	S_STEER	PEG TSK	D	N/A
RTLS fuel dissipation reference velocity magnitude	V_RTLS_FD	PITCH CMD TSK	SP	fps
Guidance fine countdown indicator	S_FCD	RTLS TRAJ 2 DISP	D	N/A
RTLS fuel dissipation ref HDOT	H_DOT_FD	PITCH CMD TSK	SP	fps
RTLS flyback discrete	S_RTLS_FB	PRTLS SEQ	D	N/A
RTLS mass display parameter	MF_DISPLAY	XXXXXX TRAJ DIP, TLM	I	ND

4.6.3 Fuel Dissipation Task (FUL DISS TSK)

The subtasks to be performed for fuel dissipation are as follows:

1. Set the flyback and pitch command discrettes on at the proper time.
2. Change the roll command at the proper time.
3. Calculate the turnaround time.
4. Calculate the predicted MECO time in MET.
5. If manual guidance is selected, set the guidance discrettes to their proper values.

A. Detailed Requirements.

1. On the first pass through the fuel dissipation task, the discrete S_PITCH_CMD is set to ON so that the pitch command task can calculate and issue the fuel dissipation thrust commands. The pitch command task then resets the discrete S_PITCH_CMD to OFF.
2. The fuel dissipation task must specify the commanded roll angle input to G/C STEER. When the relative velocity magnitude (V_RHO_MAG) first exceeds V_RHO_PHI , the commanded roll angle is set as $PHI_CMD = PHI_2STG$.
3. The following calculations are cycled when the fuel dissipation task is active.

On each cycle during which one of the three mutually exclusive display throttle level commands is actuated (($\dot{N}OM_THROT_CMD = ON$ and $\dot{N}OM_CMD_PREV = OFF$) or ($\dot{A}BT_THROT_CMD = ON$ and $\dot{A}BT_CMD_PREV = OFF$) or ($\dot{M}AX_THROT_CMD = ON$ and $\dot{M}AX_CMD_PREV = OFF$)), and if manual throttling is not being performed ($S_MAN_THROT = OFF$), and the number of SSME's is less than three ($N_SSME < 3$), then the following must be executed:

$$K_CMD = KMAX$$

Set the previous throttle command indicators to the current values.

$$\dot{N}OM_CMD_PREV = \dot{N}OM_THROT_CMD$$

$$\dot{A}BT_CMD_PREV = \dot{A}BT_THROT_CMD$$

$$\dot{M}AX_CMD_PREV = \dot{M}AX_THROT_CMD$$

The acceleration is obtained by executing the THRST PRM TSK, followed by the equation $AT_EST = FT_FACTOR FT/M$.

Then the position, acceleration, and time are extrapolated to the estimated end of the turn, and the PEG task is called to obtain the magnitude of velocity to be gained by thrust to achieve the targets.

$$\overline{RGD} = R_NAV + V_NAV DT_TURN$$

$$VEX = VEX / (1 - N_RCS_NULL MDOT_RCS / MDOT)$$

$$ATR = (VEX AT_EST / (VEX - DT_TURN AT_EST)) K / K_CMD$$

$$TGD = T_NAV + DT_TURN$$

Call PEG TSK (4.8.1)

If PEG is converged ($\dot{S}CONV = ON$), then do the following:

- a. This velocity is summed with the estimated velocity gained during the turn by thrust and used in the ideal rocket equation to predict the final mass at the end of PEG guidance. This final mass is biased to prevent a late turnaround.

$$MF = M \text{ EXP}(- (VGOMAG + AT_EST DT_TURN) / VEX) - M_BIAS$$

- b. The change in thrust direction desired during the turn is calculated from current and desired thrust direction at the beginning of the flyback. Based on this result, the time it takes to turn around is calculated by using the ideal rates and accelerations expected.

If PEG is converged ($\dot{S}CONV = ON$), then:

$$U\bar{F}_PEG = \text{UNIT}(\bar{L}\bar{A}\bar{M} + (TGD - TLAM) \bar{L}\bar{A}\bar{M}D)$$

$$\text{THETA} = \text{ARCCOS}(\text{UNIT}(\bar{D}\bar{V}\bar{S}_RTLS) \cdot U\bar{F}_PEG)$$

$$DT_TURN = \text{THETA} / D\text{THETA}_LIM + D\text{THETA}_LIM / D\text{THETA}_RATE$$

4. If PEG is converged, a calculation is performed to determine if the desired flyback attitude satisfies initial flyback attitude constraints. If the attitude constraints are satisfied, the flyback attitude test indicator is set to unity. The test indicator is subsequently used to compute the RTLS mass display parameter (MF_DISPLAY) and as a powered pitcharound test criterion.

If $\dot{S}CONV = ON$, do steps (i), (ii), (iii), and (iv) below.

Otherwise proceed to step 5.

- (i) $KDELTA = \text{MAX}(0, (1 - (K/K_CMD))^2)$

$$U\bar{F}_Z = \text{UNIT}(\bar{L}\bar{A}\bar{M}\bar{C} \times \bar{I}\bar{Y}_TVR)$$

If $(U\bar{F}_PEG \cdot U\bar{F}_Z) > \text{SQRT}(KDELTA)$ or

If $(\text{sign}(U\bar{F}_PEG \cdot (\bar{I}\bar{X} \times \bar{I}\bar{Y}_TVR)) \text{THETA} > \text{PI}/2)$,

then $KDPY = +1$. Otherwise set $KDPY = -1$.

- (ii) $MF_DISPLAY = KDPY (\text{ROUND}(\text{ABS}(100 ((MF/MBO) - 1))))$

- (iii) If $(KDPY < 0)$ then $MF_DISPLAY = \text{MIN}(MF_DISPLAY, -1)$

- (iv) If $KDPY > 0$ and $MF \leq MBO$, then set $S_RTLS_FB = ON$ and $S_PITCH_CMD = ON$.

The unit vectors $\bar{I}\bar{Y}_TVR$ and $\bar{I}\bar{X}$, obtained from PEG, define the plane of thrust vector rotation and radial direction in that plane, respectively.

5. The predicted time of MECO in MET is calculated as

$$TMET_MECO = TP + DT_PITCH - T_GMTLO$$

6. If an early turnaround is done by the crew in manual guidance, i.e., if $(V_RHO \cdot DVS_RTLS) < 0$ and $AUTO = OFF$, then set $S_RTLS_FB = ON$, $S_PITCH_CMD = ON$; and if $S_MAN_THROT = OFF$, $K_CMD = ROUND(K)$.
7. If the flyback task discrete (S_RTLS_FB) has been set to ON either as a result of automatic guidance (step 4) or as the result of a manual early turn (step 6) the RTLS mass display parameter is set to indicate powered pitcharound initiation.

$$\text{If } S_RTLS_FB = ON, MF_DISPLAY = +999$$

B. Interface Requirements. The input and output parameters for the fuel dissipation task are listed in Tables 4.6.3-1 and 4.6.3-2.

C. Processing Requirements. None.

D. Initialization Requirements. $STHROT = OFF$

Table 4.6.3-1. RTLS Fuel Dissipation Task Inputs				
Definition	Symbol	Source	Prec	Units
Desired roll command for second stage	PHI_2STG	I-LOAD	SP	rad
Switch velocity for roll command	V_RHO_PHI	I-LOAD	SP	fps
Magnitude of vehicle velocity	V_RHO_MAG	RTLS UPP	SP	fps
Current Shuttle position vector in M50	\bar{R}_{NAV}	RTLS UPP	DP	ft
Current Shuttle velocity vector in M50	\bar{V}_{NAV}	RTLS UPP	SP	fps
Time tag associated with current state	T_NAV	RTLS UPP	DP	sec
Length of turnaround	DT_TURN	K-LOAD	SP	sec
Total effective exhaust velocity	VEX	THRST PRM TSK	SP	fps
Ground relative velocity in M50	\bar{V}_{RHO}	RTLS UPP	SP	fps
Thrust scaling factor	FT_FACTOR	ACC-MASS UPD TSK, SSME-OUT SAF TSK	SP	ND
Total vehicle thrust force	FT	THRST PRM TSK	SP	lb
Desired throttle setting	K	RTLS INIT TSK, SSME-OUT SAF TSK, PEG TSK	SP	pct
Commanded SSME throttle setting	K_CMD	RTLS INIT TSK, SSME-OUT SAF TSK, GUID PRMT RINT TSK, BST THROT TSK, SBTC SOP, ASC GUID TSK, 1STG GUID INP TSK	I	pct
Discrete indicating PEG convergence	$\dot{S}CONV$	PEG TSK	D	N/A
Unit normal to the plane of thrust vector rotation	$\bar{I}Y_{TVR}$	PEG TSK	SP	ND
Guidance coordinate system X-axis in M50 coordinates	$\bar{I}X$	PEG TSK	DP	ND
Predicted time to achieve PEG targets	TP	PEG TSK	DP	sec
Magnitude of velocity to be gained	VGOMAG	PEG TSK	SP	fps
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Desired mass at end of flyback	MBO	PEG TSK	SP	slugs
Change in sensed velocity vector	$\bar{D}VS_{RTLS}$	PFG INP TSK	SP	fps
Reference thrust direction vector	$\bar{L}AM$	PEG TSK	SP	ND
Desired thrust turning rate vector	$\bar{L}AMD$	PEG TSK	DP	sec ⁻¹

Table 4.6.3-1.RTLS Fuel Dissipation Task Inputs

Definition	Symbol	Source	Prec	Units
Time associated with reference thrust vector	TLAM	PEG TSK	DP	sec
AUTO guidance mode flag	AUTO	ASC DAP	D	N/A
Maximum angular velocity	DTHETA_LIM	I-LOAD	SP	rad/sec
Maximum angular acceleration	DTHETA_RATE	I-LOAD	SP	rad/sec ²
Mass bias for turnaround	M_BIAS	K-LOAD	SP	slugs
Nominal time of powered pitchdown	DT_PITCH	K-LOAD	SP	sec
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Maximum throttle level command	MAX_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	ABT_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Nominal throttle level command	NOM_THROT_CMD	OVERRIDE DISPLAY	D	N/A
M50 desired fuel dissipation thrust vector	LAMC	PITCH CMD TSK	SP	ND
No. of active null jets	N_RCS_NULL	PFG INP TSK	I	N/A
RCS mass flow rate	MDOT_RCS	K-LOAD	SP	slug/sec
Total mass flow rate	MDOT	THRUST PRM TSK	SP	slug/sec
Number of active SSME engines	N_SSME	PFG INP TSK	I	N/A
Previous value of nominal throttle level command	NOM_CMD_PREV	1STG GUID INP TSK, ASC GUID TSK	D	N/A
Previous value of abort throttle level command	ABT_CMD_PREV	1STG GUID INP TSK, ASC GUID TSK	D	N/A
Previous value of maximum throttle level command	MAX_CMD_PREV	1STG GUID INP TSK, ASC GUID TSK	D	N/A
Maximum throttle setting for SSME	KMAX	KMAX UPDT TSK, SSME-OUT SAF TSK, I-LOAD	I	pct

Table 4.6.3-2.RTLS Fuel Dissipation Task Outputs				
Definition	Symbol	Destination	Prec	Units
Command roll angle	PHI_CMD	G/C STEER	SP	rad
Flyback task discrete	S_ṚTLS_FB	PRTL SEQ, PITCH CMD TSK	D	N/A
Vehicle position vector input to PEG	RḠD	PEG TSK	DP	ft
Thrust acceleration estimate input to PEG	ATR	PEG TSK	SP	fps ²
Time associated with RḠD and VḠD	TGD	PEG TSK	DP	sec
Pitch command discrete	S_ṖITCH_CMD	PRTL SEQ	D	N/A
Predicted SSME C/O time in MET	TMET_MECO	RTLS TRAJ 2 DISP, TLM, PRTL SEQ	SP	sec
Fuel depletion throttling discrete	S_ṪHROT	PEG TSK	D	N/A
Length of turnaround	DT_TURN	FLYBK TSK	SP	sec
Predicted final mass	MF	TLM	SP	slugs
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, FLYBK TSK, G-LIM TSK, SSME-OUT SAF TSK, SBTC SOP, RTLS TRAJ 2 DISP	I	pct
Equivalent exhaust velocity	VEX	PEG TSK	SP	fps
RTLS mass display parameter	MF_DISPLAY	XXXXXX TRAJ DIP, TLM	I	ND

4.6.4 RTLS Flyback Task (FLYBK TSK)

The following subtasks are necessary to support the flyback task:

1. Obtain an estimate of filtered acceleration, exhaust velocity, and mass.
2. Extrapolate acceleration, position, and time to the end of the turn until the end of the turn is reached.
3. Execute the powered explicit guidance (PEG) calculations.
4. Calculate the estimated time of MECO in MET.
5. Issue throttle commands.
6. Set fine countdown discrete on when $TGO \leq TGO_PPD$.
7. If manual guidance is selected, set the throttle and guidance discretetes to their proper values.

A. Detailed Requirements.

1. The RTLS flyback task must obtain an estimate of acceleration, exhaust velocity, and mass. The acceleration is calculated by executing the THRUST PRM TSK followed by the equation

$$AT_EST = FT_FACTOR FT/M$$

2. The PEG steering discrete is set to ON, and the time to turnaround is decremented by the guidance cycle. The position, acceleration, and time are then extrapolated through the turn until the end of the turn is reached.

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

$$DT_TURN = DT_TURN - DTGD$$

$$\text{If } DT_TURN < 0, \text{ then } DT_TURN = 0$$

$$R\bar{G}D = R_NAV + V_NAV DT_TURN$$

$$VEX = VEX / (1 - N_RCS_NULL MDOT_RCS / MDOT)$$

$$ATR = (VEX AT_EST / (VEX - DT_TURN AT_EST)) K / K_CMD$$

$$TGD = T_NAV + DT_TURN$$

3. The flyback task is required to execute the PEG calculations and maintain a solution by cycling PEG until it is converged or until the maximum number of cycles is reached. The convergence criterion is determined internal to the PEG task. Once PEG is converged in the turnaround, the calculated values of $L\bar{A}MC$, $L\bar{A}MDC$, and $TL\bar{A}MC$ will be used by the steering interface for the flyback rather than the $L\bar{A}MC$ calculated by the pitch command task. Prior to each PEG call, ATR is recomputed by the above equation.

4. The estimated time of MECO is then calculated as

$$TMET_MECO = TP - T_GMTLO + DT_PITCH$$

5. When the end of the turn has been reached, the guidance has converged, and the difference between the current throttle setting and the PEG throttle setting is greater than a K-load value and neither manual guidance nor manual throttling is being performed, then the SSME throttle commands for fuel depletion are issued.

If $DT_TURN = 0$, and $S_CONV = ON$, $AUTO = ON$, $S_MAN_THROT = OFF$, and $ABS(K_CMD - K) > DK_ROUND$, then $K_CMD = ROUND(K)$.

6. When TGO to start of powered pitchdown becomes less than or equal to TGO_PPD and the AUTO guidance discrete is ON or TGO becomes less than TGO_MAN and the AUTO guidance discrete is OFF, the fine countdown discrete S_MECO is set to ON and the flyback task is no longer executed.
7. If manual guidance or manual throttling is selected in the flyback phase, the fuel depletion throttling is stopped (S_THROT set OFF), and the PEG throttle is set to and maintained at the current commanded engine throttle, ($K = K_CMD$).

B. Interface Requirements. The input and output parameters for the flyback task are given in Tables 4.6.4-1 and 4.6.4-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.6.4-1. RTLS Flyback Task Inputs

Definition	Symbol	Source	Prec	Units
Length of turnaround	DT_TURN	K-LOAD, FUL DISS TSK	SP	sec
Time tag associated with current state	T_NAV	RTLS UPP	DP	sec
Current Shuttle position vector in M50	R_N̄NAV	RTLS UPP	DP	fps
Current Shuttle velocity vector in M50	V_N̄NAV	RTLS UPP	SP	fps
Total effective exhaust velocity	VEX	THRST PRM TSK	SP	fps
Desired throttle setting	K	PEG TSK, RTLS INIT TSK, SSME-OUT SAF TSK, G-LIM TSK	SP	pct
Commanded SSME throttle setting	K_CMD	RTLS INIT TSK, SSME-OUT SAF TSK, G-LIM TSK, SBTC SOP, ASC GUID TSK, 1STG GUID INP TSK	I	pct
Discrete indicating convergence	S · CONV	PEG TSK	D	N/A
Time to go	TGO	PEG TSK	SP	sec
Predicted time to achieve PEG targets	TP	PEG TSK	DP	sec
Thrust scaling factor	FT_FACTOR	ACC-MASS UPD TSK, SSME-OUT SAF TSK	SP	ND
Total vehicle thrust force	FT	THRST PRM TSK	SP	lb
TGO to initiate fine countdown for manual guidance	TGO_MAN	I-LOAD	SP	sec
TGO to initiate fine countdown	TGO_PPD	K-LOAD	SP	sec
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Auto guidance mode flag	A · UTO	ASC DAP	D	N/A
Difference needed to update SSME throttle command	DK_ROUND	K-LOAD	SP	pct
Nominal time of powered pitchdown	DT_PITCH	K-LOAD	SP	sec
Manual throttle discrete	S · MAN_THROT	SBTC SOP	D	N/A
Maximum number of PEG iterations	N_MAX	K-LOAD	I	N/A
Number of active null jets	N_RCS_NULL	PFG INP TSK	I	N/A
RCS mass flow rate	MDOT_RCS	K-LOAD	SP	slug/sec
Total mass flow rate	MDOT	THRUST PRM TSK	SP	slug/sec

Table 4.6.4-2. RTLS Flyback Task Outputs				
Definition	Symbol	Destination	Prec	Units
Vehicle position vector input to PEG	\overline{RGD}	PEG TSK	DP	ft
Thrust acceleration estimate input to PEG	ATR	PEG TSK	SP	fps ²
Time associated with \overline{RGD} and \overline{VGD}	TGD	PEG TSK	DP	sec
Steering enable flag	$\dot{S}STEER$	PEG TSK	D	N/A
Throttling discrete	$\dot{S}THROT$	PEG TSK	D	N/A
Fine countdown discrete	S_MECO	RTLS UPP SEQ, ACC-MASS UPD TSK, TLM, MSC, PRTLS SEQ, PW CONT SEQ, CONT MODE SEL TSK	D	N/A
Commanded SSME throttle setting	K_CMD	SSME SOP, SSME-OUT SAF TSK, THRST PRM TSK, PEG TSK, SBTC SOP, RTLS TRAJ 2 DISP	I	pct
Predicted SSME C/O time in MET	TMET_MECO	RTLS TRAJ 2 DISP, TLM, PRTLS SEQ	SP	sec
Exhaust velocity	VEX	PEG TSK	SP	fps
Desired throttle setting	K	PEG TSK	SP	pct

4.6.5 Powered Pitchdown Task (PPD TSK)

The following subtasks are necessary to support the powered pitchdown calculations:

1. Compute the M50-to-commanded body quaternion for the powered pitchdown, mated coast, and $-Z$ translation.
2. Command the SSME throttles to KMIN.
3. Set the powered pitchdown discrete to ON.
4. Delay completion of powered pitchdown if required for late engine failure scenarios.

A. Detailed Requirements.

1. The M50-to-commanded body quaternion is computed in the following manner:
 - a. The quaternion $Q_{M50_VR}^{\dagger}$ is found by using the function RV_TO_QLVLH. Define a coordinate system by setting the \bar{Z} axis equal to the unit negative of the first input vector, the \bar{Y} axis equal to the unit vector of the second input vector crossed into the first input vector, and the \bar{X} axis equal to $\bar{Y} \times \bar{Z}$. The quaternion representing the transformation from this coordinate system, called the VR coordinate system to the M50 coordinate system is computed as follows:

$$Q_{M50_VR}^{\dagger} = RV_TO_QLVLH(V_RHO, -R_NAV)$$

- b. From the initiation of this task until the TIMER_DELAY_MC is satisfied, the rotation angle needed to align the +X (body) axis with respect to the velocity vector with a specific off-set angle alpha is defined as follows:

$$ALPHA_Q = (PI/2 + ALPHA_PPD_INTACT)/2$$

After MECO confirmed has been set (MECO_CONFIRMED = ON), a timer is started to determine when the mated coast desired alpha target is to be used. When the timer equals or exceeds TIMER_DELAY_MC, the event flag is set, and the targeted alpha during the RTLS mated coast is calculated.

$$MC_PPD = ON$$

$$ALPHA_Q = (PI/2 + ALPHA_MC)/2$$

After ET separation (ET_SEP_CMD = ON), the targeted angle alpha is computed as:

$$ALPHA_Q = (PI/2 + ALPHA_Z)/2$$

- c. The rotation quaternion $Q_{CB_VR}^{\dagger}$ from the VR to the commanded body system is computed with the scalar element $COS(ALPHA_Q)$ and the vector part $(0, -SIN(ALPHA_Q), 0)$.
 - d. The M50-to-commanded body quaternion, $Q_{CB_M50}^{\dagger}$, is then computed by forming the conjugate of the quaternion $Q_{M50_VR}^{\dagger}$ and premultiplying it by the rotation quaternion ($Q_{CB_VR}^{\dagger}$) computed in paragraph c:

$$Q_{CB_M50}^{\dagger} = QUAT_MULT(Q_{CB_VR}^{\dagger}, Q_{VR_M50}^{\dagger})$$

2. This step controls throttling during powered pitchdown. If manual throttling is not being performed ($S_MAN_THROT = OFF$) and $M\dot{E}CO_CMD = OFF$, perform this step; otherwise, proceed to Step 3.
 - a. For the special case where an engine has failed after the last retargeting opportunity during a 3 engine RTLS, the throttling is controlled as follows:
If $IA = 4$ and $N_SSME = 2$ and manual guidance is not active ($A\dot{U}TO = ON$), perform the following. Otherwise proceed to step (b).
If $TGO > DT_K_CO_MAX$ and $S_P\dot{P}D_QUAT = ON$, set $K_CMD = K_CO_MAX$. Proceed to Step 3.
 - b. If $N_SSME < 2$, command the engines to maximum power ($K_CMD = KMAX$) and proceed to Step 3.
 - c. If manual guidance is not being performed ($A\dot{U}TO = ON$), the engines are commanded to minimum power ($K_CMD = KMIN$) and $S_K\dot{C}O$ is set to ON.
3. The powered pitchdown discrete is set to ON to reconfigure the steering interface for quaternion inputs: $S_P\dot{P}D_QUAT = ON$.
4. If a late SSME failure has occurred, the target line selected for PPD (three or two engine) may not match the current engine configuration. In these cases, a delay in completion of the powered pitchdown may be necessary to reduce ET separation dynamic pressure.

If the PPD delay is completed or is not desired ($D\dot{E}LAY_COMPLETE = ON$), then exit this task. Otherwise, set the PPD delay discrete OFF ($P\dot{P}D_DELAY = OFF$) each pass through this step.

If MECO has not occurred ($M\dot{E}CO_CONFIRM = OFF$ and $N_SSME > 0$) and $IA > 2$ (N_SSME-1), perform (a) through (c) below. Otherwise exit this task.

- a. Determine the time since initiation of powered pitchdown.

$$DT_PPD = TGD - TP$$

- b. Determine the PPD delay limit time. The PPD delay limit time is a function of when the SSME failure occurs relative to the start of PPD. If the engine failure occurs more than PPD_DELAY_MAX seconds after the start of PPD, the pitchdown is essentially complete and a PPD delay is not desired.

This step should only be executed once. Otherwise, proceed to step (c).

If $DT_PPD > PPD_DELAY_MAX$, set $D\dot{E}LAY_COMPLETE = ON$ and exit this task. Otherwise, perform the following:

$$DELAY_TOTAL = 0$$

$$DELAY_TIME = PPD_DELAY_DUR(N_SSME, LL-1)$$

$$DT_ME_FAIL = T_ME_FAIL - TP$$

$$DELAY_LIMIT = MIDVAL(DELAY_TIME, DELAY_TIME - DT_ME_FAIL, DELAY_TIME PPD_DELAY_FACTOR)$$

- c. Set the PPD delay discrete as specified below. If a PPD delay does occur, it will start no earlier than an I-loaded time (PPD_DELAY_START) after PPD initiation. This permits a reduction in the angle of attack before the continuation of the pitchdown. When it does continue, starting from a smaller angle of attack will provide more control margin in the presence of uncertain aerodynamic moments.

During the PPD delay phase, the G/C Steer maneuver smoother reduces the desired body pitch rate towards zero. When the delay period is over, the PPD maneuver resumes.

- (1) If $DT_PPD < PPD_DELAY_START(N_SSME)$, exit this task.

- (2) Increment the PPD delay timer.

$$DELAY_TOTAL = DELAY_TOTAL + DTGD$$

- (3) If $DELAY_TOTAL < DELAY_LIMIT$, set $\dot{PPD_DELAY} = ON$. Otherwise, set $DELAY_COMPLETE = ON$

B. Interface Requirements. The input and output parameters for the powered pitchdown task are given in Tables 4.6.5-1 and 4.6.5-2.

C. Processing Requirements. None

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

$$\dot{DELAY_COMPLETE} = OFF$$

$$\dot{PPD_DELAY} = OFF$$

$$S_PPD_QUAT = OFF$$

$$M\dot{C}_PPD = OFF$$

E. Supplemental Information. The outputs Q_CB_M50 and S_PPD_QUAT are a time-homogeneous set.

Table 4.6.5-1. Powered Pitchdown Task Inputs

Definition	Symbol	Source	Prec	Units
Current Shuttle position vector in M50 coordinates	$R_{\bar{NAV}}$	RTLS UPP	DP	ft
Earth relative velocity vector in M50	$V_{\bar{RHO}}$	RTLS UPP	SP	fps
Desired angle of attack at end of PPD	ALPHA_PPD_INTACT	I-LOAD	SP	rad
Desired angle of attack at start of ET separation	ALPHA_MC	I-LOAD	SP	rad
Minimum throttle setting of SSME	KMIN	I-LOAD	I	pct
Manual throttle discrete	$S_{\dot{MAN_THROT}}$	SBTC SOP	D	N/A
Auto guidance mode flag	$A_{\dot{UTO}}$	ASC DAP	D	N/A
Desired angle of attack at end of -Z translation	ALPHA_Z	I-LOAD	SP	rad
ET separation commanded discrete	$ET_{\dot{SEP_CMD}}$	ET SEP SEQ	D	N/A
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Maximum throttle setting for SSME	KMAX	I-LOAD, KMAX UPDT TSK, SSME-OUT SAF TSK	I	pct
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
Time delay between MECO_CONFIRMED and start of Mated Coast Pitchdown Maneuver	TIMER_DELAY_MC	I-LOAD	SP	sec
Minimum time-to-go to command K_CO_MAX	DT_K_CO_MAX	I-LOAD	SP	sec
RTLS PPD target index	IA	PEG TSK	I	N/A
MECO throttle command for 2 SSME's	K_CO_MAX	I-LOAD	I	pct
Index for selecting RTLS flight path angle target	LL	SSME-OUT SAF TSK	I	N/A
MECO confirmation discrete	$M_{\dot{ECO_CONFIRMED}}$	SSME OPS	D	N/A
Maximum PPD delay duration for late engine failure cases	PPD_DELAY_DUR(I,J) (I=1,2) (J=1,2)	I-LOAD	SP	sec
Maximum time after PPD initiation that an engine failure will cause a delay in completion	PPD_DELAY_MAX	I-LOAD	SP	sec
Slope of the PPD delay time curve between fine countdown and PPD	PPD_DELAY_FACTOR	I-LOAD	SP	ND
PPD delay start time (time after PPD initiation that the delay begins)	PPD_DELAY_START(J) (J = 1,2)	I-LOAD	SP	sec
Time associated with current state	TGD	PFG INP TSK	DP	sec
Time tag associated with current state	T_NAV	RTLS UPP	DP	sec
Time-to-go	TGO	MPS GUID C/O TSK	SP	sec

Table 4.6.5-1. Powered Pitchdown Task Inputs				
Definition	Symbol	Source	Prec	Units
Last predicted time of powered pitchdown	TP	PEG TSK	DP	sec
GMT time of main engine failure	T_ME_FAIL	SSME-OUT SAF TSK	DP	sec
MECO commanded discrete	MECO_CMD	SSME OPS	D	N/A

Table 4.6.5-2. Powered Pitchdown Task Outputs				
Definition	Symbol	Destination	Prec	Units
M50-to-commanded body quaternion	Q_{CB_M50}	G/C STEER	SP	ND
Commanded SSME throttle setting	K_CMD	SSME SOP, SBTC SOP, RTLS TRAJ 2 DISP	I	pct
Discrete indicating powered pitchdown commands	S_{PPD_QUAT}	ASC DAP, SSME-OUT SAF TSK	D	N/A
PPD delay discrete used in G/C Steer maneuver smoothing and control	PPD_DELAY	G/C STEER	D	N/A
Discrete to indicate pre-MECO throttle down is commanded	S_{KCO}	PRTLS SEQ	D	N/A
Mated Coast Pitch_Down discrete used in G/C STEER maneuver smoothing and control	MC_PPD	G/C STEER	D	N/A

4.6.6 Pitch Command Task (PITCH CMD TSK)

The pitch command task computes a desired thrust direction for the fuel dissipation phase and a desired flyback thrust direction to begin the RTLS turnaround and flyback. It also notifies the steering interface of the beginning of the turnaround.

A. Detailed Requirements.

1. If the flyback discrete, S_{RTLS_FB} , is OFF, the fuel dissipation thrust angle is calculated as a linear function of V_{RTLS_FD} , and the guidance ready flag (S_{GDRDY}) is set to ON: If $V_{RTLS_FD} < V_{SWTCH}$, then

$$THETA_C = THETA_0 + (THETA_1) V_{RTLS_FD} + (THETA_4) H_DOT_FD$$

$$\text{Otherwise, } THETA_C = THETA_2 + (THETA_3) V_{RTLS_FD}$$

In all cases, $THETA_C = MIDVAL(THETA_MAX, THETA_C, THETA_MIN) S_{GDRDY} = ON$

2. If the flyback discrete, S_{RTLS_FB} , is ON, the initial flyback thrust angle is set to a K-load value, the turnaround and throttle discretions are set, and the vehicle is commanded to wings level, tail up. The K-load DTTHROT controls whether or not fuel depletion throttling will be performed during flyback.

$$THETA_C = THETA_FB$$

If $DTTHROT < 1000$, $STHROT = ON$; otherwise, $STHROT = OFF$

$$S_{RTLS_TURN} = ON$$

$$PHI_CMD = 0$$

3. The RTLS azimuth is computed by transforming the vehicle's earth relative velocity vector, V_{RHO} , from M50 to the boost reference system, and obtaining the angle AZ.

$$V_{RHO_BR} = QUAT_XFORM(Q_{BR_M50}, V_{RHO})$$

$$AZ = ARCTAN2(V_{RHO_BR}(2), V_{RHO_BR}(1))$$

If AZ is negative, then $AZ = AZ + 2 \text{ PI}$.

4. The desired thrust direction is then computed by changing the desired thrust angle to a vector along the RTLS azimuth in the boost reference system and transforming the vector by quaternion multiplication to the M50 system, using the QUAT_XFORM function and the conjugate of Q_{BR_M50} .

$$L\bar{A}MC = QUAT_XFORM \{ Q_{M50_BR}, [\cos(AZ) \cos(THETA_C), \sin(AZ) \cos(THETA_C), -\sin(THETA_C)] \}$$

5. The time derivative of $\bar{L}AMC$ and the time tag of $\bar{L}AMC$ are set to zero to ensure a constant thrust attitude. The unit vector to the landing site, $\bar{I}ZC$, is set equal to $\bar{L}AMC$.

$$\dot{\bar{L}AMDC} = 0$$

$$TLAMC = 0$$

$$\bar{I}ZC = \bar{L}AMC$$

6. The pitch command discrete is set to OFF at the end of the task:

$$S_PITCH_CMD = OFF$$

B. Interface Requirements. The input and output parameters for the pitch command task are given in Tables 4.6.6-1 and 4.6.6-2.

C. Processing Requirements. Since the pitch command can be time-critical in late aborts, the pitch command task should be executed within 160 milliseconds of the previous RTLS guidance cycle. This task is executed whenever $S_PITCH_CMD = ON$ and $MM = 601$.

D. Initialization Requirements. .

$$S_RTLS_TURN = OFF$$

E. Supplemental Information. Before turnaround, $\bar{L}AMC$, $\bar{L}AMDC$, $TLAMC$, $\bar{I}ZC$, and S_GDRDY are a time-homogeneous set; and at turnaround, $LAMC$, $LAMDC$, $TLAMC$, $\bar{I}ZC$, PHI_CMD , and S_RTLS_TURN are a time-homogeneous set. The discrete S_PITCH_CMD is set to ON in the fuel dissipation task and PRTLS sequencing.

Table 4.6.6-1. Pitch Command Task Inputs				
Definition	Symbol	Source	Prec	Units
M50-to-boost reference quaternion	$Q_{\dot{B}R_M50}$	ASC UP	SP	ND
RTLS fuel dissipation reference velocity magnitude	V_{RTLS_FD}	SSME-OUT SAF TSK, RTLS INIT TSK, 1STG GUID INP TSK	SP	fps
Burn time left to stop throttling	DTTHROT	K-LOAD	SP	sec
Coefficients for calculating fuel dissipation thrust attitude	THETA_0, THETA_1, THETA_2, THETA_3, THETA_4	I-LOAD	SP	rad, rad/fps, rad, rad/fps, rad/fps
Flyback thrust direction	THETA_FB	K-LOAD	SP	rad
Flyback task discrete	$S_{\dot{R}TLS_FB}$	PRTLS SEQ, FUL DISS TSK	D	N/A
Fuel dissipation thrust attitude switch velocity	V_{SWTCH}	I-LOAD	SP	fps
RTLS H_DOT reference	H_DOT_FD	SSME-OUT SAF TSK, 1STG GUID INP TSK, RTLS INIT TSK	SP	fps
Upper fuel dissipation attitude limit	THETA_MAX	K-LOAD	SP	rad
Lower fuel dissipation attitude limit	THETA_MIN	K-LOAD	SP	rad
Earth relative velocity vector in M50	$V_{\dot{R}HO}$	RTLS UP	SP	fps

Table 4.6.6-2. Pitch Command Task Outputs				
Definition	Symbol	Destination	Prec	Units
GMT associated with desired thrust vector	TLAMC	G/C STEER, TLM	DP	sec
Commanded roll angle	PHI_CMD	G/C STEER	SP	rad
Pitch command task discrete	$S_{\dot{P}ITCH_CMD}$	PRTLS SEQ	D	N/A
Throttling discrete	STHROT	PEG TSK	D	N/A
Guidance ready flag	$S_{\dot{G}DRDY}$	MSC	D	N/A
Discrete indicating start of turn	$S_{\dot{R}TLS_TURN}$	ASC DAP, CONT MODE SEL TSK, AMI PROC, MEDS FC GNC XFER, TLM	D	N/A
M50 desired thrust vector	$\bar{L}AMC$	G/C STEER, TLM, FUL DISS TSK	SP	ND
M50 desired thrust turning rate vector	$\bar{L}AMDC$	G/C STEER, TLM	SP	sec ⁻¹
Unit vector to landing site	$\bar{I}ZC$	G/C STEER	DP	N/A

4.6.7 Parameter Tables for Powered RTLS Guidance

The IDD inputs and outputs are listed in Tables 4.6.7-1 and Table 4.6.7-2 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 4.6.7-3. K-loads are listed in Table 4.6.7-4. Constants are listed in Table 4.6.7-5. The input variable cross-references are listed in Table 4.6.7-0.

Table 4.6.7-0. Powered RTLS Input Variable Cross-Reference		
MSID	Local Name	Source Name
V95H0185CA, 6CA, 7CA	$R_{\bar{N}AV}$	R_AVGG (1) (2) (3)
V95L0190CA, 1CA, 2CA	$V_{\bar{N}AV}$	V_AVGG (1) (2) (3)
V95W0200CC	T_NAV	T_STATE
V95L0210CA, 1CA, 2CA	$V_{\bar{S}}$	V_IMU_OLD (1) (2) (3)
V95L0151CA	V_{RHO_MAG}	REL_VEL_MAG/V
V95U0503C, 4C, 5C, 6C	Q_{BR_M50}	Q_M50TOBR (1) (2) (3) (4)
V95U0507C, 8C, 9C	$R_{\bar{L}S_M50}$	R_M50_AT_LIFTOFF (1) (2) (3)
V90X8156X	MM_{103}	MM_CODE_103/MM_103
V90X8194X	MM_{601}	MM_CODE_601/MM_601
V95X1207X	$S_{\dot{E}O_E1}$	ME1_FAIL_SHUTDOWN
V95X1208X	$S_{\dot{E}O_E2}$	ME2_FAIL_SHUTDOWN
V95X1209X	$S_{\dot{E}O_E3}$	ME3_FAIL_SHUTDOWN

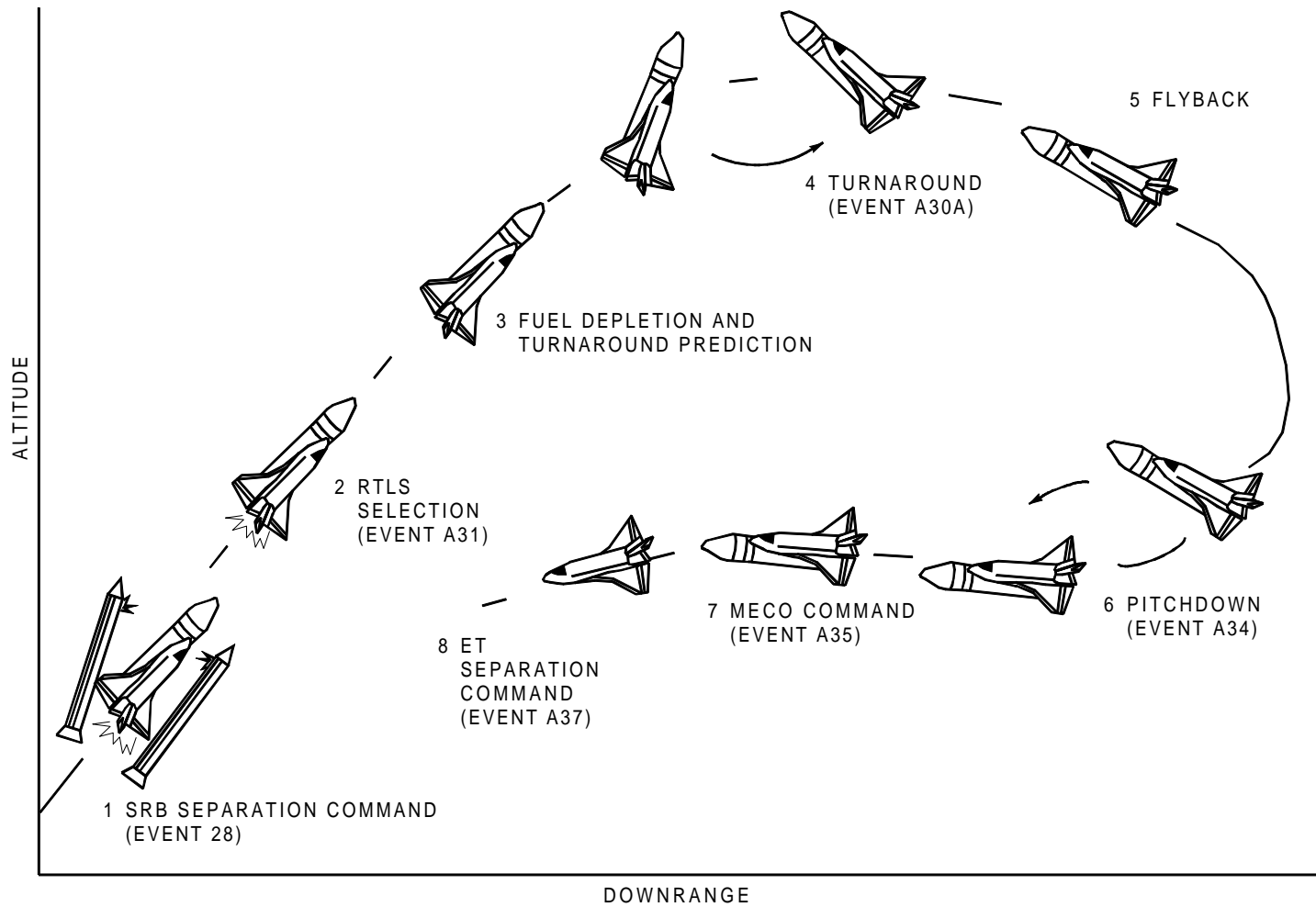


FIGURE 4.6-1. Typical PRTLs Sequence of Events

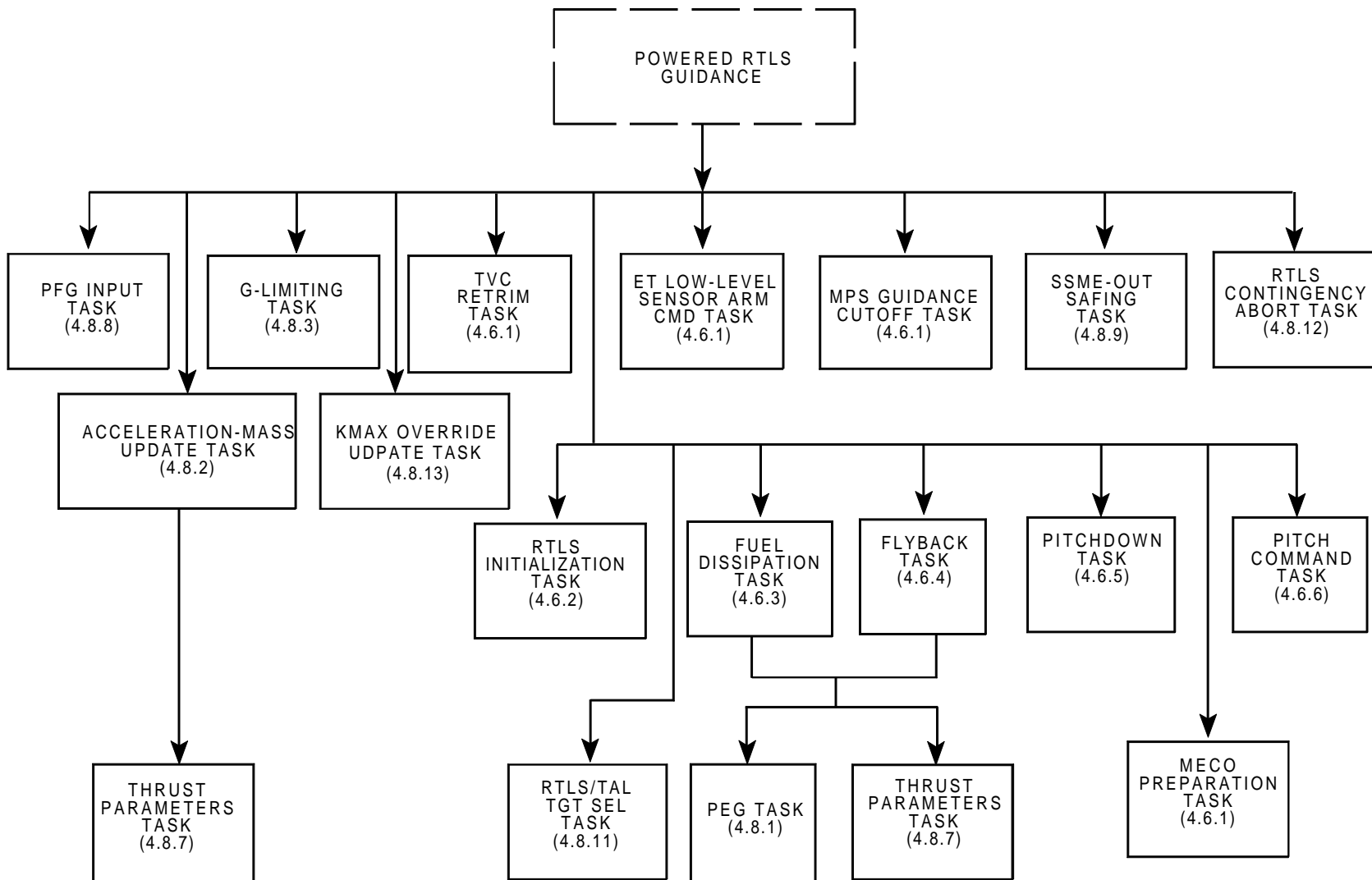
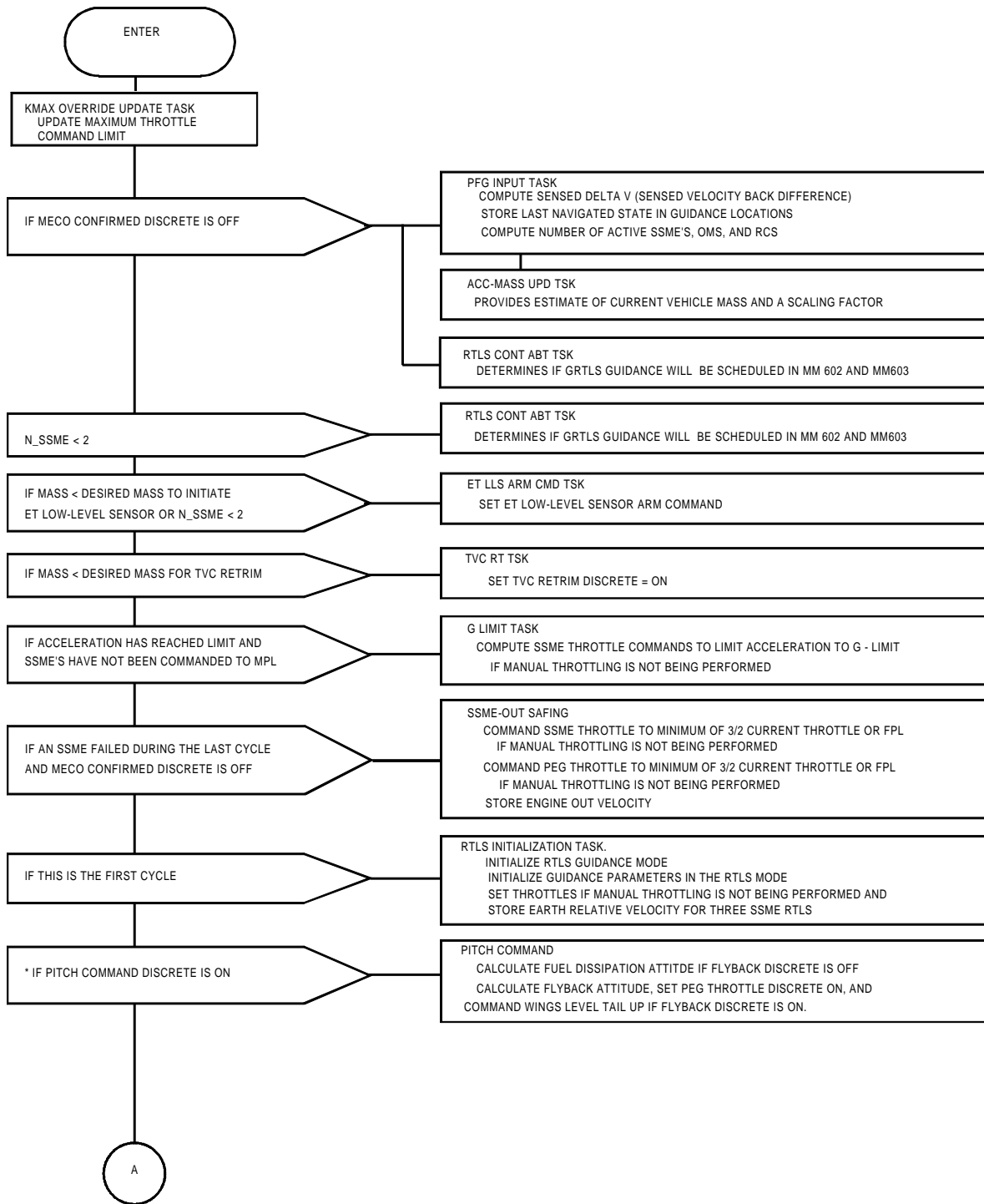


FIGURE 4.6-2. PRTLs and Guidance Principal Function Task Organization



* PITCH COMMAND TASK IS EXECUTED
 INDEPENDENT OF POWERED RTL5 GUIDANCE

FIGURE 4.6-3.(1) PRTL5 Guidance Functional Flow (Sheet 1 of 2)

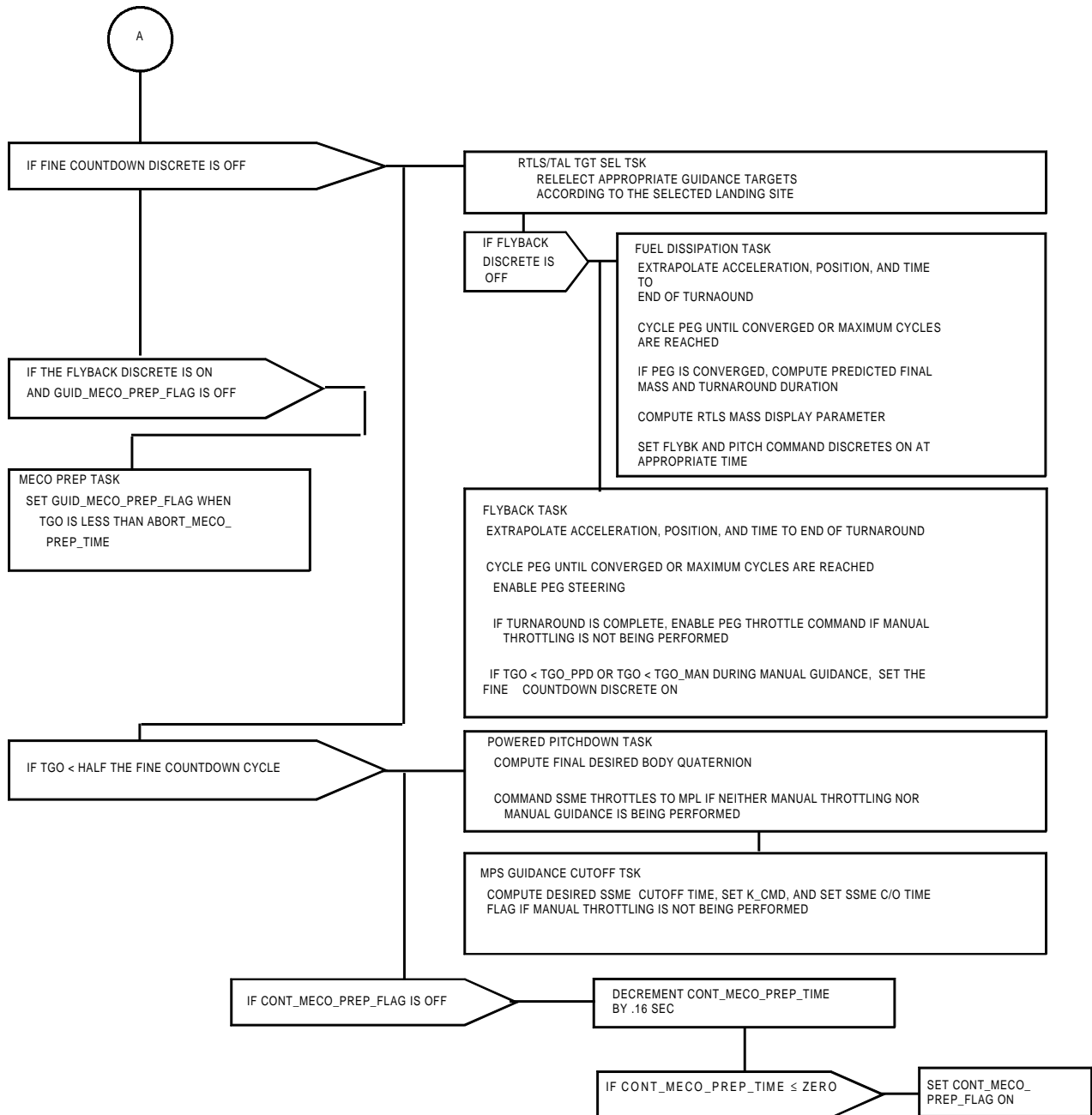


FIGURE 4.6-3.(2) PRTL Guidance Functional Flow (Sheet 2 of 2)

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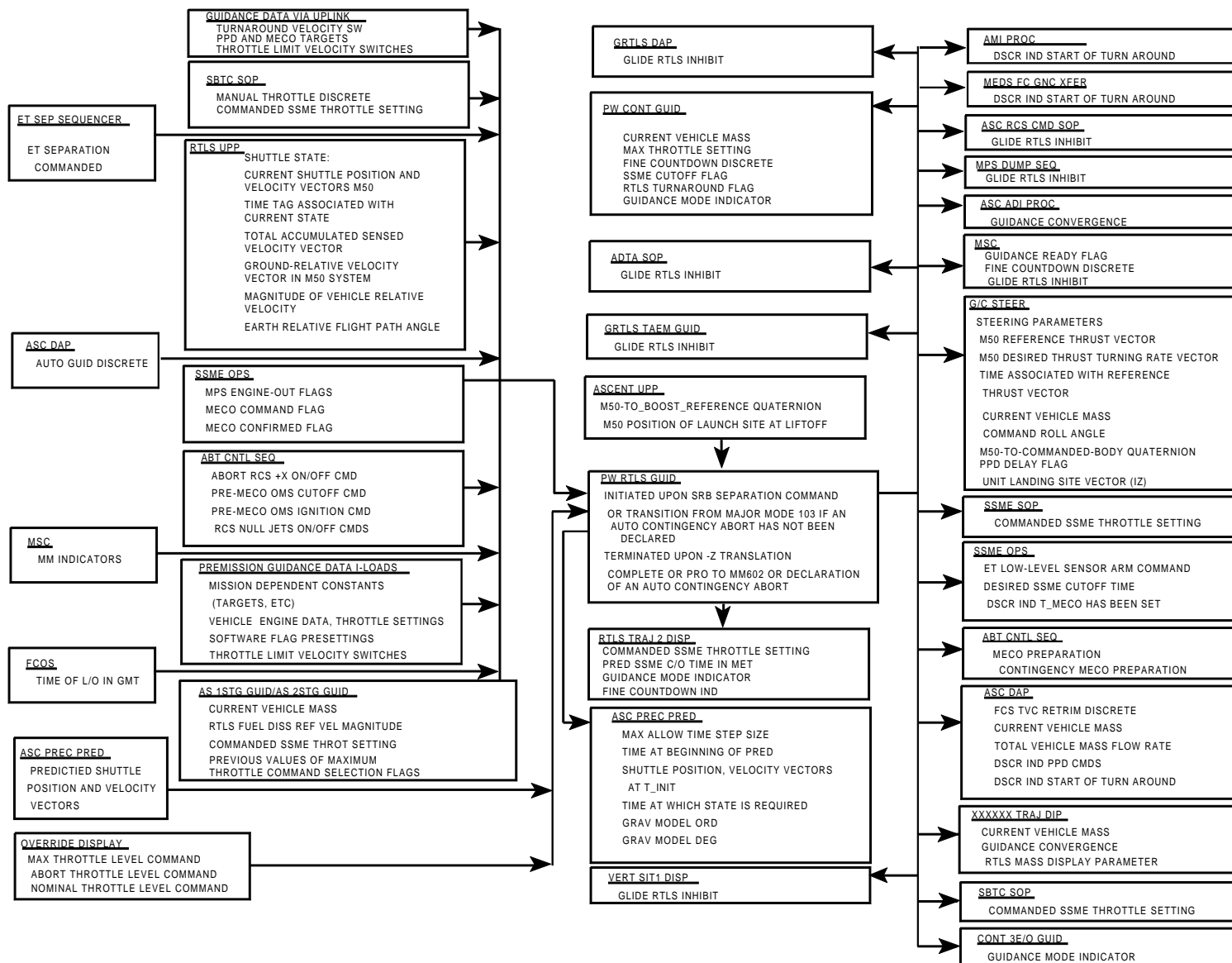


FIGURE 4.6-4 PRTLs Guidance Principal Function (Major Mode 601) Data Flow

TABLE 4.6.7-1. INPUT FUNCTIONAL PARAMETERS FOR POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_CMD_PREV	V93X1031XA	PREV KMAX CMD TO ABT	ASC 1STG GUID		BD		92608C	
ABT_CMD_PREV	V93X1031XB	PREV KMAX CMD TO ABT	ASC 2STG GUID		BD		92608C	
ABT_THROT_CMD	V93X0994X	ABORT THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
AREA_SEL	V93J4392CB	SELECTED AREA	ASC SITE LOOKUP				93017G	*
AUTO	V90X1710X	AUTO GUIDANCE MODE FLAG	ASC DAP		BD		93017G	*
D_ARC	V95H0477C	ARC LENGTH AROUND HAC(WPI TO NEP)	RTLS UPP					
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	
ET_SEP_CMD	V90X8250X	ET SEPARATION CMD FLAG	ET SEP SEQ		BD		93017G	*
FLT_PATH_ANG/GAMMA	V95H0261CC	GROUND-REL FLT PATH ANGLE	RTLS UPP	SPECIAL			93017G	*
FLT_PATH_ANG_TIME	V95W0464C	TIME OF COMPUTING FLT PATH ANG	RTLS UPP					
H_DOT_ELLIPSOID/H_DOT	V95L0265CA	EST ALTITUDE RATE	RTLS UPP	FT/S	SPL		93017G	*
H_DOT_FD	V90R2098CA	RTLS FUEL DISSP REF HDOT	ASC 1STG GUID	FT/S				
H_DOT_FD	V90R2098CB	RTLS FUEL DISSP REF HDOT	ASC 2STG GUID	FT/S				
KMAX	V97U4424CA	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 1STG GUID	PCT			90608D	
KMAX	V97U4424CB	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 2STG GUID	PCT			90608D	
K_CMD	V90U1948CA	COMMANDED SSME THROTTLE SETTING	ASC 2STG GUID	PCT			93017G	*
K_CMD	V90U1948CB	COMMANDED SSME THROTTLE SETTING	ASC 1STG GUID	PCT			93017G	*
K_CMD	V90U1948CE	COMMANDED SSME THROTTLE SETTING	SBTC SOP	PCT			93012D	
LL	V90J2007CA	RTLS FLIGHT PATH ANG TARGET INDEX	ASC 1STG GUID				89461	
LL	V90J2007CB	RTLS FLIGHT PATH ANG TARGET INDEX	ASC 2STG GUID				89461	
M/CURR_ORB_MASS/WEIGHT	V90U1961CF	CURRENT VEHICLE MASS	ASC 1STG GUID	SLUGS			93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CG	CURRENT VEHICLE MASS	ASC 2STG GUID	SLUGS			93017G	*
MASS_LOW_LEVEL	V97U4432C	MASS TO ARM MPS LOW LEVEL SENSORS	UL	SLUG	SPL	S	92175D	
MAX_CMD_PREV	V93X1032XA	PREV KMAX CMD TO MAX	ASC 1STG GUID		BD		92608C	
MAX_CMD_PREV	V93X1032XB	PREV KMAX CMD TO MAX	ASC 2STG GUID		BD		92608C	
MAX_THROT_CMD	V93X5349X	MAXIMUM THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		89990E	
MBOD(1)	V97U4438C	DESIRED MASS FOR 2 SSME RTLS PPD	UL	SLUG	SPL	S	92175D	
MBOD(2)	V97U4439C	DESIRED MASS FOR 3 SSME RTLS PPD	UL	SLUG	SPL	S	92175D	
ME1_FAIL_SHUTDOWN	V95X1207X	MPS E1 FAIL FLAG	SSME OPS		BD		93017G	*
ME2_FAIL_SHUTDOWN	V95X1208X	MPS E2 FAIL FLAG	SSME OPS		BD		93017G	*
ME3_FAIL_SHUTDOWN	V95X1209X	MPS E3 FAIL FLAG	SSME OPS		BD		93017G	*
MECO_CMD	V90X8569XA	MECO COMMAND FLAG	SSME OPS		BD		93017G	*
MECO_CONFIRMED	V90X8561X	MECO CONFIRMED FLAG	SSME OPS		BD		93017G	*
MM_CODE_102/MM_102	V90X8158X	MAJOR MODE 102 FLAG	MSC				93012D	
MM_CODE_103/MM_103	V90X8156X	MAJOR MODE 103 FLAG	MSC				93012D	
MM_CODE_601/MM_601	V90X8194X	MAJOR MODE 601 FLAG	MSC		BD		93012D	
NOM_CMD_PREV	V93X1033XA	PREV KMAX CMD TO NOM	ASC 1STG GUID		BD		92608C	
NOM_CMD_PREV	V93X1033XB	PREV KMAX CMD TO NOM	ASC 2STG GUID		BD		92608C	
NOM_THROT_CMD	V93X0995X	NOMINAL THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
N_SSME	V90U1962CA	NUMBER OF ACTIVE SSME'S	ASC 1STG GUID				93017G	*
Q_M50TOBR(1)	V95U0503C	M50-TO BOOST REF QUATERNION ELE 1	ASC UPP				89461	
Q_M50TOBR(2)	V95U0504C	M50-TO BOOST REF QUATERNION ELE 2	ASC UPP				89461	
Q_M50TOBR(3)	V95U0505C	M50-TO BOOST REF QUATERNION ELE 3	ASC UPP				89461	
Q_M50TOBR(4)	V95U0506C	M50-TO BOOST REF QUATERNION ELE 4	ASC UPP				89461	

TABLE 4.6.7-1. INPUT FUNCTIONAL PARAMETERS FOR POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
REL_VEL_MAG	V95L0151CA	GND REL VEL MAGNITUDE IN M50 SYS	RTLS UPP	FT/S	SPL		93017G	*
R_AVGG(1)	V95H0185CA	X-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CA	Y-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CA	Z-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_CC_EF(1)	V95H0478C	HAC X_POSITION EF(TOD)	RTLS UPP					
R_CC_EF(2)	V95H0479C	HAC Y_POSITION EF(TOD)	RTLS UPP					
R_CC_EF(3)	V95H0480C	HAC Z_POSITION EF(TOD)	RTLS UPP					
R_FINAL(1)	V90H0881CB	X-COMP PREDICTED SHUTTLE POS VECTR	ASC COMP PRED	FT				
R_FINAL(2)	V90H0882CB	Y-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(3)	V90H0883CB	Z-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_M50_AT_LIFTOFF(1)	V95U0507C	X-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(2)	V95U0508C	Y-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(3)	V95U0509C	Z-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
S_MAN_THROT	V96X0006X	MANUAL THROTTLE DISCRETE	SBTC SOP		BD		93017G	*
S_MECO	V90X1963XB	FINE COUNT DOWN DISCRETE	ASC 2STG GUID				93017G	*
S_OMS_CUTOFF	V90X8318XA	OMS CUTOFF CMD	ABT CNTL SEQ				93064D	
S_OMS_IGN	V90X8319X	ABORT OMS IGNITION CMD	ABT CNTL SEQ				89990E	
S_RCS_IGN	V90X8314X	ABORT RCS +X ON CMD	ABT CNTL SEQ		BD		93017G	*
S_RCS_NULL20	V90X8317X	20 RCS NULL JETS ON CMD	ABT CNTL SEQ		BD		93017G	*
TARGET10(1)	V99U8910C	RTLS/TAL GUID TARGET 10 - AREA 1	UL	RAD			92392C	
TARGET11(1)	V99U8911C	RTLS/TAL GUID TARGET 11 - AREA 1	UL	RAD			92392C	
TARGET12(1)	V99U8912C	RTLS/TAL GUID TARGET 12 - AREA 1	UL	FT			92392C	
TARGET14(1)	V98U8497C	RTLS/TAL GUID TARGET 14 - AREA 1	UL	FT/S			92392C	
TARGET2(1)	V99U8902C	RTLS/TAL GUID TARGET 2 - AREA 1	UL	FT/S			92392C	
TARGET4(1)	V99U8904C	RTLS/TAL GUID TARGET 4 - AREA 1	UL	FT/S			92392C	
TARGET6(1)	V99U8906C	RTLS/TAL GUID TARGET 6 - AREA 1	UL	FT/S			92392C	
TARGET9(1)	V99U8909C	RTLS/TAL GUID TARGET 9 - AREA 1	UL	RAD			92392C	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_NAV_PREV	V90W0151C	PREVIOUS VALUE OF T_STATE	ASC 1STG GUID	S	DPL		90608D	
T_STATE	V95W0200CC	TIME TAG ASSOC WITH CURRENT STATE	RTLS UPP	S			93017G	*
V_AVGG(1)	V95L0190CA	X-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CA	Y-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CA	Z-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CB	X-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(2)	V90L0886CB	Y-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(3)	V90L0887CB	Z-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CA	X-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CA	Y-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CA	Z-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_KMAX_DOWN	V97U0603C	THROTTLE LIMIT DECREASE VEL SW	UL	FT/S	SPL	S	92232B	
V_KMAX_UP	V97U0604C	THROTTLE LIMIT INCREASE VEL SW	UL	FT/S	SPL	S	92232B	
V_RHO(1)	V95L0215CA	X-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(2)	V95L0216CA	Y-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(3)	V95L0217CA	Z-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RTLS_FD	V90U1967CA	RTLS FUEL DISSIPATION REF VEL MAG	ASC 1STG GUID	FT/S				
V_RTLS_FD	V90U1967CB	RTLS FUEL DISSIPATION REF VEL MAG	ASC 2STG GUID	FT/S				

TABLE 4.6.7-1. INPUT FUNCTIONAL PARAMETERS FOR POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
YSGNP/YSGN	V95J0153CC	R/L CONE IND PRI RW	RTLS UPP		SPL		93017G	*

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

TABLE 4.6.7-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
AD	V90A1973CB	DESIRED THRUST ACCELERATION	DL FMT 21/1	FT/S2			93017G	*
CONT_MECO_PREP_FLAG	V90X8480XA	CONTINGENCY MECO PREP DISCRETE	ABT CNTL SEQ				90114B	
DT_MAX	V90U8500CG	MAX ALLOW TIME STEP SIZE	ASC PREC PRED	S				
FT_FACTOR	V90U1979CB	THRUST SCALING FACTOR	DL FMT 21/1				93017G	*
FT_S	V90U8120CD	ESTIMATED TOTAL THRUST	PW CONT GUID					
GLIDE_RTLS_INHIBIT	V90X2090XA	RTLS CONTINGENCY FLAG	DL FMT 21/1	LBF	SPL		93017G	*
			ADTA SOP		BD		93017G	*
			ASC RCS CMD SOP					
			DL FMT 21/1					
			ENT BRG SPEC					
			GRTLS DAP					
			GRTLS TAEM GUID					
			MEDS FC GNC XFER					
			MPS DUMP					
			MSC					
			VERT SIT1 DISP					
GMD_PRED	V90U8501CH	GRAVITY MODEL DEGREE	ASC PREC PRED					
GMO_PRED	V90U8502CH	GRAVITY MODEL ORDER	ASC PREC PRED					
GUID_MECO_PREP_FLAG	V90X1989XB	MECO PREPARATION DISCRETE	ABT CNTL SEQ					
IY(X)	V90U1976CC	X-M50 UNIT VEC NORMAL TO ORB PLANE	DL FMT 21/1				93017G	*
IY(Y)	V90U1977CC	Y-M50 UNIT VEC NORMAL TO ORB PLANE	DL FMT 21/1				93017G	*
IY(Z)	V90U1978CC	Z-M50 UNIT VEC NORMAL TO ORB PLANE	DL FMT 21/1				93017G	*
IZC(X)	V90U2095CB	X-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
IZC(Y)	V90U2096CB	Y-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
IZC(Z)	V90U2097CB	Z-UNIT VECTOR TO LANDING SITE	G/C STEER				90550	
K	V90J2091C	DESIRED THROTTLE SETTING	DL FMT 21/1	PCT	SPL		93017G	*
KMAX	V97U4424CC	MAXIMUM THROTTLE SETTING OF SSME'S	PW CONT GUID	PCT			90608D	
K_CMD	V90U1948CC	COMMANDED SSME THROTTLE SETTING	SBTC SOP					
			DL FMT 21/A	PCT			93017G	*
			RTLS TRAJ 2 DISP					
			SBTC SOP					
			SSME SOP					
LAMC(X)	V90U1954CB	X-COMP OF M50 REF THR VECTOR	DL FMT 21/1				93017G	*
LAMC(Y)	V90U1955CB	Y-COMP OF M50 REF THR VECTOR	G/C STEER					
LAMC(Z)	V90U1956CB	Z-COMP OF M50 REF THR VECTOR	DL FMT 21/1				93017G	*
LAMDC(X)	V90U1957CB	X-M50 DESIRED THR TRNING RATE VCTR	G/C STEER					
LAMDC(Y)	V90U1958CB	Y-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1	RAD/S			93017G	*
LAMDC(Z)	V90U1959CB	Z-M50 DESIRED THR TRNING RATE VCTR	G/C STEER					
LAMDAG	V90U1968CC	MAGNITUDE OF LAMDC	DL FMT 21/1	RAD/S			93017G	*

TABLE 4.6.7-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
M/CURR_ORB_MASS/WEIGHT	V90U1961CH	CURRENT VEHICLE MASS	ASC DAP DL FMT 21/1 G/C STEER PW CONT GUID XXXXXX TRAJ DIP	SLUGS			93017G	*
MC_PPD	V90X0447X	RTLS MC PITCH DOWN MNVR DISCRETE	G/C STEER		BD		93087E	
MDOT	V90R1993CB	TOTAL VEHICLE MASS FLOW RATE	ASC DAP TLM	SLUGS/S				
MF	V90U2093C	PREDICTED FINAL MASS	DL FMT 21/1	SLUGS	SPL		93017G	*
MF_DISPLAY	V90U2480C	RTLS MASS DISPLAY PARAMETER	DL FMT 21/1 XXXXXX TRAJ DIP	ND	HXS		93017G	*
N_OMS	V90J2031CC	NUMBER OF ACTIVE OMS ENGINES	TLM					
N_RCS	V90J1974CC	NUMBER OF ACTIVE RCS ENGINES	TLM					
N_RCS_NULL	V90J1975CC	NUMBER OF ACTIVE RCS NULL ENGINES	TLM					
N_SSME	V90U1962CB	NUMBER OF ACTIVE SSME'S	DL FMT 21/1				93017G	*
OTREQ	V90X0893XK	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
PHI_CMD	V90H1969CB	COMMANDED ROLL ANGLE	G/C STEER	RAD			89461	
PPD_DELAY	V90X7000X	PPD DELAY DISCRETE	G/C STEER		BD		89990E	
Q_CB_M50(1)/Q_GCB_1	V90U1949CB	M50-TO-CMD BODY QUATERNION ELE 1	G/C STEER					
Q_CB_M50(2)/Q_GCB_2	V90U1950CB	M50-TO-CMD BODY QUATERNION ELE 2	G/C STEER					
Q_CB_M50(3)/Q_GCB_3	V90U1951CB	M50-TO-CMD BODY QUATERNION ELE 3	G/C STEER					
Q_CB_M50(4)/Q_GCB_4	V90U1952CB	M50-TO-CMD BODY QUATERNION ELE 4	G/C STEER					
R_INIT(X)	V90H8508CC	X-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Y)	V90H8509CC	Y-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
R_INIT(Z)	V90H8510CC	Z-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT				
SCONV	V90X1971XD	PEG CONVERGENCE DISCRETE	DL FMT 21/1				93017G	*
SMODE	V94J3779CB	GUIDANCE MODE INDICATOR	CONT 3E/O GUID PW CONT GUID RTLS TRAJ 2 DISP		HXS		93012D	
S_FCD	V90X2086XA	FINE COUNTDOWN IND	RTLS TRAJ 2 DISP		BD		93012D	
S_GDRDY	V90X1965XB	GUIDANCE READY FLAG	MSC				90646C	
S_LOW_LEVEL	V90X1942XB	ET LEVEL SENSOR ARM CMD	DL FMT 21/A SSME OPS				93017G	*
S_MECO	V90X1963XA	FINE COUNT DOWN DISCRETE	DL FMT 21/1 MSC PW CONT GUID RTLS UPP SEQ				93017G	*
S_PPD_QUAT	V90X2087XA	DISCRETE INDICATING PPD CMDS	ASC DAP DL FMT 21/A		BD		93017G	*
S_RTLS_TURN	V90X2089X	DSCR IND START OF TURN AROUND	AMI PROC ASC DAP DL FMT 21/A MEDS FC GNC XFER PW CONT GUID		BD		93017G	*
S_SSME_TRIM	V90X1960XB	FCS TVC RETRIM DISCRETE	ASC DAP DL FMT 21/A				93017G	*

TABLE 4.6.7-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
S_TMECO	V90X1944XB	SSME C/O TIMING REQUEST FLAG	PW CONT GUID				89990E	
S_UNCONV	V90X2084XB	PEG UNCONVERGED DSCR IND	SSME OPS ASC ADI PROC XXXXXX TRAJ DIP		BD		90964	
TGD	V90W1994CD	GUIDANCE TIME TAG	DL FMT 21/1				93017G	*
TGO	V90W1941CC	TIME TO GO TO VELOCITY CUTOFF	DL FMT 21/A	S			93017G	*
TLAMC	V90W1953CB	TIME ASSOC W REF THR VECTOR	DL FMT 21/1	S			93017G	*
TMET_MECO	V90W1970CB	PREDICTED SSME C/O TIME IN MET	G/C STEER DL FMT 21/1 RTLS TRAJ 2 DISP	S			93017G	*
TP	V90W1946CC	PREDICTED TIME OF THRUST C/O	DL FMT 21/1	S			93017G	*
T_FINAL	V90W8506CG	TIME AT WHICH STATE IS DESIRED	ASC PREC PRED	S				
T_INIT	V90W8512CG	TIME AT BEGINNING OF PRED	ASC PREC PRED	S				
T_MECO	V90W1945CB	DESIRED SSME C/O TIME	SSME OPS	S				
VDMAG	V90U8499CC	DESIRED MECO VELOCITY	TLM	FT/S				
VGOMAG	V90U1966CC	MAGNITUDE OF VGO VECTOR	DL FMT 21/1	FT/S			93017G	*
V_INIT(X)	V90L8513CC	X-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Y)	V90L8514CC	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_INIT(Z)	V90L8515CC	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S				
V_ME_OUT	V90L1947CC	SSME ENGINE-OUT VELOCITY	DL FMT 21/A	FT/S			93017G	*
	V90M2938PB	CGGB_CGG_C01_FLAG_HALFWORD_1	DL FMT 21/A				93017G	*
	V90M2963PA	CGEB_MC1_LG1_FLAG1_MFE	DL FMT 21/A				93017G	*
	V90M2965PA	CGGB_CGG_C01_FLAG_HALFWORD_2	DL FMT 21/A				93017G	*
	V90M3141PA	CGGB_C01_MFE_FLGWD	DL FMT 21/1				93017G	*
	V90M3142PD	CGGB_MC16_GUID_TGT_FLAG	DL FMT 21/1				93017G	*
	V99M1855PA	CONT MNVR DISCRETES	DL FMT 21/1				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 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALPHA_MC	V97U1505C	RAD	F	S	D	C	G4.4	00	ZF1	93087E	
ALPHA_PPD_INTACT	V97U4344C	RAD	F	S	D	C	G4.4	00	ZF1	93087E	
ALPHA_Z	V97U1332C	RAD	F	S	D	C	G4.4	00	ZF1	90243C	
CONT_MECO_PREP_TIME	V97U6833C	SEC	F	S	D	P	G4.4	00	ZF1	90243C	
DTHETA_LIM	V97U4354C	RAD/SEC	F	S	D	C	G4.4	00	ZF1	90243C	
DTHETA_RATE	V97U4355C	RAD/SEC**2	F	S	D	C	G4.4	00	ZF1	90243C	
DT_K_CO_MAX	V97U8207C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
FT_SSME	V97U4392C	LBF	F	S	D	C	G4.176	00	ZF1	90243C	
							G4.2				
							G4.4				
							G4.5				
KMAX	V97U4424C	PCT	I	S	M	C	G4.1	00	A2P	89990E	
							G4.2				
							G4.4				
							G4.5				
							G4.55				
KMAX_ABT	V97U0601C	PCT	I	S	M	C	G4.1	00	A2P	92232B	
							G4.2				
							G4.4				
							G4.5				
KMAX_NOM	V97U0602C	PCT	I	S	M	C	G4.1	00	A2P	92232B	
							G4.2				
							G4.4				
							G4.5				
KMAX_SECONDARY	V99U7107C	PCT	I	S	M	C	G4.1	00	A2P	89990E	
							G4.2				
							G4.4				
							G4.5				
KMIN	V97U4425C	PCT	I	S	D	C	G4.2	00	A2P	89990E	
							G4.4				
							G4.55				
K_2ENG	V97U4854C	PCT	F	S	M	C	G4.4	00	A2P	89990E	
K_3ENG	V97U4421C	PCT	F	S	D	C	G4.4	00	A2P	89990E	
K_CO_MAX	V96U9261C	PCT	I	S	M	C	G4.2	00	A2P	89990E	
							G4.4				
MASS_LOW_LEVEL	V97U4432C	SLUGS	F	S	M	C	G4.2	00	AMC	DC2248	
							G4.4				
MASS_SSME_TRIM	V97U4436C	SLUGS	F	S	M	C	G4.2	00	AMC	DC2248	
							G4.4				
MBOD(1)	V97U4438C	SLUGS	F	S	M	C	G4.4	00	AMC	DC2248	
MBOD(2)	V97U4439C	SLUGS	F	S	M	C	G4.4	00	AMC	DC2248	
MDOT_SSME	V97U4442C	SLUGS/SEC	F	S	D	C	G4.1	00	ZF1	90243C	
							G4.2				
							G4.4				
							G4.5				
PHI_2STG	V97U4482C	RAD	F	S	D	C	G4.2	00	YD1	91019A	
							G4.4				

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
PPD_DELAY_DUR(1,1)	V97U8381C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_DUR(1,2)	V97U8382C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_DUR(2,1)	V97U8436C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_DUR(2,2)	V97U8437C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_FACTOR	V97U8215C	ND	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_MAX	V97U8384C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_START(1)	V97U8387C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
PPD_DELAY_START(2)	V97U8388C	SEC	F	S	D	P	G4.4	00	ACG	DC2248	
RADIUS_NEP	V97U5458C	FT	F	S	D	C	G4.19 G4.20 G4.4	00	ZFV	DC0617	
RTLS_PRIME_AREA	V99U8961C	ND	I	S	M	C	G4.2 G4.238 G4.4	00	AAP	DC0599	
TAL_PRIME_AREA	V99U8962C	ND	I	S	M	C	G4.2 G4.4 G6.21	00	AAP	91047C	
TARGET10(1)	V99U8910C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET10(10)	V98U8477C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET10(2)	V99U8922C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET10(3)	V99U8934C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET10(4)	V99U8946C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET10(5)	V99U8958C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET10(6)	V98U8473C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET10(7)	V98U8474C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET10(8)	V98U8475C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET10(9)	V98U8476C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET11(1)	V99U8911C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET11(10)	V98U8482C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET11(2)	V99U8923C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET11(3)	V99U8935C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET11(4)	V99U8947C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET11 (5)	V99U8959C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET11 (6)	V98U8478C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET11 (7)	V98U8479C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET11 (8)	V98U8480C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET11 (9)	V98U8481C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET12 (1)	V99U8912C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET12 (10)	V98U8491C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET12 (2)	V99U8924C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET12 (3)	V99U8936C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET12 (4)	V99U8948C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET12 (5)	V99U8960C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET12 (6)	V98U8483C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET12 (7)	V98U8484C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET12 (8)	V98U8485C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET12 (9)	V98U8490C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET13 (1)	V99U8963C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET13 (10)	V98U8496C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET13 (2)	V99U8964C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET13 (3)	V99U8965C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET13 (4)	V99U8966C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET13 (5)	V99U8967C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET13 (6)	V98U8492C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET13 (7)	V98U8493C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET13 (8)	V98U8494C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET13 (9)	V98U8495C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET14 (1)	V98U8497C	ND	F	S	M	C	G4.4	00	AA1	DC2115	
TARGET14 (10)	V98U8510C	ND	F	S	M	C	G4.4	00	A10	DC2115	
TARGET14 (2)	V98U8502C	ND	F	S	M	C	G4.4	00	AA2	DC2115	
TARGET14 (3)	V98U8503C	ND	F	S	M	C	G4.4	00	AA3	DC2115	
TARGET14 (4)	V98U8504C	ND	F	S	M	C	G4.4	00	AA4	DC2115	
TARGET14 (5)	V98U8505C	ND	F	S	M	C	G4.4	00	AA5	DC2115	
TARGET14 (6)	V98U8506C	ND	F	S	M	C	G4.4	00	AA6	90608D	
TARGET14 (7)	V98U8507C	ND	F	S	M	C	G4.4	00	AA7	DC2115	
TARGET14 (8)	V98U8508C	ND	F	S	M	C	G4.4	00	AA8	DC2115	
TARGET14 (9)	V98U8509C	ND	F	S	M	C	G4.4	00	AA9	DC2115	
TARGET2 (1)	V99U8902C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET2 (10)	V98U8285C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET2 (2)	V99U8914C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET2 (3)	V99U8926C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET2 (4)	V99U8938C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET2 (5)	V99U8950C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET2 (6)	V98U8277C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET2 (7)	V98U8278C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET2 (8)	V98U8279C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET2 (9)	V98U8284C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET3 (1)	V99U8903C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET3 (10)	V98U8290C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET3 (2)	V99U8915C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET3 (3)	V99U8927C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET3 (4)	V99U8939C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET3 (5)	V99U8951C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET3 (6)	V98U8286C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET3 (7)	V98U8287C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET3 (8)	V98U8288C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET3 (9)	V98U8289C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET4 (1)	V99U8904C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET4 (10)	V98U8299C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET4 (2)	V99U8916C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET4 (3)	V99U8928C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET4 (4)	V99U8940C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET4 (5)	V99U8952C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET4 (6)	V98U8291C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET4 (7)	V98U8296C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET4 (8)	V98U8297C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET4 (9)	V98U8298C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET5 (1)	V99U8905C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET5 (10)	V98U8439C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET5 (2)	V99U8917C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET5 (3)	V99U8929C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET5 (4)	V99U8941C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET5 (5)	V99U8953C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET5 (6)	V98U8300C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET5 (7)	V98U8436C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET5 (8)	V98U8437C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET5 (9)	V98U8438C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET6 (1)	V99U8906C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET6 (10)	V98U8450C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET6 (2)	V99U8918C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET6 (3)	V99U8930C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET6 (4)	V99U8942C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET6 (5)	V99U8954C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET6 (6)	V98U8440C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET6 (7)	V98U8447C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET6 (8)	V98U8448C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET6 (9)	V98U8449C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET7 (1)	V99U8907C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET7 (10)	V98U8455C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET7 (2)	V99U8919C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET7 (3)	V99U8931C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET7 (4)	V99U8943C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET7 (5)	V99U8955C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET7 (6)	V98U8451C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET7 (7)	V98U8452C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET7 (8)	V98U8453C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET7 (9)	V98U8454C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET8 (1)	V99U8908C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET8 (10)	V98U8467C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET8 (2)	V99U8920C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET8 (3)	V99U8932C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET8 (4)	V99U8944C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET8 (5)	V99U8956C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET8 (6)	V98U8456C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET8 (7)	V98U8457C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET8 (8)	V98U8458C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET8 (9)	V98U8459C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET9 (1)	V99U8909C	ND	F	S	M	C	G4.2 G4.4	00	AA1	DC2115	
TARGET9 (10)	V98U8472C	ND	F	S	M	C	G4.2 G4.4	00	A10	DC2115	
TARGET9 (2)	V99U8921C	ND	F	S	M	C	G4.2 G4.4	00	AA2	DC2115	
TARGET9 (3)	V99U8933C	ND	F	S	M	C	G4.2 G4.4	00	AA3	DC2115	
TARGET9 (4)	V99U8945C	ND	F	S	M	C	G4.2 G4.4	00	AA4	DC2115	
TARGET9 (5)	V99U8957C	ND	F	S	M	C	G4.2 G4.4	00	AA5	DC2115	
TARGET9 (6)	V98U8468C	ND	F	S	M	C	G4.2 G4.4	00	AA6	DC2115	
TARGET9 (7)	V98U8469C	ND	F	S	M	C	G4.2 G4.4	00	AA7	DC2115	
TARGET9 (8)	V98U8470C	ND	F	S	M	C	G4.2 G4.4	00	AA8	DC2115	
TARGET9 (9)	V98U8471C	ND	F	S	M	C	G4.2 G4.4	00	AA9	DC2115	
TARGET_INDEX (1)	V99U8901C	ND	I	S	M	C	G4.2 G4.4 G5.7	00	AID	93090E	
TARGET_INDEX (10)	V98U8276C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(11)	V98U8567C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(12)	V98U8568C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(13)	V98U8569C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(14)	V98U8570C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(15)	V98U8571C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(16)	V98U8572C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(17)	V98U8573C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(18)	V98U8574C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(19)	V98U8575C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(2)	V99U8913C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(20)	V98U8576C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(21)	V98U8577C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(22)	V98U8578C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(23)	V98U8579C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(24)	V98U8580C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(25)	V98U8581C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(26)	V97U9927C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(27)	V97U9928C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(28)	V97U9929C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(29)	V97U9930C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(3)	V99U8925C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(30)	V97U9931C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(31)	V97U9932C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(32)	V97U9933C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(33)	V97U9934C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(34)	V97U9935C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(35)	V97U9936C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(36)	V97U9937C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(37)	V97U9938C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(38)	V97U9939C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(39)	V97U9940C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(4)	V99U8937C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(40)	V97U9941C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TARGET_INDEX(41)	V97U9942C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(42)	V97U9943C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(43)	V97U9944C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(44)	V97U9945C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(45)	V97U9946C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(5)	V99U8949C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(6)	V98U8272C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(7)	V98U8273C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(8)	V98U8274C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TARGET_INDEX(9)	V98U8275C	ND	I	S	M	C	G4.2 G4.4 G5.7 G6.55	00	AID	93090E	
TGO_MAN	V97U9002C	SEC	F	S	D	P	G4.2 G4.4	00	ZF1	90243C	
THETA_0	V97U4805C	RAD	F	S	M	C	G4.4	00	AFD	DC1275A	
THETA_1	V97U4806C	RAD*SEC/FT	F	S	M	C	G4.4	00	AFD	DC1275A	
THETA_2	V97U4807C	RAD	F	S	M	C	G4.4	00	AFD	DC1275A	
THETA_3	V97U8366C	RAD*SEC/FT	F	S	M	C	G4.4	00	AFD	DC1275A	
THETA_4	V99U7322C	RAD*SEC/FT	F	S	M	C	G4.4	00	AFD	DC1275A	

TABLE 4.6.7-3. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
TIMER_DELAY_MC	V97U1506C	SEC	F	S	D	C	G4.4	00	ZF1	93087E	
V_KMAX_DOWN	V97U0603C	FT/SEC	F	S	M	C	G4.1 G4.2 G4.4	00	ATV	92232B	
V_KMAX_UP	V97U0604C	FT/SEC	F	S	M	C	G4.1 G4.2 G4.4	00	ATV	92232B	
V_RHO_PHI	V97U4823C	FT/SEC	F	S	D	C	G4.2 G4.4	00	YD1	91019A	
V_RTLS_CNTG	V98U7974C	FT/SEC	F	S	D	P	G4.4 G4.5 G4.6	00	ZF1	90705H	
V_SWITCH	V97U8368C	FT/SEC	F	S	M	C	G4.4	00	AFD	DC1275A	
X_NEP	V97U5575C	FT	F	S	M	X	G4.19 G4.20 G4.4 G5.7	01 03	XS6 XS6	DC2748	

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

TABLE 4.6.7-4. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
ABORT_MECO_PREP_TIME	V98U7961C	01	+1.0	E+01 SEC	F	S	C	G4.2 G4.4	59955	
AD_INIT INITIAL VALUE OF DESIRED ACCELERATION	V97U4306C	00	+9.42	E+01 FT/SEC**2	F	S	C	G4.2 G4.4	90329C	
AL ACCELERATION LIMIT	V97U4307C	00	+9.5500000	E+01 FT/SEC**2	F	S	C	G4.2 G4.4	90329C	
ALIM_1 LOWER LIMIT FOR TERMINATING G- LIMITING	V97U4308C	00	+9.2000000	E+01 FT/SEC**2	F	S	C	G4.2 G4.4	90329C	
ALIM_2 LOWER LIMIT FOR INITIATING G- LIMITING	V97U4309C	00	+9.47	E+01 FT/SEC**2	F	S	C	G4.2 G4.4	90329C	
DK_ROUND	V97U4345C	00	+7.5	E-01 PCT	F	S	C	G4.4	29602A	
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 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	
DTRD TGO REMAINING WHEN POSITION CONSTRAINTS RELEASED	V97U4371C	00	+4.0000000	E+01 SEC	F	S	C	G4.2 G4.4	90329C	
DTHROT TGO REMAINING WHEN FUEL DEPLETION THROTTLING TERMINATED	V97U4372C	00	+1.20	E+02 SEC	F	S	C	G4.4	90329C	
DT_PITCH NOMINAL LENGTH OF POWERED PITCHDOWN	V97U4351C	00	+2.0000000	E+01 SEC	F	S	C	G4.4	90329C	
DT_TURN NOMINAL LENGTH OF POWERED PITCHAROUND	V97U4353C	00	+1.7	E+01 SEC	F	S	C	G4.4	90329C	
EPS-X CRIT REJ THRUST SCALING FACTOR	V97U4380C	00	+2.0	E-02 ND	F	S	C	G4.2 G4.4 G4.5	89990E	

TABLE 4.6.7-4. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
EPSTGO PEG INHIBIT STEERING OUTPUT	V97U4381C	00	+4.0	E-02 ND	F	S	C	G4.2 G4.210 G4.3 G4.4	59955	
ETB MIN TBN-1 COMPUTATION OF TGO	V97U4382C	00	+5.0000000	E+00 SEC	F	S	C	G4.2 G4.4	59955	
FTF_MIN	V97U4838C	00	+5.0	E-01 ND	F	S	C	G4.2 G4.4 G4.5	90451	
FT_FACTOR THRUST SCALING FACTOR	V97U4389C	00	+9.98	E-01 ND	F	S	C	G4.2 G4.4 G4.5	90329C	
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
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	
K_INT G-LIMITING INTEGRAL GAIN	V97U4418C	00	+1.0	E-02 SEC**-2	F	S	C	G4.2 G4.4	59955	
K_PROP PROPORTIONAL GAIN	V97U4419C	00	+1.5	E-01 SEC**-1	F	S	C	G4.2 G4.4	59955	
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	

TABLE 4.6.7-4. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
MUP_TH MINIMUM CHANGE IN MASS REQUIRED FOR MASS TO BE UPDATED	V97U6150C	00	+3.0	E-01 SLUGS	F	S	P	G4.13 G4.2 G4.3 G4.4 G4.5	90608D	
M_BIAS RTLS TURNAROUND PREDICTION MASS BIAS	V97U4430C	00	+9.7000000	E+01 SLUGS	F	S	C	G4.4	90329C	
NMAX_CYCLES_UNCONV NO. OF UNCONVERGED PEG CYCLES TO STOW ERROR NEEDLES	V96U7796C	00	+5	ND	I	S	C	G4.2 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	
N_MAX MAXIMUM NUMBER OF PEG ITERATION	V97U4445C	00	+1	ND	I	S	P	G4.2 G4.209 G4.3 G4.4	90329C	
PHIDOT_MAX MAXIMUM TURNING RATE	V97U9003C	00	+3.5	E-02 RAD/SEC	F	S	C	G4.2 G4.210 G4.3 G4.4	90329C	
RNG_TURN_PRED RANGE TO BEGIN RTLS TURNAROUND PREDICTION	V98U7972C	00	+6.0	E+04 FT	F	S	C	G4.4	90329C	
RTLS_MECO_INIT_TGO MAXIMUM TGO AT WHICH S_TMECO IS SET IN MM 601	V97U2654C	00	+9.6	E-01 SEC	F	S	P	G4.4	90608D	
TGO_IA MIN TGO SEL RTLS CONSTRAINT	V97U4664C	00	+6.0000000	E+01 SEC	F	S	C	G4.4	59955	
TGO_PPD TIME TO GO TO POWERED PITCHDOWN	V97U4666C	00	+6.0000000	E+00 SEC	F	S	C	G4.4 G4.5	89990E	
THETA_FB INITIAL RTLS FLYBACK PITCH ANGLE	V97U4801C	00	+2.40855	E+00 RAD	F	S	C	G4.4	90329C	
THETA_MAX MAXIMUM RTLS FUEL DISSIPATION ANGLE	V99U7323C	00	+1.48353	E+00 RAD	F	S	C	G4.4	90329C	
THETA_MIN MINIMUM RTLS FUEL DISSIPATION ANGLE	V99U7324C	00	+4.36332	E-01 RAD	F	S	C	G4.4	90329C	
TLAG THROTTLE LAG TIME	V97U4834C	00	+5.0000000	E-01 SEC	F	S	C	G4.2 G4.4	59955	

TABLE 4.6.7-4. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) 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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NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.6.7-5. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) 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_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 4.6.7-5. POWERED RETURN-TO-LAUNCH SITE GUIDANCE (G4.4) 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 ASCENT XXXXX MANEUVER YYYYYY DISPLAY INTERFACE PROCESSING REQUIREMENTS (MM's 104, 105, AND 106)

The ascent XXXXX maneuver YYYYYY display interface processing principal function (ASC MNVR DIP, CPDS, Level B GN&C, principal function 4.210) provides software required to support the XXXXX MNVR YYYYYY display (MNVR DISP). The MNVR DISP provides the crew capability to set up maneuvers, adjust target values, monitor maneuvers, and trim burn residuals when required.

The general guidance and targeting tasks required for the ASC MNVR DIP principal function and not documented in Section 4.7 are powered explicit guidance (Section 4.8.1), thrust parameters (Section 4.8.7), and H- θ -to-M50 target (Section 4.8.6), and the Commanded Body Attitude task (Section 4.8.10). In addition, the ascent precise predictor principal function (ASC PREC PRED, CPDS, Level B GN&C, principal function 4.236) documented in the Ascent/RTLS Navigation FSSR is required.

Since the ASC MNVR DIP provides supportive software for the MNVR DISP, an understanding of the display is essential to comprehending the details of this section. It is recommended that the Level C, GN&C, Displays and Controls, FSSR document be reviewed prior to reading this section. The display format is shown for information only in Figure 4.7-1.

4.7.1 Overview

The ASC MNVR DIP is active during MM's 104, 105, and 106 and supports OMS-1 and OMS-2 insertion maneuvers for nominal missions, AOA, and ATO. For an AOA OMS-2 maneuver, the only function of the ASC MNVR DIP is to prepare targeting data for display and transfer to the OPS-3 MNVR DISP; the maneuver is performed in OPS-3 and supported by the DEORB MNVR DIP. The ASC MNVR DIP specific requirements vary slightly as a function of the major mode. Therefore, for clarity, the following is a description of the ASC MNVR DIP interactions with the crew and other software functions in each of the major modes.

For an OMS-1 (MM 104) nominal maneuver, the ASC MNVR DIP principal function is initiated by the MSC when MM 104 is entered upon completion of the -Z RCS translational maneuver for orbiter/ET separation or by crew action. Upon initialization, the I-load OMS-1 guidance targets of altitude, earth central angle from the launch site to the target position, and the terminal velocity constraint slope and intercept constants are displayed. The I-load value of delta time of ignition referenced to actual time of orbiter/ET separation is used to calculate a time of ignition and this parameter is displayed. Also displayed is the I-load value of the planned propulsion system (left OMS, right OMS, both OMS, or +X RCS). Entry into MM 104 also initiates cyclic computation of the current apogee and perigee altitudes and time to the next apsis.

A second group of calculations is initiated or performed automatically as part of the MM 104 ASC MNVR DIP initialization, but these calculations may be repeated at a later time by crew entry of the LOAD item entry (display Item 22). The display parameters supported by this group of calculations are:

1. Desired ignition attitude (pitch, yaw, and roll angles in ADI inertial coordinate frame)
2. Velocity-to-go in current body axis coordinates
3. Total delta velocity required
4. Targeted apogee and perigee altitudes

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5. Time-based time (initiates MSC calculations; additional crew action is required for this parameter to be displayed).
6. PEG 4 velocity-to-go components in an LVLH coordinate system at TIG

Concurrent with the calculation of the above display parameters, the target setup data currently displayed are transferred as a group to orbit insertion guidance and other software principal functions. Other functions performed in this group are defined in the premaneuver display support task (Subsection 4.7.8).

The vehicle may be automatically maneuvered to the desired ignition attitude, which was either manually entered or calculated and then 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 ASCENT MNVR DIP principal function.

The time to go until the attitude maneuver is complete is then calculated within the TRANS DAP, sent to the ASCENT MNVR DIP for further processing, and then to the XXXXX MNVR YYYYYY principal function for display. ASC 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 action is to arm the OMS engines via the cockpit hardware switches. This action is independent of the ASC MNVR DIP requirements. The second action is a crew-entered software engine ignition proceed to ASC MNVR DIP, which is achieved by depressing the EXEC button on the keyboard. Depressing the EXEC button subsequent to time of planned ignition minus 15 seconds is recognized by the ASC MNVR DIP as one of two required conditions that allows 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, 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; therefore, the above actions and conditions do not apply.

Maneuver parameters monitored on the MNVR DISP and calculated by the ASC MNVR DIP are the velocity-to-go components in current orbiter body axis coordinates, the velocity-to-go magnitude, PEG 4 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. The ASC MNVR DIP also monitors the status of the active OMS actuator system and sets a flag to indicate any failure condition. Time-to-go values are calculated by the ORB INS 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 MNVR DISP.

MNVR DISP capabilities not supported by the ASC MNVR DIP principal function are (for information only):

- | | |
|--|-----------------------------------|
| 1. GMBL CK (Item 34) | OMS gimbal drive check initiator |
| 2. GMBL SEL (Items 28, 29, 30, 31, 32, 33) | OMS gimbal drive system selection |
| 3. FWD RCS DUMP (Items 36, 37, 38) | Forward RCS dump |

- | | |
|------------------------------|------------------------------------|
| 4. SURF DRIVE (Items 39, 40) | Aerosurface drive |
| 5. ABORT TGT (Item 35) | AOA/ATO abort and target selection |

When an ATO abort is commanded prior to MNVR DISP initialization in MM 104, ASC MNVR DIP activities are similar to the nominal ascent OMS-1 described above except that the orbit insertion guidance targets displayed and transferred to orbit insertion guidance are provided by the AOA/ATO targeting principal function. An additional required input parameter is the new orbiter initial mass estimate to compensate for any OMS propellant burned prior to MECO. If an AOA or ATO abort is initiated subsequent to MNVR DISP initialization, and prior to crew software enablement of OMS ignition, the abort targets replace the stored I-load values on the MNVR DISP and are assumed by orbit insertion guidance. Declaration of an abort condition subsequent to crew software enablement of OMS ignition will result in a nominal OMS-1 maneuver with abort targets for the OMS-2 maneuver being selected and displayed upon proceeding into MM 105.

The ASC MNVR DIP principal function software requirements for the OMS-2 maneuver are identical to the software requirements for the OMS-1 maneuver except that the activities nominally associated with "LOAD" item entry are not performed automatically when the OMS-2 insertion maneuver major mode (105) is entered. If an AOA or ATO abort is initiated subsequent to MNVR DISP initialization upon entry into MM 105 and prior to crew software enablement of OMS ignition, the abort targets selected will be put onto the MNVR DISP, but the "LOAD" item entry is required to transfer these abort targets to the software. Declaration of an abort condition subsequent to crew software enablement of OMS ignition will result in a nominal OMS-2 maneuver. A crew activity is that the manual maneuver to the ignition vehicle attitude is performed. Additionally, a preburn commanded body quaternion is computed and transmitted to the TRANS DAP for subsequent calculation of attitude errors (A/E ATTITUDE PROCESSING principal function) for display on the ADI.

Upon entry into MM 106, the dynamic variables of the maneuver execute major modes are blanked except for the current apogee and perigee altitudes and time to next apsis. These orbital parameters are updated cyclically throughout MM 106.

The functional task organization, logic flow, and data flow for ASC MNVR DIP principal function are shown in Figures 4.7-2, 4.7-3, and 4.7-4. ASC MNVR DIP inputs and outputs are given in the Section 4.7.10.

Certain I-loads supporting this principal function are required to be in contiguous areas of memory in a specific sequence. Section 4.11 describes this requirement.

4.7.2 Ascent XXXXX Maneuver YYYYYY Display Interface Processing Sequencing (ASC MNVR DIP SEQ)

The correct sequencing of some of the tasks defined in the ascent XXXXX maneuver YYYYYY display interface processing principal function is dependent on the concurrence of specific events. These events are identified in CPDS, Level B, GN&C.

The tasks to be sequenced are:

1. Insertion targets uplink task (INS TGT UL TSK)
2. Display initialization task (DISP INIT 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)

Two 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 two additional tasks are:

1. Premaneuver display support task (PRE MAN DISP SUPT TSK)
2. Orbital altitude time task (ORB ALT TIME TSK)

A. Detailed Requirements.

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

1. The INS TGT UL TSK is performed repetitively beginning with transition into MM 104 (Event 36) or 105 (Event 44) and ending when either MM 104 is exited (Event 44), MM 105 is exited (Event 49), or OMS engine ignition has been enabled (BURN_ENABLE = ON) for an OMS-1 or OMS-2 maneuver.
2. The DISP INIT TSK is performed once upon entry into MM's 104 (Event 36), 105 (Event 44), or 106 (Event 49). This task is also performed once if either (a) an insertion guidance target uplink has occurred (TBD = ON) or (b) an AOA or ATO abort has been initiated and the AOA/ATO TGT principal function has been executed, subsequent to entry into MM 104 or 105 but prior to OMS engine ignition enablement. The abort initialization flag (ABORT_INIT) is set ON by AOA/ATO TGT following a crew selection of ATO or AOA.
3. The DISP MONIT TSK is performed repetitively beginning each time any of the following conditions occur:
 - a. Transition into MM 104.
 - b. Transition into MM 105.

- c. OMS engine ignition criteria have been met (BURN_ENABLE = ON) and current time (T_GMT) is greater than or equal to the time of ignition (TIG) and neither the left nor the right OMS ON/OFF command indicators (OMS_L_ON_CMD_IND, OMS_R_ON_CMD_IND) are set to "ON" by the OMS firing sequencer principal function.

Cyclic processing of the DISP MONIT TSK is terminated each time any of the following conditions occur.

- a. MM 104 is exited.
- b. MM 105 is exited.
- c. Engine ignition has been enabled (BURN_ENABLE = ON) and T_GMT < TIG.
4. The VGO DISP TSK is performed only in MM's 104 and 105 when the LOAD_FLASH flag is reset (OFF).
5. The PREBRN MNVR TTG TSK is performed.
6. The CUR ORBIT TSK is performed repetitively beginning with transition into MM 104 (Event 36) and ending with transition out of operational sequence 1 (Events 59, 60, or A20).

B. Interface Requirements. The input parameters for Ascent XXXXX Maneuver YYYYYY Display Interface Processing Sequencing are given in Table 4.7.2-1.

C. Processing Requirements.

The recommended execution rate for Tasks 1, 3, 4, and 5 is once every 0.96 second. The recommended execution rate for Task 6 is once every 1.92 seconds.

D. Initialization Requirements. None.

Table 4.7.2-1. Display Interface Processing Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Major mode 104 flag	MM104	MSC	D	N/A
Major mode 105 flag	MM105	MSC	D	N/A
Major mode 106 flag	MM106	MSC	D	N/A
Discrete to indicate OMS engine ignition authorization	BURN_ENABLE	DISP MONIT TSK	D	N/A
Discrete to indicate a guidance target update via uplink	TBD	INS TGT UL TSK	D	N/A
Abort initialization flag	ABORT_INIT	AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	D	N/A
Current GMT computer time	T_GMT	FCOS	DP	sec
Time of ignition	TIG	PRE-MAN DISP SUPT TSK	DP	sec
Left OMS ON/OFF command indicator	OMS_L_ON_CMD_IND	OMS FIRE SEQ	D	N/A
Right OMS ON/OFF command indicator	OMS_R_ON_CMD_IND	OMS FIRE SEQ	D	N/A
Discrete to indicate "LOAD" has become a dynamic character set	LOAD_FLASH	DISP INIT TSK, DISP MONIT TSK	D	N/A

4.7.3 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) and determines the proper set of orbit insertion guidance targets (OMS-1, OMS-2, or abort) to be displayed and utilized by the software. In addition, it performs supportive calculations for uplink.

A. Detailed Requirements. The display initialization task performs the following activities as a function of the major mode and abort condition indicators and initialization condition (uplink support or other initialization condition). If this task is performed to support uplink, then activities 7, 9, 10, 12, and 13 must be performed. Otherwise, activities 1 through 11 and 13 must be performed.

1. The default value of the guidance mode discrete (P \dot{E} G_MODE_4) is set to ON to be consistent with the I-load nominal or AOA/ATO TGT selected abort target set. Also, the abort initialization discrete (A \dot{B} ORT_INIT) is set to OFF to avoid recycling this subtask unless another abort target has been selected via keyboard (denoted by A \dot{B} ORT_INIT = ON).
2. A display title indicator (MNVR_TITLE_IND) is generated for the variable portion of the display title (XXXXX and YYYYY of the XXXXX MNVR YYYYY) based on the value of the MM indicators (MM104, MM105, MM106) and abort discretets (S_ \dot{A} OA and S_ \dot{A} TO). The value of the MNVR_TITLE_IND variable and the resulting display title, as well as the required conditions for setting the MNVR_TITLE_IND value, are as follows:

Major Mode	S_ \dot{A} OA Value	S_ \dot{A} TO Value	MNVR_TITLE_IND	Display
104	OFF	OFF	1	OMS -1 MNVR EXEC
104	OFF	ON	2	ATO-1 MNVR EXEC
104	ON	OFF	3	AOA-1 MNVR EXEC
105	OFF	OFF	4	OMS-2 MNVR EXEC
105	OFF	ON	5	ATO-2 MNVR EXEC
105	ON	OFF	6	AOA MNVR TRANS
106	OFF	OFF	7	OMS-2 MNVR COAST
106	OFF	ON	8	ATO-2 MNVR COAST

3. For MM's 104 and 105, the proper set of orbit insertion guidance targets must be selected as a function of whether the current maneuver is a nominal OMS-1, OMS-2, or an abort OMS maneuver. If an abort condition does not exist (S_ \dot{A} OA = OFF and S_ \dot{A} TO = OFF), then the nominal orbit insertion guidance targets must be used to initialize the display. (The current display values are transferred to orbit insertion guidance in the premaneuver display support task.) The I-load set of targets selected is a function of the OMS maneuver target index (I): I = 1 for an OMS-1 maneuver and I = 2 for an OMS-2 maneuver. If an abort condition does exist (S_ \dot{A} OA = ON or S_ \dot{A} TO = ON), the orbit insertion guidance targets selected by the AOA/ATO TGT principal function must be used to initialize the display: I = 3 for an AOA or ATO abort. The nominal OMS-1, nominal OMS-2, or AOA/ATO abort target values selected are then used to initialize the display as follows:

HTGT_DISP = HTGT_OMS_i NM_PER_FT: Target altitude magnitude above a spherical earth that is biased to account for noncentral body forces from planned engine ignition to the target position.

THETA_DISP = THETA_OMS_i/RAD_PER_DEG: Target earth central angle from the launch site that is biased to account for noncentral body forces from planned engine ignition to the target position.

C1_DISP = C1_OMS_i: Intercept of the vertical velocity versus the horizontal velocity target line that is biased to account for noncentral body forces from planned engine ignition to target position.

C2_DISP = C2_OMS_i: Slope of the vertical velocity versus horizontal velocity target line.

TIG = T_ET_SEP + DTIG_OMS_i: Time of ignition. (The variable T_ET_SEP is the actual GMT time of external tank separation and DTIG_OMS_i is the delta time of ignition from this reference time.)

- The unit vector normal to the desired orbital plane (\bar{IYD}) is selected from I-load vectors which are functions of the OMS maneuver. If the major mode is 104 and I (Item 3) is equal to 1 or the major mode is 105 and I is equal to 2, then

$$\bar{IYD} = \bar{IYD_OMS}_{(3I-2)}$$

- For MM 104 ($\dot{M}M104 = ON$) and no previous mass adjustment ($\dot{M}ASS_FLAG = OFF$), Compute the initial orbiter mass to be used by ORB INS GUID for the OMS-1 burn. The orbiter mass is equal to the initial orbiter mass at lift-off (not including MPS propellant in the orbiter's lines) minus the OMS propellant burned pre-MECO. The required calculations are:

$$DM_PREMECO = 2 MDOT_OMS T1$$

$$M = MASS_ORB - DM_PREMECO$$

$$\dot{M}ASS_FLAG = ON$$

where

DM_PREMECO = mass of OMS propellant burned pre-MECO

MASS_ORB = mass of orbiter at lift-off (should not include any SSME propellant or ET mass)

M = current orbiter mass

MDOT_OMS = mass flow rate of an OMS engine

T1 = equivalent pre-MECO OMS burn time

Burn time T1 is supplied by the ABT CNTL SEQ principal function, and the orbiter mass at lift-off is I-loaded premission. In the DM_PREMECO computation, the "2" refers to the number of OMS engines commanded on during pre-MECO dumps.

This OMS-1 orbiter mass calculation provides only an estimate of the actual mass since it does not account for smaller mass perturbances such as pre-MECO RCS propellant burned, APU vents, and main propulsion system dump.

For MM 105 (MM105 = ON), the current vehicle mass (M), as computed by ORB INS GUID at the end of the OMS-1 maneuver, is used.

The selected orbiter mass estimated must then be converted to a weight for display:

$$WT_DISP = M G_2_FPS2$$

G_2_FPS2 is a constant to transform mass to weight.

- For MM's 104 and 105, the desired minimum burnout mass (MBO), to be used by PEG (Section 4.8.1) to limit the out-of-plane component of the velocity-to-be-gained vector, must be selected. If either S_AOA = ON or S_ATO = ON, then there is to be no out-of-plane thrusting and MBO is set equal to M. Otherwise MBO is set to an I-load or uplinked MBO_MIN which is a function of the OMS maneuver.

If S_AOA = ON or S_ATO = ON, then MBO = M; otherwise MBO = MBO_MIN

- If the major mode is 104 and an uplink has occurred or the major mode is 105, then the target set is not accepted by guidance until positive action is taken by the crew. This function is accomplished by setting the LOAD_FLASH discrete (see Section 4.7.4) to ON.
- If the major mode is 104 (MM104 = ON) and a TAL abort has not been declared (TAL_ABORT_DECLARED=OFF), then the LOAD_CMD discrete must be set to ON to initiate the processing contained in the PRE-MAN DISP SUPT TSK (Section 4.7.4).
- The TIG value calculated in Item 3 must be converted to the proper display units (DAYS, HRS, MIN, SEC) in mission elapsed time for display.

$$TIG = TIG - T_GMTLO$$

$$TIG_DAY = TRUNCATE(TIG/86400)$$

$$TIG = MOD(TIG, 86400)$$

$$TIG_HR = TRUNCATE(TIG/3600)$$

$$TIG_MIN = TRUNCATE((TIG - 3600 TIG_HR)/60)$$

$$TIG_SEC = TIG - 3600 TIG_HR - 60 TIG_MIN$$

10. If the maneuver is an AOA OMS-2 burn, and the AOA OMS-2 targeting data ready flag (S_·AOA_OMS2) is ON, then the display targeting parameters HTGT_DISP, THETA_DISP, C1_DISP, C2_DISP, TIG_DAY, TIG_HR, TIG_MIN, TIG_SEC, and WT_DISP are loaded into protective storage for the OPS-3 maneuver display and the AOA OMS-2 targeting complete flag (S_·OPS3_TGT_RDY) is set to ON.
11. For MM 106, all parameters are assumed to retain the value they had in MM 105. The following parameters must be blanked upon entry into MM 106:
 - a. DV_TOT Magnitude of velocity-to-go
 - b. $\overline{VGO_DISP}$ Velocity-to-go in current body coordinates
 - c. TGT_HA Target apogee altitude
 - d. TGT_HP Target perigee altitude
 - e. TGO Time-to-go
 - f. VEH_PITCH Vehicle pitch angle
 - g. VEH_YAW Vehicle yaw angle
 - h. VEH_ROLL Vehicle roll angle
 - i. $\overline{VGO_LVLH}$ Velocity-to-go in LVLH coordinates
12. An uplinked target set must be identified as to guidance type (linear terminal velocity constraint or external delta-V). If the OPS code contained in the uplink word is 0101101, then linear terminal velocity constraint guidance is assumed and PEG_MODE_4 = ON.
13. Set guidance targeting update discrete (TBD) OFF.

B. Interface Requirements. The input and output parameters for the display initialization task are given in Tables 4.7.3-1 and 4.7.3-2.

During OPS-1 and OPS-9 the following parameters can be updated via uplink as part of the OMS targeting data set (OP CODE 0011001) TVR_ROLL, HTGT_OMS₁, IYD_OMS₁₋₃, THETA_OMS₁, DTIG_OMS₁, C1_OMS₁, C2_OMS₁, HTGT_OMS₂, IYD_OMS₄₋₆, THETA_OMS₂, DTIG_OMS₂, C1_OMS₂, and C2_OMS₂. Replacement of the original data with uplinked data will be transparent to the flight software.

C. Processing Requirements. The display initialization task is performed once upon entry into MM's 104, 105, or 106 and once after execution of the AOA/ATO TGT principal function for an abort selection via the abort rotary switch or crew item entry of the target index flag (ABORT_INIT = ON), occurring subsequent to entry into MM's 104 or 105 but prior to setting the burn enable discrete. This task is also performed after an uplink of guidance targets (TBD criteria).

D. Initialization Requirements. PEG_MODE_4 = ON.

M·ASS_FLAG = OFF.

Table 4.7.3-1. Display Initialization Task Inputs

Definition	Symbol	Source	Prec	Units
Discrete indicating AOA abort commanded	$S_{\dot{A}OA}$	MSC	D	N/A
Discrete indicating ATO abort commanded	$S_{\dot{A}TO}$	MSC	D	N/A
Major mode indicators	MM_{104} MM_{105} MM_{106}	MSC	D	N/A
Target altitude magnitude (I=1-3)	$HTGT_{OMS_I}$	I-LOAD, AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	SP	ft
Target earth central angle from the launch site (I=1-3)	$THETA_{OMS_I}$	I-LOAD, AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	SP	rad
Intercept of target line (I=1-3)	$C1_{OMS_I}$	I-LOAD, AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	SP	fps
Slope of target line (I=1-3)	$C2_{OMS_I}$	I-LOAD, AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	SP	ND
Actual GMT time of external tank separation	T_{ET_SEP}	MSC	DP	sec
Time interval between time of actual external tank separation and OMS-1 or OMS-2 ignition (I=1-3)	$DTIG_{OMS_I}$	I-LOAD, AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	SP	sec
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Initial orbiter-alone mass	MASS_ORB	I-LOAD, UPLINK	SP	slugs
Conversion factor for feet to nautical miles	NM_PER_FT	CONSTANT	SP	nmi/ft
Conversion factor for degrees to radians	RAD_PER_DEG	CONSTANT	SP	rad/deg
GMT time of lift-off	T_{GMTLO}	FCOS	DP	sec
Conversion factor for slugs to pounds	G_2_{FPS2}	CONSTANT	SP	lb/slug
AOA OMS-2 targeting data read flag	$S_{\dot{A}OA_OMS2}$	AOA/ATO TGT	D	N/A
Discrete indicating a guidance target update via uplink	T_{BD}	INS TGT UL TSK, ASC MNVR DIP SEQ	D	N/A
Unit vector normal to desired orbital plane (I=1,6)	$\bar{I}YD_{OMS_I}$	I-LOAD	DP	ND
Desired minimum burnout mass (I=1,2)	MBO_{MIN_I}	I-LOAD, UPLINK	SP	slugs
Abort initialization flag	A_{BORT_INIT}	AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	D	N/A
Discrete indicating a TAL abort is in progress	$T_{AL_ABORT_DECLARED}$	MSC	D	N/A
Equiv. pre-MECO OMS burn time	T1	ABT CNTL SEQ	SP	sec

Table 4.7.3-1. Display Initialization Task Inputs				
Definition	Symbol	Source	Prec	Units
OMS engine mass flow rate	MDOT_OMS	K-LOAD	SP	slug/sec

Table 4.7.3-2. Display Initialization Task Outputs				
Definition	Symbol	Destination	Prec	Units
Initial value of orbiter weight	WT_DISP	MNVR DISP,* ORB/RND NAV SEQ	SP	lb
Display title indicator	MNVR_TITLE_IND	MNVR DISP	I	N/A
Target altitude magnitude above a spherical earth ¹	HTGT_DISP	MNVR DISP,* TLM	SP	deg
Target earth central angle from the launch site ¹	THETA_DISP	MNVR DISP,* TLM	SP	deg
Intercept of vertical velocity versus horizontal target line ¹	C1_DISP	MNVR DISP,* TLM	SP	fps
Slope of vertical velocity versus horizontal target line	C2_DISP	MNVR DISP,* TLM	SP	ND
AOA OMS-2 targeting complete flag	S_ÔPS3_TGT_RDY	MNVR DISP	D	N/A
Time of ignition	TIG_DAY, TIG_HR, TIG_MIN, TIG_SEC	MNVR DISP*	SP	day, hr, min,sec
Unit vector normal to desired plane in earth-fixed system	ĪYD	PEG TSK	DP	ND
Desired minimum burnout mass	MBO	PEG TSK	SP	slugs
Guidance mode discrete	PEĠ_MODE_4	MNVR DISP, PRE-MAN DISP SUPT TSK, VGO DISP TSK	D	N/A
Abort initialization flag	ABORT_INIT	AOA ONORB TGT SEL TSK, ATO ONORB TGT SEL TSK	D	N/A
Load Command	LÔAD_CMD	DISP MONIT TSK, MNVR DISP	D	N/A
Load flash flag	LÔAD_FLASH	DISP MONIT TSK, ASC MNVR DIP SEQ	D	N/A
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Mass of OMS burned pre-MECO	DM_PREMECO	AOA ONORB TGT SEL TSK	SP	slugs

¹Biased for noncentral body forces from the time of planned ignition to the time of achieving the target position.
*Sent to protective storage in AOA OMS-2 for transfer to OPS-3.

4.7.4 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 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 to ON if the following conditions are satisfied:
 - a. An “EXEC” keyboard entry has been made subsequent to the planned time of engine ignition minus 15 seconds.
 - 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 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. The following monitoring activities must be performed. To ensure a consistent set of target and setup data and consistency between displayed and software-recognized target and setup data, OMS engine ignition is precluded (BURN_ENABLE is not set to ON) and the “LOAD” becomes a flashing character set (LOAD_FLASH = ON) for the following condition: Any of the display item entries identified as target and setup data are changed (DATA_ENTER = ON) and a subsequent “LOAD” item entry is not made. The target and setup data group consists of all numbered entries on the MNVR DISP (Figure 4.7-1) except the following:
 - a. OMS gimbal drive selection and check (Items 28, 29, 30, 31, 32, 33, and 34)
 - b. Burn attitude and maneuver to burn attitude (Items 24, 25, 26, and 27)
 - c. Surf drive (Items 39 and 40)
 - d. Forward RCS dump (Items 36, 37, and 38)
 - e. LOAD (Item 22)
 - f. Start CRT timer (Item 23)

If DATA_ENTER is set to ON (indicating an entry), the LOAD_FLASH discrete must be set to ON. The LOAD_FLASH = ON condition indicates that “LOAD” is to become a dynamic flashing character set and precludes setting the burn enable discrete to ON to allow OMS ignition.

2. If $\dot{L}OAD_FLASH = ON$ (indicating LOAD is a dynamic flashing character set) or $\dot{L}OAD_CMD = ON$, then the following activities are performed:
 - a. Reset the discrete for FCOS to display the time to ignition on the CRT:
 $\dot{C}RT_TIMER_START = OFF$
 - b. Reset the discrete to enable MSC to maintain time base calculations:
 $\dot{T}B_ENABLE = OFF$
 - c. Reset the discrete to cause EXEC to flash on the maneuver display:
 $\dot{T}IG_MINUS5_FLAG = OFF$
3. If $\dot{L}OAD_CMD = ON$, then the following activities are performed once:
 - a. The premaneuver display support task (PRE-MAN DISP SUPT TSK, Section 4.7.7) is performed.
 $CALL\ PRE-MAN\ DISP\ SUPT\ TSK$
 - b. The $\dot{L}OAD_FLASH$ discrete is set to OFF.
 - c. The $\dot{L}OAD_CMD$ discrete is set to OFF to preclude the above activities from being performed except as required upon keyboard entry.
 - d. The $\dot{D}ATA_ENTER$ discrete is set to OFF.
4. Positive crew action (pushing the keyboard EXEC button, which sets $\dot{E}XEC_CMD$ to ON, subsequent to planned OMS ignition time minus 15 seconds, that is, when $T_GMT - TIG \geq BURN_ENABLE_WINDOW$) is required to enable OMS engine ignition ($\dot{B}URN_ENABLE = ON$). Until the EXEC button is pushed, the EXEC character set is flashing ($\dot{T}IG_MINUS5_FLAG = ON$). An additional requirement for enabling engine ignition is $\dot{L}OAD_FLASH = OFF$. These requirements are depicted in the following logic:
 - a. If $\dot{T}B_TIME \geq -BURN_ENABLE_WINDOW$ and the $\dot{L}OAD_FLASH$ flag is OFF (indicating a consistent target and setup data group), then proceed to step b. Otherwise the $\dot{E}XEC_CMD$ and $\dot{T}IG_MINUS5_FLAG$ must be set to OFF to nullify 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 $\dot{E}XEC_CMD$ flag is ON (indicating crew authorization of OMS ignition), then set the $\dot{B}URN_ENABLE$ flag to ON (necessary condition for the MSC to allow OMS ignition) and set the $\dot{T}IG_MINUS5_FLAG$ to OFF (stop the EXEC dynamic characters from flashing). Otherwise the $\dot{T}IG_MINUS5_FLAG$ must be set to ON (initiate the EXEC dynamic characters flash).
 - c. The flags $\dot{E}XEC_CMD$ and $\dot{B}URN_ENABLE$ should be reset to OFF anytime the OMS firing sequencer is called to initiate OMS ignition. This will allow proper sequencing if OMS ignition does not occur and the ignition task is reattempted.

5. If the $\dot{S}T_CRT_TIMER = ON$, the following activities are performed once:
- Calculate the delta time to ignition in seconds to establish a display time base:
$$CRT_SEC = TIG - T_GMT$$
 - If CRT_SEC is positive, set the discrete indicating that FCOS should decrement CRT time:
$$\dot{C}OUNTDOWN = ON$$
 - If CRT_SEC is not positive, set the discrete such that FCOS increments CRT time and set CRT_SEC positive:
$$\dot{C}OUNTDOWN = OFF$$

$$CRT_SEC = -CRT_SEC$$
 - Set the discretes for FCOS to display the time relative to ignition:
$$\dot{C}RT_TIMER_START = ON$$
 - Reset the start CRT timer discrete to allow reinitiation of this activity:
$$\dot{S}T_CRT_TIMER = OFF$$

B. Interface Requirements. The input and output parameters for the display monitoring task are presented in Tables 4.7.4-1 and 4.7.4-2.

C. Processing Requirements. The display monitoring task is performed every 0.96 second. The beginning conditions for cyclic processing are defined in Step 3 of sequencing (Section 4.7.2).

D. Initialization Requirements. Initialization is performed on the first pass each time cyclic processing begins.

For each beginning, the following initiation occurs:

$\dot{D}ATA_ENTER = OFF$	Discrete to indicate that a target or setup data value has been crew entered is initially set to indicate no crew entry.
$\dot{B}URN_ENABLE = OFF$	Discrete to allow OMS engine ignition is initially set to disallow OMS engine ignition.
$\dot{T}IG_MINUS5_FLAG = OFF$	Discrete to indicate that the EXEC character set is to be flashed to prompt crew for an engine ignition proceed is initially set to a nonflash condition.
$\dot{L}OAD_FLASH = OFF$	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: $\dot{L}OAD_FLASH$ is initially set to a non-flash condition.

T \dot{B} _ENABLE = OFF	Discrete to initiate establishment and maintenance of ignition time base. It is initially set to not initiate this action.
S \dot{T} _CRT_TIMER = OFF	Discrete to indicate that time to ignition is to be displayed. It is initially set to a non-display condition.
C \dot{R} T_TIMER_START = OFF C \dot{O} UNTDOWN = OFF	Discrettes to initiate a decrementation of time-to-ignition are initially set to not perform decrementation.
E \dot{X} EC_CMD = OFF	Discrete to indicate that the "EXEC" button has been set to indicate a "not pushed" state.

Table 4.7.4-1. Display Monitoring Task Inputs				
Definition	Symbol	Source	Prec	Units
Discrete indicating target or setup data entries have been made	D \dot{A} T \dot{A} _ENTER	MNVR DISP	D	N/A
Load command	L \dot{O} A \dot{D} _CMD	MNVR DISP, DISP INIT TSK	D	N/A
Current GMT computer time	T_GMT	FCOS	DP	sec
Start CRT timer flag	S \dot{T} _CRT_TIMER	MNVR DISP	D	N/A
Time of ignition	TIG	PRE-MAN DISP SUPT TSK	DP	sec
Time base time (TB1 or TB2)	TB_TIME	MSC	DP	sec
Burn execute command	E \dot{X} EC_CMD	MNVR DISP	D	N/A
Load flash flag	L \dot{O} A \dot{D} _FLASH	DISP INIT TSK	D	N/A
Burn enable window	BURN_ENABLE_ WINDOW	K-LOAD	SP	sec

Table 4.7.4-2. Display Monitoring Task Outputs				
Definition	Symbol	Destination	Prec	Units
Load flash flag	L \dot{O} A \dot{D} _FLASH	MNVR DISP, TLM, ASC MNVR DIP SEQ	D	N/A
Seconds to ignition	CRT_SEC	FCOS	DP	sec
CRT timer start flag	C \dot{R} T_TIMER_START	FCOS	D	N/A
CRT timer flag to indicate countdown mode is desired	C \dot{O} UNTDOWN	FCOS	D	N/A
Engine ignition minus (15) second flag	T \dot{I} G_MINUS5_FLAG	MNVR DISP	D	N/A
Burn enable	B \dot{U} RN_ENABLE	MSC, ASC MNVR DIP SEQ	D	N/A
Discrete to initiate time base calculations	T \dot{B} _ENABLE	MSC	D	N/A

4.7.5 Current Orbit Task (CUR ORBIT TSK)

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

A. Detailed Requirements. The value of current apogee and perigee altitude and time to next apsis (measured from current time) is calculated by calling the orbital altitude time task (ORB ALT TIME TSK, Subsection 4.7.8). Inputs to this task are the current navigation state (\bar{R}_{NAV} and \bar{V}_{NAV}) which must be assigned to \bar{R} and \bar{V} respectively.

CALL ORB ALT TIME TSK

Outputs are the apogee altitude (HA), perigee altitude (HP), time to next apsis (TT_X), and an indicator for next apsis point and label field (TXX_FLAG). These outputs (HA, HP, and TXX_FLAG) must be assigned to CUR_HA, CUR_HP, and TXX_FLAG_DISP, respectively.

The MNVR DISP background field corresponding to the TXX_FLAG_DISP value is defined below

TXX_FLAG_DISP	Label Field Displayed	Next Apsis
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 4.7.5-1 and 4.7.5-2.

C. Processing Requirements. The current orbit task is performed repetitively during MM's 104, 105, and 106.

D. Initialization Requirements. None.

Table 4.7.5-1. Current Orbit Task Inputs				
Definition	Symbol	Source	Prec	Units
Apogee altitude	HA	ORB ALT TIME TSK	SP	nmi
Perigee altitude	HP	ORB ALT TIME TSK	SP	nmi
Indicator for next apsis point and label field (= 1, TTA (apogee); = 2, TTP (perigee); = 3, TTC (circular))	TXX_FLAG	ORB ALT TIME TSK	I	N/A
Time to next apsis (apogee or perigee)	TT_X	ORB ALT TIME TSK	SP	sec
Current Shuttle position vector	\bar{R}_{NAV}	ASCENT UPP	DP	ft
Current Shuttle velocity vector	\bar{V}_{NAV}	ASCENT UPP	SP	fps

Table 4.7.5-2. Current Orbit Task Outputs				
Definition	Symbol	Destination	Prec	Units
Position vector	\bar{R}	ORB ALT TIME TSK	DP	ft
Velocity vector	\bar{V}	ORB ALT TIME TSK	SP	fps
Current apogee altitude	CUR_HA	MNVR DISP	SP	nmi
Current perigee altitude	CUR_HP	MNVR DISP	SP	nmi
Indicator for next apsis point and label field (= 1, TTA (apogee); = 2, TTP (perigee); = 3, TTC (circular))	TXX_FLAG_DISP	MNVR DISP	I	N/A
Time to next apsis (apogee or perigee)	TT_X	MNVR DISP	SP	sec

4.7.6 Velocity-To-Go Display Task (VGO DISP TSK)

This task transforms the velocity-to-go vector from mean-of-1950 coordinates into current LVLH coordinates, if guidance mode is PEG 4 and if current time is greater than time of ignition, and into current orbiter body axis coordinates (Section 5.1, Figures 5.1-1 and 5.1-4) and computes the magnitude of the current velocity-to-go (DV_TOT) and orbiter weight (WT_DISP).

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), which is defined in the Level C, GN&C, Flight Control, FSSR document, and repeated (for information only) in Part E of Section 4.7.7:

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 mean-of-1950 coordinates to current body axis coordinates as computed by the A/E ATT PROC principal function.

2. The current magnitude of velocity-to-go is calculated.

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

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

$WT_DISP = M G_2_FPS2$

4. The PEG 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-of-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 (TIG). After the planned TIG, $\overline{VGO_LVLH}$ is computed for display with respect to the current LVLH coordinate system.

If the guidance mode is PEG 4 and current time is greater than or equal to TIG:

Call QUAT_XFORM

Inputs: $-Q_M50_LVLH_S$, $Q_M50_LVLH_V$, \overline{VGO}

Output: $\overline{VGO_LVLH}$

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B. Interface Requirements. The input and output parameters for the velocity-to-go display task are given in Tables 4.7.6-1 and 4.7.6-2.

C. Processing Requirements. The velocity-to-go display task is performed at 1.04 Hz only in MM's 104 and 105 when the LOAD_FLASH flag is reset (OFF). Steps 2 and 3 are performed on alternate passes of the VGO DISP TSK.

D. Initialization Requirements. None.

Table 4.7.6-1. Velocity-To-Go Display Task Inputs				
Definition	Symbol	Source	Prec	Units
Quaternion to transform from M50 coordinates to current vehicle body axis coordinates	$Q_{B_I_S}$, $Q_{\bar{B}_I_V}$	A/E ATT PROC	SP	ND
Velocity-to-be gained vector in M50 coordinates	\bar{VGO}	PEG TSK	SP	fps
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Quaternion to transform from LVLH coordinates to M50 coordinates	$Q_{M50_LVLH_S}$, $Q_{\bar{M}50_LVLH_V}$	A/E ATT PROC	SP	ND
Guidance mode discrete	$\dot{P}EG_MODE_4$	DISP INIT TSK, MNVR DISP	D	N/A
Time of ignition	TIG	PRE-MAN DISP SUPT TSK	DP	sec
Conversion factor for slugs to pounds	G_2_FPS2	CONSTANT	SP	lb/slug
Current GMT computer time	T_GMT	FCOS	DP	sec

Table 4.7.6-2. Velocity-To-Go Display Task Outputs				
Definition	Symbol	Destination	Prec	Units
Maneuver velocity to be gained in current body axis coordinates	$\bar{VGO_DISP}$	MNVR DISP	SP	fps
Total delta velocity required for the maneuver	DV_TOT	MNVR DISP	SP	fps
Velocity-to-be-gained vector in M50 coordinates	\bar{VGO}	TLM	SP	fps
Orbiter weight	WT_DISP	MNVR DISP	SP	lb
PEG 4 velocity to be gained in LVLH coordinates	$\bar{VGO_LVLH}$	MNVR DISP	SP	fps

4.7.7 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 orbit insertion 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 currently displayed value of mission elapsed time (MET) of ignition in days, hours, minutes, and seconds must be transformed to a GMT time in seconds.

$$TIG = TIG_SEC + TIG_MIN 60 + TIG_HR 3600 + TIG_DAY 86400 + T_GMTLO$$

Limit the evaluation of OMS burns to 12 hours in the future and 5 minutes in the past.

If $-300 > (TIG - T_GMT)$ or $(TIG - T_GMT) > 43200$, write "illegal entry" on the maneuver execute CRT display message line and return control to the display monitoring task.

2. A switch ($\dot{T}B_ENABLE$) is set indicating to the MSC that a new time base should be established consistent with the current value of TIG and maintained.

$$\dot{T}B_ENABLE = ON$$

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 (ASC PREC PRED), which propagates the current state (R_NAV , V_NAV , T_NAV) to the time of ignition (TIG) and outputs the propagated ignition state (RGD , VGD). Other inputs required by the ASC PREC PRED principal function are the maximum time interval step size ($DT_MAX = DTMIN$) and integers (GMD_PRED, GMO_PRED) that determine the gravity degree (4) and order (4) models to be assumed:

CALL ASC PREC PRED

Inputs: R_NAV , V_NAV , T_NAV , TIG, DT_MAX , GMD_PRED, GMO_PRED

Outputs: RGD , VGD

4. The guidance mode flag value is determined by testing the current value of the guidance mode discrete ($\dot{P}EG_MODE_4$). If $\dot{P}EG_MODE_4 = ON$, then linear terminal velocity constraint guidance is assumed. Otherwise external delta-V guidance is assumed.

If $\dot{P}EG_MODE_4 = ON$, then $S_MODE = 4$; otherwise, $S_MODE = 7$.

If external delta-V guidance is desired ($S_MODE = 7$), then the velocity targets are transformed to M50 inertial coordinates from the ignition state local vertical, local horizontal (LVLH) coordinates for input to orbit insertion guidance. Software modules documented in the Level C, GN&C, Flight Control, FSSR document 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 transform from the ignition state

local vertical, local horizontal coordinate system to the mean-of-1950 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 $\overline{EXT_DV_LVLH}$ vector to the \overline{VGO} vector in M50 coordinates required for orbit insertion guidance. A description of the RV_TO_QLVLH and QUAT_XFORM modules is 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}

If linear terminal velocity constraint guidance is assumed (SMODE = 4), then the orbit insertion guidance targets are set equal to the currently displayed values, and the target values of altitude (HTGT_DISP) and in-plane angle (THETA_DISP) from the launch site position to target position are transformed into an inertial position target vector (\overline{RT}) in the M50 coordinate system.

- | | | |
|----|--------------------------------|---|
| a. | THETA = THETA_DISP RAD_PER_DEG | Target earth central angle from the launch site |
| b. | HTGT = HTGT_DISP/NM_PER_FT | Target altitude magnitude |
| c. | C1 = C1_DISP | Intercept of the vertical velocity versus horizontal velocity target line |
| d. | C2 = C2_DISP | Slope of the vertical velocity versus horizontal velocity target line |

The altitude and the downrange angle are transformed to the mean-of-1950 position vector (\overline{RT}) by calling the H- θ -M50 TGT TSK (Section 4.8.6).

CALL H- θ -M50 TGT TSK

5. Current orbiter weight is transformed to mass for input to orbit insertion guidance.

$$M = WT_DISP/G_2_FPS2$$

6. The orbit insertion guidance principal function requires an input of the number of assumed OMS (N_OMS) and RCS (SRCS) engines to form an assumed acceleration quantity. In addition, the OMS FIRE SEQ, MSC, MNVR DISP, and TRANS DAP require a prime propulsion system indicator (PROP_FLAG_OFS). Based on the discrete settings input from the maneuver execute display, these quantities are set as follows:

If $\dot{BOTH_OMS} = ON$, then

N_OMS = 2

SRCS = 0

PROP_FLAG_OFS = 1

If LEFT_OMS = ON, then

N_OMS = 1

SRCS = 0

PROP_FLAG_OFS = 2

If RIGHT_OMS = ON, then

N_OMS = 1

SRCS = 0

PROP_FLAG_OFS = 3

If PLUS_X_RCS = ON, then

N_OMS = 0

SRCS = 4

PROP_FLAG_OFS = 4

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

PROP_FLAG_OFS_P = 0

7. 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 powered explicit guidance task (Subsection 4.8.1) is called iteratively until convergence is obtained ($\dot{S}CONV = ON$) and the steering parameters are ready ($S\dot{G}DRDY = ON$) or the maximum number of calls (NMAX_DIP) is exceeded to calculate these parameters. If the maximum number of calls is exceeded without convergence being obtained, the premaneuver display support task is exited. Additional outputs from the powered explicit guidance task are the desired thrust orientation parameters (\overline{LAMC} , \overline{LAMDC} , \overline{TLAMC}) required to calculate the desired ignition attitude and the desired burnout state (\overline{VD} , \overline{RD}) for calculating target apsis values. Before the powered explicit guidance task is called, the discrete to initiate PEG initialization ($\dot{S}INIT$) must be set to ON, and the thrust parameter task (THRST PRM TSK, Subsection 4.8.7) must be called to form the thrust and exhaust velocity parameters required by the powered explicit guidance task. Inputs to the THRST PRM TSK are the number of OMS (N_OMS), number of translational RCS (N_RCS = SRCS), number of null RCS (N_RCS_NULL = 0), and number of main engines (N_SSME = 0).

CALL THRST PRM TSK

Inputs to the powered explicit guidance task from the AS 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. Estimated initial acceleration ($ATR = FT/M$)
- d. PEG initialization discrete ($\dot{S}INIT = ON$)
- e. Guidance mode flag ($SMODE$)
- f. Number of guidance thrust phases (N)
- g. Number of OMS (N_OMS)
- h. Integration step size ($DT_LIMIT = DTMIN$)
- i. Guidance ready flag ($S_GDRDY = OFF$)
- j. Steering flag ($\dot{S}STEER = ON$)

CALL PEG TSK

Outputs from powered explicit guidance task to be used by the ASC 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{RD} , \overline{VD}) (linear terminal velocity constraint guidance only)
 - d. Initial and final offset coasting trajectory states from the PEG gravity computations ($\overline{R_INIT}$, $\overline{V_INIT}$, $\overline{R_FINAL}$, $\overline{V_FINAL}$) (linear terminal velocity constraint guidance only)
8. If guidance mode is PEG 4, 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 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{VGO}

Outputs: $\overline{VGO_LVLH}$

9. The desired vehicle attitude at ignition (pitch, yaw, and roll angles based upon the current ADI inertial attitude reference) is calculated for display as follows.
- Set time to compute commanded body attitude ($T_{CA} = TIG$)
 - Perform the commanded body attitude task (Section 4.8.10)
10. Calculation of target apogee and perigee altitudes (Item 11) requires a predicted burnout state. For linear terminal velocity constraint guidance ($SMODE = 4$), the predicted burnout state must be corrected as in a. below. For external delta-V guidance ($SMODE = 7$), the burnout state must be calculated as in b. below.

- The desired burnout state (\bar{R}_D, \bar{V}_D) obtained from PEG (see Item 7) does not contain J2 gravity acceleration during the powered flight. To compensate for this acceleration, the ASC PREC PRED principal function is used to propagate the initial state obtained from PEG through the time interval TGO with the J2 forces modeled ($GMO_PRED = 0$, $GMD_PRED = 2$).

$$DT_MAX = DTMIN$$

CALL ASC PREC PRED

Inputs: $R_INIT, V_INIT, TIG, TIG + TGO, DT_MAX, GMD_PRED,$
 GMO_PRED

Outputs: $\bar{R}C3, \bar{V}C3$

To obtain the delta position and velocity ($\bar{R}J2, \bar{V}J2$), the output state containing the J2 gravity effects ($\bar{R}C3, \bar{V}C3$) is differenced with the PEG-derived state with only central body gravity forces ($\bar{R}_FINAL, \bar{V}_FINAL$):

$$\bar{V}J2 = \bar{V}C3 - \bar{V}_FINAL$$

$$\bar{R}J2 = \bar{R}C3 - \bar{R}_FINAL$$

The desired burnout state is then corrected as follows:

$$\bar{R}_D = \bar{R}_D + \bar{R}J2$$

$$\bar{V}_D = \bar{V}_D + \bar{V}J2$$

- The desired guidance cutoff orbit is computed by defining an initial coasting trajectory (\bar{V}_D, \bar{R}_D) that when coasted through the burn time will approximate the powered-flight burnout trajectory ($SMODE = 7$).

$$\bar{V}_D = \bar{V}_{GD} + \bar{V}_{GO}$$

$$\bar{R}_D = \bar{R}_{GD} - 0.5 TGO \bar{V}_{GO}$$

where:

\bar{R}_{GD} is the predicted position vector at TIG

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

\overline{VGO} is the external delta-V guidance velocity vector

11. The target apogee (TGT_HA) and perigee (TGT_HP) altitudes are next computed for display with use of the orbital altitude time task (ORB ALT TIME TSK, Subsection 4.7.8).

The orbital altitude time task is called with the state computed in Item 10 (\overline{VD} , \overline{RD}) input as \overline{V} and \overline{R} , respectively, and outputs the resulting apogee altitude (HA) and perigee altitude (HP), which are then assigned to the target apogee altitude (TGT_HA) and target perigee altitude (TGT_HP).

CALL ORB ALT TIME TSK

12. If current time (T_NAV) exceeds the time of ignition (TIG), a state associated with T_NAV must be computed to reinitialize the state (central-body) maintained by orbit insertion guidance after TIG. This is accomplished by utilizing the navigation principal function ASC PREC PRED, which propagates the ignition state (\overline{RGD} , \overline{VGD}) computed in Item 3, in a central-body field to T_NAV and outputs the propagated state (\overline{RGD} , \overline{VGD}). Other inputs are the maximum time 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 (\overline{VSP}) must be set to ensure that the guidance principal function is consistent with this propagation.

$TGD = T_NAV$

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

$DT_MAX = DTMIN$

CALL ASC PREC PRED

Inputs: \overline{RGD} , \overline{VGD} , TIG, T_NAV, DT_MAX, GMD_PRED,
GMO_PRED, OTREQ

Outputs: \overline{RGD} , \overline{VGD} , OTREQ

If T_NAV 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 4.7.7-1 and 4.7.7-2.

C. Processing Requirements. The premaneuver display support task is performed once when the LOAD_CMD is set to ON by either keyboard input, entry into major mode 104, or the recognition of an abort condition subsequent to display initialization, but prior to burn enablement.

D. Initialization Requirements. Set number of guidance thrust phases equal to one (N = 1). The OPS transition request flag (OTREQ) is initialized to OFF.

E. Supplemental Information. The (1) QUAT_XFORM and (2) RV_TO_QLVLH modules referenced in this task and formally documented in the Level C, GN&C, Flight Control, FSSR document are presented here for information only.

1. QUAT_XFORM

$$QTMPV = -Q_{\bar{B}_I_V} \cdot VGO$$

$$Q\bar{T}MPV = Q_{\bar{B}_I_S} VGO + Q_{\bar{B}_I_V} \times VGO$$

$$VGO_DISP = -QTMPV Q_{\bar{B}_I_V} + Q_{\bar{B}_I_S} Q\bar{T}MPV - Q\bar{T}MPV \times Q_{\bar{B}_I_V}$$

2. RV_TO_QLVLH

$$X\bar{Z} = \text{UNIT}(-R\bar{G}D)$$

$$X\bar{Y} = \text{UNIT}(V\bar{G}D \times R\bar{G}D)$$

$$X\bar{X} = \text{UNIT}(X\bar{Y} \times X\bar{Z})$$

$$^*X\bar{M} = (\text{MATRIX}(X\bar{X}, X\bar{Y}, X\bar{Z}))^T$$

The output quaternion is formed from $^*X\bar{M}$ by invoking the MAT_TO_QUAT module.

Table 4.7.7-1. Premaneuver Display Support Task Inputs				
Definition	Symbol	Source	Prec	Units
Time of ignition	TIG_SEC, TIG_MIN, TIG_HR, TIG_DAY	MNVR DISP	SP	sec, min, hr, days
Current Shuttle position vector in M50 coordinates	$\overline{R_NAV}$	ASC UPP	DP	ft
Current Shuttle velocity vector in M50 coordinates	$\overline{V_NAV}$	ASC UPP	SP	fps
Time associated with current Shuttle state	T_NAV	ASC UPP	DP	sec
External delta-V velocity-to-be-gained vector in local vertical, local horizontal coordinates	$\overline{EXT_DV_LVLH}$	MNVR DISP	SP	fps
Orbiter weight	WT_DISP	MNVR DISP	SP	lb
Target altitude magnitude	HTGT_DISP	MNVR DISP	SP	nmi
Target earth central angle from launch site	THETA_DISP	MNVR DISP	SP	deg
Intercept of target line	C1_DISP	MNVR DISP	SP	fps
Slope of target line	C2_DISP	MNVR DISP	SP	ND
Left OMS engine select discrete	$\dot{L}EFT_OMS$	MNVR DISP	D	N/A
Right OMS engine select discrete	$\dot{R}IGHT_OMS$	MNVR DISP	D	N/A
Both OMS engine select discrete	$\dot{B}OTH_OMS$	MNVR DISP	D	N/A
RCS engine select discrete	$\dot{P}LUS_X_RCS$	MNVR DISP	D	N/A
Discrete indicating guidance convergence	$\dot{S}CONV$	PEG TSK	D	N/A
Desired burnout position, vector in M50 coordinates	\overline{RD}	PEG TSK	DP	ft
Desired burnout velocity vector in M50 coordinates	\overline{VD}	PEG TSK	SP	fps
Predicted position vector at TGD in M50 coordinates	\overline{RGD}	ASC PREC PRED	DP	ft
Predicted velocity vector at TGD in M50 coordinates	\overline{VGD}	ASC PREC PRED	DP	fps
Apogee altitude	HA	ORB ALT TIME TSK	SP	nmi
Perigee altitude	HP	ORB ALT TIME TSK	SP	nmi
Velocity-to-be-gained vector in M50 coordinates	\overline{VGO}	PEG TSK	SP	fps
Time-to-go to thrust cutoff	TGO	PEG TSK	SP	sec
Accumulated sensed velocity vector	\overline{VS}	ASCENT UPP	DP	fps
Current GMT computer time	T_GMT	FCOS	DP	sec
Unit desired thrust direction vector in M50 coordinates	\overline{LAMC}	PEG TSK	SP	ND

Table 4.7.7-1. Premaneuver Display Support Task Inputs

Definition	Symbol	Source	Prec	Units
Desired thrust direction turning rate in M50 coordinates	$\bar{L}AMDC$	PEG TSK	SP	sec ⁻¹
GMT associated with reference thrust vectors $\bar{L}AMC$ and $\bar{L}AMDC$	TLAMC	PEG TSK	DP	sec
Mass-to-weight conversion factor	G_2_FPS2	K-LOAD	SP	lb/slug
Time interval step-size to be used by ASC PREC PRED function to predict current state to ignition state	DTMIN	K-LOAD	SP	sec
Degrees-to-radians conversion factor	RAD_PER_DEG	CONSTANT	SP	rad/deg
Target position in M50 coordinates	$\bar{R}T$	H- θ -M50 TGT TSK	DP	ft
Maximum number of PEG iterations	NMAX_DIP	K-LOAD	I	N/A
MM104 indicator	MM104	MSC	D	N/A
MM105 indicator	MM105	MSC	D	N/A
Total vehicle thrust force	FT	THRST PRM TSK	SP	lbf
Initial coasting trajectory position vector for linear terminal velocity constraint guidance	\bar{R}_INIT	PEG TSK	DP	ft
Initial coasting trajectory velocity vector for linear terminal velocity constraint guidance	\bar{V}_INIT	PEG TSK	SP	fps
Guidance ready flag	S_GDRDY	PEG TSK	D	N/A
Final coasting trajectory position vector excluding J2 gravity effects	\bar{R}_FINAL	PEG TSK	DP	ft
Final coasting trajectory velocity vector excluding J2 gravity effects	\bar{V}_FINAL	PEG TSK	SP	fps
Final coasting trajectory position vector including J2 gravity effects	$\bar{R}C3$	ASC PREC PRED	DP	ft
Final coasting trajectory velocity vector including J2 gravity effects	$\bar{V}C3$	ASC PREC PRED	SP	fps
Feet to nautical miles conversion factor	NM_PER_FT	CONSTANT	SP	nmi/ft
Guidance mode discrete	PEG_MODE_4	DISP INIT TSK, MNVN DISP	D	N/A
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
OMS pitch trim angle	OMS_PITCH_TRIM	TRANS DAP	SP	deg
Left OMS yaw trim angle	OMS_YAW_TRIM ₁	TRANS DAP	SP	deg
Right OMS yaw trim angle	OMS_YAW_TRIM ₂	TRANS DAP	SP	deg

Table 4.7.7-2. Premaneuver Display Support Task Outputs				
Definition	Symbol	Destination	Prec	Units
Time of ignition	TIG	MSC, ASC PREC PRED, DISP MONIT TSK, PFG INP TSK, TLM, CMD BDY ATT TSK, OMS GUID TSK, VGO DISP TSK, ORB INS SEQ, ASC MNVR DIP SEQ, PREBURN MNVR TTG TSK	DP	sec
Discrete to initiate time base calculations	TB_ENABLE	MSC	D	N/A
PEG maneuver mode indicator	SMODE	PEG TSK, TLM	I	N/A
Guidance position vector	\overline{RGD}	PEG TSK, PFG INP TSK, H- θ -M50 TGT TSK, ASC PREC PRED	DP	ft
Guidance velocity vector	\overline{VGD}	PEG TSK, PFG INP TSK, H- θ -M50 TGT TSK, ASC PREC PRED	DP	fps
Time associated with \overline{RGD} , \overline{VGD}	TGD	PEG TSK, PFG INP TSK	DP	sec
Target earth central angle from the launch site	THETA	H- θ -M50 TGT TSK	SP	rad
Target altitude magnitude	HTGT	H- θ -M50 TGT TSK	SP	ft
Target position vector in M50 coordinates	\overline{RT}	PEG TSK	DP	ft
Intercept of target line	C1	LTVCON TSK	SP	fps
Slope of target line	C2	LTVCON TSK	SP	ND
Current vehicle mass	M	ACC-MASS UPD TSK, OMS GUID TSK	SP	slugs
Number of main engines operating	N_SSME	ACC-MASS UPD TSK, PEG TSK, THRST PRM TSK	I	N/A
Prime propulsion system flag	PROP_FLAG_OFS	CMD BDY ATT TSK, OMS FIRE SEQ, MSC, TRANS DAP, MNVR DISP, TLM, ASC NAV SEQ	I	N/A
PEG 4 velocity-to-go in LVLH coordinates	$\overline{VGO_LVLH}$	MNVR DISP	SP	fps
Number of guidance thrust phases	N	PEG TSK	I	N/A
Number of active OMS engines	N_OMS	THRST PRM TSK, PFG INP TSK	I	N/A
Number of active RCS engines	N_RCS	THRST PRM TSK, CMD BDY ATT TSK	I	N/A
Target apogee altitude	TGT_HA	MNVR DISP	SP	nmi

Table 4.7.7-2. Premaneuver Display Support Task Outputs

Definition	Symbol	Destination	Prec	Units
Target perigee altitude	TGT_HP	MNVR DISP	SP	nmi
External delta-V target velocity-to-go vector	\bar{V}_{GO}	PEG TSK, TLM	SP	fps
Previous value of prime propulsion system flag	PROP_FLAG_OFS_P	CMD BDY ATT TSK	I	N/A
GMT to compute commanded body attitude	T_CA	CMD BDY ATT TSK	SP	sec
Previous value of accumulated sensed velocity vector	\bar{V}_{SP}	PFG INP TSK	DP	fps
Position vector	\bar{R}	ORB ALT TIME TSK	DP	ft
Velocity vector	\bar{V}	ORB ALT TIME TSK	SP	fps
Gravity model order and degree flags	GMO_PRED, GMD_PRED	ASC PREC PRED	I	N/A
Maximum integration step interval	DT_MAX	ASC PREC PRED	SP	sec
Current Shuttle position vector	R_{NAV}	ASC PREC PRED	DP	ft
Current Shuttle velocity vector	V_{NAV}	ASC PREC PRED	SP	fps
Time associated with current Shuttle state	T_NAV	ASC PREC PRED	DP	sec
OPS transition request flag	OTREQ	ASC PREC PRED	D	N/A
Discrete indicating whether initialization (ON) or update (OFF) is to be performed	SINIT	PEG TSK	D	N/A
Nominal acceleration	ATR	PEG TSK	SP	fps ²
Number of active RCS null engines	N_RCS_NULL	THRST PRM TSK	I	N/A
Initial coasting trajectory position vector for linear terminal velocity constraint guidance	R_{INIT}	ASC PREC PRED	DP	ft
Initial coasting trajectory velocity vector for linear terminal velocity constraint guidance	V_{INIT}	ASC PREC PRED	SP	fps
Time of thrust cutoff	TIG + TGO	ASC PREC PRED	DP	sec
Maximum integration step size for gravity prediction	DT_LIMIT	PEG TSK	SP	sec
PEG steering enable flag	SSTEER	PEG TSK	D	N/A
Guidance ready flag	S_GDRDY	PEG TSK	D	N/A
Desired vehicle burn attitude in ADI coordinates	VEH_PITCH, VEH_ROLL, VEH_YAW	MNVR DISP, TLM	SP	deg
Valid angle comp flag	X_FLAG	MNVR DISP	D	N/A

4.7.8 Orbital Altitude Time Task (ORB ALT TIME TSK)

The orbital altitude time 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):

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

$$P = RMAG (2 - (RMAG/AM) - RMAG RDOT^2/EARTH_MU)$$

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 constant (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) — as follows:

$$MM = \bar{EARTH_POLE} \cdot \bar{R}_{UNIT}$$

$$NN = UNIT(\bar{V} - RDOT \bar{R}_{UNIT}) \cdot \bar{EARTH_POLE}$$

$$S_INC = MM^2 + NN^2$$

where $\bar{EARTH_POLE}$ 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):

$$AM = AM - (J2_GRAV \cdot RE^2 \cdot AM^2 / RMAG^3) (1 - 3MM^2)$$

$$NU = AM \cdot SQRT(AM/EARTH_MU)$$

6. Compute the adjusted elements: radius (RMAG), vertical velocity(RDOT), 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) — as follows:

$$M = RMAG RDOT/SQRT(EARTH_MU AM)$$

$$N = 1 - RMAG/AM$$

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, ($2 AM E < DELT_H_CIRC/NMI_PER_FT$).

If it is not a circular orbit, proceed to Step 11. For a circular orbit, set the flag (TXX_FLAG) to indicate a circular orbit, and the time to next apsis (TT_X) to zero.

$$TXX_FLAG = 3$$

$$TT_X = 0$$

Then proceed to Step 16.

11. For an elliptical orbit ($2 AM E \geq DELT_H_CIRC/NMI_PER_FT$), 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):

$$SW = SIGN(RDOT)$$

$$TT_X = ((1 + SW) PI/2 + M - ARCTAN2(M, N)) NU$$

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

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

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

If (RDOT \geq 0) then TXX_FLAG= 1

else TXX_FLAG= 2

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

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

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, proceed to Step 16. For an allowable value, compute a quantity proportional to the sine of twice the argument of perigee (DELTB) and check to ensure that it has a non-zero value:

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

If DELTB = 0, then proceed to Step 16. For a non-zero value of DELTB, compute the time correction term (KK) and the time-to-next-apsis (TT_X):

$$\text{KK} = -(\text{SW} \text{KK} + \text{DELTA}) / \text{DELTB}$$

$$\text{TT_X} = \text{TT_X} + (1 + 2 \text{SW} \text{E}) \text{NU} / (\text{KK} + \text{SIGN}(\text{KK}) \text{SQRT}(\text{KK}^2 + 2))$$

If the time-to-next-apsis (TT_X) is negative, add half the period to this time and update the TXX_FLAG:

$$\text{TT_X} = \text{TT_X} + \text{PI} \text{NU}$$

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

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

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

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

The variable NM_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 4.7.8-1 and 4.7.8-2.

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

D. Initialization Requirements. None.

Table 4.7.8-1.Orbital Altitude Time Task Inputs				
Definition	Symbol	Source	Prec	Units
Position vector	\bar{R}	CUR ORBIT TSK, PRE-MAN DISP SUPT TSK	DP	ft
Velocity vector	\bar{V}	CUR ORBIT TSK, PRE-MAN DISP SUPT TSK	SP	fps
Earth gravitational constant	EARTH_MU	CONSTANT	DP	ft ³ /sec ²
Earth's second gravitational constant (J ₂)	J2_GRAV	CONSTANT	SP	ND
Earth radius	RE	CONSTANT	DP	ft
M50 unit vector normal to equator pointing north	$\bar{EARTH_POLE}$	ASC NAV SEQ	DP	ND
Maximum difference between apogee and perigee for orbit to be considered circular	DELT_H_CIRC	K-LOAD	SP	nmi
Feet to nautical mile conversion factor	NM_PER_FT	CONSTANT	SP	nmi/ft
Ratio of the circumference of a circle to the diameter	PI	CONSTANT	SP	ND

Table 4.7.8-2.Orbital Altitude Time Task Outputs				
Definition	Symbol	Destination	Prec	Units
Apogee altitude	HA	CUR ORBIT TSK, PRE-MAN DISP TSK	SP	nmi
Perigee altitude	HP	CUR ORBIT TSK, PRE-MAN DISP TSK	SP	nmi
Time to next apsis	TT_X	CUR ORBIT TSK, PRE-MAN DISP TSK	SP	sec
Indicator for next apsis and label field (= 1, TTA (Apogee), = 2, TTP (Perigee), = 3, TTC (Circular))	TXX_FLAG	CUR ORBIT TSK	I	N/A

4.7.8A Preburn Maneuver Time to Go Task (PREBRN MNVR TTG TSK)

This task computes the condition when the nominal preburn maneuver completion time to go is displayed in double overbright versus normal intensity on the XXXXX MNVR YYYYY 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 YYYYY 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 104 or 105, 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: $MM_{104} = ON$ OR $MM_{105} = ON$

AND

$TTG + T_{GMT} > TIG - 30 \text{ SECONDS}$

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 4.7.8A-1 and 4.7.8A-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 OPS 1.

E. Supplemental Requirements. None.

Table 4.7.8A-1. Preburn Maneuver Time To Go Task Input Parameters				
Definition	Name	Source	Precision	Units
Current time (GMT)	T_GMT	FCOS	DP	sec
Flag signifying maneuver or hold state (1 = MNVR)	MNVR_HOLD	TRANS DAP	D	N/A
Major Mode 104 Flag	MM_104	MSC	D	N/A
Major Mode 105 Flag	MM_105	MSC	D	N/A
Time of ignition	TIG	PRE-MAN DISP SUPT TSK	DP	sec
Preburn mnvr time to go	MNVR_CMPL_ TIME_TGO	TRANS DAP	SP	sec

Table 4.7.8A-2. Preburn Maneuver Time To Go Task Output Parameters				
Definition	Name	Destination	Precision	Units
Preburn mnvr time to go	TTG	MNVR DISP	SP	sec
TTG display intensity flag	TTG_FLAG	MNVR DISP	D	N/A
Preburn maneuver display flag	PREBURN_MNVR_DISP	MNVR DISP	D	N/A

4.7.9 Insertion Targets Uplink Task (INS TGT UL TSK)

This task determines if insertion guidance targets have been uplinked and, if so, moves the targeting data from the uplink buffer into the correct storage locations.

A. Detailed Requirements. On the first execution of this task following an uplink of new insertion guidance targeting data, the following checks are made:

1. OP code = 0101101.
2. A previously uplinked or crew input target set is not being processed.
3. A burn is not in progress.

If any of these conditions are not met, the uplinked target data are rejected. If all conditions are met, the targeting values in memory are replaced with the values in the uplink buffer, and the guidance targeting update discrete is set to ON (TBD = ON).

B. Interface Requirements. Table 4.7.9-1 lists the insertion targeting uplink parameters and their destinations and the uplink discrete set by the task.

C. Processing Requirements. This task is performed whenever an uplink of new insertion targeting data is received.

D. Initialization Requirements. TBD must be initialized to OFF upon transition to Major Mode 101.

Table 4.7.9-1.Insertion Targets Uplink Task Inputs and Outputs					
Definition	Symbol	Source	Destination	Prec	Units
Time of ignition	TIG	UL	ASC MNVR DIP	DP	sec
OMS pitch trim angle	OMS_PITCH_TRIM	UL	MNVR DISP	SP	deg
OMS left yaw trim angle	OMS_YAW_TRIM(1)	UL	MNVR DISP	SP	deg
OMS right yaw trim angle	OMS_YAW_TRIM(2)	UL	MNVR DISP	SP	deg
Thrust vector roll angle	TVR_ROLL	UL	MNVR DISP	SP	deg
Vehicle weight	WT_DISP	UL	MNVR DISP	SP	lb
Intercept of target line	C1_DISP	UL	MNVR DISP	SP	fps
Slope of target line	C2_DISP	UL	MNVR DISP	SP	ND
Target altitude magnitude	HTGT_DISP	UL	MNVR DISP	SP	nmi
Target in-plane downrange angle from launch	THETA_DISP	UL	MNVR DISP	SP	deg
Both OMS engine select	BOTH_OMS	UL	MNVR DISP	D	N/A
Left OMS engine select	LEFT_OMS	UL	MNVR DISP	D	N/A
Right OMS engine select	RIGHT_OMS	UL	MNVR DISP	D	N/A
RCS engine select cmd	PLUS_X_RCS	UL	MNVR DISP	D	N/A
Guidance targeting update discrete	TBD	-	DISP INIT TSK, ASC MNVR DIP SEQ	D	N/A

4.7.10 Parameter Tables for Ascent Maneuver Display Interface Processing

The IDD inputs and outputs are listed in Tables 4.7.10-1 and Table 4.7.10-2 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 4.7.10-3. K-loads are listed in Table 4.7.10-4. Constants are listed in Table 4.7.10-5. The input variable cross-references are listed in Table 4.7.10-0.

Table 4.7.10-0. Ascent Maneuver Display Interface Processing Input Variable Cross-Reference		
MSID	Local Name	Source Name
V91W5000C1	T_GMT	CLOCK
V95H0185CB, 86CB, 87CB	R_NAV	R_AVGG
V95L0190CB, 91CB, 92CB	V_NAV	V_AVGG
V95W0200CD	T_NAV	T_STATE
V90H0881CB, 2CB, 3CB	R_GD, R_C3	R_FINAL
V90L0885CB, 6CB, 7CB	V_GD, V_C3	V_FINAL
V97U4855C	IYD_OMS(1)	IYD_OMS1(1)
V97U4856C	IYD_OMS(2)	IYD_OMS1(2)
V97U4857C	IYD_OMS(3)	IYD_OMS1(3)
V97U4858C	IYD_OMS(4)	IYD_OMS2(1)
V97U4859C	IYD_OMS(5)	IYD_OMS2(2)
V97U4860C	IYD_OMS(6)	IYD_OMS2(3)
V95U0507C, 8C, 9C	R_LS_M50	R_M50_AT_LIFTOFF

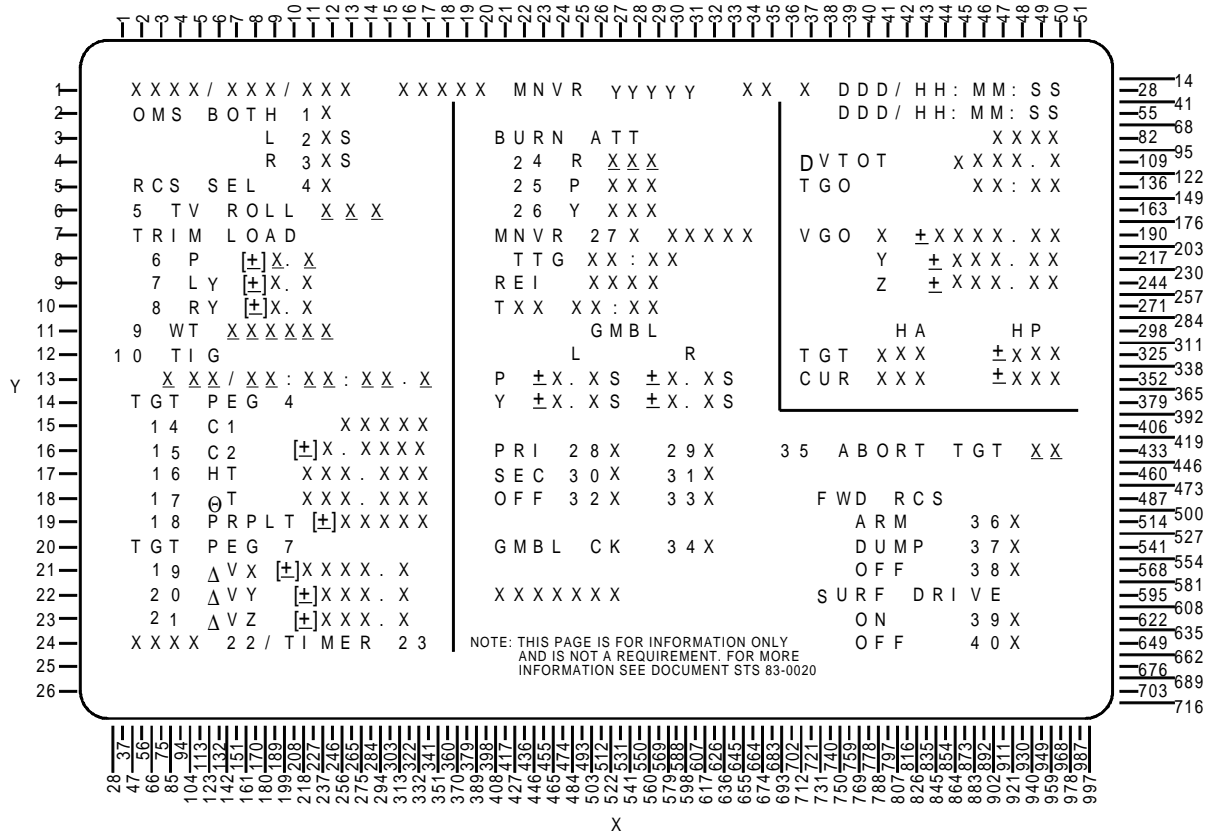


FIGURE 4.7-1. XXXXXX MNVR YYYYYY Display Format

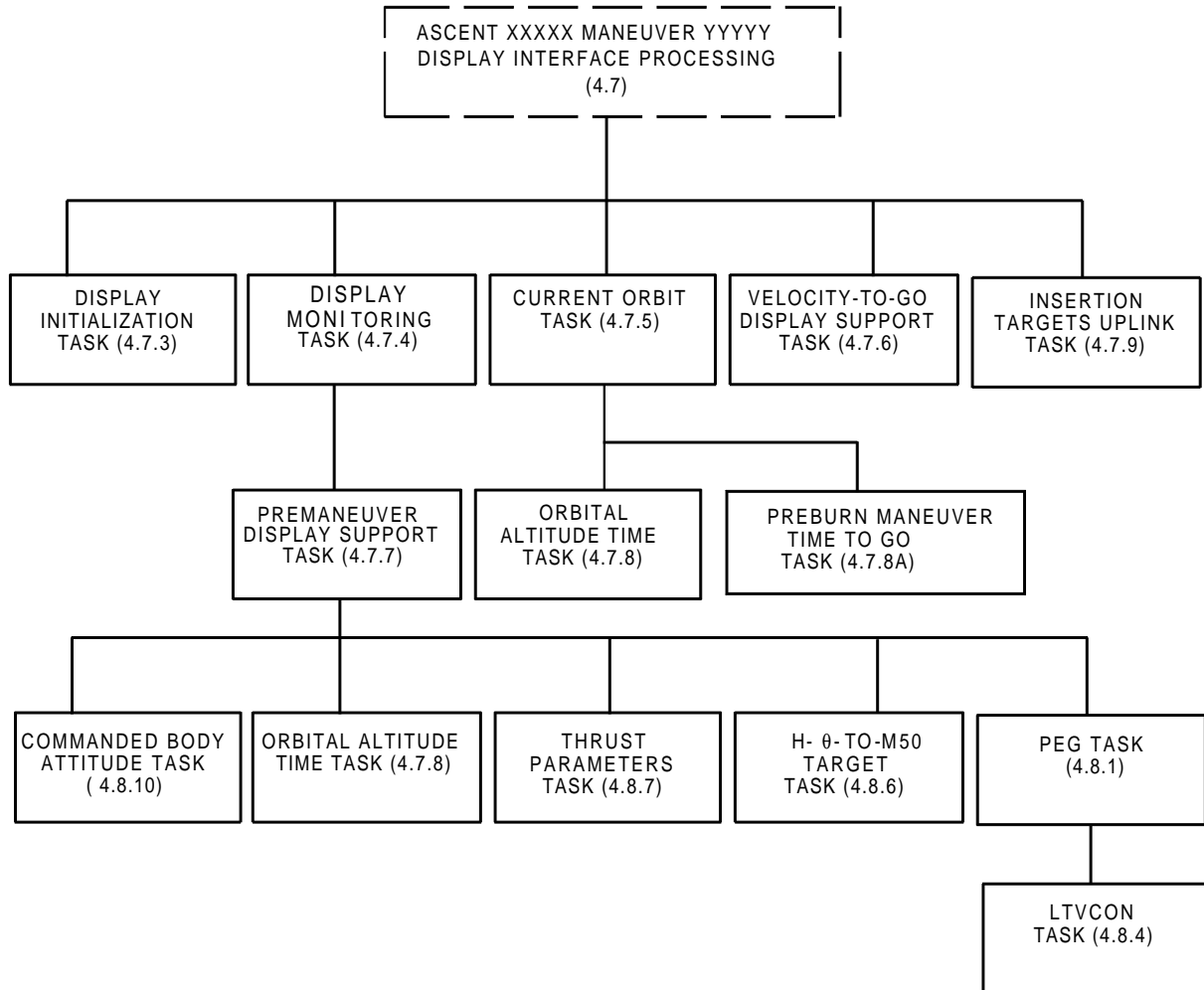


FIGURE 4.7-2. Ascent XXXXX Maneuver YYYYY Display Interface Processing Principal Function Task Organization

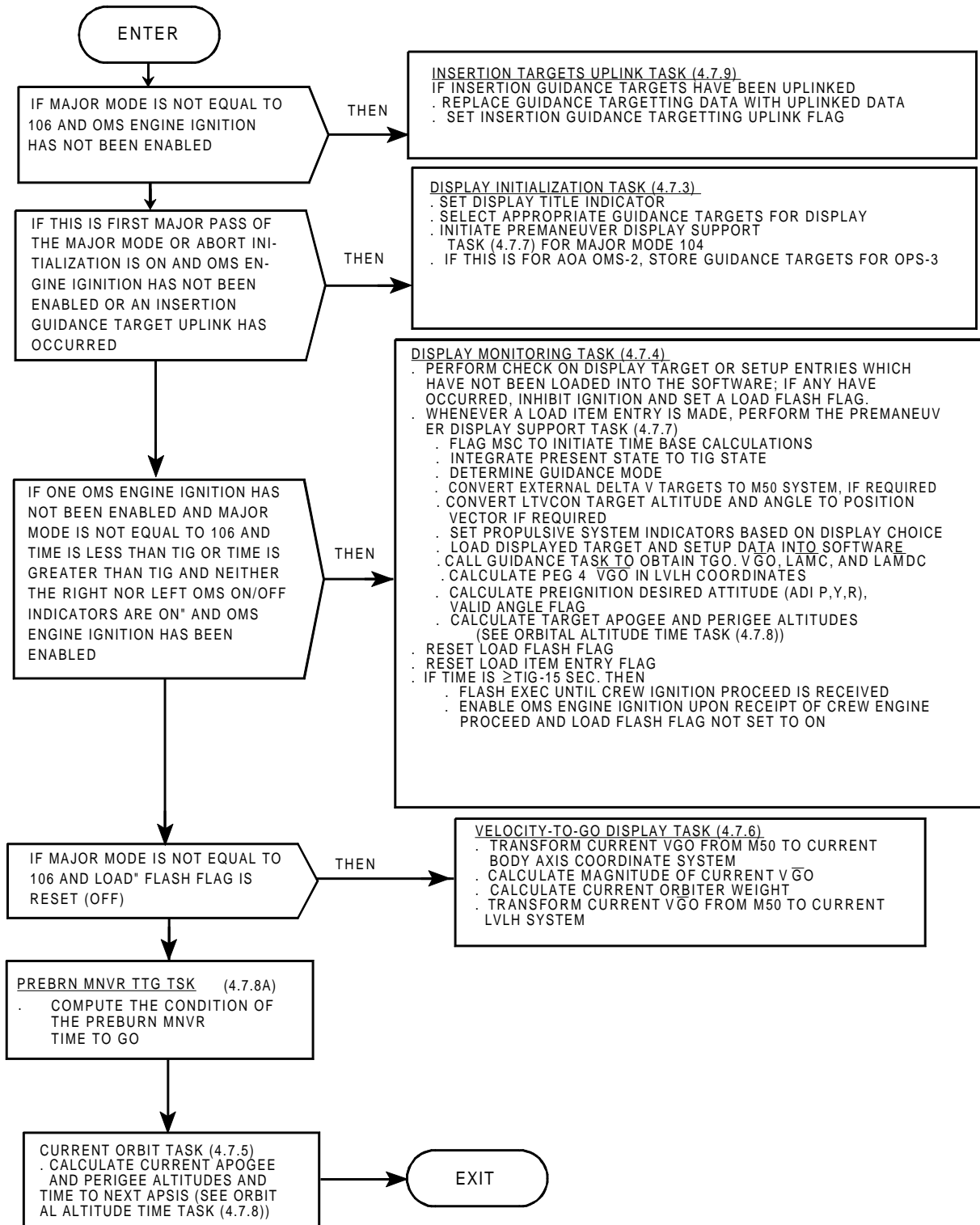


FIGURE 4.7-3. Ascent XXXXX Maneuver YYYYYY Display Interface Processing Functional Flow

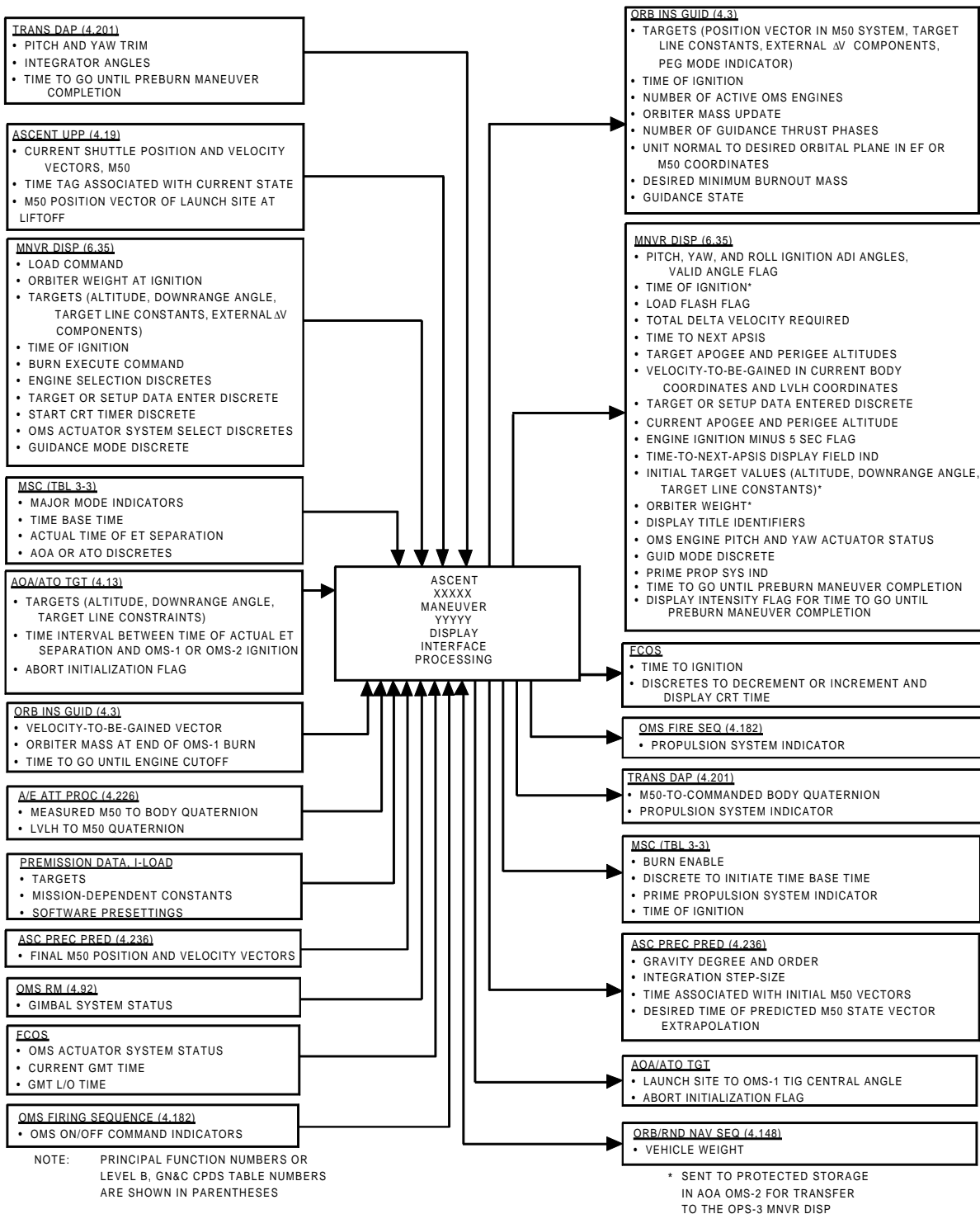


FIGURE 4.7-4. Ascent XXXXX Maneuver YYYYY Display Interface Processing Data Flow

TABLE 4.7.10-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABORT_INIT	V90X8489XA	ABORT INITIALIZATION FLAG	AOA/ATO TGT					
BOTH_OMS	V93X6922XA	BOTH OMS ENG SEL	XXXXX MNVR DISP					
BOTH_OMS	V93X6922XB	BOTH OMS ENG SEL	UL					
C1_DISP	V93U6966CA	INTERCEPT OF TARGET LINE	XXXXX MNVR DISP	FT/S				
C1_DISP	V93U6966CD	INTERCEPT OF TARGET LINE	UL	FT/S				
C1_OMS(1)	V97U4326C	OMS-1 TGT LINE INTERCEPT	UL					
C1_OMS(2)	V97U4327C	OMS-2 TGT LINE INTERCEPT	UL					
C1_OMS(3)	V90L8487C	INTERCEPT OF TARGET LINE-DIP	AOA/ATO TGT	FT/S				
C2_DISP	V93U6967CA	SLOPE OF TARGET LINE	XXXXX MNVR DISP					
C2_DISP	V93U6967CD	SLOPE OF TARGET LINE	UL					
C2_OMS(1)	V97U4342C	OMS-1 TGT LINE SLOPE	UL					
C2_OMS(2)	V97U4343C	OMS-2 TGT LINE SLOPE	UL					
C2_OMS(3)	V90U8488C	SLOPE OF TARGET LINE-DIP	AOA/ATO TGT					
CLOCK/CLOCKTIME	V91W5000C	CLOCK-COMPUTER(GMT)	FCOS	S			93160B	*
DATA_ENTER	V93X6973X	TGT/SETUP DATA ENTERED FLAG	XXXXX MNVR DISP					
DTIG_OMS(1)	V97U4367C	TIME OF OMS-1 IGN AFTER ET SEP	UL					
DTIG_OMS(2)	V97U4368C	TIME OF OMS-2 IGN AFTER ET SEP	UL					
DTIG_OMS(3)	V90W8485C	TIME OF OMS 1/2 IGN AFTER ET SEP	AOA/ATO TGT	S				
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(2)	V93L6951CA	EXT DELTA V Y-COMP	XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(3)	V93L6952CA	EXT DELTA V Z-COMP	XXXXX MNVR DISP	FT/S			93017G	*
HTGT_DISP	V93U6968CA	TGT ALTITUDE MAGNITUDE	XXXXX MNVR DISP	NM				
HTGT_DISP	V93U6968CD	TGT ALTITUDE MAGNITUDE	UL	NM				
HTGT_OMS(1)	V97U4411C	OMS-1 TGT ALT	UL					
HTGT_OMS(2)	V97U4412C	OMS-2 TGT ALT	UL					
HTGT_OMS(3)	V90H8481C	TGT ALTITUDE AT END OF COAST PHASE	AOA/ATO TGT	FT				
IYD_OMS1(1)	V97U4855C	X-M50/EF UN NORM TO ORB PLN OMS 1	UL				89461	
IYD_OMS1(2)	V97U4856C	Y-M50/EF UN NORM TO ORB PLN OMS 1	UL				89461	
IYD_OMS1(3)	V97U4857C	Z-M50/EF UN NORM TO ORB PLN OMS 1	UL				89461	
IYD_OMS2(1)	V97U4858C	X-M50/EF UN NORM TO ORB PLN OMS 2	UL				89461	
IYD_OMS2(2)	V97U4859C	Y-M50/EF UN NORM TO ORB PLN OMS 2	UL				89461	
IYD_OMS2(3)	V97U4860C	Z-M50/EF UN NORM TO ORB PLN OMS 2	UL				89461	
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/WEIGHT	V90U1961CA	CURRENT VEHICLE MASS	ORB INS GUID	SLUGS			93017G	*
MASS_ORB	V97U4435C	INITIAL ORBITER ONLY MASS	UL	SLUG	SPL	S	92175D	
MBO_MIN(1)	V97U4861C	MINIMUM BURN-OUT MASS FOR OMS-1	UL	SLUG	SPL	S	92175D	
MBO_MIN(2)	V97U4862C	MINIMUM BURN-OUT MASS FOR OMS-2	UL	SLUG	SPL	S	92175D	
MM_CODE_104/MM_104	V90X8152X	MAJOR MODE 104 FLAG	MSC				92355B	
MM_CODE_105/MM_105	V90X8623X	MAJOR MODE 105 FLAG	MSC				92355B	
MM_CODE_106/MM_106	V90X8153X	MAJOR MODE 106 FLAG	MSC				92355B	

TABLE 4.7.10-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
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	V93H6915CC	OMS PITCH TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
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)	V93H6916CC	OMS L YAW TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
OMS_YAW_TRIM(1)	V93H6916CD	OMS L YAW TRIM	UL	DEG	SPL		89645A	
OMS_YAW_TRIM(2)	V93H6918CC	OMS R YAW TRIM INTEGRATOR	TRANS DAP	DEG	SPL		93017G	*
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	*
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)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_FINAL(1)	V90H0881CB	X-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(2)	V90H0882CB	Y-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_FINAL(3)	V90H0883CB	Z-COMP PREDICTED SHUTTLE POS VECTR	ASC PREC PRED	FT				
R_M50_AT_LIFTOFF(1)	V95U0507C	X-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(2)	V95U0508C	Y-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(3)	V95U0509C	Z-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
ST_CRT_TIMER	V93X6553X	START CRT TIMER CMD	XXXXX MNVR DISP		BD		89461	
S_AOA	V90X8636X	AOA ABORT DECLARED	MSC		BD		92355B	
S_AOA_OMS2	V90X8486X	AOA OMS-2 TGT DATA READY FLAG	AOA/ATO TGT					
S_ATO	V90X8635X	ATO ABORT DECLARED	MSC				93012D	
T1	V90W8320C	OMS EQUIVALENT ON TIME	ABT CNTL SEQ	S	SPL		93017G	*
TB_TIME	V90W8625C	ENGINE IGNITION TIME BASE TIME	MSC	S			89599C	
TGO	V90W1941CB	TIME TO GO TO VELOCITY CUTOFF	ORB INS GUID	S			93017G	*
THETA_DISP	V93U6969CA	TGT INPLN DNRNG ANG FROM LANH	XXXXX MNVR DISP	DEG				
THETA_DISP	V93U6969CD	TGT INPLN DNRNG ANG FROM LANH	UL	RAD				
THETA_OMS(1)	V97U4803C	OMS-1 TGT DNRNG ANG FROM LANH	UL					

TABLE 4.7.10-1. INPUT FUNCTIONAL PARAMETERS FOR ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
THETA_OMS(2)	V97U4804C	OMS-2 TGT DNRNG ANG FROM LANH	UL					
THETA_OMS(3)	V90H8482C	TGT INPLN DNRNG ANG FROM LANH SITE	AOA/ATO TGT	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_ET_SEP	V90W8621C	TIME OF ET SEPARATION	MSC	S			90705H	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
VGO(X)	V90L2026C	X VEL TO BE GAINED VECTOR IN M50	ORB INS GUID	FT/S			89461	
VGO(Y)	V90L2027C	Y VEL TO BE GAINED VECTOR IN M50	ORB INS GUID	FT/S			89461	
VGO(Z)	V90L2028C	Z VEL TO BE GAINED VECTOR IN M50	ORB INS GUID	FT/S			89461	
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_FINAL(1)	V90L0885CB	X-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(2)	V90L0886CB	Y-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_FINAL(3)	V90L0887CB	Z-COMP PREDICTED SHUTTLE VEL VECTR	ASC PREC PRED	FT/S				
V_IMU_OLD(1)	V95L0210CB	X-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CB	Y-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CB	Z-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
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 4.7.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABORT_INIT	V90X8489XB	ABORT INITIALIZATION FLAG	AOA/ATO TGT					
BURN_ENABLE	V94X3815XA	BURN ENABLE	MSC				92876B	
C1	V94H3773CB	INTERCEPT OF TARGET LINE-GUID	ORB INS GUID	FT/S				
C1_DISP	V93U6966CC	INTERCEPT OF TARGET LINE	DL FMT 21/A XXXXX MNVR DISP	FT/S			93017G	*
C2	V94H3774CB	SLOPE OF TARGET LINE-GUID	ORB INS GUID					
C2_DISP	V93U6967CC	SLOPE OF TARGET LINE	DL FMT 21/A XXXXX MNVR DISP				93017G	*
CRT_COUNTDOWN	V94X4064XB	CRT TIMER COUNTDOWN FLAG	FCOS					
CRT_SEC	V94W4053CB	SECONDS TO IGNITION	FCOS	S				
CRT_TIMER_START	V94X4063XB	CRT TIMER START FLAG	FCOS					
CUR_HA	V94H3810CA	CURRENT APOGEE ALTITUDE	DL FMT 21/1 XXXXX MNVR DISP	NM			93017G	*
CUR_HP	V94H3811CA	CURRENT PERIGEE ALTITUDE	DL FMT 21/1 XXXXX MNVR DISP	NM			93017G	*
DM_PREMECO	V90U1924C	MASS OF OMS BURNED PRE-MECO	AOA/ATO TGT	SLUG			92235B	
DT_MAX	V90U8500CE	MAX ALLOW TIME STEP SIZE	ASC PREC PRED	S				
DV_TOT	V94L3795CA	TOTAL DELTA V REQD FOR MANEUVER	DL FMT 21/1 XXXXX MNVR DISP	FT/S			93017G	*
EXT_DV_LVLH(1)	V93L6950CD	EXT DELTA V X-COMP	XXXXX MNVR DISP	FT/S				
EXT_DV_LVLH(2)	V93L6951CD	EXT DELTA V Y-COMP	XXXXX MNVR DISP	FT/S				
EXT_DV_LVLH(3)	V93L6952CD	EXT DELTA V Z-COMP	XXXXX MNVR DISP	FT/S				
GMD_PRED	V90U8501CE	GRAVITY MODEL DEGREE	ASC PREC PRED					
GMO_PRED	V90U8502CE	GRAVITY MODEL ORDER	ASC PREC PRED					
HTGT_DISP	V93U6968CC	TGT ALTITUDE MAGNITUDE	DL FMT 21/A XXXXX MNVR DISP	FT			93017G	*
IYD(X)	V97U4413CA	UNIT VEC NORM TRAJ PLN X COMP	ORB INS GUID					
IYD(Y)	V97U4414CA	UNIT VEC NORM TRAJ PLN Y COMP	ORB INS GUID					
IYD(Z)	V97U4415CA	UNIT VEC NORM TRAJ PLN Z COMP	ORB INS GUID					
LOAD_FLASH	V94X3814XA	LOAD FLASH FLAG	DL FMT 21/A XXXXX MNVR DISP				93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CI	CURRENT VEHICLE MASS	DL FMT 21/1 ORB INS GUID	SLUGS			93017G	*
MBO	V94U3838C	DESIRED MINIMUM BURNOUT MASS	ORB INS GUID	SLUGS				
MNVR_TITLE_IND	V94U4096CB	DISPLAY TITLE IND	XXXXX MNVR DISP				91072D	
N	V94U3823C	NUMBER OF GUIDANCE THRUST PHASES	ORB INS GUID					
N_OMS	V90J2031CD	NUMBER OF ACTIVE OMS ENGINES	ORB INS GUID				90120B	
OMSL_ACT_SEL	V93J6904CB	L P/S/OFF GMBL ACTR SEL	OMS RM					
OMSR_ACT_SEL	V93J6906CB	R P/S/OFF GMBL ACTR SEL	OMS RM					
OTREQ	V90X0893XL	OPS TRANSITION REQUEST FLAG	ASC PREC PRED		BD		90121B	
PEG_MODE_4	V93X6976XC	PEG4/PEG7 TGT DATA ENTERED	XXXXX MNVR DISP				92354	
PREBURN_MNVR_DISP	V85X9529XA	PREBURN MANEUVER DISPLAY FLAG	XXXXX MNVR DISP		BD		92859C	
PROP_DEP	V93U6970CC	OUT OF PLANE PRPLT WASTE	TLM XXXXX MNVR DISP	LB				

TABLE 4.7.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
PROP_FLAG_OFS	V94J3791CA	PRIME PROP SYS INDICATOR FLAG	ASC NAV SEQ DL FMT 21/A MSC				93017G	*
Q_CB_M50_S	V94U3980CE	M50 TO BODY QUAT ELEM 1	OMS FIRE SEQ					
Q_CB_M50_V(1)	V94U3981CE	M50 TO BODY QUAT ELEM 2	ORB INS GUID					
Q_CB_M50_V(2)	V94U3982CE	M50 TO BODY QUAT ELEM 3	TRANS DAP					
Q_CB_M50_V(3)	V94U3983CE	M50 TO BODY QUAT ELEM 4	TRANS DAP					
RGD(X)	V94H3930CA	X-COMP OF GUIDANCE POS VEC AT TGD	ORB INS GUID	FT			89461	
RGD(Y)	V94H3931CA	Y-COMP OF GUIDANCE POS VEC AT TGD	ORB INS GUID	FT			89461	
RGD(Z)	V94H3932CA	Z-COMP OF GUIDANCE POS VEC AT TGD	ORB INS GUID	FT			89461	
RT(X)	V90H3781CA	X-M50 OF POSITION TARGET VECTOR	ORB INS GUID TLM	FT				
RT(Y)	V90H3782CA	Y-M50 OF POSITION TARGET VECTOR	ORB INS GUID TLM	FT				
RT(Z)	V90H3783CA	Z-M50 OF POSITION TARGET VECTOR	ORB INS GUID TLM	FT				
R_INIT(X)	V90H8508CE	X-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT			89461	
R_INIT(Y)	V90H8509CE	Y-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT			89461	
R_INIT(Z)	V90H8510CE	Z-COMP SHUTTLE POS VECTR AT T_INIT	ASC PREC PRED	FT			89461	
S_MODE	V94J3779C	GUIDANCE MODE INDICATOR	DL FMT 21/1 ORB INS GUID		HXS		93017G	*
S_OPS3_TGT_ROY	V94X3911X	AOA OMS-2 TARGETING COMPLETE FLAG	XXXXX MNVR DISP		BD			
TB_ENABLE	V94X3826XA	TIME BASE TIME INITIATOR FLAG	MSC TLM				92740D	
TGD	V94W3938CA	TIME ASSOCIATED WITH RGD,VGD	ORB INS GUID	S				
TGT_HA	V94H3798CA	TARGET APOGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
TGT_HP	V94H3799CA	TARGET PERIGEE ALTITUDE	XXXXX MNVR DISP	NM			92354	
THETA_DISP	V93U6969CC	TGT INPLN DNRNG ANG FROM LANH	DL FMT 21/A XXXXX MNVR DISP	DEG			93017G	*
THETA_LSS	V94U3808C	LNCH SITE TO OMS1 TIG CNTRL ANGLE	AOA/ATO TGT	RAD				
TIG	V94W3790CA	TIME OF IGNITION	DL FMT 21/A MSC ORB INS GUID	S			93017G	*
TIG_DAY	V93W6947CD	TIG(DAYS)	XXXXX MNVR DISP	DAYS				
TIG_HR	V93W6944CD	TIG(HOURS)	XXXXX MNVR DISP	HRS				
TIG_MIN	V93W6945CD	TIG(MIN)	XXXXX MNVR DISP	MIN				
TIG_MINUS5_FLAG	V94X3813XA	ENGINE IGNITION MINUS 5 SEC FLAG	XXXXX MNVR DISP					
TIG_SEC	V93W6946CD	TIG(SEC)	XXXXX MNVR DISP	S				
TTG	V90W2638CA	DISPLAY PREBURN MNVR TIME TO GO	XXXXX MNVR DISP	S	SPL		92510E	
TTG_FLAG	V90X2639XA	TTG DISPLAY INTENSITY FLAG	XXXXX MNVR DISP		BD		92510E	
TTX_FLAG_DISP	V94J4098CA	TIME TO XXXXX DISPLAY FIELD IND	XXXXX MNVR DISP					
TT_X_DISP	V94W3796CA	TIME TO NEXT APSIS/FREE FALL	DL FMT 21/1 XXXXX MNVR DISP	S			93017G	*

TABLE 4.7.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
TVR_ROLL	V93H6936CE	ROLL ANGLE	XXXXX MNVR DISP	DEG				
T_FINAL	V90W8506CE	TIME AT WHICH STATE IS DESIRED	ASC PREC PRED	S				
T_INIT/T_NAV, TGD	V90W8512CE	TIME AT BEGINNING OF PRED	ASC PREC PRED	S				
VEH_PITCH	V93U6909CC	PITCH ANGLE IN ADI INERTIAL COORD	DL FMT 21/A	DEG			93017G	*
VEH_ROLL	V93U6910CC	ROLL ANGLE IN ADI INERTIAL COORD	XXXXX MNVR DISP DL FMT 21/A	DEG			93017G	*
VEH_YAW	V93U6911CC	YAW ANGLE IN ADI INERTIAL COORD	XXXXX MNVR DISP DL FMT 21/A	DEG			93017G	*
VGD(X)	V94H3935CA	X-COMP OF GUIDANCE VEL VEC AT TGD	ORB INS GUID	FT/S			89461	
VGD(Y)	V94H3936CA	Y-COMP OF GUIDANCE VEL VEC AT TGD	ORB INS GUID	FT/S			89461	
VGD(Z)	V94H3937CA	Z-COMP OF GUIDANCE VEL VEC AT TGD	ORB INS GUID	FT/S			89461	
VGO(X)	V94L3804CA	X-EXTERNAL DEL V TARGET VECTOR	ORB INS GUID TLM	FT/S				
VGO(Y)	V94L3805CA	Y-EXTERNAL DEL V TARGET VECTOR	ORB INS GUID TLM	FT/S				
VGO(Z)	V94L3806CA	Z-EXTERNAL DEL V TARGET VECTOR	ORB INS GUID TLM	FT/S				
VGO_DISP(X)	V94U3800CA	X-COMP OF VGO OF MNVR-BODY COORD	DL FMT 21/A	FT/S			93017G	*
VGO_DISP(Y)	V94U3801CA	Y-COMP OF VGO OF MNVR-BODY COORD	XXXXX MNVR DISP DL FMT 21/A	FT/S			93017G	*
VGO_DISP(Z)	V94U3802CA	Z-COMP OF VGO OF MNVR-BODY COORD	XXXXX MNVR DISP DL FMT 21/A	FT/S			93017G	*
VGO_LVLH(X)	V94L3945CA	PEG 4 LVLH X-COMP OF VGO	XXXXX MNVR DISP DL FMT 21/1	FT/S			93017G	*
VGO_LVLH(Y)	V94L3946CA	PEG 4 LVLH Y-COMP OF VGO	XXXXX MNVR DISP DL FMT 21/1	FT/S			93017G	*
VGO_LVLH(Z)	V94L3947CA	PEG 4 LVLH Z-COMP OF VGO	XXXXX MNVR DISP DL FMT 21/1	FT/S			93017G	*
VSP(X)	V94H3940CA	X-COMP OF PREV ACCUM IMU VEL	ORB INS GUID	FT/S				
VSP(Y)	V94H3941CA	Y-COMP OF PREV ACCUM IMU VEL	ORB INS GUID	FT/S				
VSP(Z)	V94H3942CA	Z-COMP OF PREV ACCUM IMU VEL	ORB INS GUID	FT/S				
V_INIT(X)	V90L8513CE	X-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S			89461	
V_INIT(Y)	V90L8514CE	Y-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S			89461	
V_INIT(Z)	V90L8515CE	Z-COMP SHUTTLE VEL VECTR AT T_INIT	ASC PREC PRED	FT/S			89461	
WT_DISP	V93G6940CB	VEHICLE WEIGHT	ORB/RND NAV SEQ	LBS				
X_FLAG	V90X0414XE	VALID ANGLE COMP FLAG	XXXXX MNVR DISP		BD		90763E	
	V94M3042PA	CGZB_MNVR_DISP_FLAG1	DL FMT 21/A				93017G	*

TABLE 4.7.10-2. OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT MANEUVER DISPLAY PROCESSING (G4.210)

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 4.7.10-3. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
C1_OMS(1)	V97U4326C	FT/SEC	F	S	M	C	G4.210	00	ZF2	90243C	
C1_OMS(2)	V97U4327C	FT/SEC	F	S	M	C	G4.210	00	ZF2	90243C	
C2_OMS(1)	V97U4342C	ND	F	S	M	C	G4.210	00	ZF2	90243C	
C2_OMS(2)	V97U4343C	ND	F	S	M	C	G4.210	00	ZF2	90243C	
DTIG_OMS(1)	V97U4367C	SEC	F	S	M	C	G4.210	00	A3N	DC1275A	
DTIG_OMS(2)	V97U4368C	SEC	F	S	M	C	G4.210	00	A3N	DC1275A	
EF_PLANE_SW	V99U7441C	ND	D		M	C	G4.19 G4.2 G4.20 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
HTGT_OMS(1)	V97U4411C	FT	F	S	M	C	G4.210	00	A3N	DC1275A	
HTGT_OMS(2)	V97U4412C	FT	F	S	M	C	G4.210	00	A3N	DC1275A	
IYD(1)	V97U4413C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
IYD(2)	V97U4414C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
IYD(3)	V97U4415C	ND	F	D	M	C	G4.19 G4.2 G4.210 G4.226 G4.3 G5.26	00	A2N	93090E	
IYD_OMS(1)	V97U4855C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
IYD_OMS(2)	V97U4856C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
IYD_OMS(3)	V97U4857C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
IYD_OMS(4)	V97U4858C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
IYD_OMS(5)	V97U4859C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
IYD_OMS(6)	V97U4860C	ND	F	D	M	C	G4.210	00	A2N	DC0860	
KLAMDZX	V97U4423C	ND	F	S	D	C	G4.13 G4.209 G4.210 G4.211 G4.3	00	ZF1	90243C	
MASS_ORB	V97U4435C	SLUGS	F	S	M	C	G4.13 G4.210	00	AMC	DC2248	
MBO_MIN(1)	V97U4861C	SLUGS	F	S	M	C	G4.210	00	AMC	DC2248	

TABLE 4.7.10-3. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
MBO_MIN(2)	V97U4862C	SLUGS	F	S	M	C	G4.210	00	AMC	DC2248	
THETA_OMS(1)	V97U4803C	RAD	F	S	M	C	G4.210	00	A3N	DC1275A	
THETA_OMS(2)	V97U4804C	RAD	F	S	M	C	G4.210	00	A3N	DC1275A	
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 4.7.10-4. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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	
EPSTGO PEG INHIBIT STEERING OUTPUT	V97U4381C	00	+4.0	E-02 ND	F	S	C	G4.2 G4.210 G4.3 G4.4	59955	
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
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	

TABLE 4.7.10-4. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01	SLUGS/SEC	F	S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01	SLUGS/SEC	F	S	C G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
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	+5.2100000 +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	

TABLE 4.7.10-4. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
PHIDOT_MAX MAXIMUM TURNING RATE	V97U9003C	00	+3.5	E-02	RAD/SEC	F	S	C G4.2 G4.210 G4.3 G4.4	90329C	
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_ASCENT(1)	V97U2214CA	00	+1.0	E+00	ND	F	S	C G4.210 G4.226 G4.3	89688B	
Q_M50_INRTL_ASCENT(2)	V97U2215CA	00	+0.0	E+00	ND	F	S	C G4.210 G4.226 G4.3	89688B	
Q_M50_INRTL_ASCENT(3)	V97U2216CA	00	+0.0	E+00	ND	F	S	C G4.210 G4.226 G4.3	89688B	
Q_M50_INRTL_ASCENT(4)	V97U2217CA	00	+0.0	E+00	ND	F	S	C G4.210 G4.226 G4.3	89688B	
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	
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	

TABLE 4.7.10-4. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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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NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.7.10-5. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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 4.7.10-5. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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 4.7.10-5. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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 4.7.10-5. ASCENT MANEUVER DISPLAY PROCESSING (G4.210) 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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4.8 GENERAL GUIDANCE AND TARGETING TASKS

This section describes the detailed requirements for several general guidance and targeting tasks which may be used to support more than one guidance and targeting function. These tasks, and the principal functions which they support, are as follows:

1. PEG task (PEG TSK): AS 2STG GUID, ORB INS GUID, AOA/ATO TGT, ASC MNVR DIP, PW RTLS GUID
2. Acceleration–mass update task (ACC–MASS UPD TSK): AS 2STG GUID, ORB INS GUID, PW RTLS GUID, PW CONT GUID
3. G–limiting task (G–LIM TSK): AS 2STG GUID, PW RTLS GUID
4. Linear terminal velocity constraint task (LTVCON TSK): ORB INS GUID, AOA/ATO TGT, ASC MNVR DIP
5. MPS guidance cutoff task (MPS GUID C/O TSK): AS 2STG GUID, PW RTLS GUID
6. H– θ –to–M50 target task (H– θ –M50 TGT TSK): AOA/ATO TGT, ASC MNVR DIP
7. Thrust parameters task (THRST PRM TSK): AS 2STG GUID, PW RTLS GUID, ORB INS GUID, AOA/ATO TGT, ASC MNVR DIP, PW CONT GUID
8. PFG input task (PFG INP TSK): AS 2STG GUID, ORB INS GUID, PW RTLS GUID, PW CONT GUID
9. SSME–out safing task (SSME–OUT SAF TSK): AS 1STG GUID, AS 2STG GUID, PW RTLS GUID
10. Commanded body attitude task (CMD BDY ATT TSK): ORB INS GUID, ASC MNVR DIP
11. RTLS/TAL Target Selection Task (RTLS/TAL TGT SEL TSK): AS 2STG GUID, PW RTLS GUID
12. RTLS Contingency abort task (RTLS CONT ABT TSK): PW RTLS GUID, PW CONT GUID, CONT 3E/O GUID

4.8.1 PEG Task (PEG TSK)

PEG is a general-purpose guidance task which computes the reference thrust vector, desired thrust turning rate vector, reference thrust vector time, and time-to-go (TGO) to thrust termination for all explicitly guided Shuttle exoatmospheric maneuvers. It is used by several guidance principal functions which control the proper inputs and interfaces to meet maneuver objectives.

The ascent PEG task consists of a set of guidance modes which are designed to satisfy all currently defined ascent Shuttle powered flight maneuver guidance requirements. These modes are defined as follows:

1. Standard Ascent. This mode is intended for use during the second-stage ascent phase. The target conditions are specified preflight and defined by a desired terminal velocity, flightpath angle, radius, inclination, and ascending node. The inclination and node constraints are implicitly specified by a unit vector normal to the desired orbital plane. Thus, all components of the terminal state are specified except the downrange component of position which is computed so that the velocity-to-be-gained (\overline{VGO}), or equivalently propellant usage, is minimized.
2. Linear Terminal Velocity Constraint. This mode is intended for use in maneuvers in which the cutoff velocity is constrained so 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 mode is applicable to the nominal orbit insertion maneuvers, the AOA OMS maneuvers, and the ATO OMS maneuvers. Note that since the target position vectors for the nominal orbit insertion, AOA OMS-1, and ATO OMS maneuvers are normally desired apsis vectors, the intercept and slope constants for these maneuvers are normally input as zero.
3. External Delta-V. This mode is designed to guide the vehicle through a constant inertial 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 (\overline{VGO}) vector. This mode will normally be used for on-orbit maneuvers or when accuracy in achieving terminal conditions is not of prime concern. No corrections are made for misses in desired terminal conditions.
4. Return-to-Launch-Site. This mode is intended for use during the ascent if it has been determined that the abort mode region is an RTLS and an abort is required for various reasons; e.g., SSME failure. The target conditions are:
 - a. A preflight specified radius
 - b. A desired terminal velocity that is a function of range
 - c. A desired terminal flight path angle that is a function of the terminal vertical altitude
 - d. A desired terminal mass
 - e. A burnout flight heading such that the aim point vector is contained in the burnout plane. The burnout heading is specified by a unit vector normal to the plane defined by the burnout position vector and aim point vector.

Shuttle ascent and descent abort mission design constraints, as well as Shuttle vehicle constraints, impact the design of the ascent PEG task. In particular, these constraints are the SSME G-limiting constraints, the continuous intact-abort constraint, the AOA-preferred abort mode constraint, and the RTLS final mass constraint.

The G-limiting constraint implies that all nominal SSME burns must have at least two thrust phases—one constant thrust and one constant acceleration. This adds complexity to the time-to-go (TGO) and thrust integral calculations to account for the two phases.

To satisfy the continuous intact-abort constraint, the abort-critical missions require two constant SSME thrust phases prior to the G-limiting (constant acceleration) phase. For the first phase three SSME's are assumed and for the second phase only two are assumed. This adds complexity to the TGO calculations to account for the additional constant thrust phase.

The RTLS final mass constraint requires that propellants remaining in the ET at RTLS MECO be minimal.

The subtasks necessary to perform the ascent PEG guidance modes consist of a related group of calculations which may be unique to a particular guidance mode or may be required by two or more of the guidance modes. Therefore, the detailed requirements (Part A) describe each subtask independently of the applicability and order in which these subtasks are used to perform a guidance mode. The processing requirements (Part C) supply information regarding the necessary subtasks required for particular guidance modes in the correct order of solution. The functional flow for the PEG task is shown in Figure 4.8.1-1.

A. Detailed Requirements.

1. Position Magnitude Subtask. The magnitude of the current position vector is calculated to be used later in the PEG calculations.

$$RMAG = ABVAL(\overline{RGD})$$

- 2a. RTLS PPD Targets Subtask. The desired mass and flightpath angle at the start of PPD are selected as functions of the active SSME configuration. The desired mass and flightpath angle are set on the first RTLS pass and on every guidance cycle following, while $TGO > TGO_IA$. The desired mass is set as $MBO = MBOD_{N_SSME-1}$, and the desired flight path angle is $GAMD = GAM_{LL}$.
- 2b. VGO-Desired Subtask. The velocity to be gained for RTLS must be constrained to be consistent with the desired terminal mass, MBO. The magnitude of the desired VGO is $VGOD = VEX \text{ LOG}(M/MBO)$, where M is current mass and VEX is the equivalent exhaust velocity.
3. VGO Update Subtask. The purpose of this subtask is to update the velocity-to-be-gained, \overline{VGO} , as well as the phase counter, KPHASE, and the associated variables required by the TGO and thrust integral calculations.

First, the \overline{VGO} is updated by decrementing it by the sensed velocity change that has occurred since the last update calculation. This is accomplished by the following equation:

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

where \overline{DVS} is the current sensed velocity change, and \overline{VGO} is the current estimate of velocity-to-be-gained.

Next, if the burn time of the current guidance phase has elapsed, that is, if $TB_{KPHASE} - (TGD - TPRIME) \leq 0$ and if $KPHASE$ is less than N , then the guidance phase counter, $KPHASE$, must be incremented. Also, the current guidance phase burn time, TB_{KPHASE} , and the accumulated burn time for this guidance phase, $TGOA_{KPHASE}$, must be reset to zero as follows:

$$TB_{KPHASE} = 0$$

$$TGOA_{KPHASE} = 0$$

$$KPHASE = KPHASE + 1$$

Lastly, the value of current time, TGD , must be saved for the next pass through this subtask as follows:

$$TPRIME = TGD$$

4. TGO subtask. The purpose of this subtask is to calculate the total time-to-go until the end of the maneuver TGO , and the intermediate time-to-go for each guidance phase for use in the thrust integrals. The TGO until the end of the maneuver is obtained by computing the burn time (TB) for each remaining guidance phase and then adding these computed times. For each guidance phase, TB is either computed as the time remaining until a specified time, such as $TFAIL$; or until constant acceleration, AL , is achieved; or as a function of the computed first integral of thrust acceleration for that guidance phase, LA . In guidance phases where TB is a function of LA , LA is expressed as a function of the remaining \overline{VGO} . Therefore, it is necessary to compute LA for each guidance phase to determine the remaining \overline{VGO} for succeeding guidance phases.

The TGO parameter is a function of the current \overline{VGO} , the equivalent exhaust velocity of the thrusting engines (VEX), and the current estimated acceleration (ATR). The first calculations for TGO are as follows:

- a. The calculation of the magnitude of the \overline{VGO} vector:

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

- b. The calculation of the mass-to-mass flow rate ratio for the current phase:

$$TAU_{KPHASE} = VEX/ATR$$

- c. The first element of the equivalent exhaust velocity array is set:

$$VEXA_{KPHASE} = VEX$$

The elements of this equivalent exhaust velocity array are required by the thrust integrals subtask. If the TGO is being computed for an SSME maneuver, which may be distinguished by N_{SSME} not equal to zero, then Subtasks 1 and 3 must be performed; otherwise, Subtasks 2 and 3 must be performed.

- (1) For an SSME maneuver, the last guidance phase is assumed to be constant acceleration and the other guidance phases are constant thrust.

If the current guidance phase is the first of two successive constant thrust phases (KPHASE = 1 and N = 3), the burn time of the first guidance phase is determined as the time remaining until TFAIL

$$TB_1 = TFAIL - TGD$$

where TGD is the current guidance time.

The next calculation required is for the thrust integral, LA, for this guidance phase,

$$LA_1 = -VEX (\text{LOG}(1 - TB_1/TAU_1))$$

where LOG is a functional representation of the natural logarithm of the expression within the inner parentheses.

In addition to TB_1 and LA_1 , the initial mass-to-mass flow rate ratio for the second constant thrust guidance phase, TAU_2 , is required. Assuming that the three SSME's are thrusting prior to the time TFAIL and that one SSME will fail at TFAIL, the mass-to-mass flow rate ratio for the second constant thrust guidance phase is:

$$TAU_2 = (K_CMD/KMAX) (N_SSME/2) (TAU_1 - TB_1)$$

Also, the second element of the equivalent exhaust velocity array is required:

$$VEXA_2 = VEX$$

Although a constant acceleration is assumed for the third thrust phase, it is sometimes possible to achieve the maneuver completion before the G-limiting (constant acceleration) constraint is encountered. Therefore, to ensure that TGO and, hence, guidance prediction are compatible with the actual vehicle performance, it is necessary to provide logic to account for this possibility. This is done by introducing a parameter, LREM, which is the sum of the thrust integrals LA_{N-1} and LA_N for the last two guidance phases. Specifically, whenever KPHASE = 1 and N = 3, the remaining VGO is computed as follows

$$LREM = VGOMAG - LA_1$$

Otherwise:

$$LREM = VGOMAG$$

For the next to last guidance phase, TB is a function of when the constant acceleration, AL, for G-limiting will be reached. This TB is computed by using the following equation

$$TB_{N-1} = TAU_1 - VEX/AL$$

where I = N-1 for KPHASE < N and I = N for KPHASE = N. Since this equation is used for all values of KPHASE, logic to specify the value of I is necessary.

Whenever TB_{N-1} is less than or equal to a small positive constant, ETB, then the constant acceleration guidance phase has been reached. Therefore, to prevent computational problems, the burn time TB_{N-1} and the integral LA_{N-1} are set to zero. KPHASE is set to N, and the burn time $TGOA_{N-1}$ is set to zero. However, if TB_{N-1} exceeds the value of ETB, the following equation is used to compute the integral:

$$LA_{N-1} = -VEX \text{ LOG}(1 - TB_{N-1}/TAU_I)$$

If the acceleration falls below the minimum value required to maintain the acceleration limit AL during the constant acceleration guidance phase (when KPHASE = N), the value of TB_{N-1} will exceed ETB. This result indicates that the current guidance phase is no longer a constant acceleration phase. In this case ($TB_{N-1} > ETB$ and KPHASE = N), the values of KPHASE, and TAU_{N-1} must be reset as follows:

$$KPHASE = N-1$$

$$TAU_{N-1} = TAU_N$$

Next, a comparison between LREM and LA_{N-1} is required. A value of LREM less than or equal to that of LA_{N-1} implies that the G-limiting constant acceleration guidance phase will not be reached. Therefore, the following equations apply:

$$LA_N = 0$$

$$TB_N = 0$$

$$LA_{N-1} = LREM$$

$$TB_{N-1} = TAU_I (1 - \text{EXP}(-LA_{N-1}/VEX))$$

where $I = N-1$ whenever KPHASE < N, or $I = N$ whenever KPHASE = N. On the other hand, a value of LREM greater than LA_{N-1} implies that the G-limiting (constant acceleration) guidance phase will be reached. In this case, the thrust integral LA_N and the burn time TB_N of this phase are computed as follows:

$$LA_N = LREM - LA_{N-1}$$

$$TB_N = LA_N/AL$$

The computations continue at Subtask 3.

- (2) This subtask is performed during the ascent and abort orbit insertion maneuvers.

For these maneuvers only the OMS engines are used, so only one thrust phase is required (KPHASE = N = 1). The following calculations are required:

$$LA_N = VGOMAG$$

$$VRATIO = LA_N/(6 VEXA_N)$$

$$TB_N = 6 TAU_N VRATIO/(1. + 3 VRATIO + 3 VRATIO^2)$$

The computations continue at Subtask 3.

- (3) In addition to the burn time for each guidance phase, the thrust integrals calculations require the accumulated TB's at the end of each guidance phase. This is accomplished by summing the TB of each phase from phase I = KPHASE to N,

$$TGOA_I = \sum TB_{JJ}, \text{ where } JJ = \text{KPHASE to } I$$

The range-to-go calculations require the previous value of TGO (TGOP), as well as the current value. Therefore, the TGO calculations must save the previous value of TGO before assigning a new value to the TGO parameter. The equations are given in the proper order as follows:

$$TGOP = TGO$$

$$TGO = TGOA_N$$

The final computation required in the TGO subtask is the predicted thrust cutoff time. It is computed as follows:

$$TP = TGD + TGO$$

5. Thrust Integrals Subtask. The purpose of this subtask is to evaluate various time integrals of force over mass. These integrals are necessary to the prediction equations of PEG.

On each pass, initial values of the integrals must be set to zero.

$$L = 0 \quad S = 0 \quad JOL = 0$$

$$J = 0 \quad Q = 0$$

The thrust integrals are calculated for I = KPHASE to N, where KPHASE is the current phase indicator and N is the maximum number of thrust phases. Prior to the calculation of the integrals, TGOB is set to zero when I = 1; otherwise, it is set to TGOA_{I-1}. TGOA_{I-1} is the cumulative TGO until the end of the I-1 thrust phase.

If N_SSME ≠ 0 AND I < N, then the thrust integrals are calculated as follows:

$$SA_I = -LA_I (TAU_I - TB_I) + VEXA_I TB_I$$

$$QA_I = SA_I (TAU_I + TGOB) - 0.5 VEXA_I TB_I^2$$

Otherwise, the thrust integrals are calculated as follows:

$$SA_I = 0.5 LA_I TB_I$$

$$QA_I = SA_I (TGOB + TB_I/3)$$

Then, if N_SSME = 0, SA_I = SA_I (1. - VRATIO)

In these equations, TAU_I is defined to be the ratio of exhaust velocity for the I th phase (VEXA_I) to thrust acceleration for the I th thrust phase. TB_I is defined to be the TB for the I th thrust phase.

The required integrals are summed over all thrust phases:

$$S = S + \text{SA}_I + L \text{ TB}_I$$

$$Q = Q + \text{QA}_I + J \text{ TB}_I$$

$$L = L + \text{LA}_I$$

$$J = J + \text{LA}_I \text{ TGOA}_I - \text{SA}_I$$

If L is not equal to zero, then the quantity JOL is calculated as $\text{JOL} = J/L$. If $L = 0$, then PEG is exited.

The quantity $(Q - S \text{ JOL})$ is used in several equations in other PEG subtasks. Therefore, for computation purposes, the following quantity will be defined here:

$$\text{QPRIME} = Q - S \text{ JOL}$$

The final computation required of the thrust integrals is the time associated with the reference thrust vector expressed in GMT seconds:

$$\text{TLAM} = \text{TGD} + \text{JOL}$$

6. Reference Thrust Vector Subtask. The purpose of this subtask is to determine a reference thrust vector, LAM , for all guidance modes. This vector is a unit vector in the direction of VGO . In a computational flow, VGO will have been defined previously. The reference thrust vector is computed by setting $\text{LAM} = \text{VGO}/\text{VGOMAG}$, provided that $\text{VGOMAG} \neq 0$. If VGOMAG is zero, then PEG is to be exited.
7. Range-to-Go Subtask. The purpose of this subtask is to compute the position-to-be-gained vector, RGO . To determine RGO , it is necessary to estimate the second integral of gravitational acceleration, RGRAV over the powered trajectory. The current value is estimated from the previously determined value (last cycle value) as follows:

$$\text{RGRAV} = (\text{TGO}/\text{TGOP})^2 \text{RGRAV}$$

where TGO is the current TGO and TGOP is the TGO from the previous guidance cycle.

Next, RGO is determined on the basis of the difference between the desired position, RD specified in the previous cycle, and a corresponding position on the current coasting trajectory ($\text{RGD} + (\text{VGD})\text{TGO} + \text{RGRAV}$), where VGD is the current velocity vector:

$$\text{RGO} = \text{RD} - (\text{RGD} + \text{VGD} \text{ TGO} + \text{RGRAV}) + \text{RBIAS}$$

where RBIAS is a bias vector that compensates for the difference between RGO and RTHRUST , computed in the burnout state vector prediction subtask.

Next, if the guidance mode is RTLS (SMODE = 5), the unit normal which defines the desired crossrange component of the position-to-be-gained is computed and saved.

If SMODE = 5, then

$$\bar{IY} = \text{UNIT}(\bar{LAM} \times \bar{IX})$$

$$\bar{IY_TVR} = \bar{IY}$$

and if $\dot{SALT} = \text{ON}$, $\bar{OMEGA} = \text{LAMDY}(\bar{LAM} \times \bar{IY})$.

Next, an RGO vector to be used for unconstrained terminal position components is computed as follows:

$$\bar{RGOPRIME} = \text{QPRIME}(\bar{OMEGA} \times \bar{LAM}) + S \bar{LAM}$$

During each cycle through this subtask, it is required to monitor the status of the altitude constraint switch, \dot{SALT} . If \dot{SALT} is ON, the radial component of the position-to-be-gained, RGOX, is computed as the projection of \bar{RGO} onto the unit vector of the desired position:

$$\text{RGOX} = \bar{RGO} \cdot \bar{IX}$$

However, if \dot{SALT} is OFF, then altitude is unconstrained and RGOX is computed by the following equation:

$$\text{RGOX} = \bar{RGOPRIME} \cdot \bar{IX}$$

Likewise on each cycle, it is required to monitor the status of the orbit plane constraint switch, \dot{SPLANE} . If \dot{SPLANE} is ON, the cross-range component of position-to-be-gained, RGOY, is computed as follows:

$$\text{RGOY} = \bar{RGO} \cdot \bar{IY}$$

However, if \dot{SPLANE} is OFF, then the orbit plane is unconstrained and RGOY is computed as follows:

$$\text{RGOY} = \bar{RGOPRIME} \cdot \bar{IY}$$

The Z component (downrange component) of the \bar{RGO} vector is always unconstrained in the PEG formulation and is selected so that the dot product of the vectors \bar{LAM} and \bar{RGO} are equivalent to the integral S.

This selection is made by first computing the RGO projection in the X (radial) – Y (crossrange) plane by the equation:

$$\bar{RGOXY} = \text{RGOX} \bar{IX} + \text{RGOY} \bar{IY}$$

and then computing the downrange component of \bar{RGO} by the equation

$$\text{RGOZ} = (S - \bar{LAM} \cdot \bar{RGOXY}) / (\bar{LAM} \cdot \bar{IZ})$$

where $\bar{IZ} = \bar{IX} \times \bar{IY}$.

Then the \overline{RGO} vector is reconstructed by the following equation:

$$\overline{RGO} = \overline{RGOXY} + RGOZ \overline{I\bar{Z}}$$

8. Turning Rate Vector Subtask. The purpose of this subtask is the calculation of thrust turning rate, \overline{LAMD} , from \overline{RGO} and previously calculated integrals.

$$\overline{LAMD} = (\overline{RGO} - S \overline{LAM})/QPRIME$$

The magnitude of \overline{LAMD} is next calculated as follows:

$$LAMD\text{MAG} = \text{ABVAL}(\overline{LAMD})$$

If the flight mode is ascent, calculate the limit on LAMD MAG required to prevent a retrograde component of thrust:

If $\text{SMODE} \neq 4$,

$$\text{then } EL_LIMIT = \text{SQRT} (1/(\overline{LAM} \cdot \overline{IX})^2 - 1) / JOL$$

Otherwise $EL_LIMIT = PHIDOT_MAX$

Calculate the limit on LAMD MAG which limits the change in the tangent of the thrust angle from the previous cycle to 0.5:

$$DTA_LIMIT = (0.5 + PHI) / JOL$$

If LAMD MAG is either greater than $PHIDOT_MAX$ or DTA_LIMIT , set the guidance convergence flag OFF ($\text{SCONV} = \text{OFF}$), otherwise set it ON.

If LAMD MAG is greater than EL_LIMIT , set the low thrust to weight indicator ON ($\text{S_LOW_TW} = \text{ON}$), otherwise set it OFF.

The maximum value of LAMD MAG is computed as follows:

$$LAMD\text{MAX} = \text{MIN}(PHIDOT_MAX, DTA_LIMIT, EL_LIMIT)$$

If LAMD MAG is greater than LAMD MAX, then LAMD MAG is limited to LAMD MAX and the vectors \overline{LAMD} and \overline{RGO} are recomputed:

$$LAMD\text{MAG} = LAMD\text{MAX}$$

$$\overline{LAMD} = LAMD\text{MAG} \text{ UNIT} (\overline{LAMD})$$

$$\overline{RGO} = S \overline{LAM} + QPRIME \overline{LAMD}$$

Finally, a new value of PHI is computed for the next guidance pass:

$$PHI = JOL \text{ LAMD}\text{MAG}$$

9. Steering Inputs Update Subtask. The purpose of this subtask is to provide new steering inputs to the G/C steering interface principal function.

The steering parameters are updated only when the following conditions are met: $\dot{S}\dot{S}TEER = ON$ and the predicted cutoff time change is sufficiently small ($ABS(TP-TPREV) \leq EPSTGO$ TGO), or $S\dot{M}ODE = 7$. An additional requirement for the standard ascent mode ($S\dot{M}ODE = 1$) is that $MEXP(-VGOMAG/VEX) > MASS_MIN$. If these conditions are met, then:

- a. If the Droop Control task is not updating the steering parameters ($S_C\dot{D}ROOP = OFF$), or this is not standard ascent ($S\dot{M}ODE \neq 1$), then set:

$$\bar{L}AMC = \bar{L}AM$$

$$\bar{L}AMD_C = \bar{L}AMD$$

$$TLAMC = TLAM$$

$$\bar{I}ZC = \bar{I}Z$$

- b. If the flight mode is standard ascent ($S\dot{M}ODE = 1$), then provide a set of steering parameters to the Droop Control Task, and turn on the PEG steering updated flag for MSC:

$$\bar{L}AM_DRP = \bar{L}AM$$

$$\bar{L}AMD_DRP = \bar{L}AMD$$

$$TLAM_DRP = TLAM$$

$$P\dot{E}G_STEERING_UPD = ON$$

- c. Turn on the guidance ready flag:

$$S_G\dot{D}RDY = ON$$

These parameters are a time-homogeneous set.

Otherwise, if the conditions for updating the steering parameters are not met, and the flight mode is standard ascent ($S\dot{M}ODE = 1$), then turn off the PEG steering updated flag for MSC:

$$P\dot{E}G_STEERING_UPD = OFF$$

Whether the steering inputs are updated or not, set

$$TPREV = TP$$

The initial value of TPREV is set to zero.

10. Burnout State Vector Prediction Subtask. The purpose of this sub-task is to calculate the first integral of thrust and first and second time integrals of gravity as required in the prediction of the burnout state vector. The nature of the PEG design allows these integrals to be evaluated separately. The gravity integrals are functions of the thrust integrals, which implies that the thrust integrals must be computed first.

The thrust time integrals are obtained by calculating the thrust time integrals of each thrust phase and then summing up the contributions of each phase. The procedure is as follows:

- a. If the guidance mode is not ascent or RTLS, then $\overline{RTHRUST}$ is set equal to \overline{RGO} , $\overline{VTHRUST}$ is computed as follows, and Items b and c are not executed.

If $SMODE \neq 1$ and $SMODE \neq 5$, then

$$\overline{RTHRUST} = \overline{RGO}$$

$$\overline{VTHRUST} = (L + .5 QPRIME LAMDMAG^2) \overline{LAM}$$

Proceed to Item d.

- b. On each pass, initial values of the thrust time integrals must be set to zero

$$\overline{RTHRUST} = 0$$

$$\overline{VTHRUST} = 0$$

and the following parameters are computed

$$TI = -JOL$$

$$IF_MAG_I = \text{SQRT}(1 + LAMDMAG^2 TI^2)$$

- c. The following computations are executed for $I = KPHASE$ to JJ , where $JJ = N$ for LA_N nonzero and $JJ = (N-1)$ for $LA_N = 0$. N is the maximum number of thrust phases and LA_N was computed in the TGO subtask.

$$(1) \quad TF = TI + TB_I$$

$$IF_MAG_F = \text{SQRT}(1 + LAMDMAG^2 TF^2)$$

$$\overline{RTHRUST} = \overline{RTHRUST} + \overline{VTHRUST} TB_I$$

- (2) To prevent computational problems if the thrusting arc of the current thrust phase is small, the following computations are executed and Parts 3 through 6 are bypassed.

If $(LAMDMAG TB_I) < 0.090$, then

$$TFMEANSQ = \text{ABS}(TF^2 + TI TF + TI^2)/3$$

$$SMA_GAIN = 1/\text{SQRT}(1 + TFMEANSQ LAMDMAG^2)$$

$$\overline{RTHRUST} = \overline{RTHRUST} + SMA_GAIN (SA_I \overline{LAM} + (QA_I - SA_I) JOL) \overline{LAM}$$

$$\bar{V}THRUST = \bar{V}THRUST + SMA_GAIN (LA_1 \bar{L}AM + (LA_1 TGOA_1 - SA_1 - LA_1 JOL) \bar{L}AMD)$$

Proceed to Part 7.

- (3) If $I = N$ then the constants B and C are set equal to zero and A is set equal to the K-load AL. If I is not equal to N, then the constants A, B, and C are computed as follows:

$$C = 60(.5 TB_1^2 LA_1 + 3 TI SA_1 - 3(QA_1 - SA_1 JOL))/TB_1^5$$

$$B = 12(.5 TB_1 LA_1 - SA_1)/TB_1^3 - C (TF + TI)$$

$$A = LA_1/TB_1 - .5 B (TF + TI) - C (TB_1^2/3 + TI TF)$$

- (4) $Y_1 = \text{LOG}[ABS((TF LAMDMAG + IF_MAG_F)/(TI LAMDMAG + IF_MAG_I))]/LAMDMAG$

$$Y_2 = (TF^2 - TI^2)/(IF_MAG_I + IF_MAG_F)$$

- (5) The following two equations are executed for $X = 1$ to 3

$$Y_{(X+2)} = [IF_MAG_F (TF)^X - IF_MAG_I (TI)^X - X Y_X]/((X+1) LAMDMAG^2)$$

$$M_X = A Y_X + B Y_{(X+1)} + C Y_{(X+2)}$$

- (6) $R\bar{T}HRUST = R\bar{T}HRUST + (TF M_1 - M_2) \bar{L}AM + (TF M_2 - M_3) \bar{L}AMD$

$$\bar{V}THRUST = \bar{V}THRUST + M_1 \bar{L}AM + M_2 \bar{L}AMD$$

- (7) $TI = TF$

$$IF_MAG_I = IF_MAG_F$$

- d. $R\bar{B}IAS$ is computed

$$R\bar{B}IAS = R\bar{G}O - R\bar{T}HRUST$$

The technique used to approximate the gravity integrals is one that utilizes a coasting trajectory which remains close to the powered trajectory throughout the maneuver to predict the gravity effects. The integrals of gravity can be determined in a straightforward manner from a state extrapolation routine.

The equations for the initial state vector input to the state extrapolation routine are functions of the current guidance state vector, $R\bar{G}D$ and $V\bar{G}D$, and the thrust integrals, $R\bar{T}HRUST$ and $\bar{V}THRUST$. These equations are given as follows:

$$R\bar{I}NIT = R\bar{G}D - 0.1 R\bar{T}HRUST - \bar{V}THRUST TGO/30$$

$$V\bar{I}NIT = V\bar{G}D + (1.2 R\bar{T}HRUST/TGO) - 0.1 \bar{V}THRUST$$

A navigation principal function, ASC PREC PRED, will be utilized to determine the desired gravity integrals over the powered flight time, TGO. The inputs to the ASC PREC PRED are the initial position vector (\bar{R}_{INIT}), the initial velocity vector (\bar{V}_{INIT}), the initial time ($T_{\text{INIT}} = \text{TGD}$), the final time ($T_{\text{FINAL}} = \text{TP}$), the gravity model degree flag (GMD_PRED), the gravity model order flag (GMD_PRED) (both set to zero for central body force only), and the desired integration step size (DT_MAX). For this purpose, DT_MAX is selected as the middle value DT_LIMIT, DTMIN, and TGO/NSEG, where NSEG is desired number of integration segments.

$$\text{DT_MAX} = \text{MIDVAL}(\text{DT_LIMIT}, \text{DTMIN}, \text{TGO}/\text{NSEG})$$

The outputs of ASC PREC PRED used by PEG are the final position vector (\bar{R}_{FINAL}) and the final velocity vector (\bar{V}_{FINAL}).

After the extrapolated position and velocity vectors 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:

$$\bar{V}_{\text{GRAV}} = \bar{V}_{\text{FINAL}} - \bar{V}_{\text{INIT}}$$

$$\bar{R}_{\text{GRAV}} = \bar{R}_{\text{FINAL}} - \bar{R}_{\text{INIT}} - \bar{V}_{\text{INIT}} \text{TGO}$$

After integrals of both thrust and gravity have been computed, the predicted terminal state vector is then computed by the following equations:

$$\bar{R}_{\text{P}} = \bar{R}_{\text{GD}} + \bar{V}_{\text{GD}} \text{TGO} + \bar{R}_{\text{GRAV}} + \bar{R}_{\text{THRUST}}$$

$$\bar{V}_{\text{P}} = \bar{V}_{\text{GD}} + \bar{V}_{\text{GRAV}} + \bar{V}_{\text{THRUST}}$$

11. Desired Orbit Plane Correction Subtask. The purpose of this subtask is to constrain the position (\bar{R}_{D}) to be in a desired orbit plane whenever $\text{SP}_{\text{PLANE}} = \text{ON}$ or to allow the position to remain in the predicted cutoff orbit plane whenever $\text{SP}_{\text{PLANE}} = \text{OFF}$.

To constrain the position to lie in a desired orbit plane ($\text{SP}_{\text{PLANE}} = \text{ON}$), the following equation is required:

$$\bar{R}_{\text{D}} = \bar{R}_{\text{P}} - (\bar{R}_{\text{P}} \cdot \bar{I}_{\text{Y}}) \bar{I}_{\text{Y}}$$

where \bar{I}_{Y} is the unit vector normal to the desired orbit plane.

However, to allow the desired position to remain in the predicted cutoff plane ($\text{SP}_{\text{PLANE}} = \text{OFF}$), the following equation is required:

$$\bar{R}_{\text{D}} = \bar{R}_{\text{P}}$$

12. Desired Position Subtask for Standard Ascent and RTLS. The purpose of this subtask is to correct the magnitude of the burnout position vector when cutoff altitude is being controlled ($\text{S}_{\text{ALT}} = \text{ON}$) for the standard ascent mode and to compute a unit vector of the burnout position vector in either case. The unit vector is computed as follows:

$$\bar{I}_{\text{X}} = \text{UNIT}(\bar{R}_{\text{D}})$$

Whenever $\dot{S}ALT = ON$, the position vector is corrected by the following equation:

$$\overline{RD} = RDMAG \overline{IX}$$

where RDMAG is the desired magnitude of the burnout position vector.

Whenever $\dot{S}ALT = OFF$, the above \overline{RD} equation is not executed.

13. Desired Position Subtask for LTVCON Mode. There is no altitude constraint on the burnout position vector for this guidance mode. Therefore, the only calculation this subtask must perform is to compute the unit vector of the desired position:

$$\overline{IX} = \text{UNIT}(\overline{RD})$$

where \overline{RD} is determined by the desired orbit plane correction subtask (11).

14. Desired Plane Subtask for RTLS. The purpose of this subtask is to calculate the vector normal to the desired cutoff plane, \overline{IY} . This vector is used to specify the heading of the velocity vector at cutoff. First, the HAC center vector, \overline{RTEF} , is transformed from earth-fixed coordinates at the predicted time at the beginning of the powered pitchdown maneuver (TP), to M50 coordinates. The EARTH_FIXED_TO_M50_COORD task is a functional representation of the required transformation at a reference time.

$$\overline{RT} = \text{EARTH_FIXED_TO_M50_COORD}(TP) \overline{RTEF}$$

Next, the HAC center position vector is corrected by the radius of the alignment circle.

$$\overline{RT} = \overline{RT} - (\text{YSGNP_RADIUS_NEP} + \text{ET_BIAS}) \text{UNIT}(\overline{RT} \times \overline{RP})$$

The \overline{IY} vector is normal to the plane defined by the corrected aim point vector and predicted cutoff vector

$$\overline{IY} = \text{UNIT}(\overline{RT} \times \overline{RP})$$

In addition, if this is an RTLS abort (SMODE = 5) and the altitude constraint switch is ON ($\dot{S}ALT = ON$), then the following computations are executed to determine the desired out-of-plane thrust vector turning rate (LAMDY) to zero the PPD sideslip angle:

$$\text{LAMDYJOL} = [(\overline{LAM} + (\text{TGO} - \text{JOL}) \overline{LAM}) \cdot \overline{IZ}] \text{TAN}[-(\text{SIGN}(\overline{LAM} \cdot \overline{IY})) \\ (\text{ARCCOS}(\overline{IY_TVR} \cdot \overline{IY}))]$$

$$\text{LAMDY} = (\text{DTRD}/\text{TGO})(\text{LAMDYJOL}/(\text{TGO} - \text{JOL}))$$

where the vectors $\overline{IY_TVR}$ and \overline{IZ} were computed in the range-to-go subtask.

15. Desired Velocity Subtask for Standard Ascent. This subtask calculates the PEG standard ascent desired velocity vector, \overline{VD} from VDMAG, the desired velocity magnitude, and GAMD, the desired flight path angle.

- a. If a TAL is in progress ($\dot{T}AL_ABORT_DECLARED = ON$), VDMAG must be computed as a function of the surface range, RTHETA, between predicted cutoff and an aim point vector, \overline{RT} associated with the TAL landing site vector in earth-fixed coordinates, \overline{RTEF} ,

at the predicted cutoff time, TP. Additionally, the targeted orbit plane defined by \bar{IY} is set equal to the current orbit plane defined by the current position and velocity vectors. If the calculated crossrange based on the current TAL \bar{IY} and TAL aim point, $\bar{RT_AIM}$ exceeds the maximum allowed crossrange (CR_MAX), the TAL M50 aim point is adjusted so that the crossrange will equal CR_MAX, and a new \bar{IY} is defined so that the target plane passes through the new RT_AIM. Using the EARTH_FIXED_TO_M50_COORD task,

$$\bar{RT} = \text{EARTH_FIXED_TO_M50_COORD}(TP) \bar{RTEF}$$

The surface range is computed by

$$R\theta = \text{ABVAL}(\bar{RTEF}) \text{ARCCOS}[\bar{IX} \cdot \text{UNIT}(\bar{RT})]$$

VDMAG is a cubic function of this range defined by

$$\text{VDMAG} = A_8 + A_9 R\theta + A_{10} R\theta^2 + A_{11} R\theta^3$$

This value is then limited between a minimum, VD_TAL_MIN, and a maximum, VD_TAL_MAX

$$\text{VDMAG} = \text{MIDVAL}(\text{VD_TAL_MIN}, \text{VDMAG}, \text{VD_TAL_MAX})$$

Set $\dot{SPLANE} = \text{OFF}$ and calculate the time, measured from MECO, of closest approach to the TAL aim point, which is approximated by

$$T_{CA} = R\theta / \text{VDMAG}$$

The TAL M50 aim point at T_{CA} is calculated by

$$\bar{RT_AIM} = \text{EARTH_FIXED_TO_M50_COORD}(TP + T_{CA}) \bar{RTEF}$$

The current TAL \bar{IY} is calculated as follows

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

The current crossrange is

$$\text{CRNG_D} = \bar{RT_AIM} \cdot \bar{IY}$$

If the absolute value of CRNG_D is greater than CR_MAX, do the next three operations:

$$(1) \bar{IY} = \text{UNIT}(\bar{VP} \times \bar{RP})$$

Adjust the TAL aim point for the maximum allowed crossrange

$$(2) \bar{RT_AIM} = \bar{RT_AIM} - \bar{IY} \text{CR_MAX} \text{SGN}(\text{CRNG_D})$$

The new target \bar{IY} is then calculated by

$$(3) \bar{IY} = \text{UNIT}(\bar{RT_AIM} \times \bar{RP})$$

- b. If a TAL is not in progress ($\dot{TAL_ABORT_DECLARED} = \text{OFF}$) VDMAG and \bar{IY} remain at the value set previously from I-loads.

- c. The desired velocity vector is calculated from the following equation:

$$\overline{VD} = VDMAG [\overline{IX} \sin(GAMD) + \text{UNIT}(\overline{IX} \times \overline{IY}) \cos(GAMD)]$$

- d. Finally, if SPLANE = OFF, \overline{IY} is recomputed as follows:

$$\overline{IY} = \text{UNIT}(\overline{VD} \times \overline{RD})$$

16. Desired Velocity Subtask for the LTVCON Mode. The desired velocity subtask for this guidance mode employs the LTVCON task (Section 4.8.4) which solves for the required velocity at an initial position to intercept a target position so that a specified linear relationship between the terminal radial and horizontal velocity components is satisfied:

$$V_{\text{RADIAL}} = C1 + C2 V_{\text{HORIZONTAL}}$$

The initial position input to the LTVCON function is the desired cutoff position (\overline{RD}).

The targeting for the OMS ascent maneuvers places the target position vector in the predicted orbital plane at OMS ignition. However, the guidance logic for the LTVCON mode does not require the burnout orbit plane to be constrained. Therefore, the target position vector will be projected onto the predicted cutoff plane by the following equation:

$$\overline{RI} = \overline{RT} - (\overline{RT} \cdot \overline{IY}) \overline{IY}$$

where \overline{IY} is first computed as follows:

$$\overline{IY} = \text{UNIT}(\overline{VP} \times \overline{RP})$$

The vectors \overline{IY} and \overline{RI} are input to the LTVCON task and the outputs of the LTVCON task used by PEG are desired velocity (\overline{VD}), magnitude of desired cutoff position ($R\phi_MAG$), horizontal velocity at the target (VHI), and the resulting transfer angle ($THETA$) and its trigonometric sine (SIN_THETA).

Next, a scalar damping factor, RHOMAG, is required in the computation of \overline{VGO} (refer to VGO correction subtask). It is computed by the following equations:

$$DTCOAST = THETA/THETA_DOT$$

$$RHOMAG = 1/[1 + 0.75 TGO/DTCOAST]$$

\overline{IY} is then recomputed as follows:

$$\overline{IY} = \text{UNIT}(\overline{VD} \times \overline{RD})$$

Finally, the ideal turning rate of the \overline{LAM} vector is computed as follows:

$$\overline{OMEGA} = -WMAG \overline{IY}$$

17. Desired Velocity Subtask for RTLS. This subtask calculates the PEG RTLS desired velocity, \overline{VD} . The magnitude of this velocity vector is calculated as a function of the surface range between predicted cutoff and the aim point vectors. The heading of this vector is determined by the \overline{IY} previously calculated.

The surface range is calculated as follows:

$$RTHETA = \text{SGN}(\overline{IY} \cdot \overline{IY_SAVE}) \text{ABVAL}(\text{RTMAG } \overline{IX} - \overline{RT}) + D_ARC - X_NEP$$

where SGN produces +1, 0, -1 when $(\overline{IY} \cdot \overline{IY_SAVE})$ is positive, zero, or negative, respectively.

If RTHETA is less than a predetermined value (RNG_TURN_PRED), then the discrete $\dot{S}INIT$ is set to ON and the discrete $\dot{S}CONV$ is set to OFF. During the early portion of the fuel dissipation phase, it may not be possible to obtain a reasonable guidance solution because the Shuttle is too close to the specified landing site. Hence, a test is required to prevent PEG from attempting to solve for a solution when the surface range (RTHETA) is below a predetermined minimum value (RNG_TURN_PRED).

If $RTHETA < RNG_TURN_PRED$, then $\dot{S}INIT = ON$, $\dot{S}CONV = OFF$

The velocity magnitude is a linear function of range. One range velocity line is required for a two-engine ($N_SSME = 2$) RTLS and another for a three-engine ($N_SSME = 3$) RTLS. When an engine fails during RTLS, if TGO is greater than TGO_IA, a new target line will be selected.

If $TGO > TGO_IA$, then

$$IA = (2 N_SSME) - 2$$

If $N_SSME = 1$, then

$$IA = 2$$

Otherwise (if $TGO \leq TGO_IA$), IA retains its previous value. Then the desired velocity magnitude is computed as a function of the surface range and the selected target line:

$$VDMAG = A_{IA-1} + A_{IA} RTHETA$$

The desired relative velocity vector is

$$\overline{VD} = VDMAG [\overline{IX} \text{SIN}(GAMD) + \text{UNIT}(\overline{IX} \times \overline{IY}) \text{COS}(GAMD)]$$

Since the desired velocity from the above equation is earth-relative, the target is made inertial by adding a term earth rate (\overline{WE}) crossed into the desired position (\overline{RD}).

$$\overline{VD} = \overline{VD} + \overline{WE} \times \overline{RD}$$

Finally, \overline{IY} is recomputed as follows:

$$\overline{IY} = \text{UNIT}(\overline{VD} \times \overline{RD})$$

18. RHO Matrix Subtask for RTLS. The purpose of this subtask is to calculate a partial derivatives matrix that relates the change in \overline{VGO} ($D\overline{VGO}$) and throttle setting, K , to the velocity miss, \overline{VMISS} , and the characteristic velocity error, VGO_ERR . This matrix is required to minimize the number of convergence iterations for the RTLS flyback. The following calculations are made to form the RHO matrix.

- a. Calculate the matrix to transform elements to the guidance coordinate system and perform the transformation:

$$\overline{I\dot{Z}} = \overline{I\dot{X}} \times \overline{I\dot{Y}}$$

$$MI2G^* = \text{MATRIX}(\overline{I\dot{X}}, \overline{I\dot{Y}}, \overline{I\dot{Z}})$$

$$\overline{VMISS_G} = MI2G^* (\overline{V\dot{P}} - \overline{V\dot{D}})$$

$$\overline{L\dot{A}M_G} = MI2G^* \overline{L\dot{A}M}$$

- b. Calculate terminal acceleration and intermediate elements of the RHO matrix:

$$ATRF = \text{MIN}(\text{SCALAR}(\overline{A\dot{L}}, ATR \text{ EXP}(\overline{V\dot{G}O\text{MAG}}/\overline{V\dot{E}X})))$$

ATRF is limited to the value of the acceleration limit, $\overline{A\dot{L}}$; then compute

$$\overline{V\dot{G}RAV\dot{X}} = \overline{V\dot{G}RAV} \cdot \overline{I\dot{X}}$$

$$BETA1 = 1 + A_{IA} [TGO/2 + ((\overline{V\dot{G}D} + 0.5 \overline{V\dot{G}O}) \cdot \overline{I\dot{Z}}) \overline{L\dot{A}M_G_3}/ATRF]$$

$$BETA2 = 1 + \overline{V\dot{G}RAV\dot{X}} \overline{L\dot{A}M_G_1}/(ATRF \text{ TGO})$$

$$BETA3 = 1 + \overline{V\dot{D}MAG} \text{ TGO}/(2 \text{ RTHETA})$$

$$BETA4 = K/(\overline{V\dot{G}RAV\dot{X}} \overline{L\dot{A}M_G_1})$$

- c. Calculate the $\overline{RHO1}$ AND P_RHO vector elements and the desired throttle setting.

$$\overline{RHO1} = \text{VECTOR}(0, -\overline{L\dot{A}M_G_2}/BETA3, -\overline{L\dot{A}M_G_3}/BETA1)/\overline{L\dot{A}M_G_1}$$

$$P_RHO = BETA4 \text{ VECTOR}(\overline{L\dot{A}M_G_1}, \overline{L\dot{A}M_G_2} BETA2/BETA3, \overline{L\dot{A}M_G_3}/BETA1)$$

$$BETA5 = P_RHO \cdot \overline{VMISS_G}$$

$$KP = K$$

If $\dot{S}THROT = ON$, then

$$\overline{V\dot{G}O_ERR} = \overline{V\dot{G}O\text{MAG}} - \overline{V\dot{G}O\text{D}}$$

$$\overline{DELK} = BETA5 - BETA4 BETA2 \overline{V\dot{G}O_ERR}$$

$$\overline{DELK} = \text{SIGN}(\overline{DELK}) \text{ MIN}(2, \text{ABS}(\overline{DELK}))$$

$$K = \text{MIDVAL}(KMAX, KMIN, KP + \overline{DELK})$$

- d. Update the characteristic velocity error to be consistent with the throttle change applied.

$$\text{DELK} = K - \text{KP}$$

$$\text{VGO_ERR} = (\text{BETA5} - \text{DELK}) / (\text{BETA4} \text{ BETA2})$$

- e. Calculate the change in velocity-to-be-gained and transform it to the M50 system.

$$\overline{D\text{VGO}}_G = -\text{VECTOR}(\overline{\text{RHO}}1 \cdot \overline{\text{VMISS}}_G + \text{VGO_ERR}/\text{LAM}_G1, \\ \overline{\text{VMISS}}_G2/\text{BETA3}, \overline{\text{VMISS}}_G3/\text{BETA1})$$

$$\overline{D\text{VGO}} = \text{MI2G}^T \overline{D\text{VGO}}_G$$

19. VGO Correction Subtask. The purpose of this subtask is to calculate a miss in velocity, $\overline{\text{VMISS}}$, and a delta VGO vector ($\overline{D\text{VGO}}$), and to correct the VGO vector ($\overline{\text{VGO}}$). The velocity miss vector is computed as follows:

$$\overline{\text{VMISS}} = \overline{\text{VP}} - \overline{\text{VD}}$$

The delta VGO vector for all PEG modes except RTLS is computed as follows:

$$\overline{D\text{VGO}} = -\text{RHOMAG} \overline{\text{VMISS}}$$

For RTLS, it is computed in the RHO matrix subtask.

The VGO vector, $\overline{\text{VGO}}$, is corrected as follows:

$$\overline{\text{VGO}} = \overline{\text{VGO}} + \overline{D\text{VGO}}$$

In addition, if $\text{SMODE} = 4$, the component of $\overline{\text{VGO}}$ normal to the predicted cutoff plane must be corrected as follows:

- a. If the current vehicle mass (M) is less than or equal to the desired minimum burnout mass (MBO), then there is no propellant margin, and no additional out-of-plane thrusting should occur. Hence, proceed to Subtask 20.
- b. Compute the present out-of-plane component of $\overline{\text{VGO}}$, the inplane $\overline{\text{VGO}}$ vector, and the square of the magnitude of the in-plane $\overline{\text{VGO}}$ vector.

$$\overline{\text{VGOYP}} = \overline{\text{VGO}} \cdot \overline{\text{IY}}$$

$$\overline{\text{VGOXZ}} = \overline{\text{VGO}} - \overline{\text{VGOYP}} \overline{\text{IY}}$$

$$\overline{\text{VGOXZ_SQ}} = \overline{\text{VGOXZ}} \cdot \overline{\text{VGOXZ}}$$

- c. Compute the square of the required velocity change to deplete the propellant margin, based on current vehicle mass (M) and the desired minimum burnout mass (MBO).

$$\overline{\text{VGOMAX_SQ}} = (\text{VEX LOG}(M/MBO))^2$$

If $\overline{\text{VGOMAX_SQ}}$ is less than $\overline{\text{VGOXZ_SQ}}$, then set $\overline{\text{VGOMAX_SQ}}$ to $\overline{\text{VGOXZ_SQ}}$.

$$\overline{\text{VGOMAX_SQ}} = \overline{\text{VGOXZ_SQ}}$$

- d. Compute the square of the maximum allowable out-of-plane velocity component

$$VGOYMAX_SQ = VGOMAX_SQ - VGOXZ_SQ$$

- e. Estimate the velocity miss resulting from the difference between the desired and predicted orbital planes. If the major mode is 104, the velocity miss is defined as

$$VMISSY = VH1 (\bar{IY_DES} \cdot \bar{R1}) / (R\phi_MAG \sin_THETA)$$

If the major mode is 105

$$VMISSY = \bar{VD} \cdot \bar{IY_DES}$$

- f. Compute the magnitude of the desired out-of-plane velocity component.

$$VGOY = VGOYP - RHOMAG VMISSY$$

- g. If the square of VGOY is greater than VGOYMAX_SQ, then limit the magnitude of VGOY to that of VGOYMAX_SQ

If $(VGOY^2 > VGOYMAX_SQ)$, then

$$VGOY = \text{SIGN}(VGOY) \text{SQRT}(VGOYMAX_SQ)$$

- h. Correct \bar{VGO}

$$\bar{VGO} = \bar{VGOXZ} + VGOY \bar{IY}$$

- i. Update \bar{VMISS} so that it is consistent with the new \bar{VGO}

$$\bar{VMISS} = \bar{VMISS} + ((VGOYP - VGOY)/RHOMAG) \bar{IY}$$

20. Convergence Check Subtask. The purpose of this subtask is to determine if the \bar{VGO} is converged and to generate a flag ($\dot{S}CONV$) indicating whether or not \bar{VGO} is converged. This is accomplished by the following steps:

- a. Compute the magnitude of \bar{VGO} and the convergence criterion as follows:

$$VGOMAG = \text{ABVAL}(\bar{VGO})$$

$$EMISS = \text{KMISS} VGOMAG$$

- b. Determine whether or not \bar{VGO} is converged.

If $\text{ABVAL}(\bar{VMISS}) > (EMISS)$, then the guidance convergence flag ($\dot{S}CONV$) is set to OFF.

- c. If the initialization flag ($\dot{S}INIT$) is OFF and SMODE is equal to either 1 or 5, then the number of successive converged and unconverged PEG cycles is monitored by incrementing the counter SCOUNT as follows:

(1) Store the previous value of DSCOUNT (initialized to zero)

DSCOUNT_PREV = DSCOUNT

- (2) Determine the new value of DSCOUNT.

If $\dot{S}CONV$ is OFF, DSCOUNT = 1,

Otherwise DSCOUNT = -1

- (3) Update SCOUNT

If DSCOUNT = DSCOUNT_PREV, then

SCOUNT = MIDVAL(1,(SCOUNT + DSCOUNT),NMAX_CYCLES_UNCONV)

If (DSCOUNT is not equal DSCOUNT_PREV),

then SCOUNT = TCOUNT

- (4) If SCOUNT is equal to the K-load NMAX_CYCLES_UNCONV, then TCOUNT is set equal to NMAX_CYCLES_UNCONV and the flag \dot{S}_UNCONV is set to ON to cue the ADI PROC to stow the ADI error needles. If SCOUNT is equal to unity (1), then TCOUNT is set equal to 1 and the flag \dot{S}_UNCONV is set to OFF.

If SCOUNT = NMAX_CYCLES_UNCONV,

TCOUNT = NMAX_CYCLES_UNCONV, $\dot{S}_UNCONV = ON$

If SCOUNT = 1, TCOUNT = 1, $\dot{S}_UNCONV = OFF$

21. Throttle Constraint Release Subtask. When the burn time of the N-1 phase, TB_{N-1} , is \leq DTTHROT (a K-load) and $\dot{S}CONV = ON$, or if $TB_{N-1} < (DTTHROT - 10)$ and $\dot{S}INIT$ is OFF, then the throttle discrete is set to OFF ($\dot{S}THROT = OFF$) and the desired throttle setting is set equal to the rounded value of the current value of K:

$K = ROUND(K)$

22. Cutoff Position Constraint Release Subtask. For reasons of flight control stability near cutoff, there is a guidance requirement to release position constraints at a fixed input TGO (DTRD). Therefore, if either altitude ($\dot{S}ALT = ON$) or the orbital plane ($\dot{S}PLANE = ON$) is being constrained and if TGO is less than DTRD and VGO is converged ($\dot{S}CONV = ON$), the position constraints are released. If VGO is unconverged when TGO first becomes less than DTRD and remains unconverged on subsequent cycles, the position constraints will be released when TGO becomes less than DTRD-6 and the PEG initialization discrete ($\dot{S}INIT$) is OFF.

The position constraint release logic is as follows:

If ($\dot{S}ALT = ON$ or $\dot{S}PLANE = ON$)

and ((if either $\dot{S}CONV = ON$ and $TGO < DTRD$)

or ($TGO < DTRD - 6$ and $\dot{S}INIT = OFF$))

then proceed as follows:

$$\overline{\text{OMEGA}} = \overline{\text{LAM}} \times \overline{\text{LAMD}}$$

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

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

B. Interface Requirements. The input and output parameters and functional interfaces for the ascent PEG task are given in Tables 4.8.1-1 and 4.8.1-2. During OPS-9 and MM 101, the I-loaded vector $\overline{\text{IYD}}$ can be updated via uplink as part of the launch targeting data set (OP Code 0001111). Replacement of the original I-load vector with uplinked values will be transparent to the flight software.

C. Processing Requirements. In each cycle through the PEG calculations, the first operation is performing the position magnitude subtask (1). If the current cycle is the first pass through the PEG calculations, the initialization subtask described in the initialization requirements (Part D) must then be performed. However, if the current cycle is not the first pass, the VGO update subtask must be performed instead. The PEG processing must then proceed as described below. The applicable subsection number is shown in parentheses beside each required subtask.

The subtasks for the standard ascent mode (SMODE = 1) must be performed in the following order:

1. Position magnitude subtask (A-1).
2. Initialization subtask (D-1 and D-2; initial pass only, i.e., $\dot{\text{SINIT}} = \text{ON}$).
3. VGO update subtask (A-3, except for the initialization pass)
4. TGO subtask (A-4)
5. Thrust integrals subtask (A-5)
6. Reference thrust vector subtask (A-6)
7. Range-to-go subtask (A-7)
8. Turning rate vector subtask (A-8)
9. Steering inputs update subtask (A-9)
10. Burnout state vector prediction subtask (A-10)
11. Desired orbit plane correction subtask (A-11)
12. Desired position subtask for standard ascent and RTLS (A-12)
13. Desired velocity subtask for standard ascent (A-15)
14. VGO correction subtask (A-19)
15. Convergence check subtask (A-20)

16. Cutoff position constraint release subtask (A-22)

The subtasks for the linear terminal velocity constraint mode (SMODE = 4) must be performed in the following order:

1. Position magnitude subtask (A-1)
2. Initialization subtask (D-1 and D-3; initial pass only, i.e., (SINIT = ON)
3. VGO update subtask (A-3, except for the initialization pass)
4. TGO subtask (A-4)
5. Thrust integrals subtask (A-5)
6. Reference thrust vector subtask (A-6)
7. Range-to-go subtask (A-7)
8. Turning rate vector subtask (A-8)
9. Steering inputs update subtask (A-9)
10. Burnout state vector prediction subtask (A-10)
11. Desired orbit plane correction subtask (A-11)
12. Desired position subtask for the LTVCON mode (A-13)
13. Desired velocity subtask for the LTVCON mode (A-16)
14. VGO correction subtask (A-19)
15. Convergence check subtask (A-20)

The subtasks for the external delta-V mode (SMODE = 7) are performed in the following order:

1. Position magnitude subtask (A-1)
2. Initialization subtask (D-1 and D-4; initial pass only, i.e., (SINIT = ON)
3. VGO update subtask (A-3, except for the initialization pass)
4. TGO subtask (A-4)
5. Reference thrust vector subtask (A-6)
6. Steering inputs update subtask (A-9)

The subtasks for the RTLS mode (SMODE = 5) must be performed in the following order:

1. Position magnitude subtask (A-1)

- 2a. RTLS PPD targets (A-2a) (when $\dot{S}INIT = ON$ or $TGO > TGO_{IA}$)
- 2b. VGO desired subtask (A-2b)
3. Initialization subtask (D-1 and D-5; initial pass only, i.e., $\dot{S}INIT = ON$)
4. VGO updates subtask (A-3, except for the initialization pass)
5. TGO subtask (A-4)
6. Thrust integrals subtask (A-5)
7. Reference thrust vector subtask (A-6)
8. Range-to-go subtask (A-7)
9. Turning rate vector subtask (A-8)
10. Steering inputs update subtask (A-9)
11. Burnout state vector prediction subtask (A-10)
12. Desired orbit plane correction subtask (A-11)
13. Desired position subtask for standard ascent and RTLS (A-12)
14. Desired plane subtask for RTLS (A-14)
15. Desired velocity subtask for RTLS (A-17)
16. RHO matrix subtask for RTLS (A-18)
17. VGO correction subtask (A-19)
18. Convergence check subtask (A-20)
19. Throttle constraint release subtask (A-21)
20. Cutoff position constraint release subtask (A-22)

D. Initialization Requirements. The purpose of the guidance initialization subtask is to assign initial values to parameters used in the other PEG functional blocks. Most of these parameters such as TGO, KPHASE, etc., are independent of the PEG mode. Others, such as target position constraint switches, SALT and SPLANE, and desired cutoff vectors, \overline{RD} and \overline{IY} , are dependent upon the particular guidance mode. The following paragraphs specify the initialization subtask requirements for both mode-independent parameters and mode-dependent parameters:

1. Mode Independent. The following parameters are required to be initialized as indicated for all guidance modes:

$$KPHASE = 1$$

$$\overline{RBIAS} = 0$$

$$\text{PHI} = 0$$

$$\text{TPRIME} = \text{TGD}$$

$$\text{TGO} = 1$$

$$\overline{\text{OMEGA}} = 0$$

$$\text{B} = \text{EARTH_MU/RMAG}^3$$

$$\overline{\text{RGRAV}} = -0.5 \text{ B } \overline{\text{RGD}}$$

$$\text{S}\dot{\text{INIT}} = \text{OFF}$$

$$\text{TPREV} = 0$$

$$\text{O}\dot{\text{TREQ}} = \text{OFF}$$

2. Standard Ascent Guidance Mode (SMODE = 1). The burnout position constraints are enabled by the following operations:

$$\text{DSCOUNT} = 0$$

$$\text{TCOUNT} = 1$$

$$\text{SCOUNT} = 0$$

$$\text{S_UN}\dot{\text{CONV}} = \text{OFF}$$

$$\text{S}\dot{\text{PLANE}} = \text{ON}$$

$$\text{S}\dot{\text{ALT}} = \text{ON}$$

If trajectory lofting is desired (TFAIL is not zero), then TFAIL is converted from MET to GMT and the number of thrust phases is set to 3.

$$\text{TFAIL} = \text{TFAIL} + \text{T_GMTLO}; \text{N} = 3$$

Otherwise (TFAIL = 0) the number of thrust phases is set to 2, N = 2.

If the variable $\overline{\text{IY}}$ option is selected premission ($\text{S_I}\dot{\text{Y}} = \text{ON}$) and AOA/ATO targeting has already been performed ($\text{S_A}\dot{\text{BORT_CONTROL}} = \text{ON}$), a value for the desired orbit plane vector $\overline{\text{IY}}$ has already been determined by AOA/ATO targeting. Otherwise, the value of $\overline{\text{IY}}$ is calculated as follows: If an SSME failed ($\text{N_SSME} = 2$), and the engine fail velocity is prior to the velocity to end high Q engine-out yaw steering ($\text{V_ME_OUT} < \text{V_AZ_STOP}$), the desired orbit plane is set to the current plane. This prevents PEG from commanding yaw steering to the no-fail target orbit plane after first stage guidance has adjusted the fly out azimuth to improve abort performance. Otherwise, set the desired orbit plane based on the Earth fixed plane constraint.

If ($\text{N_SSME} = 2$) and $\text{V_ME_OUT} < \text{V_AZ_STOP}$, then

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

Otherwise, set the desired orbit plane base on the Earth fixed plane constraint as follows:

If ($\dot{\text{EF_PLANE_SW}} = \text{ON}$), then:

$$\bar{IY} = \text{EARTH_FIXED_TO_M50_COORD}(T_GMTLO) \bar{IYD}$$

else,

$$\bar{IY} = \dot{M}_NODE_ADJ \bar{IYD}$$

The standard ascent mode requires an initial estimate of \bar{VGO} .

Therefore, the following functions are performed to initialize the VGO vector:

- a. Initialize the predicted cutoff position and velocity and \bar{VGO} as follows:

$$\bar{RP} = \bar{RGD}$$

$$\bar{VP} = \bar{VGD}$$

$$\bar{VGO} = 0$$

- b. Perform the following subtasks for standard ascent:

- (1) Desired orbit plane correction subtask
- (2) Desired position subtask for standard ascent
- (3) Desired velocity subtask for standard ascent
- (4) VGO correction subtask
- (5) Convergence check subtask

3. Linear Terminal Velocity Constraint Mode (SMODE = 4). The guidance logic for the LTVCON mode does not require the burnout orbit plane to be constrained. The unit normal to the desired orbital plane is obtained as follows: If the plane constraint is earth-fixed ($\dot{\text{EF_PLANE_SW}} = \text{ON}$) then

$$\bar{IY_DES} = \text{EARTH_FIXED_TO_M50_COORD}(T_GMTLO) \bar{IYD}$$

else, rotate \bar{IYD} to adjust for nodal regression

$$\bar{IY_DES} = \dot{M}_NODE_ADJ \bar{IYD}$$

Furthermore, position constraint calculations are bypassed by setting the flags \dot{SPLANE} and \dot{SALT} to OFF.

A desired turning rate for the maneuver is computed as follows:

$$\text{THETA_DOT} = \text{SQRT}(B)$$

$$\text{WMAG} = \text{KLAMDZXZ THETA_DOT}$$

This mode also requires an initial estimate of $\overline{\text{VGO}}$. Therefore, the following calculations are performed to initialize the VGO vector for this mode:

- a. Initialize the predicted cutoff conditions and $\overline{\text{VGO}}$ as for the standard ascent mode:

$$\overline{\text{RP}} = \overline{\text{RGD}}, \overline{\text{VP}} = \overline{\text{VGD}}, \overline{\text{VGO}} = 0$$

- b. Perform the following subtasks for the LTVCON mode:

- (1) Desired orbit plane correction subtask
- (2) Desired position subtask for the LTVCON mode
- (3) Desired velocity subtask for the LTVCON mode

The initial value of the change in accumulated sensed velocity is set to zero.

$$\overline{\text{DVS}} = 0$$

4. External Delta-V Guidance Mode (SMODE = 7). For the external delta-V mode, the following functions must be performed:

- a. Initialize the thrust turning rate vector to zero:

$$\overline{\text{LAMD}} = 0$$

- b. Set the PEG convergence switch (SCONV) to ON.

5. RTLS Guidance Mode (SMODE = 5). The initial radial and out-of-plane directions must be established prior to construction of the $\overline{\text{VGO}}$ vector. The launch site vector is constructed in M50 coordinates by premultiplying the input earth-fixed vector by the earth-fixed-to-M50 transformation:

$$\overline{\text{RT}} = \text{EARTH_FIXED_TO_M50_COORD}(\text{TGD}) \overline{\text{RTEF}}$$

$$\text{RTMAG} = \text{ABVAL}(\overline{\text{RT}})$$

$$\overline{\text{IY}} = \text{UNIT}(\overline{\text{RT}} \times \overline{\text{RGD}})$$

$$\overline{\text{IY_SAVE}} = \overline{\text{IY}}$$

$$\overline{\text{IX}} = \text{UNIT}(\overline{\text{RGD}})$$

$$\text{DSCOUNT} = 0$$

$$\text{TCOUNT} = 1$$

$$\text{SCOUNT} = 0$$

$$\text{S_UNCONV} = \text{OFF}$$

The \overline{VGO} vector is then calculated as a function of the estimated burn time to deplete the propellant and the VGOD, which is consistent with the desired terminal mass.

$$V_{GOR} = B \text{ RMAG} ((M-MBO)/MDOT) (K_CMD/K) - \overline{VGD} \cdot \overline{IX}$$

$$V_{GOR} = \text{MIN}(V_{GOR}, V_{GOD})$$

$$\overline{VGO} = V_{GOR} \overline{IX} + \text{SQRT}(V_{GOD}^2 - V_{GOR}^2) (\overline{IX} \times \overline{IY})$$

The plane constraint is not required for RTLS since only the burnout heading is constrained. Therefore:

$$S\dot{P}LANE = \text{OFF}$$

The altitude constraint is required and $S\dot{A}LT = \text{ON}$.

An initial value of desired position must be available prior to executing the range-to-go subtask, therefore:

$$R\overline{D} = R\text{DMAG} \overline{IX}$$

Also the earth rate vector is used later in the desired velocity sub-task for RTLS, therefore:

$$\overline{WE} = \text{EARTH_RATE} \overline{EARTH_POLE}$$

The velocity target index LL is initialized to 1 in the BST GUID TSK (4.2.3). It is reset in the SSME-OUT SAF TSK (4.8.9) in the event of an SSME failure.

E. Supplemental Information. The PEG utilizes a modified linear tangent guidance algorithm. The associated vector equation which defines the commanded thrust vector as a function of time is:

$$\hat{U}_{fc} = \text{UNIT} \left(\hat{\lambda}_c + \dot{\lambda}_c (t - t_{\lambda c}) \right)$$

where $\hat{\lambda}_c$ is the reference thrust vector, $\dot{\lambda}_c$ is the reference thrust turning rate vector, t is the variable time, and $t_{\lambda c}$ is the time associated with $\hat{\lambda}_c$ and $\dot{\lambda}_c$. This equation will be utilized by the G/C Steer principal function. The inputs $\hat{\lambda}_c$, $\dot{\lambda}_c$, and $t_{\lambda c}$ will be supplied by the PEG.

In the flight computers, the guidance computations require two guidance minor cycles to complete, 160 msec each. To minimize transport lag between guidance and flight control, the steering output parameters, $\hat{\lambda}_c$, $\dot{\lambda}_c$, and $t_{\lambda c}$ are updated in the Steering Inputs Update Subtask, which is executed on the first guidance minor cycle. The updated steering parameters are based on the previous velocity-to-be-gained vector decremented by the current sensed velocity change vector. Furthermore, the flight control logic which uses the steering parameters executes once every 480 msec, and is synchronized to execute between the two guidance cycles. Thus, by not waiting until all guidance computations are complete to output the steering commands, the guidance/flight control transport lag is reduced by approximately 480 msec.

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An initial value is assumed to be I-loaded into the vector \overline{IYD} that identifies the desired orbital plane for PEG mode (SMODE) equal to 1. \overline{IYD} is then updated for the OMS maneuvers.

Table 4.8.1-1. Ascent Powered Explicit Guidance Task Inputs

Definition	Symbol	Source	Prec	Units
Specific force limit during SSME maneuvers	AL	K-LOAD, G-LIM TSK	SP	fps ²
Thrust acceleration estimate input to PEG	ATR	ASC GUID TSK, FUL DISS TSK, AOA ONORB TGT SEL TSK, OMS GUID TSK, FLYBK TSK, PRE-MAN DISP SUPT TSK	SP	fps ²
Maximum integration time step for gravity prediction	DT_LIMIT	AOA ONORB TGT SEL TSK, PRE-MAN DISP SUPT TSK, PFG INP TSK	SP	sec
Minimum integration time step for gravity prediction	DTMIN	K-LOAD	SP	sec
TGO remaining to release all position constraints	DTRD	K-LOAD	SP	sec
Change in accumulated sensed velocity from previous value	\overline{DVS}	PFG INP TSK	SP	fps
Earth gravitational constant	EARTH_MU	CONSTANT	DP	ft ³ /sec ²
PEG criterion for updating steering parameters	EPSTGO	K-LOAD	SP	ND
Minimum TB _{N-1} in computation of TGO	ETB	K-LOAD	SP	sec
Desired MECO flight path angle	GAMD	I-LOAD, GUID PRMT RINT TSK, ATO MECO TGT SEL TSK, UPLINK	SP	rad
Unit vector normal to desired trajectory plane in earth-fixed or M50 system	\overline{IYD}	I-LOAD, DISP INIT TSK	DP	ND
Unit vector normal to desired trajectory plane in M50 coordinates	\overline{IY}	GUID PRMT RINT TSK, ATO MECO TGT SEL TSK	DP	ND
EF plane constraint switch	EF_PLANE_SW	I-LOAD	D	N/A
Turning rate scale factor	KLAMDZX	I-LOAD	SP	ND
Decimal fraction for \overline{VGO} to be used for convergence criterion for VMISS	KMISS	K-LOAD	SP	ND
Total vehicle mass flow rate	MDOT	THRST PRM TSK	SP	slug/sec
One-engine and two-engine RTLS PPD relative velocity coefficients	A _{JJ} (JJ=1,2)	RTLS/TAL TGT SEL TSK	SP	fps or sec ⁻¹
Three-engine RTLS PPD relative velocity coefficients	A _{JJ} (JJ=3,4)	RTLS/TAL TGT SEL TSK	SP	fps or sec ⁻¹
Relative velocity magnitude at SSME failure time	V_ME_OUT	SSME-OUT SAF TSK	SP	fps

Table 4.8.1-1. Ascent Powered Explicit Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Velocity to end high q engine out yaw steering	V_AZ_STOP	I-LOAD	SP	fps
TAL MECO inertial velocity coefficient	A _{JJ} (JJ=8-11)	RTLS/TAL TGT SEL TSK	SP	fps, sec ⁻¹ , sec ⁻¹ ft ⁻¹ , or sec ⁻¹ ft ⁻²
Maximum throttle setting of SSME	KMAX	I-LOAD, KMAX UPDT TSK, SSME-OUT SAF TSK	I	pct
Minimum throttle setting of SSME	KMIN	I-LOAD	I	pct
Guidance phase counter	KPHASE	GUID PRMT RINT TSK	I	N/A
Node adjustment matrix	$\dot{M}_{\text{NODE_ADJ}}$	ASC UPF	DP	ND
Burn time remaining before G-limiting to inhibit fuel depletion throttling	DTTHROT	K-LOAD	SP	sec
Number of thrust phases	N	GUID PRMT RINT TSK, PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK, RTLS INIT TSK	I	N/A
Number of integration time steps for gravity predictions	NSEG	K-LOAD	I	N/A
Number of active SSME engines AJJ is a 1 x 11 array	N_SSME	PFG INP TSK, PRE-MAN DISP SUPT TSK	I	N/A
MECO radius	RDMAG	I-LOAD, GUID PRMT RINT TSK, ATO MECO TGT SEL TSK, RTLS INIT TSK, RTLS/TAL TGT SEL TSK	DP	ft
Vehicle position vector input to PEG	\overline{RGD}	PFG INP TSK, PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK, FUL DISS TSK, FLYBK TSK	DP	ft
Scalar damping factor applied to VMISS to correct VGO	RHOMAG	K-LOAD	SP	ND
Target position in inertial coordinates	\overline{RT}	PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK	DP	ft
PEG initialization discrete	\dot{S}_{INIT}	ASC GUID TSK, PRE-MAN DISP SUPT TSK, RTLS INIT TSK, AOA ONORB TGT SEL TSK	D	N/A
Time guidance assumes an SSME failure in MET	TFAIL	I-LOAD	SP	sec
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec

Table 4.8.1-1. Ascent Powered Explicit Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Time associated with \overline{RGD} and \overline{VGD}	TGD	PFG INP TSK, PRE-MAN DISP SUPT, AOA ONORB TGT SEL TSK, FUL DISS TSK, FLYBK TSK	DP	sec
Variable IY targeting option flag	$S_{\dot{I}Y}$	I-LOAD	D	N/A
PEG mode indicator	SMODE	ASC GUID TASK, PRE-MAN DISP SUPT, RTLS INIT TSK, AOA ONORB TGT SEL TSK	I	N/A
Commanded SSME throttle setting	K_CMD	FLYBK TSK, SSME-OUT SAF TSK, GUID PRMT RINT TSK, ASC GUID TSK, RTLS/TAL TGT SEL TSK	SP	pct
Desired thrust cutoff M50 inertial velocity vector	\overline{VD}	LTVCON TSK	SP	fps
AOA/ATO target complete flag	$S_{\dot{A}BORT_CONTROL}$	ATO OMS PRE-MECO BRN DET TSK	D	N/A
Desired MECO velocity magnitude	VDMAG	I-LOAD, GUID PRMT RINT TSK, ATO MECO TGT SEL TSK, UPLINK	SP	fps
Maximum LAMDMAG	PHIDOT_MAX	K-LOAD	SP	sec
Minimum cutoff mass to allow steering	MASS_MIN	I-LOAD	SP	slugs
Range to begin turnaround prediction	RNG_TURN_PRED	K-LOAD	SP	ft
Equivalent exhaust velocity	VEX	THRST PRM TSK, FUL DISS TSK, FLYBK TSK	SP	fps
Vehicle velocity vector input to PEG	\overline{VGD}	PFG INP TSK, PRE-MAN DISP SUPT, AOA ONORB TGT SEL TSK	DP	fps
Current vehicle mass	M	ACC-MASS UPD TSK	SP	slugs
Velocity-to-be gained vector	\overline{VGO}	PRE-MAN DISP SUPT TSK	SP	fps
Desired PPD mass for 2 engine RTLS	MBOD(1)	I-LOAD, UPLINK	SP	slugs
Desired PPD mass for 3 engine RTLS	MBOD(2)	I-LOAD, UPLINK	SP	slugs
Earth equatorial rotation rate	EARTH_RATE	CONSTANT	DP	rad/sec
Unit north pole vector in M50	$\overline{EARTH_POLE}$	CONSTANT	DP	ND
Desired throttle setting	K	RTLS INIT TSK, SSME-OUT SAF TSK, G-LIM TSK, FLYBK TSK	SP	pct
Predicted Shuttle position vector	$\overline{R_FINAL}$	ASC PREC PRED	DP	ft

Table 4.8.1-1. Ascent Powered Explicit Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Predicted Shuttle velocity vector	$V_{\bar{FINAL}}$	ASC PREC PRED	SP	fps
Steering enable flag	$\dot{S}STEER$	ASC GUID TSK, RTLS INIT TSK, FLYBK TSK, PRE-MAN DISP SUPT TSK, OMS GUID TSK	D	N/A
Throttling discrete	$S\dot{T}HROT$	PITCH CMD TSK, FUL DISS TSK	D	N/A
Minimum TGO for selecting RTLS constraint	TGO_IA	K-LOAD	SP	sec
Index for selecting RTLS flight path angle target	LL	SSME-OUT SAF TSK, BST GUID TSK	I	N/A
Desired flight path angle for RTLS	GAM_{JJ} (JJ=1,3)	RTLS/TAL TGT SEL TSK	SP	rad
Resulting transfer angle	THETA	LTVCON TSK	SP	rad
Desired minimum burnout mass	MBO	DISP INIT TASK	SP	slugs
Horizontal component of velocity at the target	VH1	LTVCON TSK	SP	fps
Magnitude of desired position vector at cutoff	$R\phi_MAG$	LTVCON TSK	DP	ft
Sine of the resulting transfer angle	SIN_THETA	LTVCON TSK	SP	ND
MM 104 discrete	MM104	MSC	D	N/A
MM 105 discrete	MM105	MSC	D	N/A
Number of successive unconverged PEG cycles before stowing the ADI error needles	NMAX_CYCLES_UNCONV	K-LOAD	I	N/A
Arc length around HAC (WP1 to NEP)	D_ARC	RTLS UPP	SP	ft
Runway X-component of the HAC center	X_NEP	I-LOAD	SP	ft
Indicator of vehicle position to runway	YSGNP	RTLS UPP	I	ND
Radius of nominal entry heading alignment circle	RADIUS_NEP	I-LOAD	SP	ft
TAL maximum value of VDMAG	VD_TAL_MAX	RTLS/TAL TGT SEL TSK	SP	fps
TAL minimum value of VDMAG	VD_TAL_MIN	RTLS/TAL TGT SEL TSK	SP	fps
Discrete to indicate that a TAL abort is in progress	$T\dot{A}L_ABORT_DECLARED$	MSC	D	N/A
Maximum TAL MECO crossrange	CR_MAX	RTLS/TAL TGT SEL TSK	SP	ft

Table 4.8.1-1. Ascent Powered Explicit Guidance Task Inputs				
Definition	Symbol	Source	Prec	Units
Runway target vector in earth-fixed coordinates	\bar{RTEF}	RTLS/TAL TGT SEL TSK	DP	ft
External tank aim point bias	ET_BIAS	RTLS/TAL TGT SEL TSK	SP	ft
Commanded droop attitude indicator	$S_{\dot{C}DROOP}$	DRP CTL TSK	D	N/A

Table 4.8.1-2. Ascent Powered Explicit Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
Time associated with desired thrust vector expressed in GMT	TLAMC	G/C STEER, TRANS DAP, PRE-MAN DISP SUPT TSK, TLM	DP	sec
Predicted time to achieve PEG targets	TP	PRTLS SEQ, FLYBK TSK, FUL DISS TSK, TLM, PPD TSK	DP	sec
M50 desired thrust vector	$\bar{L}AMC$	G/C STEER, TRANS DAP, PRE-MAN DISP SUPT TSK, TLM	SP	ND
M50 desired thrust turning rate vector	$\bar{L}AMDC$	G/C STEER, TRANS DAP, PRE-MAN DISP SUPT TSK, TLM	SP	sec ⁻¹
Unit vector normal to the transfer plane and minus the direction of the angular momentum vector of the transfer plane	$\bar{I}Y$	LTVCON TSK, TLM, AOA ONORB TGT SEL TSK	DP	ND
Desired thrust cutoff M50 position vector	$\bar{R}D$	PRE-MAN DISP SUPT TSK, LTVCON TSK	DP	ft
Guidance ready flag	$S_{\dot{G}DRDY}$	MSC, PRE-MAN DISP SUPT TSK, ASC GUID TSK	D	N/A
Target inertial position vector	$\bar{R}I$	LTVCON TSK	DP	ft
Desired thrust cutoff M50 inertial velocity vector	$\bar{V}D$	PRE-MAN DISP SUPT TSK	SP	fps
Discrete indicating convergence	$S_{\dot{C}ONV}$	ASC GUID TSK, OMS GUID TSK, PRE-MAN DISP SUPT TSK, FLYBK TSK, AOA ONORB TGT SEL TSK, FUL DISS TSK, TLM, DRP CTL TSK	D	N/A
Time-to-go	TGO	2STG SEQ, ASC GUID TSK, MNVR DISP, FLYBK TSK, OMS GUID TSK, PRE-MAN DISP SUPT TSK, TLM, XXXXXX TRAJ 2 DISP	SP	sec
Velocity-to-be gained vector	$\bar{V}GO$	PRE-MAN DISP SUPT TSK, VGO DISP TSK, OMS GUID TSK	SP	fps
Magnitude of VGO vector	VGOMAG	AOA ONORB TGT SEL TSK, FUL DISS TSK, TLM	SP	fps

Table 4.8.1-2. Ascent Powered Explicit Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
Desired reference thrust vector	$\bar{L}\bar{A}\bar{M}$	FUL DISS TSK	SP	ND
Low thrust to weight indicator	$S_{\dot{L}OW_TW}$	DRP CTL TSK	D	N/A
RTLS PPD target index	IA	PPD TSK	I	N/A
Desired thrust turning rate vector	$\bar{L}\bar{A}\bar{M}\bar{D}$	FUL DISS TSK	DP	rad/sec
Time associated with desired reference thrust vector expressed in GMT	TLAM	FUL DISS TSK	DP	sec
Desired throttle setting	K	FLYBK TSK, FUL DISS TSK, TLM, SSME-OUT SAF TSK	SP	pct
Desired mass at end of flyback	MBO	FUL DISS TSK	SP	slugs
Shuttle position vector at T_INIT	$R_{\bar{I}NIT}$	ASC PREC PRED, PRE-MAN DISP SUPT TSK	DP	ft
Shuttle velocity vector at T_INIT	$V_{\bar{I}NIT}$	ASC PREC PRED, PRE-MAN DISP SUPT TSK	SP	fps
Time at beginning of prediction	T_INIT	ASC PREC PRED	DP	sec
Time at which state is required	T_FINAL	ASC PREC PRED	DP	sec
Maximum allowable time step size	DT_MAX	ASC PREC PRED	SP	sec
Gravity model degree	GMD_PRED	ASC PREC PRED	I	N/A
Gravity model order	GMO_PRED	ASC PREC PRED	I	N/A
Predicted Shuttle position vector	$R_{\bar{F}INAL}$	PRE-MAN DISP SUPT TSK	DP	ft
Predicted Shuttle velocity vector	$V_{\bar{F}INAL}$	PRE-MAN DISP SUPT TSK	SP	fps
Magnitude of RTLS target position vector	RTMAG	MPS GUID C/O TSK	DP	ft
Magnitude of $\bar{L}\bar{A}\bar{M}\bar{C}$	LAMD_MAG	TLM	SP	sec ⁻¹
Desired MECO velocity	VDMAG	TLM, XXXXXX TRAJ DIP	SP	fps
Guidance convergence status indicator	$S_{\dot{U}NCONV}$	ASC ADI PROC	D	N/A
Unit vector to landing site	$\bar{I}\bar{Z}\bar{C}$	G/C STEER	DP	ND
Unit normal to the plane of thrust vector rotation	$\bar{I}\bar{Y}_{TVR}$	FUL DISS TSK	SP	ND
Guidance coordinate system X-axis in M50 coordinates	$\bar{I}\bar{X}$	FUL DISS TSK	DP	ND
OPS transition request flag	OTREQ	ASC PREC PRED	D	N/A
Time associated with desired thrust vector expressed in GMT for the Droop Control task	TLAM_DRP	DRP CTL TSK	DP	sec
M50 desired thrust vector for the Droop Control task	$\bar{L}\bar{A}\bar{M}_{DRP}$	DRP CTL TSK	SP	None
M50 desired thrust turning rate vector for the Droop Control task	$\bar{L}\bar{A}\bar{M}\bar{D}_{DRP}$	DRP CTL TSK	SP	sec ⁻¹

Table 4.8.1-2. Ascent Powered Explicit Guidance Task Outputs				
Definition	Symbol	Destination	Prec	Units
PEG steering updated flag	PEG_ STEERING_ UPD	MSC	D	N/A

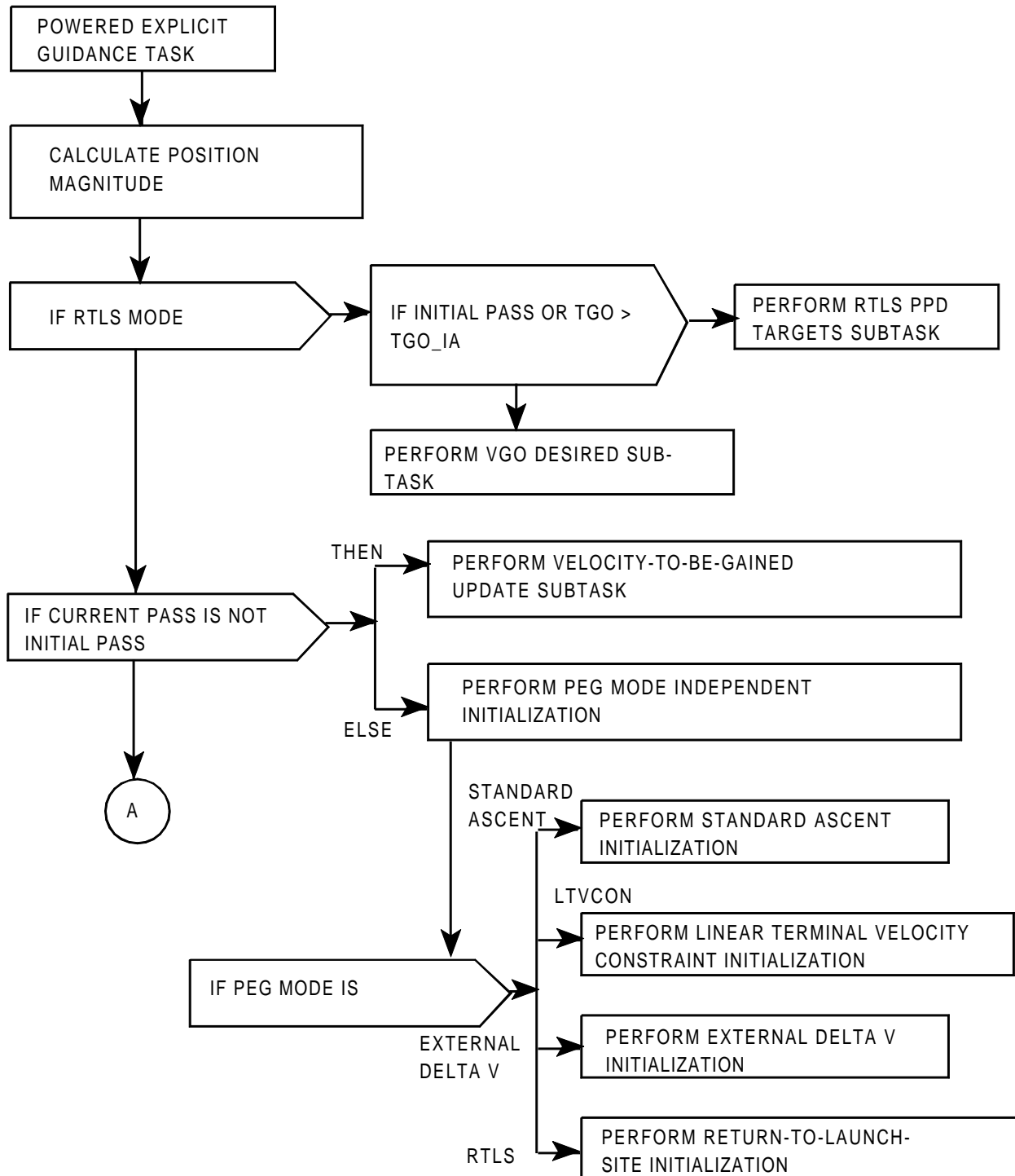


FIGURE 4.8.1-1.(1) Powered Explicit Guidance Task Functional Flow (Sheet 1 of 5)

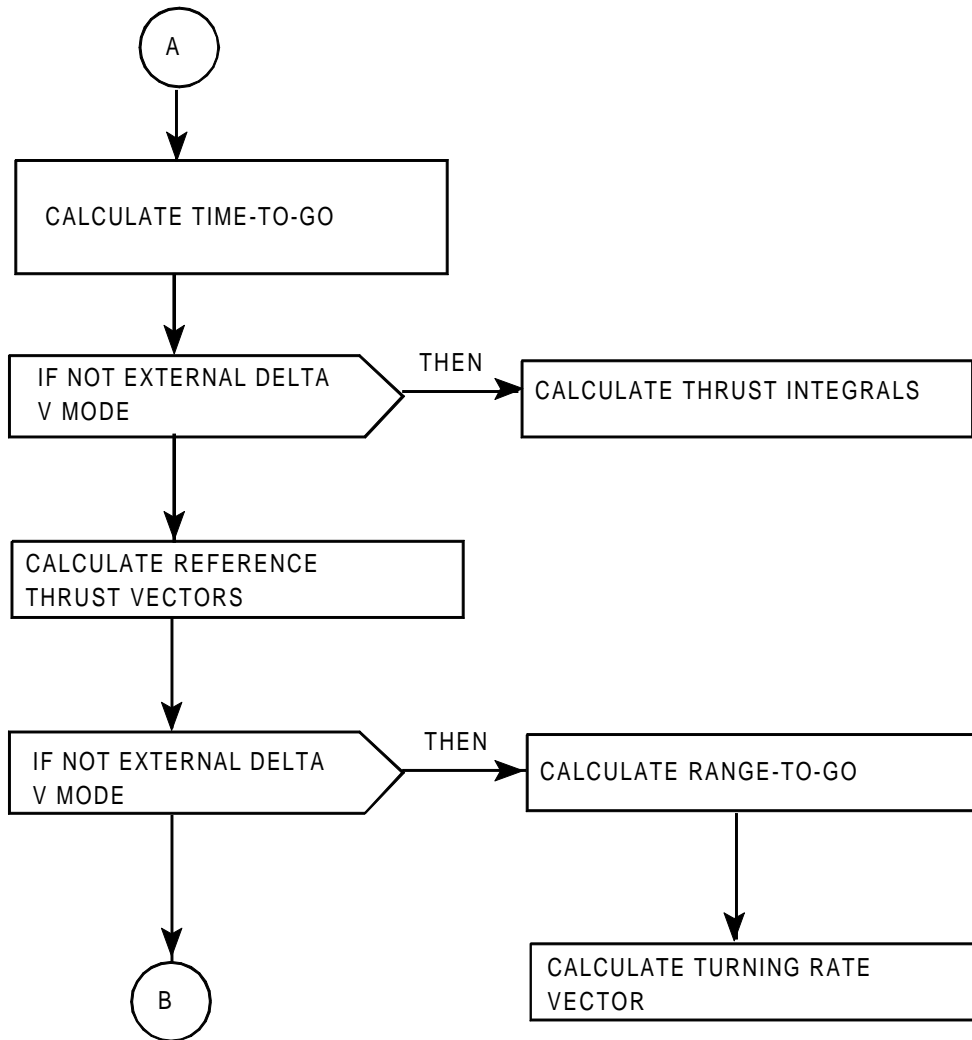


FIGURE 4.8.1-1.(2) Powered Explicit Guidance Task Functional Flow (Sheet 2 of 5)

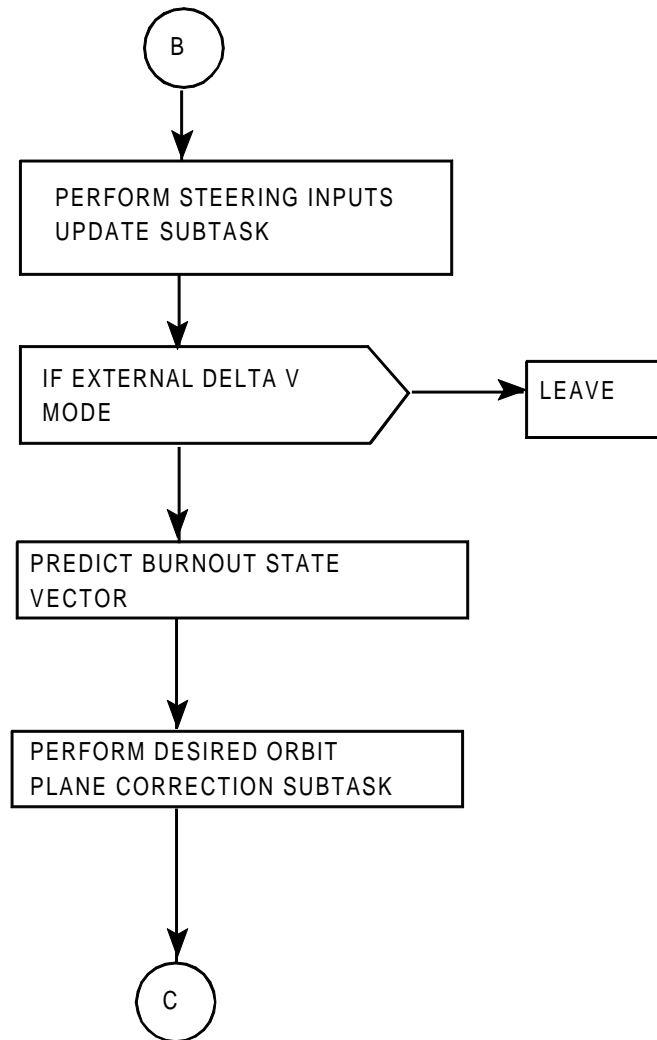


FIGURE 4.8.1-1.(3) Powered Explicit Guidance Task Functional Flow (Sheet 3 of 5)

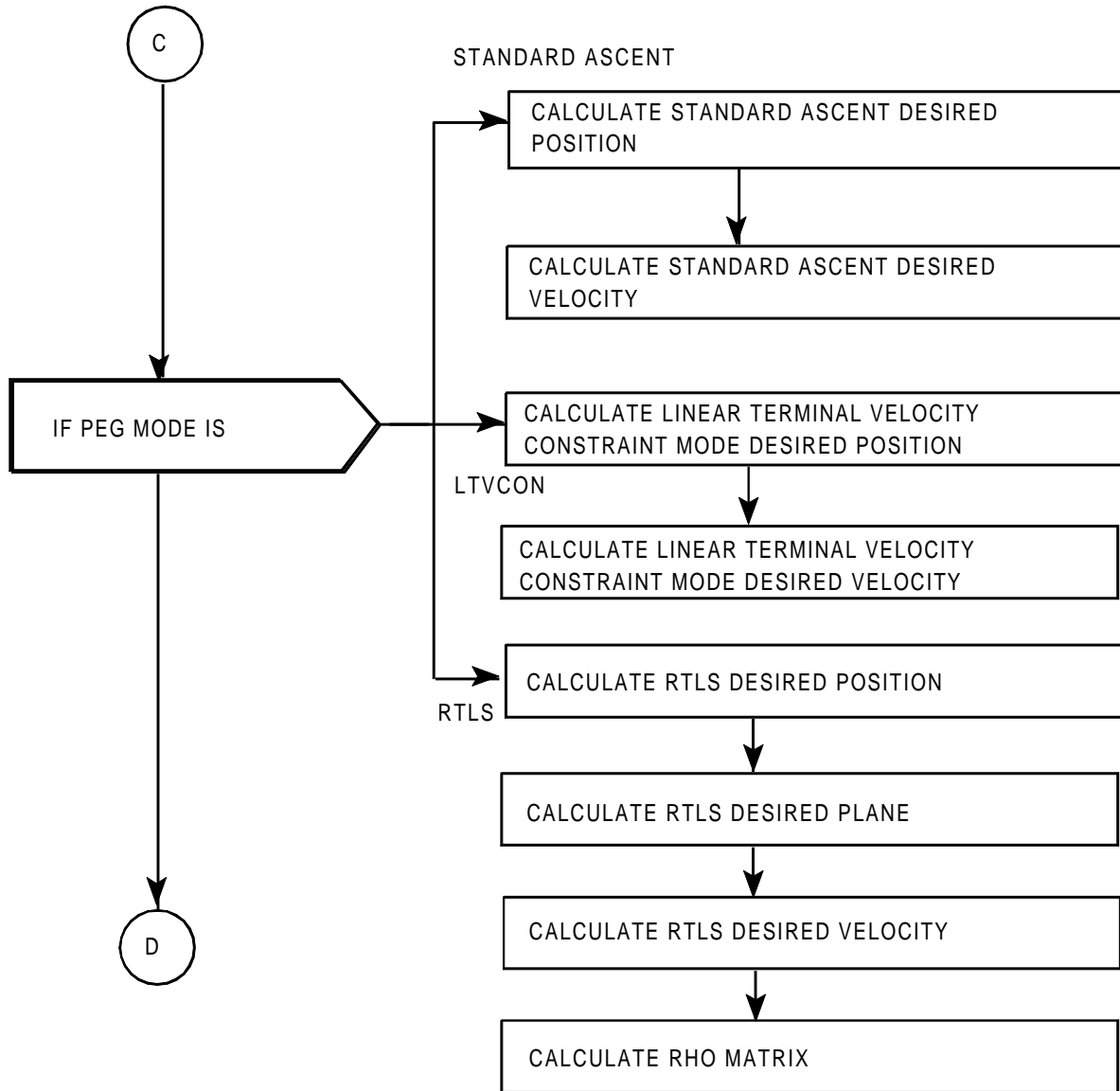


FIGURE 4.8.1-1.(4) Powered Explicit Guidance Task Functional Flow (Sheet 4 of 5)

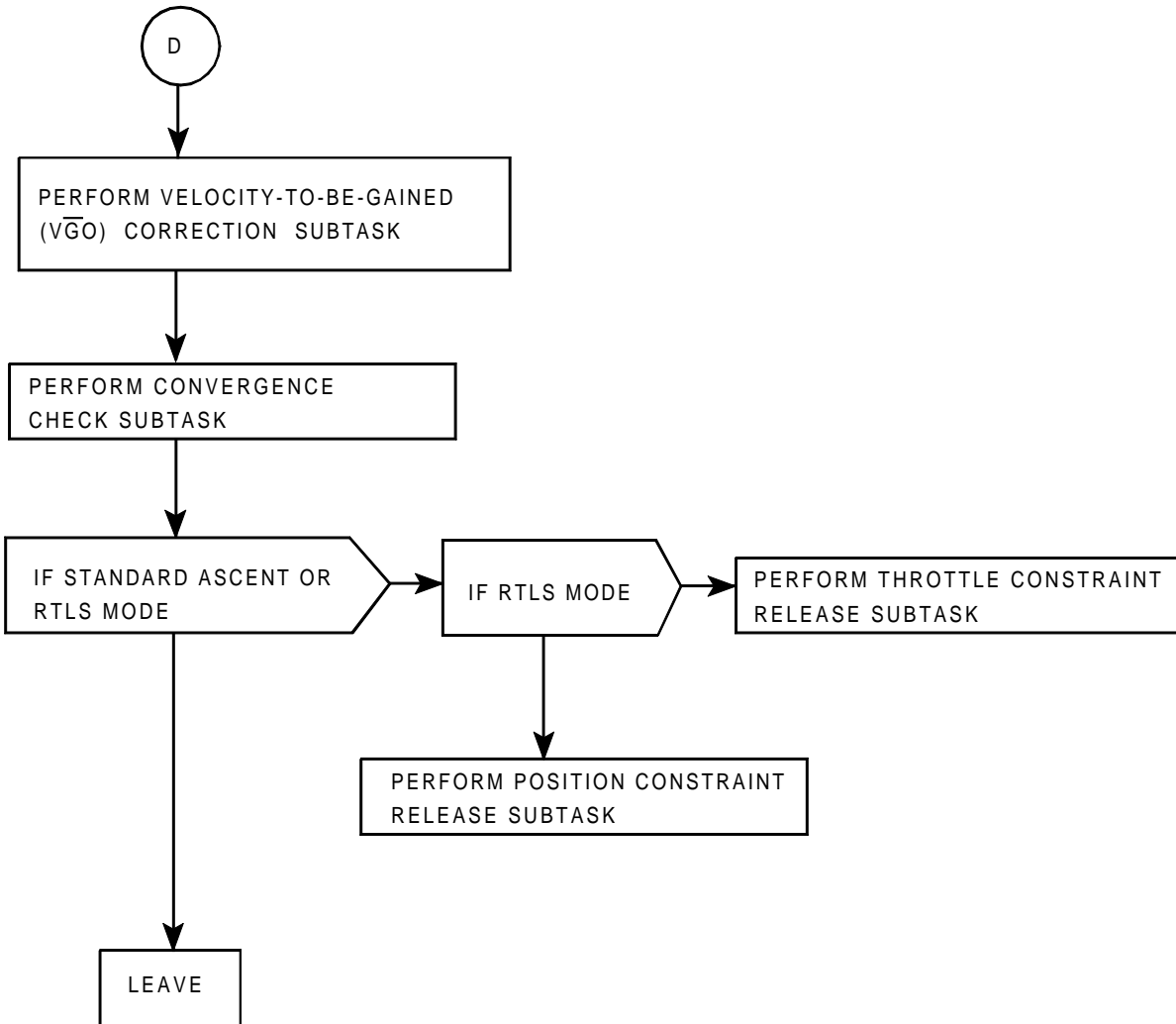


FIGURE 4.8.1-1.(5) Powered Explicit Guidance Task Functional Flow (Sheet 5 of 5)

4.8.2 Acceleration-Mass Update Task (ACC-MASS UPD TSK)

The acceleration–mass update task is a general–purpose guidance task, the purpose of which is to provide other guidance and targeting tasks estimates of the current vehicle mass (M) and a scaling factor (FT_FACTOR). FT_FACTOR is used to scale the estimated thrust force on the vehicle so that a smoothed value of thrust acceleration can be calculated.

A. Detailed Requirements. The acceleration–mass update task calls the thrust parameters task (THRST PRM TSK) for estimates of thrust force (FT), mass flow rate (MDOT), and equivalent exhaust velocity (VEX) before performing the following subtasks.

1. Vehicle Mass Estimation Subtask. The purpose of this subtask is to compute a current estimate of the vehicle mass. This is accomplished by an exponential extrapolation (approximated by the first two terms of the Taylor series expansion) of sensed velocity divided by equivalent exhaust velocity:

$$M_NEW = M (2./D-1.)$$

where

$$D = 1 + .5 DVSMAG/VEX.$$

If the current estimate of mass does not vary significantly from the past estimate, the mass estimate is not updated.

If $(M-M_NEW) \geq MUP_TH$, then

$$M = M_NEW$$

where M_NEW is the current mass estimate, M is the last mass estimate, and MUP_TH is a specified minimum change in mass required for the mass to be updated.

The estimated thrust force FT_S is calculated if DTGD is non–zero:

$$\text{If } (DTGD \neq 0), \text{ then } FT_S = M DVSMAG D / DTGD$$

Otherwise, (if $DTGD = 0$), then:

$$FT_S = 0$$

2. Thrust Scaling Factor Subtask. The purpose of this subtask is to estimate the thrust scaling factor, FT_FACTOR. For SSME maneuvers, FT_FACTOR is a weighted average of four past values of the factor except under certain conditions. The FT_FACTOR is estimated as follows only when a main engine burn occurs ($N_SSME \neq 0$), the throttle command has not changed since the last guidance cycle ($MDOT = MDOT_OLD$), the fine countdown discrete has not been set ($S_MECO = OFF$), and the time interval is greater than zero ($DTGD > 0$).

First, the sample factors are updated by using the sample factor values from the past three guidance cycles:

$$X4 = X3$$

$$X3 = X2$$

$$X2 = X1$$

$$X1 = FT_S/FT$$

The weighted average and the absolute difference between the weighted average and the current factor are calculated:

$$X_WEIGHT = (X1 + X2 + X3 + X4) 0.25$$

$$X_TEST = ABS(X1 - X_WEIGHT)$$

If the current factor differs significantly from the weighted average ($X_TEST \geq EPS_X$), then the current estimate (FT_FACTOR) is not updated; otherwise, FT_FACTOR = X_WEIGHT. When FT_FACTOR is updated and its value is less than FTF_MIN, then FT_FACTOR is set to FTF_MIN. In the event of an SSME failure, SSME-OUT SAF TSK resets FT_FACTOR to one and X1 to zero.

3. Output Parameters Subtask. The purpose of this subtask is to save the current value of mass flow rate: MDOT_OLD = MDOT.

B. Interface Requirements. The input and output parameters for the acceleration-mass update task are given in Tables 4.8.2-1 and 4.8.2-2.

C. Processing Requirements. Each subtask must be executed in the order listed in the detailed requirements.

D. Initialization Requirements. The following parameters should be initialized to zero: X1, X2, X3, and MDOT_OLD.

E. Supplemental Information. The current orbiter mass at the start of MM 104 (initial orbiter mass less any OMS propellant burned pre-MECO) is obtained from the ASC MNVR DIP.

Table 4.8.2-1. Acceleration-Mass Update Task Inputs				
Definition	Symbol	Source	Prec	Units
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
Magnitude of DVS vector	DVSMAG	PFG INP TSK	SP	fps
Criterion for rejecting the estimate of the thrust scaling factor	EPS_X	K-LOAD	SP	ND
Equivalent exhaust velocity	VEX	THRST PRM TSK	SP	fps
Current estimated thrust scaling factor	X1	SSME-OUT SAF TSK	SP	ND
Current vehicle mass	M	1STG GUID INP TSK, PRE-MAN DISP SUPT TSK	SP	slugs
Minimum change in mass required for mass to be updated	MUP_TH	K-LOAD	SP	slugs
Total vehicle mass flow rate	MDOT	THRST PRM TSK	SP	slugs /sec
Total vehicle thrust force	FT	THRST PRM TSK	SP	lbf
Number of active SSME's	N_SSME	PFG INP TSK, PRE-MAN DISP SUPT TSK	I	N/A
Fine countdown discrete	S_MECO	ASC GUID TSK, FLYBK TSK	D	N/A
Minimum value of FT_FACTOR	FTF_MIN	K-LOAD	SP	ND

Table 4.8.2-2. Acceleration-Mass Update Task Outputs				
Definition	Symbol	Destination	Prec	Units
Current vehicle mass	M	2STG SEQ, ASC GUID TSK, PRTL5 SEQ, PEG TSK, OMS GUID TSK, FLYBK TSK, ASC DAP, TLM, XXXXXX TRAJ DIP, PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK, FUL DISS TSK, DISP INIT TSK, OMS RM, VGO DISP TSK, CONT MODE 5 TSK, G/C STEER	SP	slugs
Thrust scaling factor	FT_FACTOR	ASC GUID TSK, FUL DISS TSK, FLYBK TSK, TLM, CONT MODE 5 TSK	SP	ND
Estimated total thrust	FT_S	DRP CTL TSK, TLM	SP	lbf

4.8.3 G-Limiting Task (G-LIM TSK)

The g-limiting task is a general-purpose guidance task which determines when the g limit has been achieved and then computes SSME throttle commands to limit the average acceleration to g limit. The throttling algorithm works on an integral and proportional error. This algorithm tends to drive the actual acceleration of the vehicle to the acceleration limit “on the average” since an accumulated error is included.

A. Detailed Requirements.

1. The measured vehicle acceleration, AT_AVE, is calculated if DTGD is not zero.

If $DTGD \neq 0$, $AT_AVE = DVSMAG/DTGD$.

For SSME failures during a TAL the AT_AVE will be set to zero for two guidance passes. This ensures that the acceleration from the residual thrust during tail off of the SSME does not contribute to noise to the G-limit. This must be done for a subsequent sequential engine failure.

If TAL_GLIMIT_FLAG

$AT_AVE = 0$

$TAL_GLIMIT_FLAG = OFF$

If $TAL_ABORT_DECLARED$ and $N_SSME \neq N_SSME_TAL$

$AT_AVE = 0$

$N_SSME_TAL = N_SSME$

$TAL_GLIMIT_FLAG = ON$

In the case of one or two SSME failures during a TAL, SSME throttle commands are computed to limit the average acceleration further to a value prescribed by TAL_2ENG_GLIMIT (1 SSME failure) or TAL_1ENG_GLIMIT (2 SSME failures).

If $N_SSME = 2$

$TAL_GLIMIT = TAL_2ENG_GLIMIT$

If $N_SSME = 1$

$TAL_GLIMIT = TAL_1ENG_GLIMIT$

$AL = AL_BASE \cdot TAL_GLIMIT/3$

$AD_INIT = AD_INIT_BASE \cdot TAL_GLIMIT/3$

$ALIM_1 = ALIM_1_BASE \cdot TAL_GLIMIT/3$

$ALIM_2 = ALIM_2_BASE \cdot TAL_GLIMIT/3$

2. When AT_AVE is less than the K-Load, ALIM_1, SE_MECO_PREP_K is ON, or manual throttling is being performed, the following initial values are calculated, and the g-limit switch is set to OFF:

$AD = AD_INIT$

$SUM_DA = 0$

$S_GLIMIT = OFF$

3. When AT_AVE is greater than the K-Load, ALIM_2, or S_GLIMIT = ON, and SE_MECO_PREP_K is OFF, and manual throttling is not being performed, then the following g-limit calculations are performed:

- a. Set S_GLIMIT = ON
- b. Compute the accumulated acceleration error (SUM_DA) as follows:

$$DA = AT_AVE - AL$$

$$SUM_DA = DA DTGD + SUM_DA$$

- c. Compute the desired acceleration of the vehicle (AD) as the previous desired acceleration minus the accumulated acceleration error multiplied by the integral gain (K_INT) minus the current acceleration error multiplied by the proportional gain (K_PROP):

$$AD = AD - (DA K_PROP + SUM_DA K_INT) DTGD$$

- d. If the elapsed time from the last throttle command (T_KCMD) exceeds the K-load throttle lag time, TLAG, then the following computations are performed:

- (1) Update the commanded throttle setting as a function of the previous throttle setting, the desired acceleration (AD), and the current acceleration (AT_AVE) and round off to the nearest percent:

$$K_CMD = ROUND(K_CMD AD/AT_AVE)$$

- (2) Limit the commanded throttle setting to be between KMIN and KMAX:

$$K_CMD = MIDVAL(KMIN, K_CMD, KMAX)$$

- (3) If the previously commanded throttle setting is different from K_CMD, then the time of the throttle command is recorded as follows:

$$T_KCMD = TGD$$

Set the PEG desired throttle setting to K_CMD: $K = K_CMD$.

B. Interface Requirements. The input and output parameters for the g-limiting task are given in Tables 4.8.3-1 and 4.8.3-2.

C. Processing Requirements. The subtasks must be performed in the order indicated.

D. Initialization Requirements. S_GLIMIT must be initialized to OFF, N_SSME_TAL = 3 and AT_AVE = 0, and T_KCMD = 0.

$$AL_BASE = AL$$

$$AD_INIT_BASE = AD_INIT$$

$$ALIM_1_BASE = ALIM_1$$

$$ALIM_2_BASE = ALIM_2$$

$$TAL_GLIMIT_FLAG = OFF$$

Table 4.8.3-1.G-Limiting Task Inputs				
Definition	Symbol	Source	Prec	Units
Initial value for AD	AD_INIT	K-LOAD	SP	fps ²
Initial limit for starting g-limit	ALIM_2	K-LOAD	SP	fps ²
Specific force limit during SSME maneuvers	AL	K-LOAD	SP	fps ²
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
Magnitude of DVS vector	DVSMAG	PFG INP TSK	SP	fps
G-limiting integral gain	K_INT	K-LOAD	SP	sec ⁻²
Maximum throttle setting of SSME	KMAX	I-LOAD, KMAX UPDT TSK, SSME-OUT SAF TSK	I	pct
Minimum throttle setting of SSME	KMIN	I-LOAD	I	pct
Proportional gain	K_PROP	K-LOAD	SP	sec ⁻¹
Commanded SSME throttle setting	K_CMD	BST THROT TSK, SSME-OUT SAF TSK, RTLS INIT TSK, ASC GUID TSK, 1STG GUID INP TSK, FUL DISS TSK, GUID PRMT RINT TSK, RTLS/TAL TGT SEL TSK	I	pct
Lower limit for setting g-limit off	ALIM_1	K-LOAD	SP	fps ²
Time associated with RGD and VGD	TGD	PFG INP TSK	DP	sec
Throttle lag time	TLAG	K-LOAD	SP	sec
Manual throttling discrete	S_MAN_THROT	SBTC SOP	D	N/A
Single engine MECO prep throttle discrete	SE_MECO_PREP_K	SE MECO PREP TSK	D	N/A
Two engine TAL g-limit	TAL_2ENG_GLIMIT	I-LOAD	SP	ND
Single engine TAL g-limit	TAL_1ENG_GLIMIT	I-LOAD	SP	ND
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Discrete to indicate that a TAL abort is in progress	TAL_ABORT_DECLARED	MSC	D	N/A

Table 4.8.3-2.G-Limiting Task Outputs				
Definition	Symbol	Destination	Prec	Units

Table 4.8.3-2. G-Limiting Task Outputs

Definition	Symbol	Destination	Prec	Units
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, MPS GUID C/O TSK, SSME-OUT SAF TSK, FLYBK TSK, TLM, SBTC SOP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
G-limit discrete	S_ĠLIMIT	ASC GUID TSK	D	N/A
Specific force limit during SSME maneuvers	AL	PEG TSK	SP	fps ²
Desired throttle setting	K	PEG TSK, FLYBK TSK, TLM	SP	pct
Desired acceleration	AD	TLM	SP	fps ²

4.8.4 Linear Terminal Velocity Constraint Task (LTVCON TSK)

The LTVCON task computes the conic velocity required to transfer from an inertial initial position to an inertial target position while satisfying a linear relationship between the radial and horizontal velocity components at the target.

A. Detailed Requirements. The LTVCON subtask is required to compute the conic required velocity vector \overline{VD} at the initial position \overline{RD} that satisfies the desired linear terminal velocity constraint at the terminal position $\overline{R1}$. In this case, the following quadratic equation specifies the solution:

$$A \text{ VHI}^2 - 2B \text{ VHI} - C = 0$$

where the constants A, B, and C relate the orbital geometry and the terminal velocity constraints. They may be specified by the following calculations:

$$R\phi_MAG = ABVAL(\overline{RD})$$

$$R1_MAG = ABVAL(\overline{R1})$$

$$K = (R1_MAG - R\phi_MAG)/R\phi_MAG$$

$$Z = R\phi_MAG R1_MAG - (\overline{RD} \cdot \overline{R1})$$

If Z is greater than (R ϕ _MAG R1_MAG) EP_TRANSFER then calculate the following:

$$W = -((\overline{RD} \times \overline{R1}) \cdot \overline{IY}) / Z$$

$$A = K (1 + W^2) + 2 (1 - C2 W)$$

$$B = C1 W$$

$$C = 2 \text{ EARTH_MU}/R1_MAG$$

$$\text{THETA} = \text{PI} + \text{ARCTAN2}(-2 W, 1 - W^2)$$

$$\text{SIN_THETA} = 2 W/(1 + W^2)$$

The discriminant, D, is then calculated as follows:

$$D = B^2 + AC$$

If D is less than zero, no solution to the previous equation exists, in which case the following equations are not performed. However, if D is greater than or equal to zero, the required velocity computations proceed as follows:

$$\text{VHI} = C/(-B + \text{SQRT}(D))$$

$$\text{VR1} = C1 + C2 \text{ VHI}$$

$$\overline{VD} = ((K W \text{ VHI} - \text{VR1}) \overline{RD} + (1 + K) \text{ VHI}(\overline{RD} \times \overline{IY}))/R\phi_MAG$$

Otherwise, the angle between the desired thrust cutoff position vector and plane-projected target is small, exit LTVCON TSK.

B. Interface Requirements. The guidance internal input and output parameters for the linear terminal velocity constraint task are given in Tables 4.8.4-1 and 4.8.4-2. There are no guidance external interface parameters.

C. Processing Requirements. This task will be called as required by PEG on the guidance frequency.

D. Initialization Requirements. None.

E. Supplemental Information. These equations are valid in the region of $0 < \theta < 360$ degrees, but they have a numerical accuracy problem for very small range angles.

Table 4.8.4-1.Linear Terminal Velocity Constraint Task Inputs				
Definition	Symbol	Source	Prec	Units
Earth gravitational constant	EARTH_MU	CONSTANT	DP	ft ³ /sec ²
Tolerance for near zero transfer angle.	EP_ TRANSFER	I-LOAD	SP	ND
Target intercept constraint coefficient	C1	PRE-MAN DISP SUPT TSK	SP	fps
Target slope constraint coefficient	C2	PRE-MAN DISP SUPT TSK	SP	ND
Desired thrust cutoff position vector	\bar{R}_D	PEG TSK	DP	ft
Target inertial position vector in predicted cutoff plane	\bar{R}_I	PEG TSK	DP	ft
Ratio of circumference to diameter of a circle	PI	CONSTANT	SP	ND
Unit vector normal to the transfer plane	\bar{I}_Y	PEG TSK	DP	ND

Table 4.8.4-2.Linear Terminal Velocity Constraint Task Outputs				
Definition	Symbol	Destination	Prec	Units
Desired thrust cutoff M50 inertial velocity vector	\bar{V}_D	PEG TSK	SP	fps
Resulting transfer angle	THETA	PEG TSK	SP	rad
Horizontal component of velocity at the target position	VH1	PEG TSK	SP	fps
Magnitude of desired position vector at cutoff	R ϕ _MAG	PEG TSK	DP	ft
Sine of resulting transfer angle	SIN_THETA	PEG TSK	SP	ND

4.8.5 MPS Guidance Cutoff Task (MPS GUID C/O TSK)

The MPS guidance cutoff task is a general-purpose guidance task whose primary purpose is to compute a desired SSME cutoff time based upon a desired cutoff velocity magnitude. The cutoff time calculation must include the predicted velocity change from the time the minimum throttle setting is commanded until cutoff and the predicted tailoff impulse from each active SSME.

Secondary functions of this task are to command the minimum throttle setting at such a time that ensures the minimum thrust level is applied for a desired time prior to MECO command, and to set a flag when desired MECO time is less than two guidance cycles for the SSME OPS principal function to initiate the nominal shutdown countdown timer. However, if manual guidance is active, the minimum thrust command is inhibited during RTLS (MM 601). Pitch gimbal relief throttle logic is also performed in major mode 103.

This task is used by the ascent second-stage guidance and PRTLS guidance principal functions.

A. Detailed Requirements.

1. The MPS guidance cutoff task is required to perform the following calculations for the ascent second-stage guidance principal function (MM = 103).

- a. Compute the magnitude of the current velocity vector:

$$VMAG = ABVAL(\overline{VGD})$$

- b. Compute the component of the measured acceleration vector along the current velocity vector:

$$AT_FCD = (\overline{VGD} \cdot \overline{DVS}) / (VMAG DTGD)$$

- c. Determine the MECO throttle setting:

$$K_CO = KMIN$$

$$\begin{aligned} &\text{If } N_SSME = 2 \text{ and} \\ &\quad \text{CONT_SERC} = \text{OFF then} \\ &\quad K_CO = K_CO_MAX \end{aligned}$$

- d. Predict the velocity change to be applied during the time required to change the throttle setting from the current command to the minimum setting:

$$DV_RAMP = (K_CMD + K_CO) ABS(K_CMD - K_CO) (AT_FCD) / (2 K_CMD KDOT)$$

- e. Predict the velocity change to be applied during the desired time at minimum thrust level:

$$DV_MIN_K = AT_FCD DT_MIN_K K_CO / K_CMD$$

- f. Compute the remaining velocity-to-be-gained until MECO command:

$$VGO_FCD = VDMAG - VMAG$$

- g. Whenever VGO_FCD first becomes less than the sum of the predicted velocity change over the next guidance cycle (AT_FCD DT_FCD), the predicted velocity change during throttle-down (DV_RAMP), and the predicted velocity change during the desired time at minimum thrust level (DV_MIN_K), then K_CMD = K_CO and S_KCO = ON.

If $VGO_FCD < AT_FCD \cdot DT_FCD + DV_RAMP + DV_MIN_K$, then

$$K_CMD = K_CO$$

$$S_KCO = ON$$

- h. Compute time-to-go until MECO command:

$$ITLOF = MAX(INTEGER(N_SSME-1), 1)$$

$$TGO = VGO_FCD/AT_FCD - DT_TAILOFF_{ITLOF}$$

- i. A throttle down to KMIN (K_CMD = KMIN) is commanded and S_GIMB_RELIEF is set (S_GIMB_RELIEF = ON) if (1) and (2) below are true, or if (1) and (3) and (4) are all true:

$$(1) S_MAN_THROT = OFF$$

$$(2) S_GIMB_RELIEF = ON$$

$$(3) S_EO_E1 = ON$$

$$(4) (DYC2 > DYC_GIMB_RELIEF \text{ or } DYC3 > DYC_GIMB_RELIEF)$$

The throttle down to KMIN is performed to provide pitch gimbal relief by reducing the deformation of the thrust structure. The S_GIMB_RELIEF flag is set so that the KMIN throttle command is continually commanded as long as manual throttling is not active.

2. This task performs the following calculations for the PRTL5 guidance (MM = 601).

- a. Compute the component of the acceleration vector along the current earth-relative velocity vector:

$$AT_FCD = (V_RHO \cdot D\bar{V}S)/(V_RHO_MAG \cdot DTGD)$$

- b. Compute the position of the landing site at the estimated time of MECO:

$$R\bar{T} = EARTH_FIXED_TO_M50_COORD(TGD + TGO - DTGD) \cdot R\bar{T}EF$$

$$R\bar{T} = R\bar{T} - (YSGNP_RADIUS_NEP + ET_BIAS) \cdot UNIT(R\bar{T} \times R\bar{G}D)$$

- c. Compute the distance from the current position to the estimated position of the landing site at MECO:

$$RTHETA = ABVAL(UNIT(R\bar{G}D) \cdot RTMAG - R\bar{T}) + D_ARC - X_NEP$$

- d. If FLT_PATH_ANG has been updated this cycle, then compute and limit the rate of change of the flight path angle and set the past angle equal to the current angle:

If FLT_PATH_ANG_TIME > PREVIOUS_FLT_PATH_ANG_TIME, then

$$\text{FLT_PATH_DOT} = \frac{(\text{FLT_PATH_ANG} - \text{FLT_PATH_PAST})}{(\text{FLT_PATH_ANG_TIME} - \text{PREVIOUS_FLT_PATH_ANG_TIME})}$$

During the powered pitchdown (when the MPS GUID C/O TSK is active), the vehicle should be pitching down to an I-loaded value (ALPHA_PPD_INTACT) of angle of attack, which means that the flight path angle should be decreasing. If the flight path angle is not decreasing, the following logic will prevent a prematurely commanded MECO:

If FLT_PATH_DOT > 0, then FLT_PATH_DOT = 0

Then the current values are saved for the next FLT_PATH_ANG update cycle.

$$\text{PREVIOUS_FLT_PATH_ANG_TIME} = \text{FLT_PATH_ANG_TIME}$$

$$\text{FLT_PATH_PAST} = \text{FLT_PATH_ANG}$$

$$\text{FLT_PATH_ANG_RTLS} = \text{FLT_PATH_ANG}$$

- e. If FLT_PATH_ANG is not updated, then predict the current flight path angle:

$$\text{FLT_PATH_ANG_RTLS} = \text{FLT_PATH_ANG_RTLS} + \text{FLT_PATH_DOT DTGD}$$

- f. Compute the velocity-to-be-gained:

$$\text{VGOMAG} = A_5 + A_6 \text{RTHETA} - A_7 \text{FLT_PATH_ANG_RTLS} - \text{V_RHO_MAG}.$$

- g. Compute the time rate of change of the velocity-to-be-gained:

$$\text{VGO_DOT} = \text{AT_FCD} + A_6 \text{V_RHO_MAG} + A_7 \text{FLT_PATH_DOT}$$

If VGO_DOT is less than 1 fps², then exit the MPS GUID C/O TSK.

- h. Compute time-to-go to MECO:

$$\text{TGO} = \text{VGOMAG}/\text{VGO_DOT}$$

- i. Compute the MECO time in MET for the RTLS display:

$$\text{TMET_MECO} = \text{TGD} + \text{TGO} - \text{T_GMTLO}$$

3. Whenever time-to-go becomes less than the time to execute a minimum number of guidance cycles that will ensure an accurate guided cutoff (the K-load STG2_MECO_INIT_TGO in MM 103 and RTLS_MECO_INIT_TGO in MM 601), then the following must be performed:

- a. Compute the time to command MECO:

$$T_MECO = TGD + TGO$$

- b. Set a flag (S_TMECO) for the SSME OPS principal function to initiate the nominal shutdown countdown timer.

B. Interface Requirements. The input and output parameters for the MPS guidance cutoff task are given in Tables 4.8.5-1 and 4.8.5-2.

C. Processing Requirements. This task will be initiated when S_MECO is ON, and terminated when S_TMECO is set, or to Events 33 or A36 during manual throttling. It will be cycled repetitively at a rate of $1/DT_FCD$ Hz when in MM103 and 6.25 Hz when in MM601. When MM = 103, Subtasks 1c, 1d, 1e, 1g, and 3 are not performed during manual throttling. Subtasks 1c, 1d, 1e, and 1g, also are not performed after S_KCO has been set to ON. When MM = 601, Subtask 3 is not done if manual throttling is being performed.

D. Initialization Requirements.

$$FLT_PATH_PAST = 0.0$$

$$PREVIOUS_FLT_PATH_ANG_TIME = 0.0$$

$$S_KCO = OFF$$

E. Supplemental Information. DT_MIN_K should be biased by $DT_TAILOFF$ for neglecting tailoff impulse in VGO_FCD .

Required MECO accuracy is ± 40 ms. This is the time difference between desired start of tailoff and actual start of thrust tailoff. It is a function of two types of variables: (1) GPC software timing (software design responsibility) and (2) an engine controller timing variation.

$$MECO \text{ accuracy} = \pm 30 \text{ ms}_{(GPC \text{ Timing})} \pm 10 \text{ ms}_{(Controller \text{ Timing})} = \pm 40 \text{ ms}$$

The ± 10 -ms component of MECO accuracy due to engine controller timing results from variable processing of the shutdown (S/D) command in the controller software plus any subsequent hardware delays (18 to 38 ms, currently) before the propellant valves start closing.

$$\text{Controller timing variation} = 18 \text{ to } 38 \text{ ms}$$

Guidance computes T_MECO early by the amount of $DT_TAILOFF$, which should allow for the engine tailoff ΔV to be added to the vehicle velocity resulting in the correct targeted post-MECO velocity. However, the constant $DT_TAILOFF$ is derived from the total shutdown impulse of the main engines.

The total impulse is currently obtained from the vehicle/main engine interface control document (ICD) and includes the worst-case controller software delay of 38 ms. Thus, T_MECO is not only computed early to allow for the tailoff ΔV ; it is 38 ms earlier than the start of thrust tailoff. Since the actual controller timing variation will be between 18 and 38 ms, T_MECO will be 20 ms earlier than desired if the actual delay is only 18 ms, and exactly on time if the actual delay is 38 ms.

This MECO accuracy variation of 0 to 20 ms must be corrected to ± 10 ms by adjusting the value of $DT_TAILOFF$ by 10 ms. Specifically, 10 ms must be subtracted from the value obtained by dividing the total impulse by the 65-percent thrust value:

$$DT_TAILOFF = \frac{\text{Total Impulse}}{\text{Thrust (65\%)}} - 10 \text{ ms,}$$

where Total Impulse includes engine operation for the 38–ms max controller delay. This will result in T_MECO being exactly 28 ms before the time of “begin thrust tailoff.” The MECO accuracy component due to the controller timing variation will then be ± 10 ms.

The additional ± 30 ms GPC software variation means the S/D command will go out at T_MECO ±30 ms resulting in a MECO accuracy of ± 40 ms.

To assure this, the SSME OPS will initiate output command processing based on a MECO Lead Time = Software Lead Time (I-load), which is purely a function of software timing.

As long as the controller timing variation does not change, MECO accuracy will be ± 40 ms.

Table 4.8.5-1. MPS Guidance Cutoff Task Inputs				
Definition	Symbol	Source	Prec	Units
Vehicle position vector input to PEG	\overline{RGD}	PFG INP TSK	DP	ft
Vehicle velocity vector input to PEG	\overline{VGD}	PFG INP TSK	DP	fps
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Change in accumulated sensed velocity from previous value	\overline{DVS}	PFG INP TSK	SP	fps
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
Cont single eng roll cntl flag	CONT_SERC	ASC DAP, XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP	D	N/A
Commanded SSME throttle setting	K_CMD	G-LIM TSK, SSME-OUT SAF TSK, GUID PRMT RINT TSK, SBTC SOP, RTLS/TAL TGT SEL TSK	I	pct
Magnitude of target RTLS position vector	RTMAG	PEG TSK	DP	ft
Minimum throttle setting of SSME	KMIN	I-LOAD	I	pct
MECO throttle cmd for 2 SSME's	K_CO_MAX	I-LOAD	I	pct
Maximum throttle change rate	KDOT	K-LOAD	SP	pct/sec
Desired time at minimum thrust level	DT_MIN_K	I-LOAD	SP	sec
Tailoff time at MPL	DT_TAILOFF _{1(I=1,2)}	I-LOAD	SP	sec

Table 4.8.5-1. MPS Guidance Cutoff Task Inputs				
Definition	Symbol	Source	Prec	Units
Desired MECO velocity magnitude	VDMAG	I-LOAD, GUID PRMT RINT TSK, ATO MECO TGT SEL TSK, UPLINK	SP	fps
Time associated with \overline{RGD} and \overline{VGD}	TGD	PFM INP TSK	DP	sec
Earth-relative velocity vector in M50 system	$\overline{V_RHO}$	RTLS UPP	SP	fps
Magnitude of vehicle velocity	V_RHO_MAG	RTLS UPP	SP	fps
RTLS MECO relative velocity coefficient	A ₅	RTLS/TAL TGT SEL TSK	SP	fps
RTLS MECO relative velocity coefficient	A ₆	RTLS/TAL TGT SEL TSK	SP	sec ⁻¹
RTLS MECO relative velocity coefficient	A ₇	RTLS/TAL TGT SEL TSK	SP	ft/rad-sec
MM 103 flag	MM103	MSC	D	N/A
MM 601 flag	MM601	MSC	D	N/A
Ground relative flight path angle	FLT_PATH_ANG	RTLS UPP	SP	rad
Time of computing of FLT_PATH_ANG	FLT_PATH_ANG_TIME	RTLS UPP	DP	sec
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Arc length around HAC	D_ARC	RTLS UPP	SP	ft
Runway X-component of the HAC center	X_NEP	I-LOAD	SP	ft
Indicator of vehicle position to runway	YSGNP	RTLS UPP	I	ND
Radius of nominal entry alignment circle	RADIUS_NEP	I-LOAD	SP	ft
Runway target vector in earth-fixed coordinates	\overline{RTEF}	RTLS/TAL TGT SEL TSK	DP	ft
External tank aim point bias	ET_BIAS	RTLS/TAL TGT SEL TSK	SP	ft
Time of liftoff in GMT	T_GMTLO	FCOS	DP	sec
Maximum TGO at which S_TMECO is set in MM103	STG2_MECO_INIT_TGO	K-LOAD	SP	sec
Maximum TGO at which S_TMECO is set in MM601	RTLS_MECO_INIT_TGO	K-LOAD	SP	sec
MPS E1 engine-out flag	S_EO_E1	SSME OPS	D	N/A
SSME 2 pitch gimbal cmd	DYC2	ASC DAP	SP	deg
SSME 3 pitch gimbal cmd	DYC3	ASC DAP	SP	deg
Pitch gimbal threshold for gimbal relief throttle logic	DYC_GIMB_RELIEF	I-LOAD	SP	deg
Gimbal relief throttle down flag	S_GIMB_RELIEF	ASC GUID TSK	D	N/A

Table 4.8.5-2.MPS Guidance Cutoff Task Outputs				
Definition	Symbol	Destination	Prec	Units
Commanded SSME throttle setting	K_CMD	SSME SOP, SBTC SOP, TLM, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
Desired SSME cutoff time	T_MECO	SSME OPS	DP	sec
Discrete indicating T_MECO has been set	S_TMECO	SSME OPS, PRTL5 SEQ, 2STG SEQ, CONT MODE SEL TSK, PW CONT SEQ	D	N/A
Discrete to indicate pre-MECO throttle-down is commanded	S_KCO	2STG SEQ, PRTL5 SEQ	D	N/A
Predicted SSME C/O in MET	TMET_MECO	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, TLM	SP	sec
Time to go	TGO	2STG SEQ, TLM, PPD TSK, XXXXXX TRAJ 2 DISP	SP	sec

4.8.6 H-θ-to-M50 Target Task (H-θ-M50 TGT TSK)

The H-θ-to-M50 target task computes a target position vector (\overline{RT}) for PEG, given inputs of altitude (HTGT), and central angle (THETA).

A. Detailed Requirements. The following steps are required:

1. Two unit vectors in the downrange and radial direction are calculated where \overline{RGD} is the position vector corresponding to the time of ignition.

$$\overline{IDR} = \text{UNIT}(\overline{RGD} \times (\overline{VGD} \times \overline{RGD}))$$

$$\overline{IR} = \text{UNIT}(\overline{RGD})$$

2. The angle between the ignition position vector and the target is calculated where $\overline{RLS_M50}$ is a vector to which THETA is referenced.

$$\text{THETA_LS} = \text{ARCTAN2}(-\overline{RLS_M50} \cdot \overline{IDR}, \overline{RLS_M50} \cdot \overline{IR})$$

If THETA_LS is negative, then $\text{THETA_LS} = \text{THETA_LS} + 2 \text{PI}$.

$$\text{DTHETA} = \text{THETA} - \text{THETA_LS}$$

If this is the first pass through the H-θ-to-M50 TGT TSK (first call made by ASC MNVR DIP at transition to MM 104), save THETA_LS for later use by AOA/ATO TGT:

$$\text{THETA_LSS} = \text{THETA_LS}$$

3. A unit vector in the direction of the target is calculated.

$$\overline{IRT} = \overline{IR} \cos(\text{DTHETA}) + \overline{IDR} \sin(\text{DTHETA})$$

4. Compute the magnitude of the target position vector:

$$\text{RTMAG} = \text{RE} + \text{HTGT},$$

where RE is the earth's mean equatorial radius. This value of RTMAG is used for all maneuvers except the AOA OMS-2 burn, where HTGT is relative to the Fischer ellipsoid. Also, for AOA OMS-2, the range angle THETA is referenced to the position at the time of ignition.

Thus, if the burn is AOA OMS-2 ($\dot{S_AOA_OMS2} = \text{ON}$), do the following computations:

$$\text{RTMAG} = \text{HTGT} + \text{RFE}$$

where

$$\text{RFE} = -\text{H_ELLIPSOID}(\overline{IRT})$$

$$\text{THETA} = \text{DTHETA}$$

where the H_ELLIPSOID function computes the altitude of the input position vector above the Fischer ellipsoid.

5. Last, the target position is calculated using the direction and magnitude:

$$\overline{\text{RT}} = \text{RTMAG } \overline{\text{IRT}}$$

B. Interface Requirements. The input and output parameters for the H-θ-to-M50 task are given in Tables 4.8.6-1 and 4.8.6-2.

C. Processing Requirements. Each subtask is performed once in the order indicated.

D. Initialization Requirements. None.

E. Supplemental Information. The H-θ-to-M50 task is called by both the AS MNVR DIP and AOA/ATO TGT principal functions to calculate the target position vector for PEG. For the abort OMS-2 burn, the THETA referenced to the time of ignition is also supplied to AOA/ATO TGT.

Table 4.8.6-1.H-θ-To-M50 TGT Task Inputs

Definition	Symbol	Source	Prec	Units
Target altitude	HTGT	AOA ONORB TGT SEL TSK, PRE-MAN DISP SUPT TSK	SP	ft
Mean equatorial radius	RE	CONSTANT	DP	ft
Vehicle position vector input to PEG	$\overline{\text{RGD}}$	AOA ONORB TGT SEL TSK, PRE-MAN DISP SUPT TSK	DP	ft
Vehicle velocity vector input to PEG	$\overline{\text{VGD}}$	AOA ONORB TGT SEL TSK, PRE-MAN DISP SUPT TSK	DP	fps
M50 position vector of launch site at lift-off	$\overline{\text{RLS}}_{\text{M50}}$	ASCENT UPP	DP	ft
AOA OMS-2 burn discrete	$\text{S}_{\dot{\text{AOA}}_{\text{OMS2}}}$	AOA ONORB TGT SEL TSK	D	N/A
Central angle between reference position and target position vector	THETA	AOA ONORB TGT SEL TSK, PRE-MAN DISP SUPT TSK	DP	rad
Ratio of circumference of a circle to the diameter	PI	CONSTANT	SP	ND

Table 4.8.6-2.H-θ-To-M50 TGT Task Outputs				
Definition	Symbol	Destination	Prec	Units
Target inertial position vector in OMS ignition plane	\overline{RT}	PEG TSK, PRE-MAN DISP SUPT TSK	DP	ft
Central angle between reference position and target position vector	THETA	AOA ONORB TGT SEL TSK	SP	rad
Central angle between launch site reference and OMS-1 TIG	THETA_LSS	AOA ONORB TGT SEL TSK	SP	rad

4.8.7 Thrust Parameters Task (THRST PRM TSK)

The purpose of this task is to compute the estimated thrust and associated vehicle performance parameters for the necessary operation of PEG. These parameters are total thrust force (FT), total mass flow rate (MDOT), and equivalent exhaust velocity (VEX).

A. Detailed Requirements.

1. The estimated main engine thrust force is calculated as a function of the current throttle command (K_CMD), the number of main engines thrusting (N_SSME), and an I-loaded estimate of thrust force for a single main engine (FT_SSME). The corresponding estimates of force for the OMS engines and RCS jets are added:

$$FT = 0.01 K_CMD N_SSME FT_SSME + N_OMS FT_OMS + N_RCS FT_RCS$$

2. The estimated mass flow rate for the main engines is calculated as a function of K_CMD, N_SSME, and an I-loaded estimate of mass flow rate (MDOT_SSME) for a single main engine. Correspondingly, the estimates of flow rates for the OMS engines and RCS jets are added. Note that the RCS null jets have to be included in the MDOT calculation:

$$MDOT = 0.01 K_CMD N_SSME MDOT_SSME + N_OMS MDOT_OMS + (N_RCS + N_RCS_NULL) MDOT_RCS$$

3. An estimate of equivalent exhaust velocity is then calculated:

$$VEX = FT/MDOT$$

B. Interface Requirements. The input and output parameters for the thrust parameters task are given in Tables 4.8.7-1 and 4.8.7-2.

C. Processing Requirements. None.

D. Initialization Requirements. Upon transition to OPS 101, initialize the following parameter:

$$MDOT = 0.0$$

Table 4.8.7-1. Thrust Parameters Task Inputs				
Definition	Symbol	Source	Prec	Units
Commanded SSME throttle setting	K_CMD	G-LIM TSK, GUID PRMT RINT TSK, SSME-OUT SAF TSK, RTLS INIT TSK, FLYBK TSK, BST THROT TSK, SBTC SOP, ASC GUID TSK, 1STG GUID INP TSK, FUL DISS TSK, RTLS/TAL TGT SEL TSK, AUTO CONT TSK, AUTO CONT INIT TSK	I	pct
Number of active SSME engines	N_SSME	PFG INP TSK, PRE-MAN DISP SUPT TSK	I	N/A
Nominal SSME thrust level	FT_SSME	I-LOAD	SP	lbf
Number of active OMS engines	N_OMS	PFG INP TSK, PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK	I	N/A
Nominal RCS thrust	FT_RCS	K-LOAD	SP	lbf
Nominal OMS thrust	FT_OMS	K-LOAD	SP	lbf
Nominal SSME mass flow rate	MDOT_SSME	I-LOAD	SP	slug/sec
Nominal OMS mass flow rate	MDOT_OMS	K-LOAD	SP	slug/sec
Nominal RCS mass flow rate	MDOT_RCS	K-LOAD	SP	slug/sec
Number of active RCS engines	N_RCS	PFG INP TSK, PRE-MAN DISP SUPT TSK, AOA ONORB TGT SEL TSK	I	N/A
Number of active RCS null engines	N_RCS_NULL	PFG INP TSK, PRE-MAN DISP SUPT TSK	I	N/A

Table 4.8.7-2. Thrust Parameters Task Outputs				
Definition	Symbol	Destination	Prec	Units
Equivalent exhaust velocity	VEX	ACC-MASS UPD TSK, PEG TSK, FUL DISS TSK, FLYBK TSK, DRP CTL TSK	SP	fps
Total vehicle thrust force	FT	ACC-MASS UPD TSK, ASC GUID TSK, FUL DISS TSK, PRE-MAN DISP SUPT TSK, FLYBK TSK, OMS GUID TSK, AOA ONORB TGT SEL TSK, CONT MODE 5 TSK	SP	lbf
Total vehicle mass flow rate	MDOT	ACC-MASS UPD TSK, PEG TSK, ASC DAP, FLYBK TSK, FUL DISS TSK, TLM, CONT MODE 5 TSK	SP	slug/sec

4.8.8 PFG Input Task (PFG INP TSK)

The PFG input task is a general-purpose guidance task which supports all of the ascent guidance principal functions. Its purpose is to provide a consistent set of navigation and engine configuration data to other guidance tasks.

A. Detailed Requirements.

1. To provide a consistent set of navigation data for all guidance tasks, the following computations are required:

$$D\bar{V}S = \bar{V}S - \bar{V}SP$$

$$D\bar{V}S_RTLS = D\bar{V}S$$

$$DVSMAG = ABVAL(D\bar{V}S)$$

$$\bar{V}SP = \bar{V}S$$

$$DTGD = T_NAV - T_NAV_PREV$$

$$TGD = T_NAV$$

$$T_NAV_PREV = T_NAV$$

2. In general, the guidance state vector is equivalent to the navigation state vector supplied by ASCENT UPP. However, the state required by ORB INS GUID must be consistent with the targeting compensation technique of removing from the true targets the effects of noncentral body forces from planned ignition to the target point. Therefore, if the major mode is either 104 or 105 and current navigation time (T_NAV) is greater than planned time of ignition (TIG), the guidance state is integrated from the previous guidance state:

$$\bar{R}GD = \bar{R}GD + DTGD (\bar{V}GD + 0.5(D\bar{V}S + \bar{G}CB DTGD))$$

$$\bar{G}CB_NEW = - EARTH_MU \bar{R}GD / (ABVAL(\bar{R}GD))^3$$

$$\bar{V}GD = \bar{V}GD + D\bar{V}S + 0.5(\bar{G}CB + \bar{G}CB_NEW) DTGD$$

$$\bar{G}CB = \bar{G}CB_NEW$$

where $\bar{G}CB$ initially is computed prior to TIG as

$$\bar{G}CB = - EARTH_MU \bar{R}GD / (ABVAL(\bar{R}GD))^3.$$

However, if the above conditions are not true, then the guidance state is set to the navigation state:

$$\bar{R}GD = R_NAV$$

$$\bar{V}GD = V_NAV$$

And if the major mode is 103, the guidance altitude is set to the navigation altitude:

$$\text{ALT_GD} = \text{ALT}$$

3. The following computations are required during all pre-MECO major modes to identify the number of active thrusting engines. The number of SSME's (N_SSME) is determined by subtracting the total MPS engine-out flags from three.

$$\text{N_SSME_PREV} = \text{N_SSME}$$

$$\text{N_SSME} = 3 - \text{SUM}(\text{INTEGER}(\text{S_}\dot{\text{E}}\text{O_E1}, \text{S_}\dot{\text{E}}\text{O_E2}, \text{S_}\dot{\text{E}}\text{O_E3}))$$

If the number of main engines thrusting (N_SSME) is less than the number thrusting during the last guidance cycle (N_SSME_PREV), then set the main engine failure flag:

$$\text{S_}\dot{\text{S}}\text{ME_FAIL} = \text{ON}$$

If the OMS engines are thrusting pre-MECO (S_OMS_IGN = ON), then the number of active OMS is set as indicated:

$$\text{N_OMS} = 2$$

Otherwise, if S_OMS_IGN = OFF or if S_OMS_CUTOFF = ON

$$\text{N_OMS} = 0$$

If the +X RCS jets are thrusting pre-MECO (S_RCS_IGN = ON) then the total number thrusting is set as indicated:

$$\text{N_RCS} = 4$$

Otherwise, (S_RCS_IGN = OFF)

$$\text{N_RCS} = 0$$

If 20 null RCS jets are thrusting pre-MECO S_RCS_NULL20 = ON), then

$$\text{N_RCS_NULL} = 20$$

Otherwise, (S_RCS_NULL20 = OFF)

$$\text{N_RCS_NULL} = 0$$

If an OMS dump is in progress (N_OMS > 0), then calculate the OMS burn time remaining as follows:

$$\text{TB_OMS} = (\text{OMS_DELTA_T_COMPUTED} - \text{OMS_EQUIVALENT_ON_TIME}) / \text{OMS_TIME_SCALE_FACTOR}$$

Otherwise, if an OMS dump is not in progress (N_OMS = 0), then set the burn time to zero:

$$\text{TB_OMS} = 0$$

4. The following computations are required during all post-MECO phases (MM's 104 and 105) to identify the number of active thrusting engines:
 - a. If OMS ignition has been commanded ($\text{OMS_IGNITION_CMD} = \text{ON}$), then the number of active OMS engines is determined by counting the total number of OMS engines currently commanded to fire, and the prime propulsive system flag is set as indicated:
$$\text{N_OMS} = \text{INTEGER}(\text{OMS_L_ON_CMD_IND}) + \text{INTEGER}(\text{OMS_R_ON_CMD_IND})$$

Set $\text{PROP_FLAG_OFS} = 1$.
If $\text{N_OMS} = 1$ and OMS_R_ON_CMD_IND is set, then set $\text{PROP_FLAG_OFS} = 3$.
If $\text{N_OMS} = 1$ and OMS_L_ON_CMD_IND is set, then set $\text{PROP_FLAG_OFS} = 2$.
If $\text{N_OMS} = 0$, then set $\text{PROP_FLAG_OFS} = 4$.
 - b. If $\text{N_OMS} = 0$ and $\text{N_RCS} = 0$, then $\text{N_RCS} = 4$.
5. The maximum integration time step (DT_LIMIT) for the gravity prediction is selected during all pre- and post-MECO phases (MM's 103, 104, 105, and 601).

$$\text{DT_LIMIT} = \text{DTMAX}$$

B. Interface Requirements. The input and output parameters for the PFG input task are given in Tables 4.8.8-1 and 4.8.8-2.

C. Processing Requirements. Subtasks 1 and 2 are performed each time this task is executed for all major modes. Subtasks 3 and 4 are mutually exclusive. Subtask 3 is performed each time this task is executed prior to MECO; i.e., for MM's 103 and 601. If the major mode is otherwise, Subtask 4 is performed each time this task is executed.

D. Initialization Requirements. The following parameters must be initialized as indicated the first time that Subtask 1 is executed. If that first execution occurs in MM 103, the parameters must be initialized prior to performing the Ascent User Parameter Processing (PF 4. 19) principal function. If it occurs in MM 601, they must be initialized prior to performing the RTLs User Parameter Processing (PF 4. 20) principal function. The UPP will update $\overline{\text{VS}}$ after its previous value is saved in $\overline{\text{VSP}}$ so that the resultant value of $\overline{\text{DVS}}$ in Subtask 1 is valid.

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

$$\text{SSME_FAIL} = \text{OFF}$$

Upon entry into MM 104 ($\text{MM104} = \text{ON}$), the number of active SSME's (N_SSME) is initialized to zero.

The following values must be initialized during post-MECO major modes the first time that Subtask 1 is executed after a load:

$$\text{OMS_IGNITION_CMD} = \text{OFF}$$

For current time (T_NAV) greater than time of ignition (TIG),

$$T_NAV_PREV = TGD$$

$$\overline{GCB} = -EARTH_MU \overline{RGD} / (ABVAL(\overline{RGD}))^3$$

and \overline{VSP} is initialized by the PRE-MAN DISP SUPT TSK.

For $T_NAV \leq TIG$,

$$T_NAV_PREV = T_NAV$$

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

E. Supplemental Information. The variable \overline{RGD} must be represented such that the least significant bit for each component is less than 0.005 ft/sec.

Table 4.8.8-1.PFG Input Task Inputs

Definition	Symbol	Source	Prec	Units
Current Shuttle position vector in M50	$R_{\overline{NAV}}$	ASC UPP, RTLS UPP	DP	ft
Number of active OMS engines	N_OMS	PRE-MAN DISP SUPT TSK	I	N/A
Pre-MECO OMS ignition command	$S_{\dot{OMS_IGN}}$	ABT CNTL SEQ	D	N/A
Pre-MECO OMS cutoff command	$S_{\dot{OMS_CUTOFF}}$	ABT CNTL SEQ	D	N/A
Abort +X RCS ON/OFF command	$S_{\dot{RCS_IGN}}$	ABT CNTL SEQ	D	N/A
MPS E1 engine-out flag	$S_{\dot{EO_E1}}$	SSME OPS	D	N/A
MPS E2 engine-out flag	$S_{\dot{EO_E2}}$	SSME OPS	D	N/A
MPS E3 engine-out flag	$S_{\dot{EO_E3}}$	SSME OPS	D	N/A
Time associated with state	T_NAV	ASC UPP, RTLS UPP	DP	sec
Current Shuttle velocity vector in M50	$V_{\overline{NAV}}$	ASC UPP, RTLS UPP	SP	fps
Accumulated sensed velocity vector	$V_{\overline{S}}$	ASC UPP, RTLS UPP	DP	fps
RCS 20 null jets ON/OFF COMMAND flag	$S_{\dot{RCS_NULL20}}$	ABT CNTL SEQ	D	N/A
OMS/RCS ignition time	TIG	PRE-MAN DISP SUPT TSK	DP	sec
OMS ignition command flag	OMS_IGNITION_CMD	MSC	D	N/A
L OMS on command indicator	OMS_L_ON_CMD_IND	OMS FIRE SEQ	D	N/A
R OMS on command indicator	OMS_R_ON_CMD_IND	OMS FIRE SEQ	D	N/A
OMS Delta_T computed	OMS_DELTA_T_COMPUTED	ABT CNTL SEQ, OVERRIDE SPEC	SP	sec
OMS Equivalent on time	OMS_EQUIVALENT_ON_TIME	ABT CNTL SEQ	SP	sec
OMS time scale factor	OMS_TIME_SCALE_FACTOR	ABT CNTL SEQ, OVERRIDE SPEC	SP	ND
Earth gravitational constant	EARTH_MU	CONSTANT	DP	ft ³ /sec ²
MM 103 flag	MM_{103}	MSC	D	N/A
MM 104 flag	MM_{104}	MSC	D	N/A
MM 105 flag	MM_{105}	MSC	D	N/A
MM 601 flag	MM_{601}	MSC	D	N/A
Maximum integration step size	DTMAX	K-LOAD	SP	sec
Time associated with $R_{\overline{GD}}$, $V_{\overline{GD}}$	TGD	PRE-MAN DISP SUPT TSK	DP	sec
Vehicle position vector input to PEG	$R_{\overline{GD}}$	PRE-MAN DISP SUPT TSK	DP	ft
Vehicle velocity vector input to PEG	$V_{\overline{GD}}$	PRE-MAN DISP SUPT TSK	DP	fps
Previous value of accumulated sensed velocity vector	$V_{\overline{SP}}$	PRE-MAN DISP SUPT TSK	DP	fps
Current orbiter altitude above reference ellipsoid	ALT	ASC UPP	SP	ft
Number of active SSME's	N_SSME	1STG GUID INP TSK	I	N/A
Previous value of time tag associated with current state (T_NAV)	T_NAV_PREV	1STG GUID INP TSK	DP	sec

Table 4.8.8-2.PFG Input Task Outputs

Definition	Symbol	Destination	Prec	Units
Difference between current and previous values of TGD	DTGD	G-LIM TSK, ACC-MASS UPD TSK, MPS GUID C/O TSK, FLYBK TSK, PPD TSK, CONT PPD TSK, DRP CTL TSK	SP	sec
Change in accumulated sensed velocity from previous value	\overline{DVS}	PEG TSK, MPS GUID C/O TSK, CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE5 TSK, CONT LVLH TSK	SP	fps
Magnitude of DVS vector	DVSMAG	G-LIM TSK, ACC-MASS UPD TSK	SP	fps
Number of active OMS engines	N_OMS	AOA ONORB TGT SEL TSK, THRST PRM TSK, TLM, DRP CTL TSK	I	N/A
Number of active RCS engines	N_RCS	THRST PRM TSK, CMD BDY ATT TSK, TLM, DRP CTL TSK	I	N/A
Number of active SSME engines	N_SSME	2STG SEQ, PEG TSK, ATO MECO TGT SEL TSK, ACC-MASS UPD TSK, THRST PRM TSK, PRTL SEQ, RTLS INIT TSK, TLM, MPS GUID C/O TSK, PPD TSK, FUL DISS TSK, RTLS/TAL TGT SEL TSK, CONT MODE SEL TSK, DRP CTL TSK	I	N/A
Time associated with \overline{RGD} and \overline{VGD}	TGD	PEG TSK, ORB INS SEQ, OMS GUID TSK, TLM, G-LIM TSK, MPS GUID C/O TSK, RTLS/TAL TGT SEL TSK, PPD TSK, AUTO CONT INIT TSK, CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK, CONT GUID C/O TSK, SSME-OUT SAF TSK, DRP CTL TSK	DP	sec
Vehicle velocity vector input to PEG	\overline{VGD}	PEG TSK, MPS GUID C/O TSK, CMD BDY ATT TSK, RTLS/TAL TGT SEL TSK, DRP CTL TSK	DP	fps
Number of active RCS null engines	N_RCS_NULL	THRST PRM TSK, TLM, FLYBK TSK, FUL DISS TSK	I	N/A

Table 4.8.8-2.PFG Input Task Outputs

Definition	Symbol	Destination	Prec	Units
Vehicle position vector input to PEG	\overline{RGD}	PEG TSK, CMD BDY ATT TSK, MPS GUID C/O TSK, DRP CTL TSK	DP	ft
Change in sensed velocity	$\overline{DVS_RTLS}$	FUL DISS TSK, PRTL SEQ	SP	fps
Prime propulsion system flag	PROP_FLAG_OFS	CMD BDY ATT TSK	I	N/A
Maximum integration step size for gravity prediction	DT_LIMIT	PEG TSK	SP	sec
Time of Cutoff	T_CUTOFF	OMS GUID TSK	DP	sec
Cutoff flag	\dot{SCO}	OMS GUID TSK	D	N/A
Vehicle altitude above reference ellipsoid	ALT_GD	DRP CTL TSK	SP	ft
OMS time to burn	TB_OMS	DRP CTL TSK	SP	sec
Main engine failure flag	$\dot{SSME_FAIL}$	2STG SEQ, PRTL SEQ	D	N/A

4.8.9 SSME-Out Safing Task (SSME-OUT SAF TSK)

The SSME-out safing task is a general-purpose guidance task used by ascent first-stage guidance, ascent second-stage guidance, and PW RTLS guidance when an SSME fails. The purpose of this task is to command a two-engine power level equivalent to three engines or a full power level to obtain maximum vehicle performance within the flight constraints and to provide required data for the abort guidance and targeting functions.

A. Detailed Requirements.

1. This task is required to store the earth-relative velocity magnitude for use by the AOA/ATO targeting function and the PW RTLS guidance function, respectively. For AOA/ATO targeting, the failure velocity is saved:

$$V_ME_OUT = V_RHO_MAG$$

For PRTLS, a reference velocity and altitude rate are saved. If an SSME fails during first stage ascent, the 1STG GUID INP TSK saves these parameters at the last guidance cycle of MM 102. Otherwise (MM102 = OFF) set $V_RTLS_FD = V_RHO_MAG$ and $H_DOT_FD = H_DOT_ELLIPSOID$ at engine failure.

2. The index for selecting the RTLS flight path target (LL) must be reset to reflect the engine-out configuration:

$$\text{IF } S_EO_E1 = \text{ON, then } LL = 2;$$

otherwise $LL = 3$

3. If V_RHO_MAG is less than V_PYR_SW , then the first-stage pitch bias index is reset for the engine-out condition ($L = LL$). Also, if $L > 1$, and this is the first pass through this task, do the following computations:

$$DELSEL = V_RHO_MAG P_SLP(L-1) + P_INT(L-1)$$

If V_RHO_MAG is greater than V_EO_SW , set

$$DELSEL = DEL_CST(L-1) \text{ and}$$

$$S_LOAD_RMP = \text{ON}$$

DELSEL is the I-load-dependent engine-out pitch bias which is used in the calculation of the first-stage engine-out pitch command in the BST GUID TSK. S_LOAD_RMP is an indicator of whether the engine failure occurred in a high loads region of first stage.

4. The GMT time of the SSME failure is stored for use during RTLS powered pitchdown.

$$T_ME_FAIL = TGD$$

If the RTLS powered pitchdown has begun ($S_PPD_QUAT = \text{ON}$), exit this task.

5. If manual throttling is not being performed ($S_MAN_THROT = OFF$), and $SE_MECO_PREP_K$ is OFF, and no more than one SSME has failed ($N_SSME > 1$), and no display throttle level commands have been actuated ($NOM_THROT_CMD = OFF$ and $ABT_THROT_CMD = OFF$ and $MAX_THROT_CMD = OFF$), set the throttle limit $KMAX$ as a function of two I-loaded and uplinkable velocity breakpoints as follows:

If $V_RHO_MAG < V_KMAX_UP$ or $V_RHO_MAG > V_KMAX_DOWN$, then:

$$KMAX = KMAX_NOM$$

Otherwise, $KMAX = KMAX_ABT$.

6. If $MM102 = ON$ or $MM103 = ON$, then $K_CMD = KMAX$; otherwise, the throttle command must be set to the minimum of the three-engine equivalent value or $KMAX$, and the desired throttle setting is set and limited:

IF ($KMAX > (1.5 K_CMD)$),

then $K_CMD = ROUND(1.5 K_CMD)$

else $K_CMD = KMAX$

$$K = MIN(1.5 K, KMAX)$$

None of the above changes to K and K_CMD are made if $SE_MECO_PREP_K$ is ON or manual throttling is being performed.

7. This task resets the values of the thrust scaling factor and the current estimated thrust scaling factor, respectively:

$$FT_FACTOR = 1$$

$$X1 = 0$$

8. This task sets the main engine failure flag ($SSME_FAIL$) to OFF.

B. Interface Requirements. The input and output parameters for the SSME-out safing task are given in Tables 4.8.9-1 and 4.8.9-2.

C. Processing Requirements. This task is called only on the first guidance cycle following an engine failure.

D. Initialization Requirements. L and LL must be initialized to 1. This is done as an initialization of the BST GUID TSK in first-stage guidance.

Table 4.8.9-1.SSME-Out Safing Task Inputs

Definition	Symbol	Source	Prec	Units
MM 102 flag	MM102	MSC	D	N/A
Navigated earth-relative velocity magnitude	V_RHO_MAG	ASC UPP	SP	fps
MPS E1 engine-out flag	S_ĖO_E1	SSME OPS	D	N/A
MPS E2 engine-out flag	S_ĖO_E2	SSME OPS	D	N/A
MPS E3 engine-out flag	S_ĖO_E3	SSME OPS	D	N/A
Maximum throttle setting of SSME	KMAX	I-LOAD, KMAX UPDT TSK	I	pct
Abort throttle limit	KMAX_ABT	I-LOAD	I	pct
Nominal throttle limit	KMAX_NOM	I-LOAD	I	pct
Max throttle level command	MAX_ĖTHROT_CMD	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	ABT_ĖTHROT_CMD	OVERRIDE DISPLAY	D	N/A
Nominal throttle level command	NOM_ĖTHROT_CMD	OVERRIDE DISPLAY	D	N/A
Throttle limit decrease velocity switch	V_KMAX_DOWN	I-LOAD, UPLINK	SP	fps
Throttle limit increase velocity switch	V_KMAX_UP	I-LOAD, UPLINK	SP	fps
Number of active SSME's	N_SSME	1STG GUID INP TSK, PFG INP TSK	I	N/A
Commanded SSME throttle setting	K_CMD	G-LIM TSK, GUID PRMT RINT TSK, RTLS INIT TSK, BST THROT TSK, FLYBK TSK, SBTC SOP, ASC GUID TSK, 1STG GUID INP TSK, FUL DISS TSK, RTLS/TAL TGT SEL TSK	I	pct
Maximum velocity for changing pitch/yaw profile in first stage	V_PYR_SW	I-LOAD	SP	fps
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
EST altitude rate	H_DOT_ELLIPSOID	ASC UPP	SP	fps
Pitch bias intercepts for early first-stage engine failure	P_INT(I) (I=1,2)	I-LOAD	SP	rad
Pitch bias slopes for early first-stage engine failure	P_SLP(I) (I=1,2)	I-LOAD	SP	rad/fps
Constant pitch bias for later first-stage engine failure	DEL_CST(I) (I=1,2)	I-LOAD	SP	rad
Engine-out pitch bias selection switch velocity	V_EO_SW	I-LOAD	SP	fps
Desired throttle setting	K	PEG TSK	SP	pct
Discrete indicating powered pitchdown commands	S_PPD_QUAT	PPD TSK	D	N/A
Time associated with \overline{RGD} and \overline{VGD}	TGD	PFG INP TSK	DP	sec

Table 4.8.9-1.SSME-Out Safing Task Inputs				
Single engine MECO prep throttle discrete	SE_MECO_PREP_K	SE MECO PREP TSK	D	N/A

Table 4.8.9-2.SSME-Out Safing Task Outputs

Definition	Symbol	Destination	Prec	Units
Commanded SSME throttle setting	K_CMD	SSME SOP, FLYBK TSK, MPS GUID C/O TSK, G-LIM TSK, 1STG GUID INP TSK, THRST PRM TSK, FUL DISS TSK, PEG TSK, TLM, SBTC SOP, DRP CTL TSK, XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
Maximum throttle setting of SSME	KMAX	RTLS INIT TSK, PEG TSK, G-LIM TSK, SBTC SOP, PPD TSK, 1STG GUID INP TSK, AUTO CONT INIT TSK, ASC DAP	I	pct
Index for selecting RTLS flight path angle target	LL	PEG TSK, PPD TASK	I	N/A
Relative velocity magnitude at SSME failure time	V_ME_OUT	ATO MECO TGT SEL TSK, ATO OMS PRE-MECO BRN DET TSK, TLM, PEG TSK, BST GUID TSK	SP	fps
Index for nominal/engine-out pitch and yaw polynomials	L	BST GUID TSK, TLM	I	N/A
RTLS fuel dissipation reference velocity magnitude	V_RTLS_FD	PITCH CMD TSK	SP	fps
Desired throttle setting	K	PEG TSK, FUL DISS TSK, FLYBK TSK, TLM	SP	pct
Thrust scaling factor	FT_FACTOR	ASC GUID TSK, FUL DISS TSK, FLYBK TSK, TLM, CONT MODE 5 TSK	SP	ND
Current estimated thrust scaling factor	X1	ACC-MASS UPD TSK	SP	ND
RTLS fuel dissipation reference HDOT	H_DOT_FD	PITCH CMD TSK	SP	fps
Engine-out pitch bias	DELSEL	BST GUID TSK	SP	rad
Engine-out pitch bias load ramp discrete	S_LOAD_RMP	BST GUID TSK	D	N/A
GMT time of main engine failure	T_ME_FAIL	PPD TSK	DP	sec
Main engine failure flag	SSME_FAIL	2STG SEQ, PRTLS SEQ	D	N/A

4.8.10 Commanded Body Attitude Task (CMD BDY ATT TSK)

This task computes a quaternion relating body axes to the mean-of-1950 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 burn attitude during the burn.

A. Detailed Requirements. Computation of an M50 inertial-to-commanded body quaternion is based upon a unit thrust vector in the body axis coordinate system ($\overline{\text{THRUST_BODY}}$), the desired thrust orientation vector in M50 ($\overline{\text{UF}}$), the roll reference vector ($\overline{\text{ROLL_REF}}$), and the desired thrust vector roll angle (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 occur:

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

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

If ($\text{PROP_FLAG_OFS} \neq \text{PROP_FLAG_OFS_P}$), then execute Item 1 to compute the body-fixed thrust direction.

If ($\text{PROP_FLAG_OFS} = \text{PROP_FLAG_OFS_P}$), then skip Item 1 and go to Item 2.

- 1a. If the prime propulsive system is RCS ($\text{PROP_FLAG_OFS} = 4$), then the body thrust vector is set equal to the K-load vector that defines the force direction resulting from firing the high acceleration +X RCS thrusters ($\overline{\text{THRUST_BODY_RCS_X}}$), the OMS thrust calculations are omitted, and the next calculation is the $\overline{\text{UF}}$ vector below.

If $\text{PROP_FLAG_OFS} = 4$, then $\overline{\text{THRUST_BODY}} = \overline{\text{THRUST_BODY_RCS_X}}$ and skip Item 1b.

- b. If an OMS configuration is to be used or if a parallel OMS, RCS maneuver is required ($\text{PROP_FLAG_OFS} \neq 4$), then the body thrust vector is calculated as a function of the OMS trim angles and the RCS thrust. These OMS trim angles are related to the displayed desired OMS trim angles through constant bias terms. These bias terms transform the displayed desired OMS trim angles from an electrical null reference to a body axis reference.

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.

If ($\text{PROP_FLAG_OFS_P} = 0$), then:

$$\text{YAW_TRIM}_1 = \text{OMS_YAW_TRIM}_1$$

$$\text{YAW_TRIM}_2 = \text{OMS_YAW_TRIM}_2$$

$$\text{PITCH_TRIM} = \text{OMS_PITCH_TRIM}$$

If (PROP_FLAG_OFS_P \neq 0), then

$$\text{YAW_TRIM}_1 = \text{ONE_ENG_OMS_YAW_TRIM}_1$$

$$\text{YAW_TRIM}_2 = \text{ONE_ENG_OMS_YAW_TRIM}_2$$

$$\text{PITCH_TRIM} = \text{ONE_ENG_OMS_PITCH_TRIM}$$

The subscript 1 denotes LEFT OMS and 2 denotes RIGHT OMS.

$$\text{OMS_YAW_BODY}_1 = \text{YAW_TRIM}_1 \text{ RAD_PER_DEG} + \text{YAW_BIAS}$$

$$\text{OMS_YAW_BODY}_2 = \text{YAW_TRIM}_2 \text{ RAD_PER_DEG} - \text{YAW_BIAS}$$

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

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

$$\text{If PROP_FLAG_OFS} = 2 \text{ then } J2 = 1 \text{ (LEFT OMS)}$$

$$\text{If PROP_FLAG_OFS} = 3 \text{ then } J1 = 2 \text{ (RIGHT OMS)}$$

Convert the displayed 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

$$C_YAW = \text{COS}(\text{OMS_YAW_BODY}_J)$$

$$\overline{\text{THRUST_BODY_OMS}}_J = \text{VECTOR}(\text{COS}(\text{OMS_PITCH_BODY}) C_YAW, \\ \text{SIN}(\text{OMS_YAW_BODY}_J), \text{SIN}(\text{OMS_PITCH_BODY}) C_YAW)$$

The resultant body unit thrust direction is computed:

$$\overline{\text{THRUST_BODY}} = \text{UNIT}(\text{FT_RCS } N_RCS \overline{\text{THRUST_BODY_RCS_X}} + \\ \text{FT_OMS } ((2-J1) \overline{\text{THRUST_BODY_OMS}}_1 + (J2-1) \overline{\text{THRUST_BODY_OMS}}_2))$$

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{UF}) at the desired time (T_CA) is calculated from the \overline{LAMC} , \overline{LAMDC} , \overline{TLAMC} parameters.

$$\overline{UF} = \text{UNIT}(\overline{LAMC} + \overline{LAMDC} (T_CA - \overline{TLAMC}))$$

If $T_CA > TIG$, then perform Items b and c. Otherwise, perform Items a and c.

- a. The roll reference vector ($\overline{RÖLL_REF}$) defined to be the unit radius vector is calculated:

$$\overline{RÖLL_REF} = \text{UNIT}(\overline{R\overline{GD}})$$

where $\overline{R\overline{GD}}$ is the radius vector used by guidance to solve for $\overline{L\overline{AMC}}$, $\overline{L\overline{AMDC}}$, 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:

$$\overline{CBETA} = \overline{RÖLL_REF} \cdot \overline{UF}$$

If $\text{ABS}(\overline{CBETA}) > \overline{CBETA_EPS}$, then a different roll reference must be saved. The new roll reference is determined as follows:

$$\overline{RÖLL_REF} = -\overline{V\overline{GD}} \text{ for } \overline{CBETA} > 0$$

$$\overline{RÖLL_REF} = \overline{V\overline{GD}} \text{ for } \overline{CBETA} \leq 0$$

where $\overline{CBETA_EPS}$ is a K-load quantity.

The attitude matrix ($\overline{M\overline{T}\overline{P}}$) is then computed:

$$\overline{Y\overline{N}} = \text{UNIT}(\overline{T\overline{HRUST_BODY}} \times \text{VECTOR}(0, -1, 0))$$

$$\overline{Y\overline{T}} = \text{UNIT}(\overline{UF} \times \overline{RÖLL_REF}) \text{ SIN}(\overline{TVR_ROLL_RAD_PER_DEG}) - \overline{UF} \times \text{UNIT}(\overline{UF} \times \overline{RÖLL_REF}) \text{ COS}(\overline{TVR_ROLL_RAD_PER_DEG})$$

$$\overline{M\overline{T}\overline{P}} = \text{MATRIX}(\overline{T\overline{HRUST_BODY}}, \overline{T\overline{HRUST_BODY}} \times \overline{Y\overline{N}}, -\overline{Y\overline{N}})$$

$$\overline{M\overline{T}\overline{P}} = \overline{M\overline{T}\overline{P}}^{\text{T}} \text{ MATRIX}(\overline{UF}, \overline{UF} \times \overline{Y\overline{T}}, -\overline{Y\overline{T}})$$

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`

Inputs: $\overline{M\overline{T}\overline{P}}$

Outputs: $\overline{Q_CB_M50_S}$, $\overline{Q_CB_M50_V}$

- b. The following computations are performed whenever item (T_CA) is greater than time of ignition.

- (1) 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}

- (2) Obtain the difference of $\overline{THRUST_BODY}$ and \overline{UFB}

$$\overline{YN} = \overline{UFB} - \overline{THRUST_BODY}$$

If the magnitude of \overline{YN} is less than 0.001, then no attitude change is required; hence, set the body-to-commanded body quaternion to identity and proceed to Item (5).

If $ABVAL(\overline{YN}) < 0.001$, then $Q_CB_B_S = 1$, $Q_CB_B_V = 0$, and proceed to Item (5).

- (3) Construct the single rotation axis

$$\overline{SRA} = \text{UNIT}(0, YN_3, -YN_2)$$

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

- (4) Compute the body-to-commanded body quaternion

$$\overline{ATB} = (\overline{SRA} \times \overline{THRUST_BODY}) \times \overline{SRA}$$

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

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

$$Q_CB_B_S = \overline{B} \cdot \overline{ATB}$$

$$Q_CB_B_V = [(\overline{B} \times \overline{ATB}) \cdot \overline{SRA}] \overline{SRA}$$

- (5) Compute the M50-to-commanded body quaternion by calling the QUAT_MULT utility routine

CALL QUAT_MULT

Inputs: $Q_CB_B_S$, $Q_CB_B_V$, $Q_B_I_S$, $Q_B_I_V$

Outputs: $Q_CB_M50_S$, $Q_CB_M50_V$

- c. Compute the commanded body attitude.

The ADI-to-commanded body quaternion ($Q_CB_ADI_S$, $Q_CB_ADI_V$) is obtained by multiplying the M50-to-commanded body quaternion with the K-load ADI to M50 quaternion ($Q_M50_INTRL_ASCENT$):

CALL QUAT_MULT

Inputs: $Q_CB_M50_S$, $Q_CB_M50_V$, $Q_M50_INTRL_ASCENT$

Outputs: $Q_CB_ADI_S$, $Q_CB_ADI_V$

The resulting quaternion ($Q_CB_ADI_S$, $Q_CB_ADI_V$) 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

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 4.8.10-1 and 4.8.10-2.

C. Processing Requirements. The commanded body attitude task is performed once each time the premaneuver display support task (4.7.7) is called and cyclically from when current time (T_GMT) exceeds time of ignition (TIG) until transition to the next major mode.

D. Initialization Requirements. None.

Table 4.8.10-1. Commanded Body Attitude Task Inputs				
Definition	Symbol	Source	Prec	Units
OMS pitch trim angle	OMS_PITCH_TRIM	TRANS DAP	SP	deg
Left OMS yaw trim angle	OMS_YAW_TRIM ₁	TRANS DAP	SP	deg
Right OMS yaw trim angle	OMS_YAW_TRIM ₂	TRANS DAP	SP	deg
Prime propulsion system indicator	PROP_FLAG_OFS	PFG INP TSK, PRE-MAN DISP SUPT TSK	I	N/A
Previous value for prime propulsion system indicator flag	PROP_FLAG_OFS_P	PRE-MAN DISP SUPT TSK	I	N/A
Nominal RCS thrust	FT_RCS	K-LOAD	SP	lbf
Nominal OMS thrust	FT_OMS	K-LOAD	SP	lbf
Number of active RCS engines	N_RCS	PFG INP TSK, RE-MAN DISP SUPT TSK	I	N/A
Unit body thrust vector for the 4 +X RCS propulsive system in body coordinates	$\bar{T}HRUST_BODY_RCS_X$	K-LOAD	SP	ND
Unit desired thrust direction vector in M50 coordinates	$\bar{L}AMC$	PEG TSK	SP	ND
Desired thrust direction turning rate in M50 coordinates	$\bar{L}AMDC$	PEG TSK	SP	sec ⁻¹
GMT associated with reference thrust vectors ($\bar{L}AMC$, $\bar{L}AMDC$)	TLAMC	PEG TSK	DP	sec
GMT to compute commanded body attitude	T_CA	PRE-MAN DISP SUPT TSK, OMS GUID TSK	SP	sec
Vehicle position vector input to PEG	$\bar{R}GD$	PFG INP TSK, PRE-MAN DISP SUPT TSK	DP	ft
Vehicle velocity vector input to PEG	$\bar{V}GD$	PFG INP TSK, PRE-MAN DISP SUPT TSK	DP	fps
Thrust vector roll angle	TVR_ROLL	I-LOAD	SP	deg
Constant bias term to convert OMS engine electrical null pitch trim angles to the body axis reference	PITCH_BIAS	K-LOAD	SP	rad
Constant bias term to convert OMS engine electrical null yaw trim angles to the body axis reference	YAW_BIAS	K-LOAD	SP	rad
Degrees to radians conversion factor	RAD_PER_DEG	CONSTANT	SP	rad/deg

Table 4.8.10-1. Commanded Body Attitude Task Inputs				
Definition	Symbol	Source	Prec	Units
Tolerance on allowable angle between commanded thrust direction and radius vector before a new reference must be established	CBETA_EPS	K-LOAD	SP	ND
M50-to-body quaternion	Q_B_I_S, Q_B_I_V	A/E ATT PROC	SP	ND
Time of ignition	TIG	PRE-MAN DISP SUPT TASK	DP	sec
Left OMS engine yaw trim for one engine*	ONE_ENG_OMS_YAW_TRIM ₁	K-LOAD	SP	deg
Right OMS engine yaw trim for one engine*	ONE_ENG_OMS_YAW_TRIM ₂	K-LOAD	SP	deg
Pitch trim for one engine*	ONE_ENG_OMS_PITCH_TRIM	K-LOAD	SP	deg
ADI to M50 quaternion	Q_M50_INRTL_ASCENT	K-LOAD	SP	ND
*This K-load is shared with the Transition DAP principal function (4.201).				

Table 4.8.10-2. Commanded Body Attitude Task Outputs				
Definition	Symbol	Destination	Prec	Units
M50-to-commanded body quaternion	Q_CB_M50_S, Q_CB_M50_V	PRE-MAN DISP SUPT TSK, TRANS DAP	SP	ND
Desired vehicle burn attitude in ADI coordinates	VEH_PITCH, VEH_YAW, VEH_ROLL	MNVR DISP, TLM	SP	deg
Unit engine thrust direction in body coordinates	THRUST_BODY	OMS GUID TSK	SP	ND
Valid angle comp flag	X_FLAG	MNVR DISP	D	ND

4.8.11 RTLS/TAL Target Selection Task (RTLS/TAL TGT SEL TSK)

This task is used by the TAL ascent second-stage guidance and PRTLS guidance principal functions. Its function is to allow selection of alternate landing sites for RTLS and TAL aborts and reselect appropriate guidance targets according to the target selected. This task tests the compatibility of the abort mode with the selected landing site and will not allow incompatible targets to be selected.

Note that the eight I-Loads in the RTLS/TAL landing area guidance target set 1 (see Table 4.8.11-1) can be uplinked. This capability was implemented for use in RTLS via the RTLS Guidance Parameters Uplink Load (see section 6.3.61 of the Uplink CPDS SS-P-0002-140). Functionally, this target set could be configured for use in a TAL via I-Loaded abort mode designator indices which would allow an uplink of the same I-Loads. However, this capability is not operationally practical and will not be exercised or enabled.

A. Detailed Requirements.

This task stores up to ten different target sets that are shared by RTLS and TAL landing areas. The desired target set is selected by the integer AREA_SEL and the array TARGET_INDEX. If the value of AREA_SEL is zero the area is for entry only. For a TAL area the value is a positive integer and for a RTLS area the value is a negative integer. The absolute value of TARGET_INDEX serves as the target array's index for the selected ascent target area.

1. If a TAL is in progress ($\dot{TAL_ABORT_DECLARED} = ON$), the abort mode is compared with the selected target area in order to check for compatibility. The abort mode designator I-load, $TARGET_INDEX_{(AREA_SEL)}$, is set to a positive integer for a TAL abort.

If $TARGET_INDEX_{(AREA_SEL)} > 0$, then

$$TAL_AREA = ABS(TARGET_INDEX(AREA_SEL))$$

If this is the first execution of the RTLS/TAL Target Selection Task after TAL selection, the current vehicle velocity is compared to each of two site-dependent velocity boundaries. If the vehicle velocity exceeds a boundary, the specific action associated with that boundary is taken.

If this is the first pass after TAL selection, then set $VGDMAG = ABVAL(\overline{VGD})$, set $TGD_TAL_LATE = TGD$, and do the following two steps (a) and (b).

- (a) If $VGDMAG > TARGET11(TAL_AREA)$, set the rollover inhibit discrete $S_TAL_ROLL_INH = ON$.
- (b) If $S_MAN_THROT = OFF$ and either:
 - (i) $N_SSME = 2$ and $VGDMAG > TARGET12(TAL_AREA)$
 - (II) $N_SSME = 3$ and $VGDMAG > TARGET13(TAL_AREA)$

then $K_CMD = KMIN$.

$$RTEF(1) = R_LS_EF(1)$$

$$\text{RTEF (2)} = \text{R_LS_EF (2)}$$

$$\text{RTEF (3)} = \text{R_LS_EF (3)}$$

The guidance targets are set to the appropriate targeting I-loads according to the TAL area selected.

$$A_8 = \text{TARGET2}_{(\text{TAL_AREA})}$$

$$A_9 = \text{TARGET3}_{(\text{TAL_AREA})}$$

$$A_{10} = \text{TARGET4}_{(\text{TAL_AREA})}$$

$$A_{11} = \text{TARGET5}_{(\text{TAL_AREA})}$$

If $\dot{\text{S_DROOP_TARGETS}} = \text{ON}$, then the TAL crossrange, flight path angle, and position magnitude guidance targets are changed to their respective low energy targets:

$$\text{GAMD} = \text{GAMD_LOW}$$

$$\text{RDMAG} = \text{RD_LOW}$$

$$\text{CR_MAX} = \text{CR_MAX_LOW}$$

Otherwise use the normal TAL values for this area:

$$\text{GAMD} = \text{TARGET6}_{(\text{TAL_AREA})}$$

$$\text{RDMAG} = \text{TARGET7}_{(\text{TAL_AREA})}$$

$$\text{CR_MAX} = \text{TARGET8}_{(\text{TAL_AREA})}$$

$$\text{VD_TAL_MAX} = \text{TARGET9}_{(\text{TAL_AREA})}$$

$$\text{VD_TAL_MIN} = \text{TARGET10}_{(\text{TAL_AREA})}$$

2. If an RTLS abort is in progress ($\dot{\text{MM601}} = \text{ON}$), the abort mode is compared with the selected target area in order to check for compatibility. The abort mode designator I-load, $\text{TARGET_INDEX}_{(\text{AREA_SEL})}$, is set to a negative integer for an RTLS abort.

If $\text{TARGET_INDEX}_{(\text{AREA_SEL})} < 0$, then

$$\text{RTLS_AREA} = \text{ABS}(\text{TARGET_INDEX}_{(\text{AREA_SEL})})$$

$$\text{RTEF (1)} = \text{R_CC_EF (1)}$$

$$\text{RTEF (2)} = \text{R_CC_EF (2)}$$

$$\text{RTEF (3)} = \text{R_CC_EF (3)}$$

The guidance targets are equivalenced to the appropriate targeting I-loads according to the RTLS area selected.

$$A_1 = \text{TARGET2}_{(\text{RTLS_AREA})}$$

$$A_2 = \text{TARGET3}_{(\text{RTLS_AREA})}$$

$$A_3 = \text{TARGET4}_{(\text{RTLS_AREA})}$$

$$A_4 = \text{TARGET5}_{(\text{RTLS_AREA})}$$

$$A_5 = \text{TARGET6}_{(\text{RTLS_AREA})}$$

$$A_6 = \text{TARGET7}_{(\text{RTLS_AREA})}$$

$$A_7 = \text{TARGET8}_{(\text{RTLS_AREA})}$$

$$\text{GAM}(1) = \text{TARGET9}_{(\text{RTLS_AREA})}$$

$$\text{GAM}(2) = \text{TARGET10}_{(\text{RTLS_AREA})}$$

$$\text{GAM}(3) = \text{TARGET11}_{(\text{RTLS_AREA})}$$

$$\text{RDMAG} = \text{TARGET12}_{(\text{RTLS_AREA})}$$

$$\text{ET_BIAS} = \text{TARGET13}_{(\text{RTLS_AREA})}$$

$$\text{V_LATE_RTLS} = \text{TARGET14}_{(\text{RTLS_AREA})}$$

B. Interface Requirements. The input and output parameters for the RTLS/TAL target selection task are given in Tables 4.8.11-1 and 4.8.11-2.

C. Processing Requirements. This task is executed every guidance pass following the selection of the RTLS or TAL abort.

D. Initialization Requirements.

$$\text{TAL_AREA} = \text{ABS}(\text{TARGET_INDEX}_{(\text{TAL_PRIME_AREA})})$$

$$\text{RTLS_AREA} = \text{ABS}(\text{TARGET_INDEX}_{(\text{RTLS_PRIME_AREA})})$$

$$\text{S_TAL_ROLL_INH} = \text{OFF}$$

$$\text{CR_MAX} = 3341855.$$

Table 4.8.11-1. RTLS/TAL Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
Discrete to indicate that a TAL abort is in progress	TAL_ABORT_DECLARED	MSC	D	N/A
Selected area	AREA_SEL	ASC SITE LOOKUP	I	N/A
Abort mode designator	TARGET_INDEX _J (J=1,45)	I-LOAD	I	N/A
RTLS/TAL landing area guidance target	TARGET2 ₁	I-LOAD, UPLINK	SP	fps
RTLS/TAL landing area guidance target	TARGET4 ₁	I-LOAD, UPLINK	SP	fps
RTLS/TAL landing area guidance target	TARGET6 ₁	I-LOAD, UPLINK	SP	fps
RTLS/TAL landing area guidance target	TARGET9 ₁	I-LOAD, UPLINK	SP	rad
RTLS/TAL landing area guidance target	TARGET10 ₁	I-LOAD, UPLINK	SP	rad
RTLS/TAL landing area guidance target	TARGET11 ₁	I-LOAD, UPLINK	SP	rad
RTLS/TAL landing area guidance target	TARGET12 ₁	I-LOAD, UPLINK	SP	ft
RTLS/TAL landing area guidance target	TARGET14 ₁	I-LOAD, UPLINK	SP	fps
RTLS/TAL landing area guidance targets	TARGET2 _J (J=2,10)	I-LOAD	SP	fps
RTLS/TAL landing area guidance targets	TARGET3 _J (J=1,10)	I-LOAD	SP	sec ⁻¹
RTLS/TAL landing area guidance targets	TARGET4 _J (J=2,10)	I-LOAD	SP	fps or sec ⁻¹ ft ⁻¹
RTLS/TAL landing area guidance targets	TARGET5 _J (J=1,10)	I-LOAD	SP	sec ⁻¹ or ft ⁻² -sec ⁻¹
RTLS/TAL landing area guidance targets	TARGET6 _J (J=2,10)	I-LOAD	SP	fps or rad
RTLS/TAL landing area guidance targets	TARGET7 _J (J=1,10)	I-LOAD	SP	sec ⁻¹ or ft
RTLS/TAL landing area guidance targets	TARGET8 _J (J=1,10)	I-LOAD	SP	ft or ft-rad ⁻¹ -sec ⁻¹
RTLS/TAL landing area guidance targets	TARGET9 _J (J=2,10)	I-LOAD	SP	fps or rad
RTLS/TAL landing area guidance targets	TARGET10 _J (J=2,10)	I-LOAD	SP	fps or rad
RTLS/TAL landing area guidance targets	TARGET11 _J (J=2,10)	I-LOAD	SP	rad or fps
RTLS/TAL landing area guidance targets	TARGET12 _J (J=2,10)	I-LOAD	SP	ft or fps
TAL prime area designator	TAL_PRIME_AREA	I-LOAD	I	N/A
RTLS prime area designator	RTLS_PRIME_AREA	I-LOAD	I	N/A
HAC center position vector	R _{CC} _EF	RTLS UPP	DP	ft
TAL runway target vector	R _{LS} _EF	ASC SITE LOOKUP	DP	ft

Table 4.8.11-1. RTLS/TAL Target Selection Task Inputs				
Definition	Symbol	Source	Prec	Units
RTLS/TAL landing area guidance targets	TARGET13 _J (J=1, 10)	I-LOAD	SP	ft or fps
RTLS/TAL landing area guidance targets	TARGET14 _J (J=2,10)	I-LOAD	SP	fps
MM 601 flag	MM601	MSC	D	N/A
Minimum SSME throttle setting	KMIN	I-LOAD	I	pct
Manual throttle discrete	S_MAN_THROT	SBTC SOP	D	N/A
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Vehicle velocity vector	V \bar{G} D	PFG INP TSK	DP	fps
Time associated with R \bar{G} D and V \bar{G} D state vectors	TGD	PFG INP TSK	DP	sec
Low energy TAL droop targets desired indicator	S_DROOP_TARGETS	DRP CTL TSK	D	N/A
Desired TAL MECO radius for low energy entry	RD_LOW	I-LOAD	DP	ft
Maximum TAL MECO crossrange for low energy entry	CR_MAX_LOW	I-LOAD	SP	ft
Desired MECO flight path angle for low energy entry	GAMD_LOW	I-LOAD	SP	rad

Table 4.8.11-2. RTLS/TAL Target Selection Task Outputs				
Definition	Symbol	Destination	Prec	Units
TAL MECO inertial velocity coefficient	A ₈	PEG TSK	SP	fps
TAL MECO inertial velocity coefficient	A ₉	PEG TSK	SP	sec ⁻¹
TAL MECO inertial velocity coefficient	A ₁₀	PEG TSK	SP	sec ⁻¹ ft ⁻¹
TAL MECO inertial velocity coefficient	A ₁₁	PEG TSK	SP	sec ⁻¹ ft ⁻²
Desired MECO flight path angle	GAMD	PEG TSK	SP	rad
Desired MECO radius	RDMAG	PEG TSK	DP	ft
Maximum TAL MECO crossrange	CR_MAX	PEG TSK, ASC UPP	SP	ft
One- and two-engine RTLS PPD relative velocity coefficient	A ₁	PEG TSK	SP	fps
One- and two-engine RTLS PPD relative velocity coefficient	A ₂	PEG TSK	SP	sec ⁻¹
Three-engine RTLS PPD relative velocity coefficient	A ₃	PEG TSK	SP	fps
Three-engine RTLS PPD relative velocity coefficient	A ₄	PEG TSK	SP	sec ⁻¹
RTLS MECO relative velocity coefficient	A ₅	MPS GUID C/O TSK	SP	fps
RTLS MECO relative velocity coefficient	A ₆	MPS GUID C/O TSK	SP	sec ⁻¹
RTLS MECO relative velocity coefficient	A ₇	MPS GUID C/O TSK	SP	ft-rad ⁻¹ -sec ⁻¹
Desired flight path angle for RTLS	GAM, (J=1,3)	PEG TSK	SP	rad
TAL maximum value of VDMAG	VD_TAL_MAX	PEG TSK	SP	fps
TAL minimum value of VDMAG	VD_TAL_MIN	PEG TSK	SP	fps
Runway target vector in earth-fixed coordinates	RTEF	PEG TSK, MPS GUID C/O TSK	DP	ft
External tank aim point bias	ET_BIAS	PEG TSK, MPS GUID C/O TSK	SP	ft
Relative velocity magnitude for latest RTLS	V_LATE_RTLS	PRTLSE SEQ	SP	fps
Commanded SSME throttle setting	K_CMD	SSME SOP, SBTC SOP, TLM, THRST PRM TSK, SSME-OUT SAF TSK, PEG TSK, G-LIM TSK, MPS GUID C/O TSK, DRP CTL TSK, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
TAL rollover inhibit discrete	S_TAL_ROLL_INH	ASC GUID TSK	D	N/A
Vehicle velocity magnitude at TAL selection	VGDMAG	BFS	SP	fps

Table 4.8.11-2. RTLS/TAL Target Selection Task Outputs				
Definition	Symbol	Destination	Prec	Units
Time of TAL selection	TGD_TAL_LATE	BFS	DP	sec

4.8.12 RTLS Contingency Abort Task (RTLS CONT ABT TSK)

This task determines whether a contingency or intact abort is being attempted. The following tests are required to determine if the orbiter is flying back toward the launch site. If all of these tests are passed, a flag is set to OFF to indicate an intact abort. If any of these tests are failed, the flag is set ON to indicate a contingency abort.

A. Detailed Requirements.

1. If the magnitude of the current navigated velocity ($ABVAL(V_{\bar{NAV}})$) is greater than a permission stored decision velocity (V_{RTLS_CNTG}), then continue with Step 2. Otherwise, set the RTLS contingency flag ($GLIDE_RTLS_INHIBIT$) ON and exit this task.
2. A launch site heading vector ($R_{\bar{CNTG_TGT}}$) is calculated by subtracting the current position vector ($R_{\bar{NAV}}$) from the launch site vector ($R_{\bar{LS_M50}}$):

$$R_{\bar{CNTG_TGT}} = R_{\bar{LS_M50}} - R_{\bar{NAV}}$$

To determine if the orbiter is heading back toward the launch site, rather than downrange, a dot product of $R_{\bar{CNTG_TGT}}$ and the current navigated velocity vector $V_{\bar{NAV}}$ is computed. If this dot product is positive, then set $GLIDE_RTLS_INHIBIT$ to OFF; otherwise, set $GLIDE_RTLS_INHIBIT$ to ON.

B. Interface Requirements. The input and output parameters for the RTLS contingency abort task are given in Tables 4.8.12-1 and 4.8.12-2.

C. Processing Requirements. During powered RTLS guidance this task is executed once when two or more SSME's have failed ($N_{SSME} < 2$) if the SSME cutoff timing request flag $S_{\dot{T}MECO}$ has not been set; and once when $\dot{M}ECO_CONFIRM$ has occurred.

During powered contingency guidance when $\dot{C}ONT_2EO_START = ON$ and the major mode is 601 this task is executed once when $\dot{M}ECO_CONFIRM$ has occurred.

During Contingency 3 Engine Out Guidance when $\dot{C}ONT_3EO_START = ON$ this task is executed once on first pass.

D. Initialization Requirements. None.

Table 4.8.12-1. RTLS Contingency Abort Task Inputs				
Definition	Symbol	Source	Prec	Units
M50 position vector of launch site at liftoff	$R_{\overline{LS_M50}}$	ASC UPP	DP	ft
Current Shuttle position vector in M50	$R_{\overline{NAV}}$	RTLS UPP, ASC UPP	DP	ft
Current Shuttle velocity vector in M50	$V_{\overline{NAV}}$	RTLS UPP, ASC UPP	SP	fps
RTLS contingency decision velocity	V_{RTLS_CNTG}	I-LOAD	SP	fps

Table 4.8.12-2. RTLS Contingency Abort Task Outputs				
Definition	Symbol	Destination	Prec	Units
RTLS contingency flag	$GLIDE_RTLS_INHIBIT$	MSC, ADTA SOP, GRTLS TAEM GUID, GRTLS DAP, TLM, ASC RCS CMD SOP, MPS DUMP SEQ	D	N/A

4.8.13 KMAX Override Update Task (KMAX UPDT TSK)

The purpose of the KMAX Override Update Task is to update the maximum throttle limit setting on demand when Item 4 (THROT MAX), Item 50 (THROT ABT), or Item 51 (THROT NOM) is entered on the Override Display. These items provide the crew with the capability to change the SSME upper throttle level limit to one of three pre-mission I-Loaded throttle limit values and to re-scale the SBTC to the new throttle level.

A. Detailed Requirements

On each cycle during which one of the three mutually exclusive display throttle level commands is actuated ($NOM_THROT_CMD = ON$ or $ABT_THROT_CMD = ON$ or $MAX_THROT_CMD = ON$), the following must occur:

If $NOM_THROT_CMD = ON$, then $KMAX = KMAX_NOM$.

If $ABT_THROT_CMD = ON$, then $KMAX = KMAX_ABT$.

If $MAX_THROT_CMD = ON$, then $KMAX = KMAX_SECONDARY$.

B. Interface Requirements. The input and output parameters for the KMAX Override Update Task are given in Tables 4.8.13-1 and 4.8.13-2.

C. Processing Requirements. This task is called during the first-stage guidance (MM102), second-stage guidance (MM103), RTLS abort (MM601), and contingency abort (MM103/MM601).

D. Initialization Requirements. None.

Table 4.8.13-1. KMAX Override Update Task Inputs				
Definition	Symbol	Source	Prec	Units
Nominal throttle level command	NOM_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	ABT_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Maximum throttle level command	MAX_THROT_CMD	OVERRIDE DISPLAY	D	N/A
Nominal throttle limit	KMAX_NOM	I-LOAD	I	pct
Abort throttle limit	KMAX_ABT	I-LOAD	I	pct
Secondary throttle limit	KMAX_SECONDARY	I-LOAD	I	pct

Table 4.8.13-2. KMAX Override Update Task Outputs				
Definition	Symbol	Destination	Prec	Units
Maximum throttle setting for SSME	KMAX	1STG GUID INP TSK, ASC GUID TSK, FUL DISS TSK, PPD TSK, AUTO CONT TSK, SSME-OUT SAF TSK, G-LIM TSK	I	pct

4.9 POWERED CONTINGENCY REQUIREMENTS

Principal function PW CONT GUID (CPDS, Level B, principal function 4.5). Execution of this principal function requires the following general guidance and targeting tasks: PFG Input (Section 4.8.8), Acceleration–Mass Update (Section 4.8.2), Thrust Parameters (Section 4.8.7), and RTLS Contingency Abort (Section 4.8.12).

This principal function is active during the second–stage major mode (MM 103) and during the powered RTLS major mode (MM 601). It also initializes the contingency 2 engine out mode index and 3 engine out mode index among other parameters at MM101 transition. It is initiated at SRB separation command if the 3 engine out contingency start flag has not been set (Event 28D or Event A30G). Powered contingency guidance normally executes concurrently with AS 2STG GUID in MM103 or PW RTLS GUID in MM 601. Its normal function is to provide the crew with visibility of the current two engines out contingency abort procedure region status. PW CONT GUID performs this display support function by providing the XXXXXX TRAJ 2 and RTLS TRAJ 2 displays with contingency mode index information. Powered contingency guidance will normally be terminated when a point is reached in the powered flight trajectory where a contingency abort procedure would no longer be necessary even if all three main engines were to fail at that time. The termination events for PW CONT GUID in MM 103 are Events 33C and A36B and in MM601 it is terminated at Event A39A or A36B.

If the need for a contingency abort procedure were to arise after SRB separation and at least one main engine is still running, the crew can initiate an auto contingency maneuver. The crew invokes the powered contingency maneuver, either before or after SRB separation, by performing arm and start item entries on the XXXXXX TRAJ 1, XXXXXX TRAJ 2, or RTLS TRAJ 2 display (see section 4.2.38, 4.2.39, and 4.2.40 of Displays and Controls FSSR). Powered contingency guidance then switches from its display support function into an actual auto guidance steering process. The MSC terminates the normal guidance principal function (either AS 2STG GUID or PW RTLS GUID) and all the commands necessary for the powered contingency maneuver are generated by PW CONT GUID. For this situation the AS 2STG GUID principal function is terminated at Event 28B in MM 103. The PW RTLS GUID principal function is terminated at Event A30F in MM601 if an auto contingency abort is invoked.

The auto contingency capability may be initiated by the crew in MM 102, 103 or 601. If invoked in MM 102 an immediate contingency OMS dump is commanded but the auto contingency maneuver does not begin until SRB separation. For this situation the AS 2STG GUID principal function is not initiated (Event 28A does not occur). Likewise the PW RTLS GUID principal function is not initiated (Event A30D does not occur) if RTLS is selected in MM 102.

Crew initiation is required for all powered contingency maneuvers except for two scenarios. The first is a second engine failure on an RTLS abort in the RTLS single engine completion region (see section 4.9.2). For this case if the second engine failure is recognized ($N_{SSME} = 1$) the RTLS completion powered contingency maneuver is automatically invoked. The second scenario is a second engine failure on an RTLS abort when the horizontal downrange velocity is close to zero (2 E/O Mode 3 or late in 2E/O Mode 2). In this region, if the second engine failure is recognized the powered contingency guidance is automatically invoked. All other auto contingency maneuvers require manual initiation.

To increase mission manifesting and design flexibility closer to launch when required, the contingency Mode 5 Guidance mass that represents the mass of both the orbiter and ET with all MPS depleted can be updated via pre-mission uplink.

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The crew may initiate an auto contingency abort in major mode 103 and then select RTLS to transition the software to OPS 6. This is done to provide GRTLS DAP flight control after MECO and during entry. This action (Event A31) will not affect the auto contingency maneuver already in progress (PW CONT GUID will continue to execute). All other principal functions will execute as they normally would for the major mode 103 to 601 transition (See CPDS, Level B, GN&C, Table 3-6d).

The tasks to be performed by the powered contingency guidance sequencer are:

1. Contingency mode select task (CONT MODE SEL TSK)
2. PFG input task (PFG INP TSK)
3. RTLS contingency abort task (RTLS CONT ABT TSK)
4. KMAX override update task (KMAX UPDT TSK)
5. Acceleration-mass update task (ACC-MASS UPD TSK)
6. Auto contingency task (AUTO CONT TSK)
7. Contingency powered pitchdown task (CONT PPD TSK)
8. Contingency guidance cutoff task (CONT GUID C/O TSK)

The acceleration-mass update task calls the thrust parameters task. The auto contingency task calls the auto contingency initialization task, and, depending on the contingency 2 engine out mode index, the appropriate contingency mode task (either contingency mode 1 task, contingency mode 2 task, contingency mode 3 task, or contingency mode 5 task). The contingency LVLH task is called by the auto contingency initialization task, contingency mode 1 task, contingency mode 2 task, contingency mode 3 task, and the contingency powered pitchdown task.

Figures 4.9-1, 4.9-2, and 4.9-3 illustrate the powered contingency guidance task organization, functional flow, and data flow. The principal function interfaces are given in Section 4.9.12.

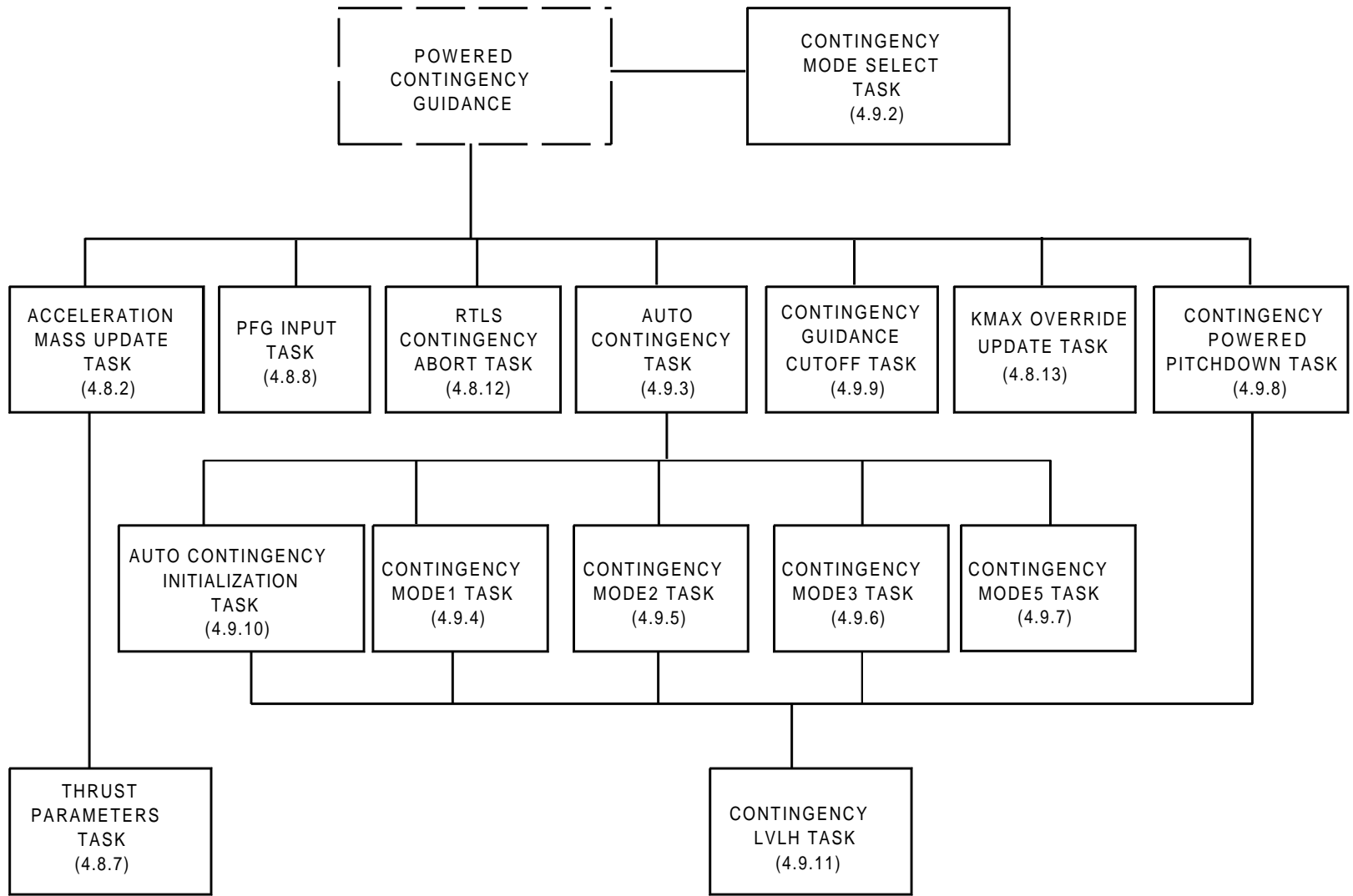


FIGURE 4.9-1. Powered Contingency Guidance Principal Function Task Organization

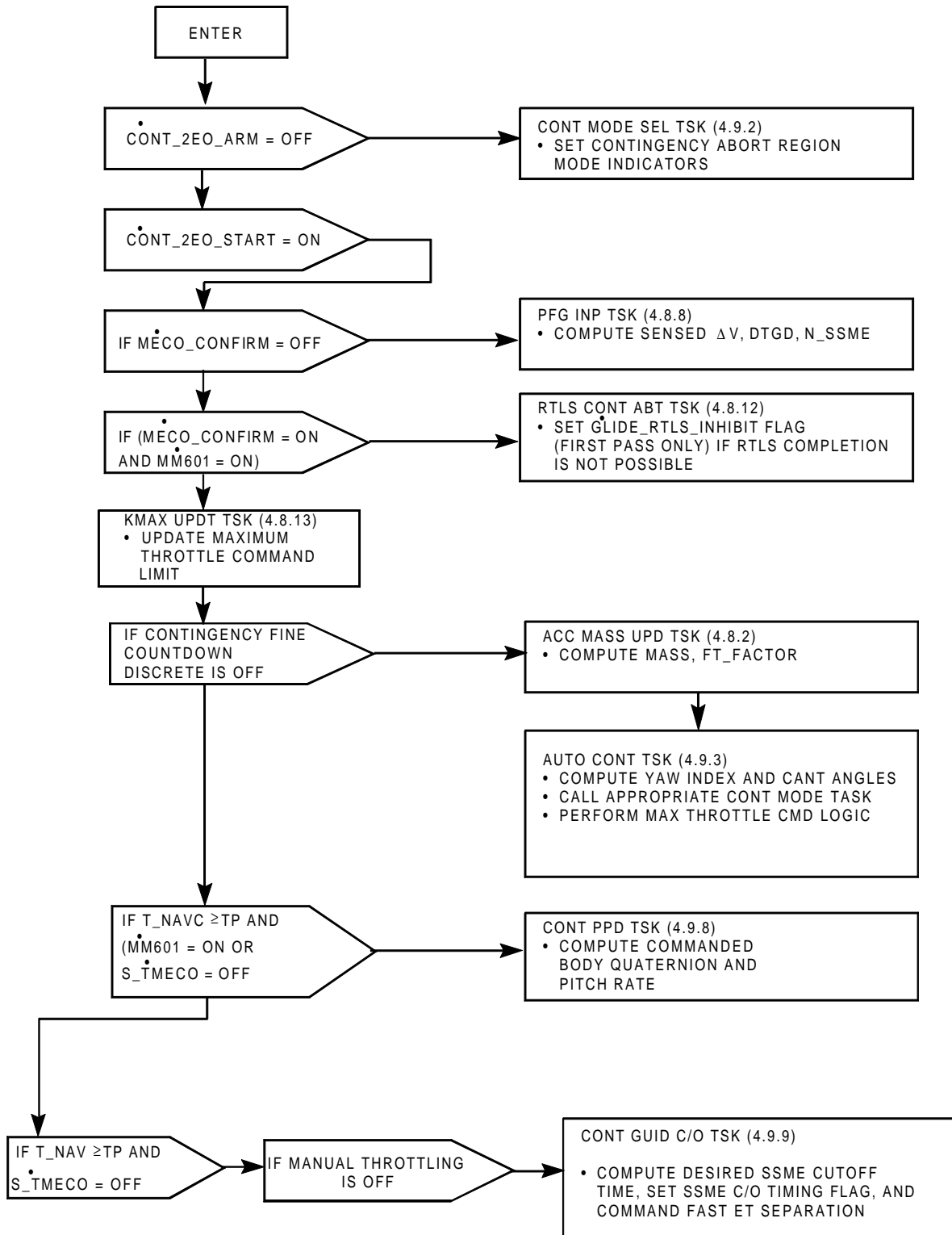


FIGURE 4.9-2. Powered Contingency Guidance Functional Flow

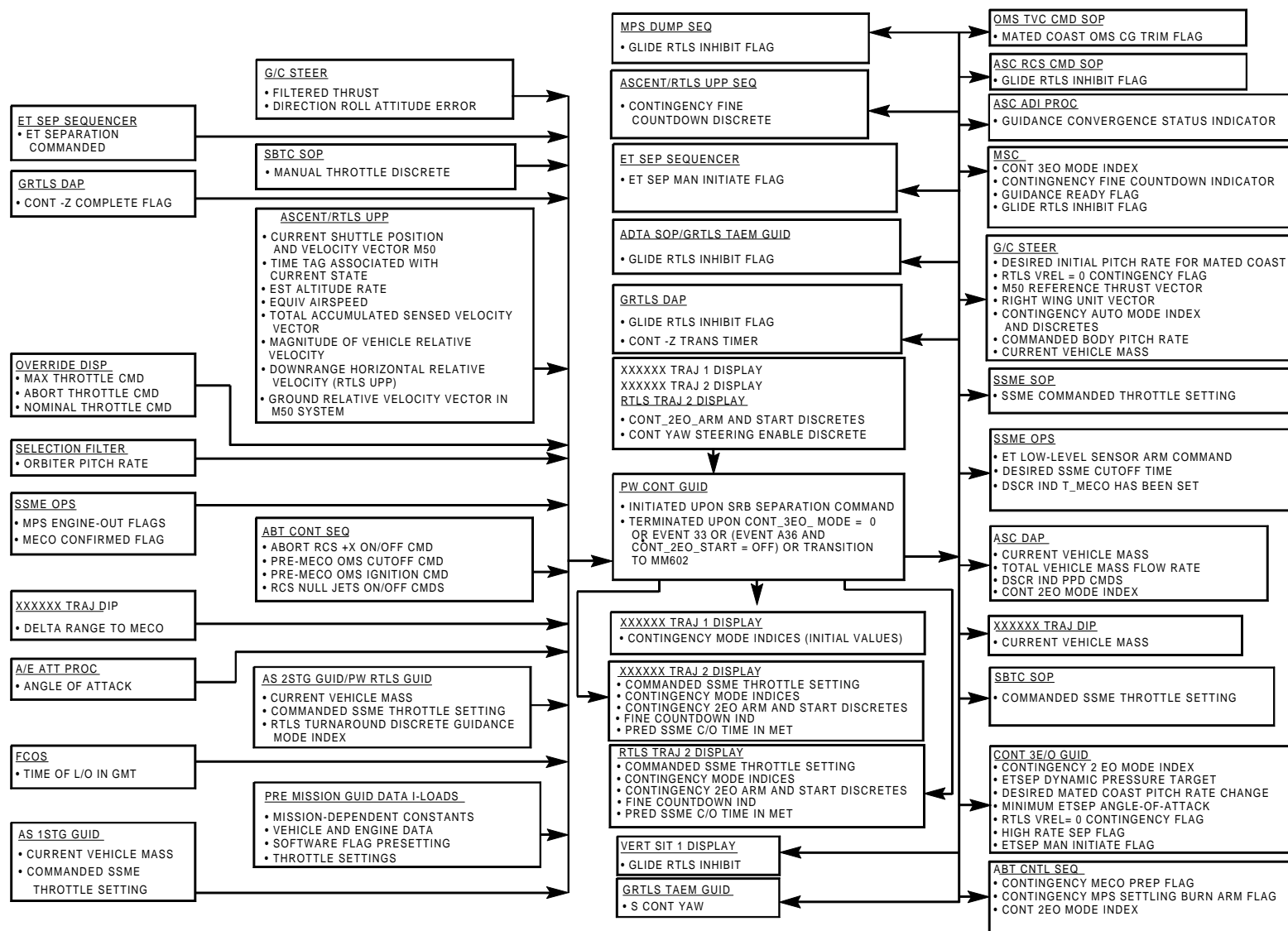


FIGURE 4.9-3. Powered Contingency Guidance Principal Function Data Flow

4.9.1 Powered Contingency Sequencing (PW CONT SEQ)

During powered contingency flight, several tasks that support the powered contingency guidance principal function are performed periodically or on specific events. (These events are identified in the CPDS, Level B, Volume 5, Book 1.) These tasks are:

1. Contingency mode select task (CONT MODE SEL TSK)
2. PFG input task (PFG INP TSK)
3. RTLS contingency abort task (RTLS CONT ABT TSK)
4. KMAX override update task (KMAX UPDT TSK)
5. Acceleration—mass update task (ACC—MASS UPD TSK)
6. Auto contingency task (AUTO CONT TSK)
7. Contingency powered pitchdown task (CONT PPD TSK)
8. Contingency guidance cutoff task (CONT GUID C/O TSK)

A. Detailed Requirements.

Task 1. The contingency mode select task must be performed repetitively every guidance cycle that the PW CONT GUID principal function is active and CONT_2EO_ARM = OFF. This task is not performed if CONT_2EO_ARM = ON. The detailed requirements for this task are given in Section 4.9.2.

The following tasks are only performed if CONT_2EO_START = ON.

Task 2. The PFG input task must be performed repetitively every guidance cycle from the time that CONT_2EO_START = ON until SSME cutoff confirmation (Event A36, MECO_CONFIRM = ON). The detailed requirements for this task are given in Section 4.8.8.

Task 3. The RTLS contingency abort task must be performed once when SSME cutoff confirmation (Event A36) occurs in major mode 601 and CONT_2EO_START = ON. The detailed requirements for this task are given in Section 4.8.12.

Task 4. The KMAX override update task is performed on demand from the time that CONT_2EO_START = ON until SSME cutoff confirmation (Event A33, MECO_CONFIRM = ON) if in MM103 or until entry to MM602 (Event A39A) if in MM601. The demand occurs when either item 4, 50, or 51 is entered on the Override Display (SPEC 51). The detailed requirements for this task are given in Section 4.8.13.

Task 5. The acceleration—mass update task must be performed repetitively every guidance cycle from the time that CONT_2EO_START = ON until contingency fine countdown (S_CONT_MECO = ON). The detailed requirements for this task are given in Section 4.8.2.

- Task 6. The auto contingency task must be performed repetitively every guidance cycle from the time that $\dot{C}O\dot{N}T_2EO_START = ON$ until contingency fine countdown ($S_C\dot{O}N\dot{T}_MECO = ON$). The detailed requirements for this task are given in Section 4.9.3.
- Task 7. The contingency powered pitchdown task must be performed repetitively every guidance cycle from the time that the current time is greater than or equal to the predicted time of contingency powered pitchdown ($T_NAV \geq TP$) until either the powered contingency guidance principal function is terminated if in major mode 601 ($MM601 = ON$) or the MECO discrete S_TMECO is set ON if in major mode 103 ($MM103 = ON$). The detailed requirements for this task are given in Section 4.9.8.
- Task 8. The contingency guidance cutoff task must be performed repetitively every guidance cycle from the time that the current time is greater than or equal to the predicted time of contingency powered pitchdown ($T_NAV \geq TP$) until the MECO discrete S_TMECO is set ON. This task will not be performed if the manual throttling discrete S_MAN_THROT is set ON. The detailed requirements for this task are given in Section 4.9.9.

On the guidance cycle that $S_C\dot{O}N\dot{T}_MECO$ is set ON, powered contingency sequencing will set S_FCD to ON to cue the crew that fine countdown is in progress. S_FCD will be set OFF by powered contingency sequencing when the MECO discrete S_TMECO is set ON or when SSME cutoff confirmation occurs (Event A36).

If manual guidance ($A\dot{U}T\dot{O} = OFF$) is selected during the time that the powered contingency guidance principal function is executed, all the above tasks continue to be executed as specified above.

B. Interface Requirements.

The input and output parameters for powered contingency sequencing are given in Tables 4.9.1–1 and 4.9.1–2.

C. Processing Requirements.

The recommended execution rates for the tasks are as follows:

Task 1: If $MM103 = ON$, 1.92 seconds from Event 28D until Event 33C or A36B. If $MM601 = ON$, 1.92 seconds from initiation until $S_MECO = ON$, then 0.16 seconds until Event A39A or A36B. This task is not executed if $\dot{C}O\dot{N}T_2EO_ARM = ON$

Tasks 2 through 8 are only executed if $\dot{C}O\dot{N}T_2EO_START = ON$

Task 2: 1.92 seconds from initiation until $S_C\dot{O}N\dot{T}_MECO = ON$, then 0.16 seconds until $M\dot{E}C\dot{O}_CONFIRM = ON$

Task 3: One time only when $M\dot{E}C\dot{O}_CONFIRM = ON$ and $MM601 = ON$

Task 4: Prior to $S_C\dot{O}N\dot{T}_MECO = ON$, one time only within 1.92 seconds of the event for each item entry event; thereafter, within 0.16 second if in MM601 and within 0.32 second if in MM103.

Task 5: 1.92 seconds from initiation until $S_C\dot{O}N\dot{T}_MECO$ is set ON

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Task 6: 1.92 seconds from initiation until S_ĊONT_MECO is set ON

Task 7: 0.16 seconds from the time T_NAV ≥ TP until Event A39 if MM601 = ON, or until S_ṪMECO = ON if MM103 = ON

Task 8: 0.16 seconds from the time T_NAV ≥ TP until S_ṪMECO is set ON. This task is not executed if S_ṀAN_THROT is set ON

These tasks should be executed in the order listed.

D. Initialization Requirements. None.

Table 4.9.1-1. Powered Contingency Sequencing Inputs				
Definition	Symbol	Source	Prec	Units
Contingency 2 engine out arm discrete	C \dot{O} NT_2EO_ARM	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, CONT MODE SEL TSK	D	N/A
Contingency 2 engine out start discrete	C \dot{O} NT_2EO_START	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, CONT MODE SEL TSK	D	N/A
MECO confirmation discrete	M \dot{E} CO_CONFIRM	SSME OPS	D	N/A
Major mode 103 discrete	M \dot{M} 103	MSC	D	N/A
Major mode 601 discrete	M \dot{M} 601	MSC	D	N/A
Contingency fine countdown discrete	S_ \dot{C} ONT_MECO	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK, AUTO CONT INIT TSK	D	N/A
Manual throttle discrete	S_ \dot{M} AN_THROT	SBTC SOP	D	N/A
Fine countdown discrete	S_ \dot{M} ECO	FLYBK TSK	D	N/A
SSME cutoff timing request flag	S_ \dot{T} MECO	CONT GUID C/O TSK	D	N/A
Time tag associated with current state	T_NAV	ASCENT UPP, RTLS UPP	DP	sec
Predicted time of contingency powered pitchdown	TP	AUTO CONT INIT TSK, CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK	DP	sec

Table 4.9.1-2. Powered Contingency Sequencing Outputs				
Definition	Symbol	Destination	Prec	Units
Fine countdown indicator	S_ \dot{F} CD	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	D	N/A

4.9.2 Contingency Mode Select Task (CONT MODE SEL TSK)

The primary purpose of this task is to provide contingency abort region recommendations to the crew by determining appropriate values for contingency 2 engine out and 3 engine out mode indexes. The values of these indexes are determined each guidance cycle by comparing certain trajectory-related parameters (inertial velocity, altitude rate, equivalent airspeed) with pre-mission stored I-loads. The contingency mode indexes are passed to the ascent TRAJ displays and are used there to assist the crew in tracking their current contingency region status if a second or third engine were to fail at the current time. If the need for a 2 engine out contingency abort procedure arises, the crew can initiate an auto contingency abort via item entries on the ascent TRAJ displays.

Although a 3 engines out mode index is computed in this task, it will normally not be used by the ascent TRAJ displays. This is because the 3 engines out contingency region will normally be determined by Contingency 3 E/O Guidance (see section 4.10). That principal function commands automated 3 engines out maneuvers. The three engines out field on the ascent TRAJ displays thus normally provides the crew with information on which automated maneuver would be commanded if three engines were to fail at the current time.

The 3 engines out mode index computed in this task provides manual maneuver region information that will only be used by the ascent TRAJ displays if the automated maneuvers computed by Contingency 3 E/O Guidance are disabled. This will only occur if the I-load ENA_CONT_3EO_GUID is set off (see ascent TRAJ displays requirements in Section 4.2.38, 4.2.39, and 4.2.40 of Displays & Controls FSSR).

The displayed regions assist the crew in tracking their current status on one of two sides of the contingency abort cue card. The CONTINGENCY ABORT side of the cue card is tracked by the crew if no abort has been selected (e.g. during nominal ascent). It is also used if TAL or ATO abort has been declared. The RTLS CONTINGENCY side of the cue card is used if an RTLS abort has been declared by the crew. The guidance mode indicator SMODE is passed to the RTLS TRAJ 2 display along with the contingency mode indexes. SMODE is initialized to 1 for uphill (non-RTLS) scenarios and is changed to 5 when powered RTLS guidance is initiated.

Each side of the cue card identifies different procedure regions by different colors (BLUE, GREEN, etc.). As the powered flight continues, the vehicle passes from one procedure region to another. The 2 engine out and 3 engine out contingency mode indexes and the guidance mode indicator are used by the ascent TRAJ displays to provide current contingency region status for two and three engine out scenarios. The different values of the indexes correspond to the following contingency regions.

CONT_MODE		CONTINGENCY REGION	
<u>2 OR 3 EO</u>	<u>S.MODE</u>	<u>2 EO</u>	<u>3 EO*</u>
0	1	(blank)	(blank)
1	1	CONT BLUE	CONT BLUE
2	1	CONT GREEN	CONT GREEN
0	5	(blank)	(blank)
1	5	RTLS BLUE	RTLS BLUE
2	5	RTLS YELLOW	RTLS YELLOW
3	5	RTLS ORANGE	RTLS ORANGE
4	5	RTLS GREEN	RTLS GREEN
5	5	RTLS RED	N/A

* The 3E/O colors given here are valid only if auto 3E/O maneuvers are disabled.

The contingency region field for 2 and 3 engines out will blank when its respective mode index is set to zero. When the 2 engine out field is blanked the contingency guidance is recommending that a contingency abort need not be performed for 2 engines out after this time. The ascent TRAJ displays will indicate an “illegal entry” if the crew attempts to arm or start an auto contingency maneuver after this time. When the 3 engine out field is blanked the contingency guidance is recommending that a contingency abort need not be performed for 3 engines out after this time.

The 2 and 3 engine out mode indexes are initialized to 1 by powered contingency guidance (initialized in OPS 1 memory prior to execution). If the auto contingency abort capability is invoked by the crew prior to SRB separation, the Contingency Mode Select task is not invoked by the powered contingency sequencer. A contingency Mode 1 maneuver is commanded upon SRB separation as this is the initial value of the 2 engine out mode index. This is the appropriate maneuver for an auto contingency abort invoked in first stage.

This task also makes a 2 engine out yaw steering contingency maneuver determination. Contingency yaw steering is a capability used to help turn the heading of the vehicle with the one remaining active SSME to assist in reaching contingency landing sites. This task sets an indicator for yaw steering based on the current value of certain trajectory parameters (altitude rate, inertial velocity). If the crew were to invoke a 2 engine out auto contingency abort, this indicator would be used to command the yaw steering maneuver. The crew has the ability to inhibit the yaw steering capability via an item entry on the ascent TRAJ displays. The yaw steering indicator set in this task is also an I-loaded discrete to permit yaw steering if desired for an auto contingency abort invoked in first stage.

There are times when flight dynamic conditions are such that should two engines fail, it is desirable to fly a 2 engine out contingency Mode 1 maneuver for a while and then complete the maneuver as a contingency Mode 2 maneuver. Logic exists in the Contingency Mode Select Task to set a discrete to allow this to happen if dynamic conditions are appropriate.

If an RTLS abort has been declared by the crew, fine countdown to powered pitchdown has not yet started, a single engine RTLS completion capability currently exists, and the number of active SSME’s drops to one: then the Contingency Mode Select Task automatically invokes a Contingency Mode 5 maneuver without awaiting a manual request from the crew via the RTLS TRAJ 2 display.

This task also sets the contingency MECO prep discrete (CONT_MECO_PREP_FLAG) during RTLS aborts when the contingency 2 engine out mode index is equal to 3 or 4. If a second engine fails during these regions of RTLS powered flight, the required contingency maneuver is of short duration. CONT_MECO_PREP_FLAG is set on for these regions so that if a second engine fails, the pre-MECO OMS/RCS interconnect is inhibited. For these cases, single engine roll control propellant is provided by the RCS tanks.

A. Detailed Requirements.

1. Each pass through this step, set the combined maneuver discrete off ($S_{\dot{C}OMB_MNVR} = OFF$), the contingency guidance yaw steering indicator off ($C\dot{O}NT_GUID_YAW = OFF$), and the RTLS VREL=0 contingency mode flag off ($S\dot{E}LECT_VREL0_CONT = OFF$).

Check to see if this is an RTLS abort.

If SMODE = 5, proceed to Step 5.

Check the altitude rate for 2 engine out yaw steering Mode 1 capability.

If HDOT > HDOT_YAW1 perform the following. Otherwise, proceed to Step 2.

CONT_GUID_YAW = ON

CONT_2EO_MODE = 1

Proceed to Step 4.

2. Check the inertial velocity magnitude for 2 engine out Mode 2 yaw steering capability.

If VI_MAG > VI_YAW2_MIN and VI_MAG < VI_YAW2_MAX, perform the following. Otherwise, proceed to Step 3.

C\dot{O}NT_GUID_YAW = ON

Set the combined maneuver discrete if the current altitude rate exceeds an I-loaded value.

If HDOT > HDOT_COMB_YAW, set $S_{\dot{C}OMB_MNVR} = ON$

Set the 2 engine out mode index to its Mode 2 value.

CONT_2EO_MODE = 2

Proceed to Step 4.

3. Determine the in-plane (no yaw steering) 2 engine out contingency abort mode.

Check the altitude rate for 2 engine out Mode 1 capability.

If HDOT > HDOT_MODE1, set CONT_2EO_MODE = 1 and proceed to Step 4.

Check the inertial velocity for 2 engine out minimum droop capability.

If $VI_MAG > VI_MIN_DROOP$, set $CONT_2EO_MODE = 0$ and proceed to Step 4.

Set the combined maneuver discrete if the current altitude rate exceeds an I-loaded value.

If $HDOT > HDOT_COMB_MNVR$, set $S_COMB_MNVR = ON$

Set the contingency 2 engine out mode index to indicate Mode 2.

$CONT_2EO_MODE = 2$

Proceed to Step 4.

4. Set the contingency 3 engine out mode index based on the magnitude of the current inertial velocity. If inertial velocity is greater than an I-loaded value, set the 3 engine out mode index to zero.

If $VI_MAG > VI_LATE_TAL$, set $CONT_3EO_MODE = 0$. Otherwise, set $CONT_3EO_MODE = 2$.

Exit this task.

5. Check for RTLS powered pitcharound.

If $S_RTLS_TURN = ON$, proceed to Step 6.

Set the contingency 3 engine out mode index to the value appropriate for RTLS fuel dissipation phase.

$CONT_3EO_MODE = 1$

During fuel dissipation the contingency 2 engine out mode index will be set to either a Mode 1 or a Mode 2 value depending on the current altitude rate. Contingency yaw steering is set ON if certain trajectory conditions are satisfied.

If $HDOT > HDOT_RTLS_YAW1$, perform the following:

$C_CONT_GUID_YAW = ON$

$CONT_2EO_MODE = 1$

and exit this task.

If $HDOT > HDOT_RTLS_MODE1$, set $CONT_2EO_MODE = 1$ and exit this task. Otherwise, perform the following:

$CONT_2EO_MODE = 2$

Check the altitude rate and current equivalent airspeed for RTLS Mode 2 yaw steering capability.

If $HDOT > HDOT_RTLS_YAW2$, and $EAS < EAS_RTLS_YAW2$ set $C_CONT_GUID_YAW = ON$

Exit this task.

6. If MECO has been commanded ($S_{\dot{T}MECO} = ON$), set $CONT_3EO_MODE = 0$ and exit this task. This will blank the 3 engine out contingency region field on the RTLS TRAJ 2 display.

Otherwise, check the horizontal downrange relative velocity to determine the appropriate contingency modes after powered pitcharound. If a second SSME has failed near RTLS "VREL=0", as indicated by N_{SSME} and the horizontal downrange velocity, automatically initiate a Mode 2 powered contingency maneuver by setting the appropriate guidance discrettes, and set a flag to trim the OMS actuators in preparation for an MPS settling burn during Mated Coast.

If $V_HORIZ_DNRNG > V_HORIZ_3EO$,
set $CONT_3EO_MODE = 2$,
Otherwise, set $CONT_3EO_MODE = 3$.

If $V_HORIZ_DNRNG > V_HORIZ_VRELO_MODE$, set $CONT_2EO_MODE = 2$ and exit this task.

If $V_HORIZ_DNRNG > V_HORIZ_2EO$, perform the following. Otherwise, proceed to Step 7.

Set $CONT_2EO_MODE = 2$.

If $N_{SSME} = 1$, set $C\dot{O}NT_2EO_ARM = ON$, $C\dot{O}NT_2EO_START = ON$,
 $S\dot{E}LECT_VRELO_CONT = ON$, and $M\dot{A}TED_CG_TRIM = ON$.

Exit this task.

7. When the vehicle is near its maximum downrange position or has not developed an I-loaded equivalent airspeed on the uprange leg, the 2 and 3 engine out mode indexes are set to their Mode 3 values.

If $EAS < EAS_MODE4$, perform the following. Otherwise, proceed to Step 8.

$CONT_2EO_MODE = 3$
 $CONT_3EO_MODE = 3$

Also set the contingency MECO prep discrete ON ($C\dot{O}NT_MECO_PREP_FLAG = ON$). This will inhibit an OMS/RCS interconnect if a second engine failure occurs.

If the number of active SSME's equals one, automatically initiate a Mode 3 powered contingency maneuver by setting the appropriate guidance discrettes, and set a flag to trim the OMS actuators in preparation for an MPS settling burn during Mated Coast.

If $N_{SSME} = 1$, set $C\dot{O}NT_2EO_ARM = ON$, $C\dot{O}NT_2EO_START = ON$,
 $S\dot{E}LECT_VRELO_CONT = ON$, and $M\dot{A}TED_CG_TRIM = ON$.

Exit this task.

8. When the equivalent airspeed reaches EAS_MODE4 , the contingency 3 engine out mode index is set to its Mode 4 value.

$CONT_3EO_MODE = 4$

Check the current altitude rate to determine if the vehicle has passed through the 2 engine out Mode 4 region.

If $HDOT < HDOT_MODE5$, set $CONT_2EO_MODE = 4$, and exit this task.

9. If the RTLS fine countdown discrete has been set ($S_MECO = ON$), set $CONT_2EO_MODE = 0$ and exit this task. This will blank the 2 engine out contingency region field on the RTLS TRAJ 2 display.

Otherwise, set $CONT_2EO_MODE = 5$ to indicate that a single engine RTLS completion capability currently exists.

Also set the contingency MECO prep discrete OFF ($CONT_MECO_PREP_FLAG = OFF$). If a second engine failure occurs and the $CONT_2EO_MODE$ index is either equal to 5 or becomes equal to 5, the OMS/RCS interconnect is commanded to support single engine roll control.

A check is then made to see if the number of active SSME's equals one. If so, the RTLS single engine completion maneuver is automatically invoked by setting the $CONT_2EO_ARM$ and $CONT_2EO_START$ discrettes. This will cause the MSC to issue Event A30F (Powered Contingency Abort Request in MM 601). PW RTLS GUID will be terminated and the guidance commands for the RTLS single engine completion maneuver will be issued by PW CONT GUID.

If $N_SSME = 1$, set $CONT_2EO_ARM = ON$ and $CONT_2EO_START = ON$

B. Interface Requirements. The input and output parameters for the contingency mode select task are given in Tables 4.9.2-1 and 4.9.2-2.

C. Processing Requirements. None.

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

$CONT_2EO_MODE = 1$

$CONT_3EO_MODE = 1$

$S_COMB_MNVR = OFF$

$MATED_CG_TRIM = OFF$

Table 4.9.2-1. Contingency Mode Select Task Inputs				
Definition	Symbol	Source	Prec	Units
Equivalent airspeed	EAS	RTLS UPP	SP	fps
Equivalent airspeed boundary between mode 3/4 for 2 and 3 engines out	EAS_MODE4	I-LOAD	SP	fps
RTLS Mode 2 yaw steering equivalent airspeed	EAS_RTLS_YAW2	I-LOAD	SP	fps
Estimated altitude rate	HDOT	ASC UPP, RTLS UPP	SP	fps
Mode 1 altitude rate (no yaw steering)	HDOT_MODE1	I-LOAD	SP	fps
Combined maneuver altitude rate (no yaw steering)	HDOT_COMB_MNVR	I-LOAD	SP	fps
Combined maneuver yaw steering altitude rate	HDOT_COMB_YAW	I-LOAD	SP	fps
Mode 1 RTLS altitude rate (no yaw steering)	HDOT_RTLS_MODE1	I-LOAD	SP	fps
Mode 1 RTLS yaw steering altitude rate	HDOT_RTLS_YAW1	I-LOAD	SP	fps
Mode 2 RTLS yaw steering altitude rate	HDOT_RTLS_YAW2	I-LOAD	SP	fps
Mode 5 altitude rate	HDOT_MODE5	I-LOAD	SP	fps
Mode 1 yaw steering altitude rate	HDOT_YAW1	I-LOAD	SP	fps
Number of active SSME's	N_SSME	PFG INP TSK	I	N/A
Fine countdown discrete	S_MECO	FLYBK TSK	D	N/A
Guidance mode indicator	S_MODE	ASC GUID TSK, RTLS INIT TSK	I	N/A
Discrete indicating start of RTLS powered pitcharound	S_RTLS_TURN	PITCH CMD TSK	D	N/A
Discrete indicating T_MECO has been set	S_TMECO	MPS GUID C/O TSK	D	N/A
Downrange horizontal earth relative velocity	V_HORIZ_DNRNG	RTLS UPP	SP	fps
Two engine out RTLS Mode 2/3 horizontal velocity boundary	V_HORIZ_2EO	I-LOAD	SP	fps
Three engine out RTLS Mode 2/3 horizontal velocity boundary	V_HORIZ_3EO	I-LOAD	SP	fps
Current vehicle inertial velocity	VI_MAG	ASC UPP	SP	fps
Late TAL minimum inertial velocity	VI_LATE_TAL	I-LOAD	SP	fps
Minimum droop TAL inertial velocity	VI_MIN_DROOP	I-LOAD	SP	fps
Minimum inertial velocity for second stage Mode 2 yaw steering	VI_YAW2_MIN	I-LOAD	SP	fps
Maximum inertial velocity for second stage Mode 2 yaw steering	VI_YAW2_MAX	I-LOAD	SP	fps

Table 4.9.2-1. Contingency Mode Select Task Inputs				
Definition	Symbol	Source	Prec	Units
Downrange horizontal earth relative velocity boundary for RTLS VREL=0 procedures during two engine out Mode 2	V_HORIZ_VREL0_MODE	I-LOAD	SP	fps

Table 4.9.2-2. Contingency Mode Select Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency MECO preparation discrete	CONT_MECO_PREP_FLAG	ABORT CNTL SEQ	D	N/A
Contingency 2 engine out arm discrete	CONT_2EO_ARM	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, TLM, PW CONT SEQ	D	N/A
Contingency 2 engine out start discrete	CONT_2EO_START	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, MSC, GRTLS DAP, TLM, HORIZ SIT DISP, HORIZ SIT SPEC, PW CONT SEQ	D	N/A
Contingency 2 engine out mode index	CONT_2EO_MODE	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, AUTO CONT TSK, DRP CTL TSK, TLM, ASC DAP, ABT CNTL SEQ, CONT PPD TSK, CONT GUID C/O TSK, CONT 3E/O GUID	I	N/A
Contingency 3 engine out mode index	CONT_3EO_MODE	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, MSC, TLM	I	N/A
Combined maneuver discrete	S_COMB_MNVR	AUTO CONT TSK, CONT MODE1 TSK, TLM	D	N/A
Mated coast CG trim flag	MATED_CG_TRIM	OMS TVC CMD SOP	D	N/A
Contingency guidance yaw steering discrete	CONT_GUID_YAW	AUTO CONT TSK, TLM	D	N/A
Flag indicating contingency armed near RTLS VREL=0	SELECT_VREL0_CONT	CONT PPD TSK, CONT GUID C/O TSK, G/C STEER, CONT MODE2 TSK	D	N/A

4.9.3 Auto Contingency Task (AUTO CONT TSK)

The primary purpose of this task is to call the appropriate contingency mode task for the selected contingency mode. Initialization functions are performed first pass. The main engine yaw index is updated each guidance cycle. Body axis sensed thrust vector components are updated each guidance cycle. Crew initiation of maximum throttle level is also supported in this task.

A. Detailed Requirements.

1. Perform this step first pass only. Otherwise, proceed to Step 2.

- a. Copy the current selected contingency 2 engine out mode index into an equivalent guidance mode index to be used to call the appropriate contingency mode task.

$$\text{GUID_2EO_MODE} = \text{CONT_2EO_MODE}$$

- b. If the crew has disabled yaw steering, the contingency yaw steering discrete is set off. If the crew has not disabled yaw steering, set the contingency yaw steering discrete to the value that guidance has determined is appropriate.

$$\text{If } \dot{\text{CONT_YAW_ENA}} = \text{OFF, set } \dot{\text{S_CONT_YAW}} = \text{OFF. Otherwise, set } \dot{\text{S_CONT_YAW}} = \dot{\text{CONT_GUID_YAW}}$$

- c. If this is an auto contingency abort case that will continue to maneuver after reaching apogee, set the guidance 2 engine out mode index appropriately.

$$\text{If } \dot{\text{S_COMB_MNVR}} = \text{ON, set } \text{GUID_2EO_MODE} = 1$$

- d. Call the Auto Contingency Initialization Task (AUTO CONT INIT TSK).

2. Set the main engine yaw index for yaw axis maneuver smoothing based on the current status of the SSME #1 fail flag.

$$\text{If } \dot{\text{S_EO_E1}} = \text{ON, then set } \text{ME_YAW_INDEX} = 2. \text{ Otherwise, set } \text{ME_YAW_INDEX} = 1$$

3. If the current filtered thrust vector is available from G/C Steer ($\dot{\text{S_TDF}} = \text{ON}$), set the yaw and pitch cant angles equal to the second and third components of the estimated filtered thrust vector.

$$\text{YAW_CANT_ANGLE} = \text{UFE}(2)$$

$$\text{PITCH_CANT_ANGLE} = \text{UFE}(3)$$

Otherwise, use average cant angles (a pitch angle of 13 degrees and a yaw angle of zero degrees) as given below:

$$\text{PITCH_CANT_ANGLE} = 0.2269$$

$$\text{YAW_CANT_ANGLE} = 0.0$$

4. On each cycle during which one of the three mutually exclusive display throttle level commands is recognized ((NOM_THROT_CMD = ON and NOM_CMD_PREV_PC = OFF) or (ABT_THROT_CMD = ON and ABT_CMD_PREV_PC = OFF) or (MAX_THROT_CMD = ON and MAX_CMD_PREV_PC = OFF)) and if manual throttling is not being performed (S_MAN_THROT = OFF), then execute the following:

K_CMD = KMAX

5. Set the previous throttle command indicators to the current values.

NOM_CMD_PREV_PC = NOM_THROT_CMD

ABT_CMD_PREV_PC = ABT_THROT_CMD

MAX_CMD_PREV_PC = MAX_THROT_CMD

6. Call the appropriate contingency 2 engine out contingency mode task based on the value of GUID_2EO_MODE:
 - a. If GUID_2EO_MODE = 1, call the CONT MODE1 TSK.
 - b. If GUID_2EO_MODE = 2, call the CONT MODE2 TSK.
 - c. If GUID_2EO_MODE = 3 or GUID_2EO_MODE = 4, call the CONT MODE3 TSK.
 - d. If GUID_2EO_MODE = 5, call the CONT MODE5 TSK.

B. Interface Requirements. The input and output parameters for the auto contingency task are given in Tables 4.9.3-1 and 4.9.3-2.

C. Processing Requirements. None.

D. Initialization Requirements. The previous values of the maximum throttle level limit commands (NOM_CMD_PREV_PC, ABT_CMD_PREV_PC, and MAX_CMD_PREV_PC) are initialized OFF.

E. Supplemental Information. The maximum throttle level processing in step 4 will be performed either if the maximum throttle level command was activated prior to the initiation of an auto contingency abort, or during such an abort.

Table 4.9.3-1. Auto Contingency Task Inputs

Definition	Symbol	Source	Prec	Units
Contingency guidance yaw steering discrete	$\dot{C}ONT_GUID_YAW$	I-LOAD, CONT MODE SEL TSK	D	N/A
Contingency yaw enable discrete	$\dot{C}ONT_YAW_ENA$	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	D	N/A
Contingency 2 engine out mode index	CONT_2EO_MODE	CONT MODE SEL TSK	I	N/A
Guidance 2 engine out mode index	GUID_2EO_MODE	CONT MODE1 TSK	I	N/A
Nominal throttle level command	$\dot{N}OM_THROT_CMD$	OVERRIDE DISPLAY	D	N/A
Abort throttle level command	$\dot{A}BT_THROT_CMD$	OVERRIDE DISPLAY	D	N/A
Maximum throttle level command	$\dot{M}AX_THROT_CMD$	OVERRIDE DISPLAY	D	N/A
Combined maneuver discrete	\dot{S}_COMB_MNVR	CONT MODE SEL TSK	D	N/A
MPS E1 engine-out flag	\dot{S}_EO_E1	SSME OPS	D	N/A
Manual throttle discrete	\dot{S}_MAN_THROT	SBTC SOP	D	N/A
Thrust direction filter ready discrete	\dot{S}_TDF	G/C STEER	D	N/A
Filtered estimated thrust direction (element 2)	UFE(2)	G/C STEER	SP	ND
Filtered estimated thrust direction (element 3)	UFE(3)	G/C STEER	SP	ND
Maximum throttle setting for SSME	KMAX	KMAX UPDT TSK	I	pct

Table 4.9.3-2.Auto Contingency Task Outputs				
Definition	Symbol	Destination	Prec	Units
Guidance 2 engine out mode index	GUID_2EO_MODE	CONT MODE3 TSK, AUTO CONT INIT TSK	I	N/A
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, SBTC SOP, TLM, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
Main engine yaw index	ME_YAW_INDEX	CONT MODE2 TSK	I	N/A
Pitch cant angle between the current sensed thrust vector and the orbiter X-Y plane	PITCH_CANT_ ANGLE	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE5 TSK	SP	rad
Contingency yaw steering discrete	S_·CONT_YAW	CONT MODE1 TSK, CONT MODE2 TSK, CONT PPD TSK, GRTLS TAEM GUID	D	N/A
Yaw cant angle between the current sensed thrust vector and the orbiter X-Z plane	YAW_CANT_ANGLE	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK	SP	rad

4.9.4 Contingency Mode 1 Task (CONT MODE1 TSK)

This task provides guidance commands for contingency abort scenarios that call for a “fly horizontal” type of maneuver to minimize apogee altitude and separate from the external tank near apogee in a heads up orientation. Two different procedures are provided by this task. The first is an in-plane, fly horizontal procedure that consists of the following maneuvers:

1. Pitch and yaw the vehicle to an attitude in-plane, near the horizontal.
2. Roll heads up with respect to the downrange direction.
3. After apogee has been reached, pitch down to achieve a desired attitude prior to MECO.

The second procedure provided by this task is a yaw steering maneuver to change the heading of the velocity vector while minimizing apogee altitude. This procedure consists of the following maneuvers:

1. Pitch and yaw the vehicle to a desired out-of-plane attitude.
2. Roll heads up with respect to the downrange direction.
3. When the altitude rate is less than a desired value, yaw back to the current orbital plane.
4. Pitch down to achieve a desired attitude prior to MECO.

This task also provides logic to transition from a fly horizontal maneuver before apogee to a more vertical attitude (Contingency Mode 2 Task) after apogee to reduce entry pullout loads.

This task computes a desired thrust unit vector as well as a right wing unit vector. It also passes a contingency auto mode index and several discretized values to G/C Steer to support maneuver smoothing and control. This task also sets the duration of the open-loop -Z translation maneuver after ET separation.

A. Detailed Requirements.

1. Perform the following calculations first pass only. Otherwise, proceed to Step 2.
 - a. Set the contingency body pitch and yaw angles to their Mode 1 values based on whether this is a yaw steering contingency maneuver. Also set the Mode 1 pitch down altitude rate parameter to determine when the final maneuver before MECO will occur.

If $S_{\dot{C}ONT_YAW} = ON$, perform the following:

$$THETA_CONT = THETA_MODE1_YAW$$

$$PSI_CONT = PSI_MODE1_YAW$$

$$HDOT_MODE1_PD = HDOT_MODE1_BACK$$

Otherwise, set the maneuver parameters to the values appropriate for an in-plane (no yaw steering) case.

$$THETA_CONT = THETA_CONT_MODE1$$

$$\text{PSI_CONT} = 0$$

$$\text{HDOT_MODE1_PD} = 0$$

- b. Set the contingency roll inhibit discrete. This flag is sent to G/C Steer and permits the initial pitch and yaw maneuver to occur without any undesired commanded roll rate.

$$\text{S_CONT_ROLL_INHIB} = \text{ON}$$

- c. Initialize the local Mode 1 maneuver discretetes.

$$\text{S_ROLL_COMPLETE} = \text{OFF}$$

$$\text{S_YAW_BACK_INIT} = \text{OFF}$$

$$\text{S_MNVR_INIT} = \text{ON}$$

- d. Following ET separation a –Z translation using RCS jets will occur. During contingency aborts this translation is performed without any interruption due to rotational jet commands. The duration of this open-loop –Z translation maneuver may be different for the various auto contingency modes. Set this timer to its I-loaded Mode 1 value.

$$\text{CONT_2EO_PR_DELAY} = \text{CONT_MINUSZ_TIMER1}$$

- e. Set the right wing unit vector to command a heads down roll attitude. For the in-plane procedure, this is a heads down, wings level attitude. For the yaw steering procedure, this is an attitude that, when the roll to heads up is commanded later in the maneuver, the subsequent yaw back to the current orbital plane will be a pure yaw maneuver.

$$\text{Y_SYM_GUID} = -\text{SIN}(\text{PSI_CONT}) \text{SIN}(\text{THETA_CONT}) \bar{\text{I}}\bar{\text{X}}\bar{\text{C}}$$

$$- \text{COS}(\text{PSI_CONT}) \bar{\text{I}}\bar{\text{Y}}\bar{\text{C}}$$

$$- \text{SIN}(\text{PSI_CONT}) \text{COS}(\text{THETA_CONT}) \bar{\text{I}}\bar{\text{Z}}\bar{\text{C}}$$

- f. Set the contingency auto mode index to a value that supports the needs of the initial pitch and yaw maneuver.

$$\text{AUTO_MODE} = 11$$

2. If the initial pitch and yaw maneuver has already been completed ($\text{ROLL_DELAY_COUNTER} \leq 0$), proceed to Step 5. Otherwise, set the heads down thrust vector pitch attitude to a value consistent with the contingency body pitch attitude.

$$\text{THETA_HEADS_DOWN} = \text{THETA_CONT} + \text{PITCH_CANT_ANGLE}$$

Set the desired thrust yaw angle to a value consistent with the contingency body yaw angle.

$$\text{PSI_DESIRED} = \text{PSI_CONT} + \text{YAW_CANT_ANGLE}$$

Compute the coefficients of the desired thrust unit vector. They are formed by rotating the desired thrust vector frame from a local-vertical, local-horizontal frame through a specified pitch, then yaw, sequence of rotations.

$$IXC_COEF = \sin(\text{THETA_HEADS_DOWN}) \cos(\text{PSI_DESIRED})$$

$$IYC_COEF = -\sin(\text{PSI_DESIRED})$$

$$IZC_COEF = \cos(\text{THETA_HEADS_DOWN}) \cos(\text{PSI_DESIRED})$$

3. When apogee is approached on a case that continues to maneuver after apogee (via the CONT MODE2 TSK), the guidance 2 engine out mode index is changed from 1 to 2.

If $S_{\dot{C}OMB_MNVR} = ON$, perform (a) below. Otherwise, perform (b) below.

- a. If the current altitude rate is less than an I-loaded value ($H\dot{D}OT < H\dot{D}OT_MODE_SWITCH$), set $GUID_2EO_MODE = 2$

Proceed to Step 12.

- b. If this is the first pass through this part of the maneuver ($S_{\dot{M}NVR_INIT} = ON$), set $S_{\dot{M}NVR_INIT} = OFF$ and proceed to Step 12.

4. The initial pitch and yaw maneuver is terminated when the roll delay counter decrements to zero. This counter is decremented from its previous value when the angle between the current sensed thrust vector and the commanded thrust vector is less than an I-loaded value.

$$\text{IF } \text{UNIT}(\overline{DVS}) \cdot \overline{L\dot{A}MC} > \text{COS_ANG_ROLL_DELAY},$$

$$\text{ROLL_DELAY_COUNTER} = \text{ROLL_DELAY_COUNTER} - 1$$

Proceed to Step 12.

5. If the roll to heads up has already been initiated ($\text{ROLL_DELAY_COUNTER} < 0$), proceed to Step 6. Otherwise, command the roll to heads up by performing the following:

- a. Command the roll to heads up by changing the sign of the right wing unit vector.

$$Y_{\overline{S}YM_GUID} = -Y_{\overline{S}YM_GUID}$$

- b. Set the contingency roll to heads up discrete. This flag is sent to G/C Steer and permits the roll to heads up to occur without any undesired pitch or yaw rates.

$$S_{\dot{C}ONT_ROLL} = ON$$

- c. Turn the contingency roll inhibit discrete OFF.

$$S_{\dot{C}ONT_ROLL_INHIB} = OFF$$

- d. Set the contingency auto mode index to a value that supports the needs of the roll to heads up maneuver.

$$\text{AUTO_MODE} = 12$$

- e. Set the heads up thrust vector pitch attitude to a value consistent with the contingency body pitch attitude.

$$\text{THETA_HEADS_UP} = \text{THETA_CONT} - \text{PITCH_CANT_ANGLE}$$

Set the desired thrust yaw angle to a value consistent with the contingency body yaw angle.

$$\text{PSI_DESIRED} = \text{PSI_CONT} - \text{YAW_CANT_ANGLE}$$

- f. Compute the coefficients of the desired thrust unit vector.

$$\text{IXC_COEF} = \text{SIN}(\text{THETA_HEADS_UP}) \text{COS}(\text{PSI_DESIRED})$$

$$\text{IYC_COEF} = -\text{SIN}(\text{PSI_DESIRED})$$

$$\text{IZC_COEF} = \text{COS}(\text{THETA_HEADS_UP}) \text{COS}(\text{PSI_DESIRED})$$

- g. Set the roll delay counter to indicate the roll to heads up has begun.

$$\text{ROLL_DELAY_COUNTER} = -1$$

Proceed to Step 12.

6. If the roll to heads up is finished ($\text{S_}\dot{\text{R}}\text{OLL_COMPLETE} = \text{ON}$), proceed to Step 7. Otherwise, check the commanded-to-desired body roll attitude error (fed back to guidance from G/C Steer). If this error is smaller than an I-loaded value, the roll to heads up is complete.

$$\text{If } \text{ABS}(\text{ECBDB}(1)) < \text{CONT_ROLL_ERR},$$

$$\text{set } \text{S_}\dot{\text{R}}\text{OLL_COMPLETE} = \text{ON}$$

Proceed to Step 12.

7. If this is a yaw steering scenario and the yaw back in-plane has been initiated ($\text{S_}\dot{\text{Y}}\text{AW_BACK_INIT} = \text{ON}$), proceed to Step 9. Otherwise, perform the following:

- a. Set the contingency roll to heads up discrete OFF. This will permit G/C Steer to begin accepting new desired thrust vector commands.

$$\text{S_}\dot{\text{C}}\text{ONT_ROLL} = \text{OFF}$$

- b. After the roll to heads up, small corrections in commanded attitude may be needed. Set the contingency auto mode index to a value that supports these maneuver corrections.

$$\text{AUTO_MODE} = 13$$

8. If the current altitude rate is less than the mode 1 altitude rate parameter set in step 1a, begin the final maneuver (either a pitch down if an in-plane procedure, or a yaw back if a yaw steering case).

If $\text{HDOT} < \text{HDOT_MODE1_PD}$, proceed to Step 9.

Otherwise, proceed to Step 12.

9. Perform the following:
 - a. If this is an in-plane procedure, proceed to the step that will command a powered pitchdown at this time.

If $S_{\dot{\text{CONT_YAW}}} = \text{OFF}$, proceed to Step 11.

- b. Compute the thrust vector coefficients to command the yaw back in-plane so that the sideslip angle is zeroed by maneuver completion.

$$\text{IXC_COEF} = \text{SIN}(\text{THETA_HEADS_UP}) \text{COS}(\text{YAW_CANT_ANGLE})$$

$$\text{IYC_COEF} = \text{SIN}(\text{YAW_CANT_ANGLE})$$

$$\text{IZC_COEF} = \text{COS}(\text{THETA_HEADS_UP}) \text{COS}(\text{YAW_CANT_ANGLE})$$

- c. If the yaw back in-plane has already been commanded, proceed to the step that checks for completion of the yaw back in-plane maneuver.

If $S_{\dot{\text{YAW_BACK_INIT}}} = \text{ON}$, proceed to Step 10.

- d. Command the yaw back in-plane by first determining the current orbital plane, then setting the right wing unit vector equal to the out-of-plane unit vector. Also set the discrete indicating the yaw back in-plane has begun.

Call the Contingency LVLH task.

$$Y_{\bar{\text{SYM_GUID}}} = \bar{\text{IYC}}$$

$$S_{\dot{\text{YAW_BACK_INIT}}} = \text{ON}$$

Proceed to Step 12.

10. The yaw back in-plane maneuver is terminated when the pitch down delay counter decrements to zero.

If $\text{PD_DELAY_COUNTER} \leq 0$, proceed to Step 11.

Otherwise, the pitch down delay counter is decremented from its previous value when the angle between the current sensed thrust vector and the commanded thrust vector is less than an I-loaded value.

If $\text{UNIT}(\overline{DVS}) \cdot \overline{LAMC} > \text{COS_ANG_PITCH_DELAY}$,

$\text{PD_DELAY_COUNTER} = \text{PD_DELAY_COUNTER} - 1$

Proceed to Step 12.

11. Command an immediate powered pitchdown (and guidance fine countdown) to achieve the desired attitude at MECO.

$S_CONT_MECO = ON$

$TP = TGD$

Set the contingency auto mode index to a value that supports the needs of the powered pitchdown.

$AUTO_MODE = 14$

Exit this task.

12. Calculate the commanded thrust direction using the thrust vector coefficients and LVLH unit vectors previously computed.

$\overline{LAMC} = \text{IXC_COEF} \overline{IXC} + \text{IYC_COEF} \overline{IYC} + \text{IZC_COEF} \overline{IZC}$

B. Interface Requirements. The input and output parameters for this task are given in Tables 4.9.4–1 and 4.9.4–2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.9.4-1. Contingency Mode 1 Task Inputs				
Definition	Symbol	Source	Prec	Units
Contingency ET separation –Z translation timer for Mode 1	CONT_MINUSZ_TIMER1	I-LOAD	SP	sec
Maximum roll attitude error before the contingency roll to heads up is complete	CONT_ROLL_ERR	I-LOAD	SP	deg
Cosine of the maximum total thrust vector angular error before the contingency powered pitchdown may begin	COS_ANG_PITCH_DELAY	I-LOAD	SP	ND
Cosine of the maximum total thrust vector angular error before the contingency roll to heads up may begin	COS_ANG_ROLL_DELAY	I-LOAD	SP	ND
Change in accumulated sensed velocity from previous cycle	DVS	PFG INP TSK	SP	fps
Roll attitude error, commanded to desired body	ECBDB(1)	G/C STEER	SP	deg
Estimated altitude rate	HDOT	ASC UPP, RTLS UPP	SP	fps
Altitude rate for the combined maneuver switch from Mode 1 to Mode 2	HDOT_MODE_SWITCH	I-LOAD	SP	fps
Altitude rate at which the Mode 1 yaw back in-plane begins	HDOT_MODE1_BACK	I-LOAD	SP	fps
Local vertical unit vector	$\bar{I}X_C$	CONT LVLH TSK	SP	ND
Local out-of-plane unit vector	$\bar{I}Y_C$	CONT LVLH TSK	SP	ND
Local horizontal unit vector	$\bar{I}Z_C$	CONT LVLH TSK	SP	ND
Pitchdown delay counter used to control moding to the contingency powered pitchdown maneuver	PD_DELAY_COUNTER	I-LOAD	I	N/A
Pitch cant angle between thrust vector and the orbiter X–Y plane	PITCH_CANT_ANGLE	AUTO CONT TSK	SP	rad
Yaw attitude for Mode 1 yaw steering	PSI_MODE1_YAW	I-LOAD	SP	rad
Roll delay counter used to control moding to the roll to heads up maneuver	ROLL_DELAY_COUNTER	I-LOAD	I	N/A
Combined maneuver discrete	S_COMB_MNVR	CONT MODE SEL TSK	D	N/A
Contingency yaw steering flag	S_CONT_YAW	AUTO CONT TSK	D	N/A
Pitch attitude for Mode 1 in-plane	THETA_CONT_MODE1	I-LOAD	SP	rad
Pitch attitude for Mode 1 yaw steering	THETA_MODE1_YAW	I-LOAD	SP	rad
Time associated with current state	TGD	PFG INP TSK	DP	sec
Yaw cant angle between the thrust vector and the orbiter X–Z plane	YAW_CANT_ANGLE	AUTO CONT TSK	SP	rad

Table 4.9.4-2. Contingency Mode 1 Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index sent to G/C Steer to control maneuver smoothing	AUTO_MODE	G/C STEER	I	N/A
Contingency ET separation open loop -Z translation timer	CONT_2EO_PR_DELAY	GRTLS DAP	SP	sec
Guidance 2 engine out mode index	GUID_2EO_MODE	AUTO CONT TSK	I	N/A
M50 desired thrust vector	$\bar{L}AMC$	G/C STEER, TLM	SP	ND
Contingency fine countdown discrete	$S_{\dot{C}ONT_MECO}$	MSC, PW CONT SEQ, ASC UPP SEQ, RTLS UPP SEQ	D	N/A
Contingency roll heads up discrete	$S_{\dot{C}ONT_ROLL}$	G/C STEER	D	N/A
Contingency roll inhibit discrete	$S_{\dot{C}ONT_ROLL_INHIB}$	G/C STEER	D	N/A
GMT time of powered pitchdown	TP	PW CONT SEQ, TLM	DP	sec
Right wing unit vector	$Y_{\bar{S}YM_GUID}$	G/C STEER	SP	ND

4.9.5 Contingency Mode 2 Task (CONT MODE2 TSK)

This task provides guidance commands for contingency abort scenarios that call for a “stand on the tail” type of maneuver to minimize entry pullout loads while separating safely from the external tank in a heads up orientation. Two different procedures are provided by this task. The first is an in-plane, “stand on the tail” procedure that consists of the following maneuvers:

1. Maneuver the vehicle to an attitude in-plane, near the vertical.
2. Roll heads up with respect to the downrange direction.
3. After apogee has been reached and a desired equivalent airspeed has been attained, pitch down to achieve a desired attitude rate prior to MECO.

The second procedure provided by this task is a yaw steering maneuver to change the heading of the velocity vector while reducing entry pullout loads. This procedure consists of the following maneuvers:

1. Maneuver the vehicle to a desired out-of-plane attitude.
2. Roll heads up with respect to the downrange direction.
3. After apogee has been reached and a desired equivalent airspeed has been attained, maneuver back to the current orbital plane.
4. Pitch down to achieve a desired attitude rate prior to MECO.

This task computes a desired thrust unit vector as well as a right wing unit vector. It also passes a contingency auto mode index and several discrettes to G/C Steer to support maneuver smoothing and control. This task also sets the duration of the open-loop -Z translation maneuver after ET separation.

A. Detailed Requirements.

1. Perform the following calculations first pass only. Otherwise, proceed to Step 2.
 - a. Set the contingency body pitch and yaw angles to their Mode 2 values based on whether this is a yaw steering contingency maneuver.

If $S_CONT_YAW = ON$, perform the following:

$$THETA_CONT = THETA_MODE2_YAW$$

$$PSI_CONT = PSI_MODE2_YAW$$

Otherwise, set the contingency body pitch and yaw angles to the values appropriate for an in-plane (no yaw steering) case.

$$THETA_CONT = THETA_CONT_MODE2$$

$$PSI_CONT = 0$$

- b. Set the contingency roll inhibit discrete. This flag is sent to G/C Steer and permits the initial pitch and yaw maneuver to occur without any undesired commanded roll rate.

$$S_{\dot{C}}\text{CONT_ROLL_INHIB} = \text{ON}$$

- c. Initialize the local Mode 2 maneuver discrettes.

$$S_{\dot{R}}\text{ROLL_COMPLETE} = \text{OFF}$$

$$S_{\dot{Y}}\text{AW_BACK_INIT} = \text{OFF}$$

$$S_{\dot{M}}\text{NVR_INIT} = \text{ON}$$

- d. Set the contingency $-Z$ translation timer to its I-loaded Mode 2 value.

$$\text{CONT_2EO_PR_DELAY} = \text{CONT_MINUSZ_TIMER2}$$

If the vehicle is close to zero downrange velocity, set the timer to its I-loaded $V_{REL}=0$ Mode 2 value.

If $S_{\dot{S}}\text{ELECT_VREL0_CONT} = \text{ON}$, set

$$\text{CONT_2EO_PR_DELAY} = \text{VREL0_MINUSZ_TIMER2}$$

- e. Set the right wing unit vector to command a heads down roll attitude. For the in-plane procedure, this is a heads down, wings level attitude. For the yaw steering procedure, this is an attitude that, when the roll to heads up is commanded later in the maneuver, the subsequent yaw back to the current orbital plane will be a pure yaw maneuver.

$$Y_{\bar{S}}\text{YM_GUID} = -\text{SIN}(\text{PSI_CONT}) \text{SIN}(\text{THETA_CONT}) \bar{I}X_C$$

$$-\text{COS}(\text{PSI_CONT}) \bar{I}Y_C$$

$$-\text{SIN}(\text{PSI_CONT}) \text{COS}(\text{THETA_CONT}) \bar{I}Z_C$$

- f. Set the contingency auto mode index to a value that supports the needs of the initial pitch and yaw maneuver.

$$\text{AUTO_MODE} = 21$$

2. If the initial pitch and yaw maneuver has already been completed ($\text{ROLL_DELAY_COUNTER} \leq 0$), proceed to Step 4. Otherwise, set the heads down thrust vector pitch attitude to a value consistent with the contingency body pitch attitude.

$$\text{THETA_HEADS_DOWN} = \text{THETA_CONT} + \text{PITCH_CANT_ANGLE}$$

Set the desired thrust yaw angle to a value consistent with the contingency body yaw angle.

$$\text{PSI_DESIRED} = \text{PSI_CONT} + \text{YAW_CANT_ANGLE}$$

Compute the coefficients of the desired thrust unit vector. They are formed by rotating the desired thrust vector frame from a local-vertical, local-horizontal frame through a specified pitch, then yaw, sequence of rotations.

$$\text{IXC_COEF} = \text{SIN}(\text{THETA_HEADS_DOWN}) \text{COS}(\text{PSI_DESIRED})$$

$$IYC_COEF = -\text{SIN}(\text{PSI_DESIRED})$$

$$IZC_COEF = \text{COS}(\text{THETA_HEADS_DOWN}) \text{COS}(\text{PSI_DESIRED})$$

If this is the first pass through this part of the maneuver ($S_MNVR_INIT = \text{ON}$), set $S_MNVR_INIT = \text{OFF}$ and proceed to Step 11.

3. The initial pitch and yaw maneuver is terminated when the roll delay counter decrements to zero. This counter is decremented from its previous value when the angle between the current sensed thrust vector and the commanded thrust vector is less than an I-loaded value.

$$\text{IF UNIT}(\overline{DVS}) \cdot \overline{LAMC} > \text{COS_ANG_ROLL_DELAY},$$

$$\text{ROLL_DELAY_COUNTER} = \text{ROLL_DELAY_COUNTER} - 1$$

Proceed to Step 11.

4. If the roll to heads up has already been initiated ($\text{ROLL_DELAY_COUNTER} < 0$), proceed to Step 5. Otherwise, command the roll to heads up by performing the following:

- a. Command the roll to heads up by changing the sign of the right wing unit vector.

$$Y_SYM_GUID = -Y_SYM_GUID$$

- b. Set the contingency roll to heads up discrete. This flag is sent to G/C Steer and permits the roll to heads up to occur without any undesired pitch or yaw rates.

$$S_CONT_ROLL = \text{ON}$$

- c. Turn the contingency roll inhibit flag OFF.

$$S_CONT_ROLL_INHIB = \text{OFF}$$

- d. Set the contingency auto mode index to a value that supports the needs of the roll to heads up maneuver.

$$\text{AUTO_MODE} = 22$$

- e. Set the heads up thrust vector pitch attitude to a value consistent with the contingency body pitch attitude.

$$\text{THETA_HEADS_UP} = \text{THETA_CONT} - \text{PITCH_CANT_ANGLE}$$

Set the desired thrust yaw angle to a value consistent with the contingency body yaw angle.

$$\text{PSI_DESIRED} = \text{PSI_CONT} - \text{YAW_CANT_ANGLE}$$

- f. Compute the coefficients of the desired thrust unit vector.

$$IXC_COEF = \text{SIN}(\text{THETA_HEADS_UP}) \text{COS}(\text{PSI_DESIRED})$$

$$IYC_COEF = -\text{SIN}(\text{PSI_DESIRED})$$

$$IZC_COEF = \text{COS}(\text{THETA_HEADS_UP}) \text{COS}(\text{PSI_DESIRED})$$

- g. Set the roll delay counter to indicate the roll to heads up has begun.

$$\text{ROLL_DELAY_COUNTER} = -1$$

Proceed to Step 11.

5. If the roll to heads up is finished ($\text{S_}\dot{\text{R}}\text{OLL_COMPLETE} = \text{ON}$), proceed to Step 6. Otherwise, check the commanded-to-desired body roll attitude error (fed back to guidance from G/C Steer). If this error is smaller than an I-loaded value, the roll to heads up is complete.

$$\text{If } \text{ABS}(\text{ECBDB}(1)) < \text{CONT_ROLL_ERR},$$

$$\text{set } \text{S_}\dot{\text{R}}\text{OLL_COMPLETE} = \text{ON}$$

Proceed to Step 11.

6. If this is a yaw steering scenario and the yaw back in-plane has been initiated ($\text{S_}\dot{\text{Y}}\text{AW_BACK_INIT} = \text{ON}$), proceed to Step 8. Otherwise, perform the following:

- a. Set the contingency roll to heads up discrete OFF. This will permit G/C Steer to begin accepting new desired thrust vector commands.

$$\text{S_}\dot{\text{C}}\text{ONT_ROLL} = \text{OFF}$$

- b. After the roll to heads up, small corrections in commanded attitude may be needed. Set the contingency auto mode index to a value that supports these maneuver corrections.

$$\text{AUTO_MODE} = 23$$

7. The final maneuver during a Mode 2 procedure begins at a designated equivalent airspeed. For a yaw steering scenario, this maneuver is a yaw back to the current orbital plane. The duration of the yaw maneuver is dependent on which engine is still running. Use the main engine yaw index to determine when the yaw back in-plane maneuver should begin.

If $\text{S_}\dot{\text{C}}\text{ONT_YAW} = \text{ON}$, perform the following:

$$\text{EAS_PY} = \text{EAS_YAW}(\text{ME_YAW_INDEX})$$

Otherwise, set $\text{EAS_PY} = \text{EAS_PD}$ (the final maneuver for an in-plane procedure is a pitch down that begins at an I-loaded equivalent airspeed).

When the equivalent airspeed is greater than EAS_PY and apogee has been reached, begin the final maneuver.

If $\text{EAS} > \text{EAS_PY}$ and $\text{HDOT} < 0$ proceed to Step 8.

Otherwise, proceed to Step 11.

8. Perform the following:

- a. If this is an in-plane procedure, proceed to the step that will command a powered pitchdown at this time.

If $S_{\dot{C}ONT_YAW} = OFF$, proceed to Step 10.

- b. Compute the thrust vector coefficients to command the yaw back in-plane so that the sideslip angle is zeroed by maneuver completion.

$$IXC_COEF = SIN(THETA_HEADS_UP) COS(YAW_CANT_ANGLE)$$

$$IYC_COEF = SIN(YAW_CANT_ANGLE)$$

$$IZC_COEF = COS(THETA_HEADS_UP) COS(YAW_CANT_ANGLE)$$

- c. If the yaw back in-plane has already been commanded, proceed to the step that checks for completion of the yaw back in-plane maneuver.

If $S_{\dot{Y}AW_BACK_INIT} = ON$, proceed to Step 9.

- d. Command the yaw back in-plane by first determining the current orbital plane, then setting the right wing unit vector equal to the out-of-plane unit vector. Also set the discrete indicating the yaw back in-plane has begun.

Call the Contingency LVLH task.

$$Y_{\bar{S}YM_GUID} = \bar{I}YC$$

$$S_{\dot{Y}AW_BACK_INIT} = ON$$

Proceed to Step 11.

9. The yaw back in-plane maneuver is terminated when the pitch down delay counter decrements to zero.

If $PD_DELAY_COUNTER \leq 0$, proceed to Step 10.

Otherwise, the pitch down delay counter is decremented from its previous value when the angle between the current sensed thrust vector and the commanded thrust vector is less than an I-loaded value.

If $UNIT(D\bar{V}S) \cdot \bar{L}AMC > COS_ANG_PITCH_DELAY$,

$$PD_DELAY_COUNTER = PD_DELAY_COUNTER - 1$$

Proceed to Step 11.

10. Command the contingency powered pitchdown (and guidance fine countdown) by performing the following:

Set the contingency fine countdown discrete ON.

$$S_{\dot{C}ONT_MECO} = ON$$

Set the time of powered pitchdown equal to the current time.

$$TP = TGD$$

Set the contingency auto mode index to a value that supports the needs of the Mode 2 powered pitchdown.

$$AUTO_MODE = 24$$

Set the high rate ET separation discrete ON to indicate a constant pitch rate is desired at MECO and ET separation.

$$HIGH_RATE_SEP = ON$$

Exit this task.

11. Calculate the commanded thrust direction using the thrust vector coefficients and LVLH unit vectors previously computed.

$$\bar{L}AMC = IXC_COEF \bar{I}XC + IYC_COEF \bar{I}YC + IZC_COEF \bar{I}ZC$$

B. Interface Requirements. The input and output parameters for this task are given in Tables 4.9.5-1 and 4.9.5-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.9.5-1. Contingency Mode 2 Task Inputs				
Definition	Symbol	Source	Prec	Units
Contingency ET separation –Z translation timer for Mode 2	CONT_MINUSZ_TIMER2	I-LOAD	SP	sec
Maximum roll attitude error before the contingency roll to heads up is complete	CONT_ROLL_ERR	I-LOAD	SP	deg
Cosine of the maximum total thrust vector angular error before the contingency powered pitchdown may begin	COS_ANG_PITCH_DELAY	I-LOAD	SP	ND
Cosine of the maximum total thrust vector angular error before the contingency roll to heads up may begin	COS_ANG_ROLL_DELAY	I-LOAD	SP	ND
Change in accumulated sensed velocity from previous cycle	\overline{DVS}	PFG INP TSK	SP	fps
Equivalent airspeed	EAS	ASC UPP, RTLS UPP	SP	fps
Equivalent airspeed at which the powered pitchdown begins	EAS_PD	I-LOAD	SP	fps
Equivalent airspeed at which the Mode 2 yaw back in-plane begins	EAS_YAW(J) (J=1,2)	I-LOAD	SP	fps
Roll attitude error, commanded to desired body	ECBDB(1)	G/C STEER	SP	deg
Estimated altitude rate	HDOT	ASC UPP, RTLS UPP	SP	fps
Local vertical unit vector	\overline{IXC}	CONT LVLH TSK	SP	ND
Local out-of-plane unit vector	\overline{IYC}	CONT LVLH TSK	SP	ND
Local horizontal unit vector	\overline{IZC}	CONT LVLH TSK	SP	ND
Main engine yaw steering index	ME_YAW_INDEX	AUTO CONT TSK	I	N/A
Pitchdown delay counter used to control moding to the contingency powered pitchdown maneuver	PD_DELAY_COUNTER	I-LOAD	I	N/A
Pitch cant angle between thrust vector and the orbiter X–Y plane	PITCH_CANT_ANGLE	AUTO CONT TSK	SP	rad
Yaw attitude for Mode 2 yaw steering	PSI_MODE2_YAW	I-LOAD	SP	rad
Roll delay counter used to control moding to the contingency roll to heads up maneuver	ROLL_DELAY_COUNTER	I-LOAD	I	N/A
Contingency yaw steering flag	S_CONT_YAW	AUTO CONT TSK	D	N/A
Pitch attitude for Mode 2 in-plane	THETA_CONT_MODE2	I-LOAD	SP	rad

Table 4.9.5-1. Contingency Mode 2 Task Inputs				
Definition	Symbol	Source	Prec	Units
Flag designating 2 E/O VREL = 0 mode has been selected	\dot{S} SELECT_VREL0_CONT	CONT MODE SEL TSK	D	N/A
Pitch attitude for Mode 2 yaw steering	THETA_MODE2_YAW	I-LOAD	SP	rad
Time associated with current state	TGD	PFG INP TSK	DP	sec
Contingency ET separation -Z timer for Mode 2 near VREL = 0	VREL0_MINUSZ_TIMER2	I-LOAD	SP	sec
Yaw cant angle between the thrust vector and the orbiter X-Z plane	YAW_CANT_ANGLE	AUTO CONT TSK	SP	rad

Table 4.9.5-2. Contingency Mode 2 Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index sent to G/C Steer to control maneuver smoothing	AUTO_MODE	G/C STEER	I	N/A
Contingency ET separation open loop -Z translation timer	CONT_2EO_PR_DELAY	GRTLS DAP	SP	sec
High rate ET separation flag	\dot{H} IGH_RATE_SEP	CONT PPD TSK, CONT GUID C/O TSK, G/C STEER, CONT 3E/O GUID	D	N/A
M50 desired thrust vector	\bar{L} AMC	G/C STEER, TLM	SP	ND
Contingency fine countdown discrete	\dot{S} _CONT_MECO	MSC, PW CONT SEQ, ASC UPP SEQ, RTLS UPP SEQ	D	N/A
Contingency roll heads up discrete	\dot{S} _CONT_ROLL	G/C STEER	D	N/A
Contingency roll inhibit discrete	\dot{S} _CONT_ROLL_INHIB	G/C STEER	D	N/A
GMT time of powered pitchdown	TP	PW CONT SEQ, TLM	DP	sec
Right wing unit vector	\bar{Y} _SYM_GUID	G/C STEER	SP	ND

4.9.6 Contingency Mode 3 Task (CONT MODE3 TSK)

This task provides guidance commands for RTLS contingency abort scenarios occurring during Mode 3 and Mode 4 regions. A Mode 3 maneuver is commanded for a second engine out after powered pitcharound when the vehicle is near the “VREL = 0” point of the RTLS trajectory. This region begins just before the downrange horizontal relative velocity component is equal to zero (VREL = 0), and extends to a point after VREL = 0 beyond which a safe ET separation cannot be achieved in a Mode 3 maneuver. The Mode 3 procedure consists of flying in-plane at a pitch attitude that keeps the thrust vector at a constant elevation angle. This is done to increase horizontal velocity before MECO. When the equivalent airspeed reaches a specified level, a pitchdown is commanded to achieve a constant attitude rate before MECO.

A Mode 4 contingency maneuver is commanded for a second engine out after VREL = 0 on RTLS when the vehicle does not have the energy to press to a single engine RTLS completion procedure and the equivalent airspeed is too high to safely separate from the ET in a Mode 3 maneuver. The Mode 4 contingency procedure consists of an immediate powered pitchdown to reach a small (I-loaded) angle of attack prior to MECO.

This task computes a desired thrust vector and a desired right wing unit vector. It also passes a contingency auto mode index to G/C Steer to support maneuver smoothing and control. It also sets the duration of the open-loop -Z translation maneuver after ET separation.

A. Detailed Requirements.

1. If GUID_2EO_MODE = 4, perform the following:

Set the contingency -Z translation timer to its I-loaded Mode 4 value.

$$\text{CONT_2EO_PR_DELAY} = \text{CONT_MINUSZ_TIMER4}$$

Set the contingency auto mode index to a value that supports the needs of the Mode 4 powered pitchdown.

$$\text{AUTO_MODE} = 41$$

And proceed to Step 7.

2. If this is the first pass through this task, perform the following. Otherwise, proceed to Step 3.

Set the contingency -Z translation timer to its I-loaded Mode 3 value.

$$\text{CONT_2EO_PR_DELAY} = \text{CONT_MINUSZ_TIMER3}$$

Set the contingency auto mode index to a value that supports the needs of the Mode 3 maneuver.

$$\text{AUTO_MODE} = 31$$

3. During Mode 3 contingency aborts the magnitude of the relative velocity vector is small. Because of this the current orbital plane can change during the maneuver (due to small out of plane thrusting). To keep the sideslip angle near zero, call the Contingency LVLH Task (CONT LVLH TSK) every guidance cycle to update the current orbital plane.

4. Set the right wing unit vector equal to the out-of-plane unit vector. This will command a wings-level attitude.

$$Y_{\bar{S}YM_GUID} = I\bar{Y}C$$

5. Calculate the Mode 3 thrust vector coefficients and thrust vector to command an in-plane pitch attitude.

$$IXC_COEF = \sin(\text{THETA_LAMC_MODE3}) \cos(\text{YAW_CANT_ANGLE})$$

$$IYC_COEF = \sin(\text{YAW_CANT_ANGLE})$$

$$IZC_COEF = \cos(\text{THETA_LAMC_MODE3}) \cos(\text{YAW_CANT_ANGLE})$$

$$L\bar{AMC} = IXC_COEF I\bar{X}C + IYC_COEF I\bar{Y}C + IZC_COEF I\bar{Z}C$$

6. If the equivalent airspeed is greater than or equal to an I-loaded value ($EAS \geq EAS_MODE3$) and the altitude rate is less than zero ($H\dot{D}OT < 0$), command the Mode 3 powered pitchdown by performing the following. Otherwise, exit this task.

Set the contingency auto mode index to a value that supports the needs of the Mode 3 powered pitchdown.

$$AUTO_MODE = 32$$

Set the high rate ET separation discrete ON to indicate a constant pitch rate is desired at MECO and ET separation.

$$H\dot{I}GH_RATE_SEP = ON$$

7. Command an immediate powered pitchdown (and guidance fine countdown) by computing the following:

Set the contingency fine countdown discrete ON.

$$S_C\dot{O}NT_MECO = ON$$

Set the time of powered pitchdown equal to the current time.

$$TP = TGD$$

B. Interface Requirements. The input and output parameters for this task are given in Tables 4.9.6-1 and 4.9.6-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.9.6-1. Contingency Mode 3 Task Inputs				
Definition	Symbol	Source	Prec	Units
Contingency ET separation -Z translation timer for Mode 3	CONT_MINUSZ_TIMER3	I-LOAD	SP	sec
Contingency ET separation -Z translation timer for Mode 4	CONT_MINUSZ_TIMER4	I-LOAD	SP	sec
Guidance 2 engine out mode index	GUID_2EO_MODE	AUTO CONT TSK	I	N/A
Estimated altitude rate	HDOT	RTLS UPP	SP	fps
Equivalent airspeed	EAS	RTLS UPP	SP	fps
Equivalent airspeed to begin the Mode 3 powered pitchdown	EAS_MODE3	I-LOAD	SP	fps
Local vertical unit vector	$\bar{I}X_C$	CONT LVLH TSK	SP	ND
Local plane unit vector	$\bar{I}Y_C$	CONT LVLH TSK	SP	ND
Local horizontal unit vector	$\bar{I}Z_C$	CONT LVLH TSK	SP	ND
Desired thrust vector angle relative to the vertical	THETA_LAMC_MODE3	I-LOAD	SP	rad
Time associated with current state	TGD	PFG INP TSK	DP	sec
Yaw cant angle between the thrust vector and the orbiter X-Z plane	YAW_CANT_ANGLE	AUTO CONT TSK	SP	rad

Table 4.9.6-2. Contingency Mode 3 Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index sent to G/C STEER to control maneuver smoothing	AUTO_MODE	G/C STEER	I	N/A
Contingency ET separation open loop -Z translation timer	CONT_2EO_PR_DELAY	GRTLS DAP	SP	sec
High rate ET separation flag	HIGH_RATE_SEP	CONT PPD TSK, CONT GUID C/O TSK, G/C STEER, CONT 3E/O GUID	D	N/A
M50 desired thrust vector	$\bar{L}AMC$	G/C STEER, TLM	SP	ND
Contingency fine countdown discrete	S_CONT_MECO	MSC, PW CONT SEQ, RTLS UPP SEQ	D	N/A
GMT time of powered pitchdown	TP	PW CONT SEQ, TLM	DP	sec
Right wing unit vector	Y_{SYM_GUID}	G/C STEER	SP	ND

4.9.7 Contingency Mode 5 Task (CONT MODE5 TSK)

This task provides guidance commands for contingency abort scenarios that call for the RTLS single engine completion maneuver. The procedure consists of the following maneuvers:

1. Command a pitch attitude to reach an I-loaded altitude rate before powered pitchdown without exceeding a specified maximum pitch angle. Keep the wings level with sideslip angle near zero.
2. When the time to MECO becomes as small as the time required to pitchdown, command a powered pitchdown to achieve a desired attitude before MECO.

This task computes a desired thrust unit vector as well as a right wing unit vector. It also passes a contingency auto mode index to G/C Steer to support maneuver smoothing and control. It also sets the duration of the open-loop -Z translation maneuver after ET separation. This task also calculates the predicted time of MECO in MET for display. If the time to go to MPS propellant depletion becomes less than an I-loaded value, this task commands a throttle down to a specified setting to protect for possible net positive suction pressure (NPSP) violation in the event of a low-level cutoff.

A. Detailed Requirements.

1. Perform the following calculations first pass only. Otherwise, proceed to Step 2.
 - a. Set the right wing unit vector equal to the out-of-plane unit vector. This commands a wings-level attitude.

$$Y_SYM_GUID = \bar{I}YC$$

- b. Initialize the previously commanded thrust direction to be in the same direction as the current thrust vector.

$$\bar{L}AMC_OLD = UNIT(D\bar{V}S)$$

- c. In order to track the vehicle mass accurately, an accounting is made of mass loss due to single engine roll control OMS propellant usage. Initialize this mass value to zero.

$$M_SEROLL = 0$$

- d. Set the contingency auto mode index to a value that supports the needs of the Mode 5 maneuver.

$$AUTO_MODE = 51$$

- e. Set the contingency -Z translation timer to its I-loaded Mode 5 value.

$$CONT_2EO_PR_DELAY = CONT_MINUSZ_TIMER5$$

2. Compute the time to go to a guided MECO by estimating the time to go to reaching the RTLS TRAJ 2 display MECO cutoff tick. Delta range to cutoff is provided by the XXXXXX TRAJ display processor. An average range rate is used to determine TGO. This TGO is smoother and decreases more uniformly than the TGO from the MPS GUID C/O TSK.

$$TGO = -DELTA_R / DELTA_R_DOT$$

3. Update the estimated mass loss due to single engine roll control propellant usage.

$$M_SEROLL = M_SEROLL + DELTA_M_SEROLL$$

4. Calculate the time remaining before MPS propellant depletion.

$$TGO_EMPTY = (M - M_EMPTY - M_SEROLL) / MDOT$$

5. If propellant depletion will occur before the MECO cutoff tick is reached, set the time remaining to MECO equal to the time-to-go until fuel depletion.

$$\text{If } TGO_EMPTY < TGO \text{ then set } TGO = TGO_EMPTY$$

6. The time required for the pitchdown maneuver is calculated by dividing the expected angle of pitchdown by an average rate of pitchdown.

$$DT_CONT_PITCH = (ALPHA_N - ALPHA_PPD \text{ DEG_PER_RAD}) / \\ AVE_PPD_RATE$$

Limit the expected duration of PPD to be within specified values.

$$DT_CONT_PITCH = \text{MIDVAL}(DT_PPD_MIN, DT_CONT_PITCH, DT_PPD_MAX)$$

7. Set the time to go to PPD and the GMT of PPD.

$$TGO = TGO - DT_CONT_PITCH$$

$$TP = TGD + TGO$$

8. Calculate an estimate of the magnitude of the current thrust acceleration.

$$EST_AT = FT_FACTOR FT / M$$

9. Calculate the desired vertical component of the thrust acceleration vector. The desired vertical acceleration is constructed to reach a desired altitude rate prior to powered pitchdown.

$$AX = G_2_FPS2 + (HDOT_TGT_MODE5 - HDOT) / TGO$$

10. Compute the maximum value of the vertical component of thrust so that the commanded body pitch attitude does not exceed a specified value.

$$ELEV_MAX = THETA_MODE5_MAX - PITCH_CANT_ANGLE$$

$$IXC_COEF_MAX = \text{SIN}(ELEV_MAX)$$

11. Compute the coefficients of the desired thrust unit vector. The vertical component is limited to the maximum elevation angle previously computed, and the yaw component of thrust is computed to keep the sideslip angle near zero.

$$IXC_COEF = \text{MIN}(AX/EST_AT, IXC_COEF_MAX)$$

$$IYC_COEF = \text{SIN}(YAW_CANT_ANGLE)$$

$$IZC_COEF = \text{SQRT}(1. - IXC_COEF^2 - IYC_COEF^2)$$

12. Calculate the commanded thrust direction unit vector using the vector coefficients and LVLH unit vectors previously computed.

$$\bar{L}AMC = IXC_COEF \bar{I}XC + IYC_COEF \bar{I}YC + IZC_COEF \bar{I}ZC$$

13. Changes in the guidance commanded thrust direction are limited from cycle to cycle if they exceed a specified value. This keeps the changes in the guidance commanded thrust direction within the capabilities of the G/C Steer maneuver smoother.

Calculate the change in commanded thrust direction since the previous guidance cycle.

$$\bar{D}EL_LAMC = \bar{L}AMC - \bar{L}AMC_OLD$$

$$MAG_DEL_LAMC = \text{ABVAL}(\bar{D}EL_LAMC)$$

If the change in the commanded thrust direction is less than a specified value ($MAG_DEL_LAMC < DEL_LAMC_MODE5$), proceed to Step 14. Otherwise, the change in commanded thrust direction is limited and the commanded thrust direction is recomputed.

$$\bar{D}EL_LAMC = (DEL_LAMC_MODE5 / MAG_DEL_LAMC) \bar{D}EL_LAMC$$

$$\bar{L}AMC = \bar{L}AMC_OLD + \bar{D}EL_LAMC$$

$$\bar{L}AMC = \text{UNIT}(\bar{L}AMC)$$

14. Store the current value of the commanded thrust direction unit vector so that it may be used during the next guidance cycle.

$$\bar{L}AMC_OLD = \bar{L}AMC$$

15. If the time to go to MPS propellant depletion is less than an I-loaded value and manual throttling is not being performed, a special set of commands are issued to permit completion of the PPD at a safe throttle level.

If $TGO_EMPTY < TGO_CONT_THROT$, and $S_MAN_THROT = OFF$, perform the following. Otherwise, proceed to Step 16.

The throttle is commanded to a level that will permit a safe shutdown were a low-level cutoff to occur before MECO.

$$K_CMD = K_CONT_THROT$$

Set the time required to perform the pitchdown maneuver to a specified value.

$$DT_CONT_PITCH = DT_CONT_THROT$$

Command an immediate guidance fine countdown and set the GMT of powered pitchdown so that the PPD will begin at a specified time after fine countdown.

$$S_CONT_MECO = ON$$

$$TP = TGD + TGO_CONT_FCD$$

Set the contingency auto mode index to a value that supports the needs of the powered pitchdown at the reduced throttle setting.

$$AUTO_MODE = 53$$

Proceed to Step 17.

16. If the time remaining until pitchdown is less than a specified value, set the guidance fine countdown discrete. Also set the contingency auto mode index to a value that supports the needs of the Mode 5 powered pitchdown.

$$\text{If } TGO < TGO_PPD, \text{ set } S_CONT_MECO = ON, \text{ and } AUTO_MODE = 52$$

17. Compute the predicted mission elapsed time of MECO for display purposes.

$$TMET_MECO = TP + DT_CONT_PITCH - T_GMTLO$$

B. Interface Requirements. The input and output parameters for this task are given in Tables 4.9.7-1 and 4.9.7-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.9.7-1. Contingency Mode 5 Task Inputs				
Definition	Symbol	Source	Prec	Units
Compensated nav-derived angle of attack	ALPHA_N	A/E ATT PROC	SP	deg
Desired angle of attack at end of PPD	ALPHA_PPD	I-LOAD	SP	rad
Average pitch rate during Mode 5 powered pitchdown	AVE_PPD_RATE	I-LOAD	SP	deg/sec
Contingency ET separation -Z translation timer for Mode 5	CONT_MINUSZ_TIMER5	I-LOAD	SP	sec
Degrees per radian	DEG_PER_RAD	CONSTANT	SP	deg/ rad
Max change in commanded thrust vector direction in Mode 5	DEL_LAMC_MODE5	I-LOAD	SP	ND
Average mass loss due to single engine roll control OMS usage	DELTA_M_SEROLL	I-LOAD	SP	slugs
Range to the RTLS TRAJ MECO cutoff tic	DELTA_R	XXXXXX TRAJ DIP	SP	nm
Average change in range to MECO cutoff tic	DELTA_R_DOT	I-LOAD	SP	nm/ sec
Estimated duration of PPD for the reduced throttle Mode 5	DT_CONT_THROT	I-LOAD	SP	sec
Minimum duration of Mode 5 powered pitchdown	DT_PPD_MIN	I-LOAD	SP	sec
Maximum duration of Mode 5 powered pitchdown	DT_PPD_MAX	I-LOAD	SP	sec
Change in accumulated sensed velocity from previous cycle	\overline{DVS}	PFG INP TSK	SP	fps
Total vehicle thrust force	FT	THRST PARM TSK	SP	lbs
Thrust scaling factor	FT_FACTOR	ACC MASS UPD TSK, SSME-OUT SAF TSK	SP	ND
Gravitational acceleration	G_2_FPS2	CONSTANT	SP	ft/ sec ²
Estimated altitude rate	HDOT	RTLS UPP	SP	fps
Desired Mode 5 altitude rate	HDOT_TGT_MODE5	I-LOAD	SP	fps
Local vertical unit vector	\overline{IXC}	CONT LVLH TSK	SP	ND
Local plane unit vector	\overline{IYC}	CONT LVLH TSK	SP	ND
Local horizontal unit vector	\overline{IZC}	CONT LVLH TSK	SP	ND
Throttle setting for Mode 5 PPD if low-level shutdown is a potential	K_CONT_THROT	I-LOAD	I	pct
Current vehicle mass	M	ACC MASS UPD TSK	SP	slugs
Total vehicle mass flow rate	MDOT	THRST PARM TSK	SP	slg/ sec
Mass of orbiter and ET at RTLS MECO w/ all MPS depleted	M_EMPTY	I-LOAD, UPLINK	SP	slugs
Pitch cant angle between thrust vector and the orbiter X-Y plane	PITCH_CANT_ANGLE	AUTO CONT TSK	SP	rad

Table 4.9.7-1. Contingency Mode 5 Task Inputs				
Definition	Symbol	Source	Prec	Units
Manual throttling discrete	S _{MAN_THROT}	SBTC SOP	D	N/A
Current state vector time	TGD	PFM INP TSK	DP	sec
Time of lift-off in GMT	T_GMTLO	FCOS	DP	sec
Duration of fine countdown during Mode 5 reduced throttle cases	TGO_CONT_FCD	I-LOAD	SP	sec
Time to go to fuel depletion that results in a reduced throttle command	TGO_CONT_THROT	I-LOAD	SP	sec
TGO to initiate fine countdown	TGO_PPD	K-LOAD	SP	sec
Maximum body pitch angle during Mode 5	THETA_MODE5_MAX	I-LOAD	SP	rad
Yaw cant angle between the thrust vector and the orbiter X-Z plane	YAW_CANT_ANGLE	AUTO CONT TSK	SP	rad

Table 4.9.7-2. Contingency Mode 5 Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index sent to G/C Steer to control maneuver smoothing	AUTO_MODE	G/C STEER	I	N/A
Contingency ET separation open loop -Z translation timer	CONT_2EO_PR_DELAY	GRTLS DAP	SP	sec
Commanded SSME throttle setting	K_CMD	SSME SOP, SBTC SOP, TLM, RTLS TRAJ 2 DISP	I	pct
M50 desired thrust vector	L _{AMC}	G/C STEER, TLM	SP	ND
Contingency fine countdown discrete	S _{CONT_MECO}	MSC, PW CONT SEQ, RTLS UPP SEQ	D	N/A
Predicted SSME cutoff time in MET	TMET_MECO	RTLS TRAJ 2 DISP, TLM	SP	sec
Time to go	TGO	TLM	SP	sec
GMT time of powered pitchdown	TP	PW CONT SEQ, TLM	DP	sec
Right wing unit vector	Y _{SYM_GUID}	G/C STEER	SP	ND

4.9.8 Contingency PPD Task (CONT PPD TASK)

This task calculates guidance parameters necessary to perform a powered pitchdown maneuver for each of the powered auto contingency modes. It also commands maneuvers that may be necessary following completion of the $-Z$ translation after ET separation.

This task commands two types of maneuvers during powered pitchdown and after the $-Z$ translation. The first is a pitchdown maneuver to a desired angle of attack performed by constructing an M50-to-commanded body quaternion. This type of maneuver (performed when HIGH_RATE_SEP = OFF) is used during the pitchdown prior to ET separation for contingency modes 1, 4, and 5.

The second type of maneuver is a constant pitch rate command that does not require a quaternion construction. This type of maneuver is performed during the powered pitchdown phase of powered auto contingency modes 2 and 3 (i.e. when HIGH_RATE_SEP = ON). It is also used after completion of the $-Z$ translation for all of the powered auto contingency modes.

A. Detailed Requirements.

1. Set the powered pitchdown discrete ON to reconfigure the steering interface for powered pitchdown and for maneuvers after ET separation: $S_PPD_QUAT = ON$.

If ET separation has been commanded ($ET_SEP_CMD = ON$), proceed to Step 3.

If a contingency abort has been selected near RTLS VREL=0 ($SELECT_VREL0_CONT = ON$), set the desired powered pitch down rate for VREL=0 contingencies and exit this task:

IF ($SELECT_VREL0_CONT = ON$), perform the following:

$$QDESIRE_INIT = Q_MC_INIT_MODE3$$

$$IF (CONT_2EO_MODE = 2) QDESIRE_INIT = Q_MC_INIT_MODE2$$

$$WCB2 = QDESIRE_INIT$$

Exit this task.

If a high body rate at MECO and ET separation is required ($HIGH_RATE_SEP = ON$), set $WCB2 = CONT_HIGH_SEP_RATE$ and exit this task.

The pitchdown to the desired angle of attack is commanded by constructing the M50-to-commanded body quaternion in the following manner (the same as in the PPD Task, Section 4.6.5):

- (a) The quaternion Q_M50_VR is found by using the function RV_to_QLVLH. Define a coordinate system by setting the Z axis equal to the unit negative of the first input vector, the Y axis equal to the unit vector of the second input vector crossed into the first input vector, and the X axis equal to $Y \times Z$. The quaternion representing the transformation from this coordinate system, called the VR coordinate system, to the M50 coordinate system is computed as follows:

$$Q_M50_VR = RV_TO_QLVLH(V_RHO, -R_NAV)$$

- (b) Compute the rotation angle necessary to align the body X axis with the relative velocity vector as specified below:

$$\text{ALPHA_Q} = (\text{PI}/2 + \text{ALPHA_PPD}) / 2$$

- (c) Compute the rotation quaternion $Q_{CB_VR}^+$ from the VR to the commanded body system as follows. The scalar element is $\text{COS}(\text{ALPHA_Q})$. The vector elements are $(0, -\text{SIN}(\text{ALPHA_Q}), 0)$.
- (d) The M50-to-commanded body quaternion, $Q_{CB_M50}^+$, is then computed by forming the conjugate of the quaternion $Q_{M50_VR}^+$ and premultiplying it by the rotation quaternion $Q_{CB_VR}^+$ as given below:

$$Q_{CB_M50}^+ = \text{QUAT_MULT}(Q_{CB_VR}^+, Q_{VR_M50}^+)$$

2. Calculate a commanded body pitch rate equal to the time rate of change of the relative velocity vector by performing the following:

Calculate the current (new) relative flight path angle as given below:

Call the Contingency LVLH task (CONT LVLH TSK).

$$\text{RDOT} = V_{\text{RHO}} \cdot \bar{I}X_C$$

$$\text{FPANG_NEW} = \text{RDOT} / V_{\text{RHO_MAG}}$$

If this is the first time this step has been executed, set FPANG_OLD equal to FPANG_NEW .

Calculate the commanded body pitch rate as the time rate of change of the relative flight path angle:

$$\text{FPANG_DOT} = (\text{FPANG_NEW} - \text{FPANG_OLD}) / \text{DTGD}$$

$$\text{FPANG_OLD} = \text{FPANG_NEW}$$

$$\text{WCB2} = \text{FPANG_DOT DEG_PER_RAD}$$

Exit this task.

3. If the open-loop contingency -Z maneuver is still in progress ($\dot{\text{CONT_MINUS_Z_COMPL}} = \text{OFF}$), exit this task.

If $\dot{\text{HIGH_RATE_SEP}} = \text{ON}$, proceed to Step 4. Otherwise, perform the following:

Set the contingency auto mode index equal to the value appropriate for a pitch up from the ET separation attitude.

$$\text{AUTO_MODE} = 61$$

Set the commanded body pitch rate equal to the I-loaded value appropriate for the pitch up after ET separation.

WCB2 = CONT_LOW_SEP_RATE

Exit this task.

4. This step commands a pitch up maneuver after completion of the $-Z$ translation for high rate yaw steering cases. For all other high rate maneuver cases the commanded body pitch rate previously determined continues until the transition to major mode 602 occurs.

If $S_{\dot{C}ONT_YAW} = ON$, perform the following. Otherwise, exit this task.

WCB2 = $-$ CONT_HIGH_SEP_RATE

Set the contingency auto mode index equal to the value appropriate for this pitch up maneuver following completion of the $-Z$ translation during yaw steering cases.

AUTO_MODE = 62

B. Interface Requirements. The input and output parameters for the contingency powered pitchdown task are given in Tables 4.9.8-1 and 4.9.8-2.

C. Processing Requirements. None.

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

$S_{\dot{P}PD_QUAT} = OFF$ $WCB2 = 0.0$

E. Supplemental Information. The outputs $Q_{\dot{C}B_M50}$ and $S_{\dot{P}PD_QUAT}$ are a time-homogeneous set.

Table 4.9.8-1. Contingency Powered Pitchdown Task Inputs				
Definition	Symbol	Source	Prec	Units
Desired angle of attack at end of PPD	ALPHA_PPD	I-LOAD	SP	rad
Contingency high ET separation pitch rate	CONT_HIGH_SEP_RATE	I-LOAD	SP	deg/sec
Contingency low ET separation pitch rate	CONT_LOW_SEP_RATE	I-LOAD	SP	deg/sec
Contingency -Z maneuver complete discrete	CONT_MINUS_Z_COMPL	GRTLS DAP	D	N/A
Degrees per radian	DEG_PER_RAD	CONSTANT	SP	deg/rad
Difference between current and previous values of TGD	DTGD	PFG INP TSK	SP	sec
ET separation commanded discrete	ET_SEP_CMD	ET SEP SEQ	D	N/A
High rate ET separation flag	HIGH_RATE_SEP	AUTO CONT INIT TSK, CONT MODE2 TSK, CONT MODE3 TSK	D	N/A
Local vertical unit vector	$\bar{I}X_C$	CONT LVLH TSK	SP	ND
Ratio of circumference to diameter of a circle	PI	CONSTANT	DP	ND
Current Shuttle position vector in M50 coordinates	R_{NAV}	ASC UPP, RTLS UPP	DP	ft
Contingency yaw steering discrete	S_CONT_YAW	AUTO CONT TSK	D	N/A
Earth relative velocity vector in M50 coordinates	V_{RHO}	ASC UPP, RTLS UPP	SP	fps
Navigated earth-relative velocity magnitude	V_RHO_MAG	ASC UPP, RTLS UPP	SP	fps
Desired initial pitch rate for Mated Coast for contingency Mode 2	Q_MC_INIT_MODE2	I-LOAD	SP	deg/sec
Desired initial pitch rate for Mated Coast for contingency Mode 3	Q_MC_INIT_MODE3	I-LOAD	SP	deg/sec
Contingency 2 engine out mode index	CONT_2EO_MODE	CONT MODE SEL TSK	I	N/A
Flag indicating contingency armed near RTLS VREL=0	SELECT_VREL0_CONT	CONT MODE SEL TSK	D	N/A

Table 4.9.8-2.Contingency Powered Pitchdown Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index sent to G/C Steer to control maneuver smoothing	AUTO_MODE	G/C STEER	I	N/A
M50-to-commanded body quaternion	Q_{CB_M50}	G/C STEER	SP	ND
Discrete indicating powered pitchdown commands	S_{PPD_QUAT}	ASC DAP, TLM	D	N/A
Desired initial pitch rate for Mated Coast	QDESIRED_INIT	G/C STEER, CONT GUID C/O TSK	SP	deg/ sec
Commanded body pitch rate	WCB2	G/C STEER	SP	deg/ sec

4.9.9 Contingency Guidance Cutoff Task (CONT GUID C/O TSK)

This task sets the SSME cutoff timing request flag and the ET separation manual initiate discrete when the appropriate MECO conditions are reached for the given powered contingency abort mode.

A. Detailed Requirements.

1. If HIGH_RATE_SEP = ON, proceed to Step 2. Otherwise, perform the following:

If (a) and (b) below are both true, set T_MECO = TGD and proceed to Step 3. Otherwise, exit this task.

$$(a) \quad \text{ABS} (\text{ALPHA}_N - \text{ALPHA_PPD DEG_PER_RAD}) < \text{DALF_PPD}$$

$$(b) \quad \text{ABS} (\text{QORB}) < \text{QMECO_CONT_LOW}$$

2. Perform the following:

If (QORB < QMECO_CONT_HIGH and SELECT_VREL0_CONT = OFF), or (QORB - QDESIRED_INIT < QERR_CONT_MECO and SELECT_VREL0_CONT = ON), set T_MECO = TGD and proceed to Step 3. Otherwise, exit this task.

3. Command main engine cutoff by performing the following:

$$\text{S_TMECO} = \text{ON}$$

4. If guidance has selected a contingency abort near RTLS VREL=0 (SELECT_VREL0_CONT = ON), proceed to Step 5. Otherwise, set ET_SEP_MAN_INITIATE = ON to command fast ET separation and exit this task.
5. Set a flag to initiate RTLS VREL=0 post-MECO contingency mode (NEAR_VREL0_MODE), arm the post-MECO MPS settling burn, set the Mated Coast pitch rate change target, and set the minimum angle-of-attack and maximum dynamic pressure for ET separation.

$$\text{NEAR_VREL0_MODE} = \text{ON}$$

$$\text{ARM_CONT_MPS_SETTLING_BURN} = \text{ON}$$

IF CONT_2EO_MODE = 2, set

$$\text{DELTA_Q_RAMP} = \text{DELTA_Q_MC_MODE2}$$

$$\text{ALFA_SEP_MIN} = \text{ALFA_SEP_MIN_MODE2}$$

$$\text{QBAR_SEP_DESIRED} = \text{QBAR_SEP_MODE2}$$

Otherwise, set

$$\text{DELTA_Q_RAMP} = \text{DELTA_Q_MC_MODE3}$$

$$\text{ALFA_SEP_MIN} = \text{ALFA_SEP_MIN_MODE3}$$

$$\text{QBAR_SEP_DESIRED} = \text{QBAR_SEP_MODE3}$$

B. Interface Requirements. The input and output parameters for the contingency guidance cutoff task are given in Tables 4.9.9-1 and 4.9.9-2.

C. Processing Requirements. None.

D. Initialization Requirements. Upon transition to OPS 101, initialize NEAR_VRELO_MODE = OFF.

Table 4.9.9-1. Contingency Guidance Cutoff Task Inputs				
Definition	Symbol	Source	Prec	Units
Desired initial pitch rate for contingency Mated Coast	QDESIRED_INIT	CONT PPD TASK	SP	deg/sec
Contingency 2 engine out mode index	CONT_2EO_MODE	CONT MODE SEL TSK	I	N/A
Desired pitch rate change for Mode 2 Mated Coast	DELTA_Q_MC_MODE2	I-LOAD	SP	deg/sec
Desired pitch rate change for Mode 3 Mated Coast	DELTA_Q_MC_MODE3	I-LOAD	SP	deg/sec
Minimum angle-of-attack for Mode 2 ET Separation	ALFA_SEP_MIN_MODE2	I-LOAD	SP	deg
Minimum angle-of-attack for Mode 3 ET Separation	ALFA_SEP_MIN_MODE3	I-LOAD	SP	deg
ET Separation dynamic pressure target for contingency Mode 2	QBAR_SEP_MODE2	I-LOAD	SP	psf
ET Separation dynamic pressure target for contingency Mode 3	QBAR_SEP_MODE3	I-LOAD	SP	psf
Compensated nav-derived angle of attack	ALPHA_N	A/E ATT PROC	SP	deg
Desired angle of attack at end of PPD	ALPHA_PPD	I-LOAD	SP	rad
Delta angle of attack for MECO command	DALF_PPD	I-LOAD	SP	deg
Degrees per radian	DEG_PER_RAD	CONSTANT	SP	deg/rad
High rate ET separation discrete	HIGH_RATE_SEP	AUTO CONT INIT TSK, CONT MODE2 TSK, CONT MODE3 TSK	D	N/A
Pitch rate, orbiter rate gyro	QORB	SF (ORB RGA)	SP	deg/sec
Pitch rate for commanding MECO for contingency Modes 2 and 3	QMECO_CONT_HIGH	I-LOAD	SP	deg/sec
Pitch rate magnitude threshold at MECO for contingency Modes 1, 4, and 5	QMECO_CONT_LOW	I-LOAD	SP	deg/sec
Time associated with current state	TGD	PFG INP TSK	DP	sec
Flag indicating contingency armed near RTLS VREL = 0	SELECT_VRELO_CONT	CONT MODE SEL TSK	D	N/A
Pitch rate error for commanding MECO	QERR_CONT_MECO	I-LOAD	SP	deg/sec

Table 4.9.9-2. Contingency Guidance Cutoff Task Outputs				
Definition	Symbol	Destination	Prec	Units
ET separation manual initiate flag	ET_SEP_MAN_INITIATE	SSME OPS, ET SEP SEQ, CONT 3E/O GUID	D	N/A
SSME cutoff timing request flag	S_TMECO	PW CONT SEQ, SSME OPS	D	N/A
Desired SSME cutoff time	T_MECO	SSME OPS	DP	sec
Contingency MPS settling burn arm flag	ARM_CONT_MPS_SETTLING_BURN	ABT CNTL SEQ	D	N/A
Near VREL = 0 contingency flag	NEAR_VREL0_MODE	CONT 3E/O GUID, G/C STEER	D	N/A
Desired Mated Coast pitch rate change for a contingency near RTLS "VREL=0"	DELTA_Q_RAMP	CONT 3 E/O GUID	SP	deg/ sec
ET Separation dynamic pressure target for a contingency near RTLS "VREL=0"	QBAR_SEP_DESIRE	CONT 3 E/O GUID	SP	psf
Minimum angle-of-attack for ET Separation near RTLS "VREL=0"	ALFA_SEP_MIN	CONT 3 E/O GUID	SP	deg

4.9.10 Auto Contingency Initialization Task (AUTO CONT INIT TSK)

This task performs initialization functions for auto contingency aborts. It is executed at the beginning of an auto contingency abort maneuver and is executed only once.

A. Detailed Requirements.

1. If manual throttling has not been initiated ($S_{\dot{M}AN_THROT} = OFF$), set the commanded SSME throttle setting equal to the current maximum throttle level.

$$K_CMD = KMAX$$

2. Call the Contingency LVLH task (CONT LVLH TSK) to construct a set of coordinate system unit vectors to be used by other auto contingency mode tasks.
3. Perform the following:

Set the M50 desired thrust turning rate vector equal to zero. This vector is sent to G/C Steer and, when zeroed, indicates that the commanded thrust direction will be identical to the M50 desired thrust vector $\overline{L}AMC$.

$$\overline{L}AMDC = 0$$

Set the guidance ready flag on ($S_{\dot{G}DRDY} = ON$) to insure that G/C Steer is ready to receive thrust vector steering commands.

Set $S_{\dot{U}NCONV} = OFF$ to insure that the ADI error needles are not stowed during the auto contingency abort maneuvers. The needles assist the crew in monitoring the performance of the auto contingency maneuvers.

4. Perform the following:

Set the predicted GMT time of powered pitchdown to a large initial value. It will be accurately set in the appropriate contingency mode task later in the maneuver.

$$TP = TGD + 1000$$

5. During powered contingency abort maneuvers a displayed mission elapsed time of MECO is not of value and is not easily calculated (excepting RTLS single engine completion cases). For all cases except Mode 5 contingency aborts, MECO will occur as the sequence of maneuvers (different for each mode) completes. A discrete shall be sent to the XXXXXX TRAJ 2 and RTLS TRAJ 2 displays indicating that the MET of MECO is to be blanked.

If $GUID_2EO_MODE \neq 5$, set $S_{\dot{B}LANK_TMECO} = ON$ and exit this task. Otherwise, perform the following:

RTLS single engine completion scenarios may approach MPS propellant depletion by the time of main engine cutoff. The MPS low-level sensors are activated for these cases by sending a signal to the SSME operations principal function.

$$S_{\dot{L}OW_LEVEL} = ON$$

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B. Interface Requirements. The input and output parameters for this task are given in Tables 4.9.10–1 and 4.9.10–2.

C. Processing Requirements. None

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

Set the contingency fine countdown flag OFF. It will be set ON by the individual contingency mode tasks.

$$S_{\dot{C}ONT_MECO} = OFF$$

Set the fine countdown indicator OFF. It will be set ON by PW CONT SEQ when fine countdown is commanded.

$$S_{\dot{F}CD} = OFF$$

Set the contingency auto mode index to zero. It will be set to other values appropriate to the auto contingency maneuvers in the individual contingency mode tasks. This index is sent to G/C Steer for maneuver smoothing and control.

$$AUTO_MODE = 0$$

Set the contingency roll heads up flag and the contingency roll inhibit flag OFF. These discrettes are passed to G/C Steer and will be set ON, where appropriate, by the individual contingency mode tasks.

$$S_{\dot{C}ONT_ROLL} = OFF$$

$$S_{\dot{C}ONT_ROLL_INHIB} = OFF$$

Set the discrete to blank the TMECO field on the XXXXXX TRAJ 2 and RTLS TRAJ 2 displays OFF.

$$S_{\dot{B}LANK_TMECO} = OFF$$

Set the high rate ET separation discrete OFF. If a high rate ET separation is required, this discrete will be set on by the individual contingency mode tasks.

$$H\dot{I}GH_RATE_SEP = OFF$$

Initialize $S_{\dot{M}ECO}$, the fine countdown discrete, and $S_{\dot{T}MECO}$, the cut-off timing request flag, to OFF.

Table 4.9.10-1. Auto Contingency Initialization Task Inputs				
Definition	Symbol	Source	Prec	Units
Guidance 2 engine out mode index	GUID_2EO_MODE	AUTO CONT TSK	I	N/A
Maximum throttle setting of SSME	KMAX	I-LOAD, 1STG GUID INP TSK, ASC GUID TSK, FUL DISS TSK, FLYBK TSK, SSME-OUT SAF TSK	I	pct
Manual throttle discrete	S _{MAN} _THROT	SBTC SOP	D	N/A
Current guidance state vector time	TGD	PFG INP TSK	DP	sec

Table 4.9.10-2. Auto Contingency Initialization Task Outputs				
Definition	Symbol	Destination	Prec	Units
Contingency auto mode index	AUTO_MODE	G/C STEER	I	N/A
High rate ET separation flag	HIGH_RATE_SEP	CONT PPD TSK, CONT GUID C/O TSK, G/C STEER	D	N/A
Commanded SSME throttle setting	K_CMD	SSME SOP, THRST PRM TSK, SBTC SOP, TLM, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	I	pct
M50 desired thrust turning rate vector	L _{AMDC}	G/C STEER, TLM	SP	sec ⁻¹
Blank TMECO field discrete	S _{BLANK} _TMECO	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	D	N/A
Contingency fine countdown discrete	S _{CONT} _MECO	MSC, PW CONT SEQ, ASC UPP SEQ, RTLS UPP SEQ	D	N/A
Contingency roll heads up flag	S _{CONT} _ROLL	G/C STEER	D	N/A
Contingency roll heads up inhibit flag	S _{CONT} _ROLL_INHIB	G/C STEER	D	N/A
Fine countdown indicator	S _{FCD}	XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP	D	N/A
Discrete to activate MPS low-level sensors	S _{LOW} _LEVEL	SSME OPS, TLM	D	N/A
Guidance ready flag	S _{GDRDY}	MSC	D	N/A
Guidance convergence status indicator	S _{UNCONV}	ASC ADI PROC	D	N/A
GMT time of powered pitchdown	TP	PW CONT SEQ, TLM	DP	sec

4.9.11 Contingency LVLH Task (CONT LVLH TSK)

This task constructs a local vertical, local horizontal coordinate system for use in other powered flight contingency tasks. In most cases, the current position vector ($\overline{R_NAV}$) and relative velocity vector ($\overline{V_RHO}$) are used in constructing the reference axes. In certain RTLS cases the current sensed delta velocity vector (\overline{DVS}) is used instead of $\overline{V_RHO}$.

A. Detailed Requirements.

1. The vertical direction unit vector is calculated.

$$\overline{IXC} = \text{UNIT}(\overline{R_NAV})$$

2. The out-of-plane unit vector is constructed, in most cases, by taking the vector cross product of the relative velocity vector and the vertical direction unit vector. During RTLS cases where the auto contingency is initiated near $VREL = 0$ the out-of-plane unit vector is constructed using the current delta velocity vector \overline{DVS} rather than $\overline{V_RHO}$. This is because near $VREL = 0$. \overline{IXC} and $\overline{V_RHO}$ are nearly 180 degrees apart and should not be used in a cross product.

If $SMODE = 1$, set $\overline{IYC} = \text{UNIT}(\overline{V_RHO} \times \overline{IXC})$ and proceed to Step 3.

Otherwise, if $\text{ABS}(\overline{V_HORIZ_DNRNG}) > \overline{V_HORIZ_DVS}$, set $\overline{IYC} = \text{UNIT}(\overline{V_RHO} \times \overline{IXC})$ and proceed to Step 3. Otherwise, set $\overline{IYC} = \text{UNIT}(\overline{DVS} \times \overline{IXC})$

3. Complete the reference axes:

$$\overline{IZC} = \overline{IXC} \times \overline{IYC}$$

4. During RTLS contingency aborts a check is made of the relative horizontal downrange velocity to insure the \overline{IYC} and \overline{IZC} unit vectors are consistent with the desired auto contingency mode when the vehicle is near the Mode 2 / Mode 3 boundary.

If $SMODE = 5$ and { (a) or (b) } are true below, perform (c).

(a) $\overline{V_HORIZ_2EO} > \overline{V_HORIZ_DNRNG} > \overline{V_HORIZ_DVS}$

(b) $\overline{V_HORIZ_DVS} > \overline{V_HORIZ_DNRNG} > \overline{V_HORIZ_2EO}$

(c) $\overline{IYC} = -\overline{IYC}$

$$\overline{IZC} = -\overline{IZC}$$

The situation when (a) is true is when a Mode 3 maneuver is desired but the $\overline{V_RHO}$ vector is used in the construction of the contingency LVLH unit vectors. For such a case \overline{IZC} as originally constructed would point downrange but the desired direction of the Mode 3 maneuver is uprange. Likewise, \overline{IYC} as originally constructed would point the right wing in a direction to cause a heads down orientation if headed uprange, but the desired orientation is heads up during Mode 3.

The situation when (b) is true is when a Mode 2 maneuver is desired but the \overline{DVS} vector is used in the construction of the contingency LVLH unit vectors. This also results in incorrect directions for \overline{IYC} and \overline{IZC} .

- B. Interface Requirements. The input and output parameters for the contingency LVLH task are given in Tables 4.9.11-1 and 4.9.11-2.
- C. Processing Requirements. None.
- D. Initialization Requirements. None.
- E. Supplemental Information. None.

Table 4.9.11-1. Contingency LVLH Task Inputs				
Definition	Symbol	Source	Prec	Units
Change in accumulated sensed velocity from previous cycle	\overline{DVS}	PFG INP TSK	SP	fps
Current shuttle position vector in M50 coordinates	$R_{\overline{NAV}}$	ASC UPP, RTLS UPP	DP	ft
PEG maneuver mode flag	SMODE	ASC GUID TSK, RTLS INIT TSK	I	N/A
Downrange horizontal earth relative velocity	V_HORIZ_DNRNG	RTLS UPP	SP	fps
Horizontal relative velocity below which sensed delta-V is used in forming the reference axes	V_HORIZ_DVS	I-LOAD	SP	fps
Horizontal velocity boundary between Mode 2 and Mode 3 for RTLS 2 engine out contingency mode recommendation	V_HORIZ_2EO	I-LOAD	SP	fps
Earth-relative velocity vector in M50 system	$V_{\overline{RHO}}$	ASC UPP, RTLS UPP	SP	fps

Table 4.9.11-2. Contingency LVLH Task Outputs				
Definition	Symbol	Destination	Prec	Units
Local vertical unit vector	\overline{IXC}	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK, CONT PPD TSK	SP	ND
Local out-of-plane unit vector	\overline{IYC}	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK	SP	ND
Local downrange unit vector	\overline{IZC}	CONT MODE1 TSK, CONT MODE2 TSK, CONT MODE3 TSK, CONT MODE5 TSK	SP	ND

4.9.12 Parameter Tables for Powered Contingency Guidance

The IDD inputs and outputs are listed in Tables 4.9.12-1 and Table 4.9.12-2 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 4.9.12-3. K-loads are listed in Table 4.9.12-4. Constants are listed in Table 4.9.12-5. The input variable cross-references are listed in Table 4.9.12-0.

Table 4.9.12-0. Powered Contingency Input Variable Cross-Reference		
MSID	Local Name	Source Name
V95H0185CA, 6CA, 7CA, 5CB, 6CB, 7CB	$R_{\bar{N}AV}$	R_AVGG
V95W0200CC, CD	T_NAV	T_STATE
V95L0151CA, CE	V_RHO_MAG	REL_VEL_MAG
V95L0210CA, 1CA, 2CA, 0CB, 1CB, 2CB	$V_{\bar{S}}$	V_IMU_OLD
V95U0507C, 8C, 9C	$R_{\bar{L}S_M50}$	R_M50_AT_LIFTOFF
V95X1207X	$S_{\dot{E}O_E1}$	ME1_FAIL_SHUTDOWN
V95X1208X	$S_{\dot{E}O_E2}$	ME2_FAIL_SHUTDOWN
V95X1209X	$S_{\dot{E}O_E3}$	ME3_FAIL_SHUTDOWN
V90X8156X	$MM_{\dot{1}03}$	MM_CODE_103
V90X8194X	$MM_{\dot{6}01}$	MM_CODE_601
V90U1949CA, 50CA, 51CA, 52CA, 49CB, 50CB, 51CB, 52CB	$Q_{\dot{G}CB}$	Q_CB_M50
V95L0190CA, 1CA, 2CA, 0CB, 1CB, 2CB	$V_{\bar{N}AV}$	V_AVGG
V95L0510CA	VI_MAG	V_INERTIAL_MAG

TABLE 4.9.12-1. INPUT FUNCTIONAL PARAMETERS FOR POWERED CONTINGENCY GUIDANCE (G4.5)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ABT_THROT_CMD	V93X0994X	ABORT THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
ALPHA_N	V90H2246C	NAV DERIVED ANGLE OF ATTACK	A/E ATT PROC	DEG	SPL		93017G	*
CONT_2EO_ARM	V93X6680XA	CONTINGENCY 2-ENG OUT ARM FLAG	XXXXXX TRAJ 1 DISP		BD		93017G	*
CONT_2EO_ARM	V93X6680XC	CONTINGENCY 2-ENG OUT ARM FLAG	XXXXXX TRAJ 2 DISP		BD		93017G	*
CONT_2EO_ARM	V93X6680XD	CONTINGENCY 2-ENG OUT ARM FLAG	RTLS TRAJ 2 DISP		BD		93017G	*
CONT_2EO_START	V93X6681XA	CONTINGENCY 2-ENG OUT START FLAG	XXXXXX TRAJ 1 DISP		BD		93017G	*
CONT_2EO_START	V93X6681XC	CONTINGENCY 2-ENG OUT START FLAG	XXXXXX TRAJ 2 DISP		BD		93017G	*
CONT_2EO_START	V93X6681XD	CONTINGENCY 2-ENG OUT START FLAG	RTLS TRAJ 2 DISP		BD		93017G	*
CONT_MINUS_Z_COMPL	V90X7002X	CONTINGENCY MINUS Z COMPLETE FLAG	GRTLS DAP		BD		90705H	
CONT_YAW_ENA	V93X6600X	CONTINGENCY YAW ENABLE FLAG	XXXXXX TRAJ 1 DISP		BD		93017G	*
CONT_YAW_ENA	V93X6600XA	CONTINGENCY YAW ENABLE FLAG	XXXXXX TRAJ 2 DISP		BD		93017G	*
CONT_YAW_ENA	V93X6600XB	CONTINGENCY YAW ENABLE FLAG	RTLS TRAJ 2 DISP		BD		93017G	*
DELTA_R	V90H6981C	RANGE TO RTLS MECO TARGET LINE	XXXXXX TRAJ DIP	NM			90705H	
EAS	V95L0514CA	EQUIVALENT AIRSPEED	ASC UPP	FT/S			89990E	
EAS	V95L0514CB	EQUIVALENT AIRSPEED	RTLS UPP				93017G	*
ECBDB(1)	V95H3550C	ROLL ATT ERR(CMD-TO-DESIRED)	G/C STEER	DEG			89990E	
ET_SEP_CMD	V90X8250X	ET SEPARATION CMD FLAG	ET SEP SEQ		BD		93017G	*
FT_FACTOR	V90U1979CB	THRUST SCALING FACTOR	PW RTLS GUID				93017G	*
H_DOT_ELLIPSOID/H_DOT	V95L0265CA	EST ALTITUDE RATE	RTLS UPP	FT/S	SPL		93017G	*
H_DOT_ELLIPSOID/H_DOT	V95L0265CE	EST ALTITUDE RATE	ASC UPP	FT/S			93012D	
KMAX	V97U4424CA	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 1STG GUID	PCT			90608D	
KMAX	V97U4424CB	MAXIMUM THROTTLE SETTING OF SSME'S	ASC 2STG GUID	PCT			90608D	
KMAX	V97U4424CC	MAXIMUM THROTTLE SETTING OF SSME'S	PW RTLS GUID	PCT			90608D	
K_CMD	V90U1948CE	COMMANDED SSME THROTTLE SETTING	SBTC SOP	PCT			93012D	
M/CURR_ORB_MASS/WEIGHT	V90U1961CF	CURRENT VEHICLE MASS	ASC 1STG GUID	SLUGS			93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CG	CURRENT VEHICLE MASS	ASC 2STG GUID	SLUGS			93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CH	CURRENT VEHICLE MASS	PW RTLS GUID	SLUGS			93017G	*
MAX_THROT_CMD	V93X5349X	MAXIMUM THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		89990E	
ME1_FAIL_SHUTDOWN	V95X1207X	MPS E1 FAIL FLAG	SSME OPS		BD		93017G	*
ME2_FAIL_SHUTDOWN	V95X1208X	MPS E2 FAIL FLAG	SSME OPS		BD		93017G	*
ME3_FAIL_SHUTDOWN	V95X1209X	MPS E3 FAIL FLAG	SSME OPS		BD		93017G	*
MECO_CONFIRMED	V90X8561X	MECO CONFIRMED FLAG	SSME OPS		BD		93017G	*
MM_CODE_103/MM_103	V90X8156X	MAJOR MODE 103 FLAG	MSC				93012D	
MM_CODE_601/MM_601	V90X8194X	MAJOR MODE 601 FLAG	MSC		BD		93012D	
M_EMPTY	V97U8376C	CONT ORBITER/ET DEPLETION MASS	UL	SLUG			92392C	
NOM_THROT_CMD	V93X0995X	NOMINAL THROTTLE LEVEL COMMAND	OVERRIDE DISP		BD		92232B	
N_SSME	V90U1962CA	NUMBER OF ACTIVE SSME'S	ASC 1STG GUID				93017G	*
Q_ORB/Q	V90R5321CA	SELECTED RGA PITCH RATE	SF	DEG/S			93017G	*
REL_VEL_MAG	V95L0151CA	GND REL VEL MAGNITUDE IN M50 SYS	RTLS UPP	FT/S	SPL		93017G	*
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S			93017G	*
R_AVGG(1)	V95H0185CA	X-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(1)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CA	Y-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CA	Z-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*

TABLE 4.9.12-1. INPUT FUNCTIONAL PARAMETERS FOR POWERED CONTINGENCY GUIDANCE (G4.5)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
R_M50_AT_LIFTOFF(1)	V95U0507C	X-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(2)	V95U0508C	Y-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(3)	V95U0509C	Z-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
SMODE	V94J3779CA	GUIDANCE MODE INDICATOR	ASC 2STG GUID		HXS		93012D	
SMODE	V94J3779CB	GUIDANCE MODE INDICATOR	PW RTLS GUID		HXS		93012D	
S_MAN_THROT	V96X0006X	MANUAL THROTTLE DISCRETE	SBTC SOP		BD		93017G	*
S_MECO	V90X1963XA	FINE COUNT DOWN DISCRETE	PW RTLS GUID				93017G	*
S_OMS_CUTOFF	V90X8318XA	OMS CUTOFF CMD	ABT CNTL SEQ				93064D	
S_OMS_IGN	V90X8319X	ABORT OMS IGNITION CMD	ABT CNTL SEQ				89990E	
S_RCS_IGN	V90X8314X	ABORT RCS +X ON CMD	ABT CNTL SEQ		BD		93017G	*
S_RCS_NULL20	V90X8317X	20 RCS NULL JETS ON CMD	ABT CNTL SEQ		BD		93017G	*
S_RTLS_TURN	V90X2089X	DSCR IND START OF TURN AROUND	PW RTLS GUID		BD		93017G	*
S_TDF	V90X8914X	THRST DIR FLTR READY FLAG	G/C STEER		BD		89990E	
S_TMECO	V90X1944XB	SSME C/O TIMING REQUEST FLAG	PW RTLS GUID				89990E	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_NAV_PREV	V90W0151C	PREVIOUS VALUE OF T_STATE	ASC 1STG GUID	S	DPL		90608D	
T_STATE	V95W0200CC	TIME TAG ASSOC WITH CURRENT STATE	RTLS UPP	S			93017G	*
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
UFE(2)	V95H3551C	Y-COMP ESTMTD FLTRD THRST DIR	G/C STEER				89990E	
UFE(3)	V95H3552C	Z-COMP ESTMTD FLTRD THRST DIR	G/C STEER				89990E	
V_AVGG(1)	V95L0190CA	X-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CA	Y-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CA	Z-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_HORIZ_DNRNG	V90L0474C	DOWNRANGE HORIZ EARTH REL VEL	RTLS UPP	FT/S			90705H	
V_IMU_OLD(1)	V95L0210CA	X-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_IMU_OLD(1)	V95L0210CB	X-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CA	Y-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_IMU_OLD(2)	V95L0211CB	Y-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CA	Z-COMP OF CURRENT ACCUM IMU VEL	RTLS UPP	FT/S			89990E	
V_IMU_OLD(3)	V95L0212CB	Z-COMP OF CURRENT ACCUM IMU VEL	ASC UPP	FT/S			89990E	
V_INERTIAL_MAG	V95L0510CA	MAG OF VEHICLE INERTIAL VELOCITY	ASC UPP	FT/S			93090E	
V_RHO(1)	V95L0215CA	X-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(1)	V95L0215CE	X-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(2)	V95L0216CA	Y-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(2)	V95L0216CE	Y-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(3)	V95L0217CA	Z-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(3)	V95L0217CE	Z-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	

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

TABLE 4.9.12-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED CONTINGENCY GUIDANCE (G4.5)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALFA_SEP_MIN	V90H3297C	MINIMUM ANGLE-OF-ATTACK FOR ET SEP	CONT 3E/O GUID	DEG	SPL		92504G	
ARM_CONT_MPS_SETTLING_BURN	V90X3234X	CONT MPS SETTling BURN ARM FLAG	ABT CNTL SEQ		BD		92504G	
AUTO_MODE	V94J1401C	CONTINGENCY AUTO MODE INDEX	G/C STEER				89990E	
CONT_2EO_ARM	V93X6680XB	CONTINGENCY 2-ENG OUT ARM FLAG	DL FMT 21/1 RTLS TRAJ 2 DISP XXXXXX TRAJ 2 DISP		BD		93017G	*
CONT_2EO_MODE	V90J2077C	CONTINGENCY 2-ENG OUT MODE INDEX	ABT CNTL SEQ ASC 2STG GUID ASC DAP CONT 3E/O GUID DL FMT 21/1 RTLS TRAJ 2 DISP XXXXXX TRAJ 1 DISP XXXXXX TRAJ 2 DISP		HXS		93017G	*
CONT_2EO_PR_DELAY	V90W6985C	MINUS Z CONT BURN TIMER	GRTLS DAP	S	SPL		90705H	
CONT_2EO_START	V93X6681XB	CONTINGENCY 2-ENG OUT START FLAG	A/E ATT PROC ASC BRG DISP ASC BRG SPEC GRTLS DAP HORIZ SIT DISP HORIZ SIT SPEC MSC RTLS TRAJ 2 DISP XXXXXX TRAJ 2 DISP		BD		93090E	
CONT_3EO_MODE	V90J2088C	CONTINGENCY 3-ENG OUT MODE INDEX	DL FMT 21/1 MSC RTLS TRAJ 2 DISP XXXXXX TRAJ 1 DISP XXXXXX TRAJ 2 DISP		HXS		93017G	*
CONT_GUID_YAW	V90X8917X	CONTINGENCY GUIDANCE YAW FLAG	DL FMT 21/1		BD		93017G	*
CONT_MECO_PREP_FLAG	V90X8480X	CONTINGENCY MECO PREP DISCRETE	ABT CNTL SEQ				90243C	
DELTA_Q_RAMP	V90R3295C	DESIRED MC PITCH RATE CHANGE	CONT 3E/O GUID	DEG/S	SPL		92504G	
ET_SEP_MAN_INITIATE	V90X8584XB	ET SEP MAN INITIATE FLAG	CONT 3E/O GUID ET SEP SEQ SSME OPS		BD		90964	
FT_FACTOR	V90U1979CC	THRUST SCALING FACTOR	DL FMT 21/1				93017G	*
FT_S	V90U8120CF	ESTIMATED TOTAL THRUST	DL FMT 21/1	LBF	SPL		93017G	*

TABLE 4.9.12-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED CONTINGENCY GUIDANCE (G4.5)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
GLIDE_RTLS_INHIBIT	V90X2090XC	RTLS CONTINGENCY FLAG	ADTA SOP ASC RCS CMD SOP DL FMT 21/1 ENT BRG SPEC GRTLS DAP GRTLS TAEM GUID MEDS FC GNC XFER MPS DUMP MSC VERT SIT1 DISP		BD		93017G	*
HIGH_RATE_SEP	V90X6989X	HIGH RATE ET SEPARATION FLAG	CONT 3E/O GUID G/C STEER		BD		90705H	
KMAX	V97U4424CD	MAXIMUM THROTTLE SETTING OF SSME'S	SBTC SOP	PCT			90608D	
K_CMD	V90U1948CF	COMMANDED SSME THROTTLE SETTING	DL FMT 21/A RTLS TRAJ 2 DISP SBTC SOP SSME SOP XXXXXX TRAJ 2 DISP	PCT			93017G	*
LAMC(X)	V90U1954CF	X-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMC(Y)	V90U1955CF	Y-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMC(Z)	V90U1956CF	Z-COMP OF M50 REF THR VECTOR	DL FMT 21/1 G/C STEER				93017G	*
LAMDC(X)	V90U1957CE	X-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
LAMDC(Y)	V90U1958CE	Y-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
LAMDC(Z)	V90U1959CE	Z-M50 DESIRED THR TRNING RATE VCTR	DL FMT 21/1 G/C STEER	RAD/S			93017G	*
M/CURR_ORB_MASS/WEIGHT	V90U1961CL	CURRENT VEHICLE MASS	ASC DAP DL FMT 21/1 G/C STEER XXXXXX TRAJ DIP	SLUGS			93017G	*
MATED_CG_TRIM	V90X3120X	MATED COAST C.G. TRIM	OMS TVC CMD SOP		BD		92504G	
MDOT	V90R1993CC	TOTAL VEHICLE MASS FLOW RATE	ASC DAP TLM	SLUGS/S			89990E	
NEAR_VREL0_MODE	V90X3238X	NEAR RTLS VREL=0 CONTINGENCY FLAG	CONT 3E/O GUID G/C STEER		BD		92504G	
N_OMS	V90J2031CE	NUMBER OF ACTIVE OMS ENGINES	TLM				89990E	
N_RCS	V90J1974CD	NUMBER OF ACTIVE RCS ENGINES	TLM				89990E	
N_RCS_NULL	V90J1975CD	NUMBER OF ACTIVE RCS NULL ENGINES	TLM				89990E	
N_SSME	V90U1962CC	NUMBER OF ACTIVE SSME'S	DL FMT 21/1				93017G	*
QBAR_SEP_DESIRED	V90P3296C	DESIRED ET SEP DYNAMIC PRESSURE	CONT 3E/O GUID	LBF/FT2	SPL		92504G	
QDESIRED_INIT	V90R3294C	DESIRED INITIAL MC PITCH RATE	G/C STEER	DEG/S	SPL		92504G	
Q_CB_M50(1)/Q_GCB_1	V90U1949CC	M50-TO-CMD BODY QUATERNION ELE 1	G/C STEER				89990E	

TABLE 4.9.12-2. OUTPUT FUNCTIONAL PARAMETERS FROM POWERED CONTINGENCY GUIDANCE (G4.5)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
Q_CB_M50(2)/Q_GCB_2	V90U1950CC	M50-TO-CMD BODY QUATERNION ELE 2	G/C STEER				89990E	
Q_CB_M50(3)/Q_GCB_3	V90U1951CC	M50-TO-CMD BODY QUATERNION ELE 3	G/C STEER				89990E	
Q_CB_M50(4)/Q_GCB_4	V90U1952CC	M50-TO-CMD BODY QUATERNION ELE 4	G/C STEER				89990E	
SELECT_VRELO_CONT	V90X3299X	CONTINGENCY VREL = 0 SELECT FLAG	G/C STEER		BD		92504G	
S_BLANK_TMECO	V90X7001X	BLANK TMECO FIELD FLAG	RTLS TRAJ 2 DISP XXXXXX TRAJ 2 DISP		BD		93012D	
S_COMB_MNVR	V90X8905X	COMBINED MANEUVER DISCRETE	DL FMT 21/1		BD		93017G	*
S_CONT_MECO	V90X6988X	CONTINGENCY FINE COUNTDOWN DSCR	ASC UPP SEQ MSC RTLS UPP SEQ				89990E	
S_CONT_ROLL	V90X8915X	CONTINGENCY ROLL HEADS UP FLAG	G/C STEER				89990E	
S_CONT_ROLL_INHIB	V90X8916X	CONTINGENCY ROLL INHIBIT FLAG	G/C STEER				89990E	
S_CONT_YAW	V99X6557X	CONTINGENCY YAW STEERING DISCRETE	GRTLS TAEM GUID		BD		90724D	
S_FCD	V90X2086XB	FINE COUNTDOWN IND	RTLS TRAJ 2 DISP XXXXXX TRAJ 2 DISP		BD		93012D	
S_GDRDY	V90X1965XC	GUIDANCE READY FLAG	MSC				90646C	
S_LOW_LEVEL	V90X1942XC	ET LEVEL SENSOR ARM CMD	DL FMT 21/A SSME OPS				93017G	*
S_PPD_QUAT	V90X2087XB	DISCRETE INDICATING PPD CMDS	ASC DAP DL FMT 21/A		BD		93017G	*
S_TMECO	V90X1944XC	SSME C/O TIMING REQUEST FLAG	SSME OPS				89990E	
S_UNCONV	V90X2084XC	PEG UNCONVERGED DSCR IND	ASC ADI PROC		BD		90964	
TGD	V90W1994CA	GUIDANCE TIME TAG	DL FMT 21/1	S			93017G	*
TGO	V90W1941CE	TIME TO GO TO VELOCITY CUTOFF	DL FMT 21/A	S			93017G	*
TMET_MECO	V90W1970CC	PREDICTED SSME C/O TIME IN MET	DL FMT 21/1 RTLS TRAJ 2 DISP	S			93017G	*
TP	V90W1946CD	PREDICTED TIME OF THRUST C/O	DL FMT 21/1	S			93017G	*
T_MECO	V90W1945CC	DESIRED SSME C/O TIME	SSME OPS	S			89990E	
WCB2	V90R6980C	COMMANDED BODY PITCH RATE	G/C STEER	DEG/S			89990E	
Y_SYM_GUID(X)	V90U8918B	X-M50 RIGHT WING UNIT VECTOR	G/C STEER				89990E	
Y_SYM_GUID(Y)	V90U8919B	Y-M50 RIGHT WING UNIT VECTOR	G/C STEER				89990E	
Y_SYM_GUID(Z)	V90U8920B	Z-M50 RIGHT WING UNIT VECTOR	G/C STEER				89990E	
	V90M2963PB	CGEB_MCI_LG1_FLAG1_MFE	DL FMT 21/A				93017G	*
	V90M2965PB	CGGB_CGG_C01_FLAG_HALFWORD_2	DL FMT 21/A				93017G	*
	V99M1855PB	CONT MNVR DISCRETES	DL FMT 21/1				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 4.9.12-3. POWERED CONTINGENCY GUIDANCE (G4.5) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALFA_SEP_MIN_MODE2	V97U6291C	DEG	F	S	D	P	G4.5	00	ACG	92504G	
ALFA_SEP_MIN_MODE3	V97U6292C	DEG	F	S	D	P	G4.5	00	ACG	92504G	
ALPHA_PPD	V97U4310C	RAD	F	S	D	P	G4.5	00	ZF1	93087E	
							G4.6				
AVE_PPD_RATE	V97U8322C	DEG/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
CONT_GUID_YAW	V97U8208C	ND	D		M	P	G4.5	00	ACG	DC2248	
CONT_HIGH_SEP_RATE	V97U8434C	DEG/SEC	F	S	D	P	G4.175	00	ACG	92504G	
							G4.5				
							G4.6				
CONT_LOW_SEP_RATE	V97U8435C	DEG/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
CONT_MINUSZ_TIMER1	V97U8209C	SEC	F	S	D	P	G4.5	00	ACS	DC2067	
CONT_MINUSZ_TIMER2	V97U8210C	SEC	F	S	D	P	G4.5	00	ACS	DC2067	
CONT_MINUSZ_TIMER3	V97U8211C	SEC	F	S	D	P	G4.5	00	ACS	DC2067	
CONT_MINUSZ_TIMER4	V97U8212C	SEC	F	S	D	P	G4.5	00	ACS	DC2067	
CONT_MINUSZ_TIMER5	V97U8213C	SEC	F	S	D	P	G4.5	00	ACS	DC2067	
CONT_ROLL_ERR	V97U8323C	DEG	F	S	D	P	G4.5	00	ACG	DC2248	
COS_ANG_PITCH_DELAY	V97U8324C	ND	F	S	D	P	G4.5	00	ACG	DC2248	
COS_ANG_ROLL_DELAY	V97U8325C	ND	F	S	D	P	G4.5	00	ACG	DC2248	
DALF_PPD	V97U8346C	DEG	F	S	D	P	G4.5	00	ACG	DC2248	
DELTA_M_SEROLL	V97U8348C	SLUGS	F	S	D	P	G4.5	00	ACG	DC2248	
DELTA_Q_MC_MODE2	V97U6288C	DEG/SEC	F	S	D	P	G4.5	00	ACG	92504G	
DELTA_Q_MC_MODE3	V97U6289C	DEG/SEC	F	S	D	P	G4.5	00	ACG	92504G	
DELTA_R_DOT	V97U8349C	NMI/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
DEL_LAMC_MODE5	V97U8347C	ND	F	S	D	P	G4.5	00	ACG	DC2248	
DT_CONT_THROT	V97U8350C	SEC	F	S	D	P	G4.5	00	ACG	DC2248	
DT_PPD_MAX	V97U8352C	SEC	F	S	D	P	G4.5	00	ACG	DC2248	
DT_PPD_MIN	V97U8351C	SEC	F	S	D	P	G4.5	00	ACG	DC2248	
EAS_MODE3	V97U8353C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
EAS_MODE4	V97U8354C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
EAS_PD	V97U8355C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
EAS_RTLS_YAW2	V97U8214C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
EAS_YAW(1)	V97U8356C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
EAS_YAW(2)	V97U8357C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
FT_SSME	V97U4392C	LBF	F	S	D	C	G4.176	00	ZF1	90243C	
							G4.2				
							G4.4				
							G4.5				
HDOT_COMB_MNVR	V97U8367C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_COMB_YAW	V97U8369C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_MODE1	V97U8359C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_MODE1_BACK	V97U8360C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
HDOT_MODE5	V97U8365C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
HDOT_MODE_SWITCH	V97U8358C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
HDOT_RTLS_MODE1	V97U8370C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_RTLS_YAW1	V97U8371C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_RTLS_YAW2	V97U8372C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
HDOT_TGT_MODE5	V97U8373C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	

TABLE 4.9.12-3. POWERED CONTINGENCY GUIDANCE (G4.5) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
HDOT_YAW1	V97U8374C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
KMAX	V97U4424C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5 G4.55	00	A2P	89990E	
KMAX_ABT	V97U0601C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5	00	A2P	92232B	
KMAX_NOM	V97U0602C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5	00	A2P	92232B	
KMAX_SECONDARY	V99U7107C	PCT	I	S	M	C	G4.1 G4.2 G4.4 G4.5	00	A2P	89990E	
K_CONT_THROT	V97U8375C	PCT	I	S	D	P	G4.5	00	ACG	DC2248	
MDOT_SSME	V97U4442C	SLUGS/SEC	F	S	D	C	G4.1 G4.2 G4.4 G4.5	00	ZF1	90243C	
M_EMPTY	V97U8376C	SLUGS	F	S	D	P	G4.5	00	AMC	DC2248	
PD_DELAY_COUNTER	V97U8380C	ND	I	S	D	P	G4.5	00	ACG	DC2248	
PSI_MODE1_YAW	V97U8389C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
PSI_MODE2_YAW	V97U8390C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
QBAR_SEP_MODE2	V97U6293C	LB/FT**2	F	S	D	P	G4.5	00	ACG	92504G	
QBAR_SEP_MODE3	V97U6294C	LB/FT**2	F	S	D	P	G4.5	00	ACG	92504G	
QERR_CONT_MECO	V97U8480C	DEG/SEC	F	S	D	P	G4.5	00	ACG	92504G	
QMECO_CONT_HIGH	V97U8391C	DEG/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
QMECO_CONT_LOW	V97U8402C	DEG/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
Q_MC_INIT_MODE2	V97U6290C	DEG/SEC	F	S	D	P	G4.5	00	ACG	92504G	
Q_MC_INIT_MODE3	V97U8479C	DEG/SEC	F	S	D	P	G4.5	00	ACG	92504G	
ROLL_DELAY_COUNTER	V97U8392C	ND	I	S	D	P	G4.5	00	ACG	DC2248	
TGO_CONT_FCD	V97U8399C	SEC	F	S	D	P	G4.5	00	ACG	DC2248	
TGO_CONT_THROT	V97U8400C	SEC	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_CONT_MODE1	V97U8393C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_CONT_MODE2	V97U8394C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_LAMC_MODE3	V97U8398C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_MODE1_YAW	V97U8396C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_MODE2_YAW	V97U8397C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
THETA_MODE5_MAX	V97U8395C	RAD	F	S	D	P	G4.5	00	ACG	DC2248	
VI_LATE_TAL	V97U8413C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
VI_MIN_DROOP	V97U8414C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
VI_YAW2_MAX	V97U8411C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	
VI_YAW2_MIN	V97U8412C	FT/SEC	F	S	M	P	G4.5	00	ACG	DC2248	

TABLE 4.9.12-3. POWERED CONTINGENCY GUIDANCE (G4.5) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
VRELO_MINUSZ_TIMER2	V97U8499C	SEC	F	S	D	P	G4.5	00	ACG	92504G	
V_HORIZ_2EO	V97U8403C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
V_HORIZ_3EO	V97U8404C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
V_HORIZ_DVS	V97U8401C	FT/SEC	F	S	D	P	G4.5	00	ACG	DC2248	
V_HORIZ_VRELO_MODE	V97U6287C	FT/SEC	F	S	D	P	G4.5	00	ACG	92504G	
V_RTLS_CNTG	V98U7974C	FT/SEC	F	S	D	P	G4.4 G4.5 G4.6	00	ZF1	90705H	

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

TABLE 4.9.12-4. POWERED CONTINGENCY GUIDANCE (G4.5) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
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	
EPS-X CRIT REJ THRUST SCALING FACTOR	V97U4380C	00	+2.0	E-02 ND	F	S	C	G4.2 G4.4 G4.5	89990E	
FTF_MIN	V97U4838C	00	+5.0	E-01 ND	F	S	C	G4.2 G4.4 G4.5	90451	
FT_FACTOR THRUST SCALING FACTOR	V97U4389C	00	+9.98	E-01 ND	F	S	C	G4.2 G4.4 G4.5	90329C	
FT_OMS OMS VACUUM THRUST	V97U4390C	00	+6.0870000	E+03 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
FT_RCS PRIMARY RCS VACUUM THRUST	V97U4391C	00	+8.772	E+02 LBF	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
MDOT_OMS OMS MASS FLOW RATE	V97U4440C	00	+6.0048490	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	90924B	
MDOT_RCS NOMINAL RCS MASS FLOW RATE	V97U4441C	00	+1.0655714	E-01 SLUGS/SEC	F	S	C	G4.13 G4.2 G4.210 G4.3 G4.4 G4.5	91072D	
MUP_TH MINIMUM CHANGE IN MASS REQUIRED FOR MASS TO BE UPDATED	V97U6150C	00	+3.0	E-01 SLUGS	F	S	P	G4.13 G4.2 G4.3 G4.4 G4.5	90608D	
TGO_PPD TIME TO GO TO POWERED PITCHDOWN	V97U4666C	00	+6.0000000	E+00 SEC	F	S	C	G4.4 G4.5	89990E	

TABLE 4.9.12-4. POWERED CONTINGENCY GUIDANCE (G4.5) 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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NOTE: REFERENCE TABLE 1.3-1 FOR EXPLANATION OF DATA ELEMENTS.

TABLE 4.9.12-5. POWERED CONTINGENCY GUIDANCE (G4.5) 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	
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	

TABLE 4.9.12-5. POWERED CONTINGENCY GUIDANCE (G4.5) 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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4.10 CONTINGENCY 3 E/O GUIDANCE REQUIREMENTS

Principal function CONT 3 E/O GUID (CPDS, Level B, principal function 4.6). Execution of this principal function requires the RTLS Contingency Abort Task (Section 4.8.12).

This principal function is active during the second stage major mode (MM103) and during the powered RTLS major mode (MM601). It may also be active in first-stage (MM102) if three engines are out. In addition, CONT 3 E/O GUID initializes the 3 engine out region index among other parameters at MM101 transition.

It is initiated at SRB separation command (Event 28C or A30A) if the ENA_CONT_3EO_GUID flag is set. Contingency 3 E/O guidance normally executes concurrently with AS 2STG GUID in MM103 or PW RTLS GUID in MM601. Its normal function is to provide the crew with visibility of the current 3 E/O contingency abort procedure region status. CONT 3 E/O GUID performs this display support function by providing the XXXXXX TRAJ 1, XXXXXX TRAJ 2, and RTLS TRAJ 2 displays with a 3 engine out contingency region index.

Contingency 3 E/O guidance will normally be terminated when a point is reached in the powered flight trajectory where an OPS 6 contingency abort procedure would no longer be necessary even if three main engines were to fail at that time. The termination events for CONT 3 E/O GUID are Event 36C in MM103 and Event A39C in MM601.

If MECO confirmed occurs in MM103 and an OPS 6 contingency abort procedure is still required, contingency 3 E/O guidance sets the CONT_3EO_START flag ON. Contingency 3 E/O guidance then switches from its display support function into an actual auto guidance steering process. The MSC terminates AS 2STG GUID at Event 33 (MECO confirmed). Contingency 3 E/O guidance sets the RTLS abort declared flag and the MSC performs the transition from major mode 103 to 601. The contingency 3 E/O guidance maneuver takes place in major mode 601. If powered contingency guidance (PW CONT GUID, p.f. 4.5) had been active in major mode 103, it is terminated when the CONT_3EO_START is set ON (Event A36B).

If MECO confirmed occurs in major mode 601 and a contingency abort procedure is still required, contingency 3 E/O guidance sets the CONT_3EO_START flag ON. This causes the MSC to terminate PW RTLS GUID (if active) and/or PW CONT GUID (if active) at Event A36B. Contingency 3 E/O guidance then commands 3 E/O auto maneuvers in major mode 601.

If PW CONT GUID commands a guided MECO during a 2 E/O auto contingency maneuver, CONT 3 E/O GUID may set the CONT_3EO_START flag on at MECO confirmed and take over from PW CONT GUID at Event A36B as described above.

If MECO confirmed occurs in first-stage (MM102) and the ENA_CONT_3EO_GUID flag is set, Event 33D will occur and CONT 3 E/O GUID will be initiated. Contingency 3 E/O guidance will command a fast ET separation during SRB tailoff in major mode 102. CONT 3 E/O GUID will then command maneuvers post-sep in MM601. Contingency 3 E/O guidance is terminated at Event A39C.

Figures 4.10-1, 4.10-2, and 4.10-3 illustrate the contingency 3 E/O guidance task organization, functional flow, and data flow. The Principal function interfaces are given in Section 4.10.4.

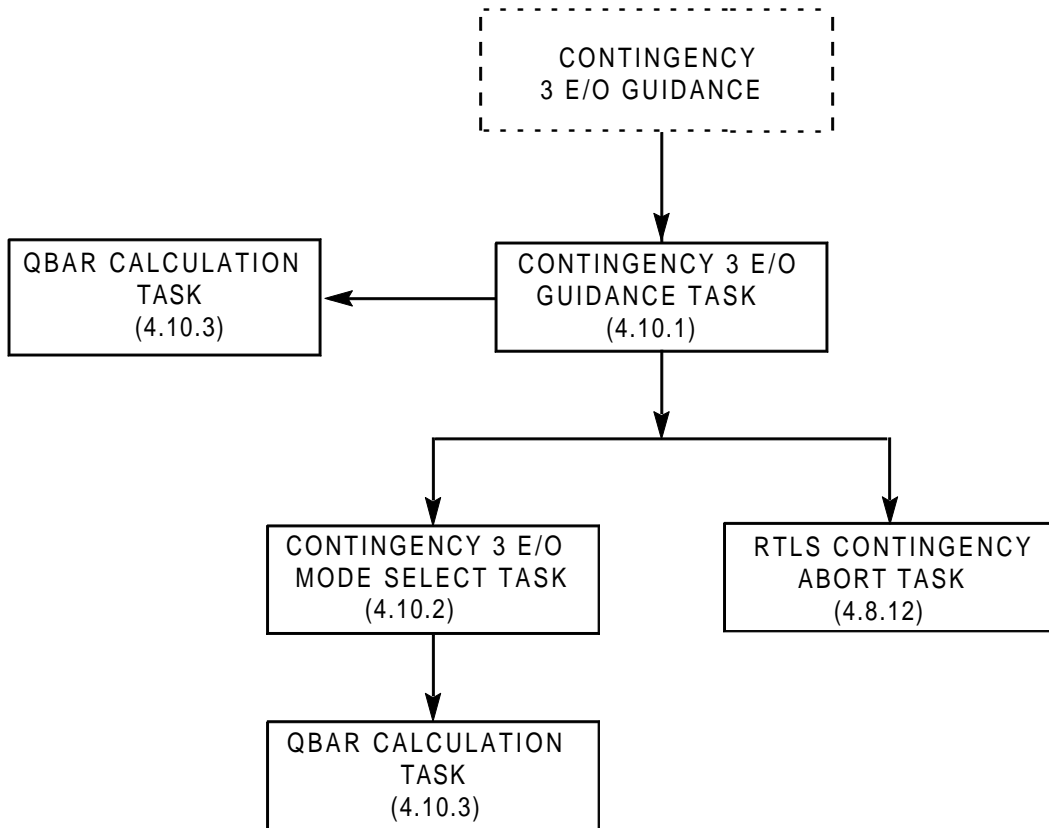


FIGURE 4.10-1. Contingency 3 E/O Guidance Principal Function Task Organization

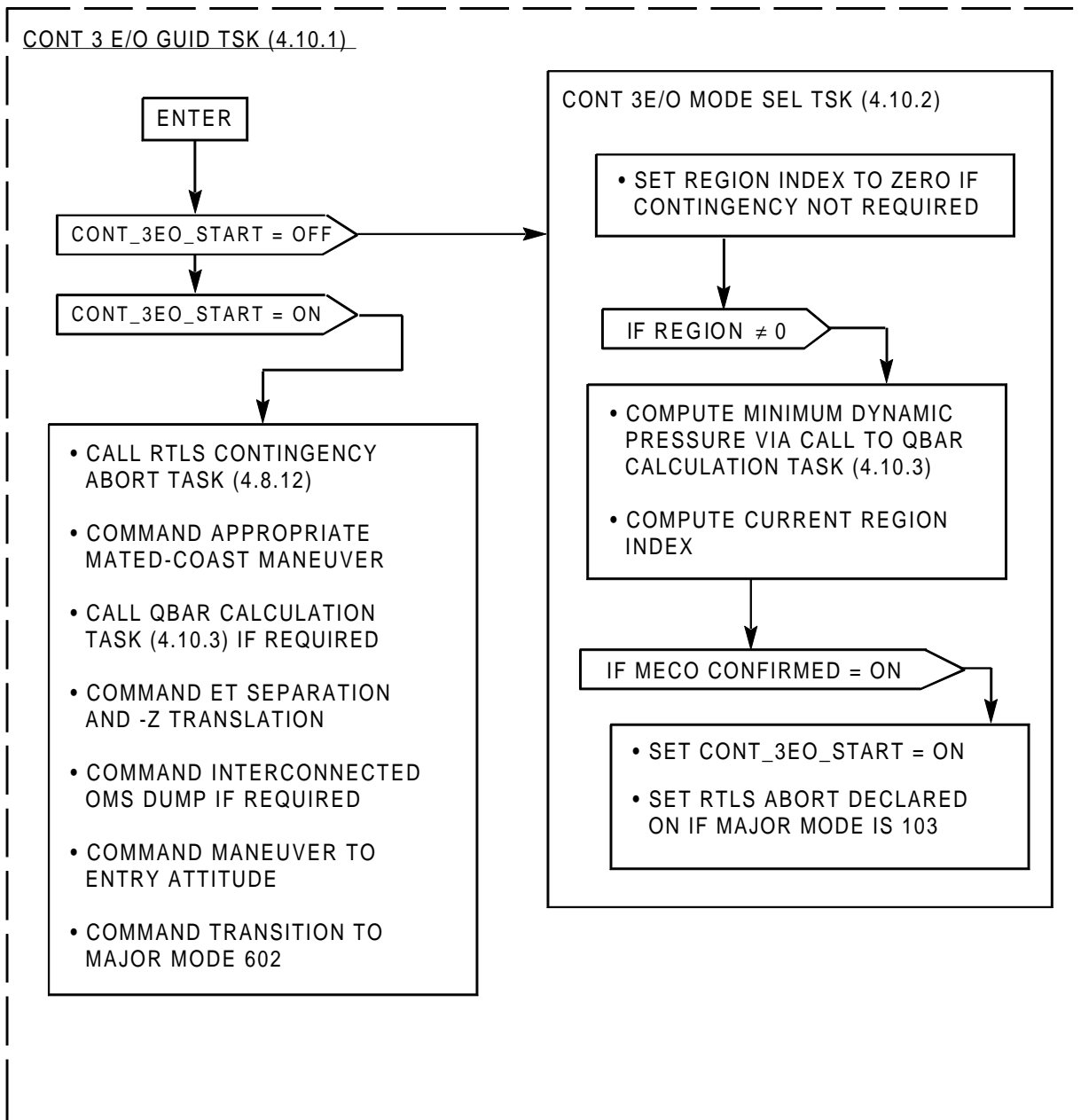


FIGURE 4.10-2. Contingency 3 E/O Guidance Functional Flow

4.10.1 Contingency 3EO Guidance Task (CONT 3EO GUID TSK)

This task is the main driver task for Contingency 3 E/O Guidance (CONT 3 E/O GUID, p.f. 4.6). It also includes the detailed maneuver logic for each maneuver region determined in the Contingency 3 E/O Mode Select Task. The recommended execution rates for this task are 1.92 seconds from SRB separation to MECO confirmed in major modes 103 and 601. After MECO confirmed, the recommended execution rate is 0.16 seconds. If MECO confirmed occurs in major mode 102, this task runs at a recommended execution rate of 0.16 seconds. If manual guidance (AUTO = OFF) is selected by the crew during the time that contingency 3 E/O guidance is commanding maneuvers, this task continues to execute. This task includes, calls to the Contingency 3EO Mode Select Task (Section 4.10.2), the QBAR Calculation Task (4.10.3), and the RTLS Contingency Abort Task (Section 4.8.12).

A. Detailed Requirements.

1. Check to see if the 3 engine contingency start flag has been set. If it has been set, a 3 engine out region index has already been determined and the 3 engine out mode select task is not called.

If $\dot{C}ONT_3EO_START = OFF$, call the CONT 3EO MODE SEL TSK

Proceed to Step 2.

2. Check the 3 engine out contingency start flag to see if it has been set in the mode select task above. If it has, proceed with the 3 E/O auto contingency maneuver logic. Otherwise, exit this task.

If $\dot{C}ONT_3EO_START = ON$ proceed to Step 3.
Otherwise, exit this task.

3. Perform this step only on the first pass after the 3 engine out contingency start flag has been set. Otherwise, proceed to Step 4.

- a. Set the flag to unstow the ADI needles if they had previously been stowed.

$S_UNCONV = OFF$

- b. Store the GMT at which the three-engine out logic was invoked.

$T_3EO = T_NAV$

- c. Call the RTLS Contingency Abort Task to set the contingency abort flag so that the Auto Nz guidance is used during entry.

Call the RTLS CONT ABT TSK

- d. Start the contingency mated coast +X RCS burn to assist in settling the remaining MPS propellant.

$\dot{C}ONT_RCS_PLUSX_ON = ON$

- e. If a powered contingency abort was initiated near $VREL=0$, enable the mated post-MECO OMS burn. This OMS firing provides + X acceleration to settle the MPS propellant, thereby reducing slosh dynamics prior to structural separation.

If $NEAR_VREL0_MODE=ON$, set $SETTLING_BURN_ENA$ to ON.

Otherwise, proceed to Step 4.

- f. Perform the following to find the Mated Coast duration that satisfies the ET separation dynamic pressure target:

- (1) Predict the maximum ET separation dynamic pressure by performing the following:

$$Q_ORB_AVG = Q_ORB + 0.5 \text{ DELTA_Q_RAMP}$$

$$T_DEL = - (\text{ALPHA_N} - \text{ALFA_SEP_MIN}) / Q_ORB_AVG$$

$$T_DEL = \text{MIDVAL}(T_DEL_MIN, T_DEL, T_DEL_MAX)$$

Call the QBAR CALC TSK

- (2) If the maximum dynamic pressure is below or at the target, proceed to Step 3A.

If $QBAR_PRED \leq QBAR_SEP_DESIRED$, proceed to Step 3A.

Otherwise, set

$$QBAR_MAX = QBAR_PRED$$

$$T_DEL_MAX = T_DEL$$

- (3) Predict the minimum ET separation dynamic pressure by performing the following:

$$T_DEL = T_DEL_MIN$$

Call the QBAR CALC TSK

- (4) If the minimum dynamic pressure is at or above the target, proceed to Step 3A.

If $QBAR_PRED \geq QBAR_SEP_DESIRED$, proceed to Step 3A.

Otherwise, set $QBAR_MIN = QBAR_PRED$

- (5) Set $ITCOUNT = 0$ and perform the following until an ET separation time is found that satisfies the dynamic pressure target:

Repeat the following calculations until $|QBAR_PRED - QBAR_SEP_DESIRED| < \text{MAX_QBAR_MISS}$ or $ITCOUNT > 7$:

$$ITCOUNT = ITCOUNT + 1$$

$$DQ_MAX = QBAR_MAX - QBAR_SEP_DESIRED$$

$$DQ_MIN = QBAR_MIN - QBAR_SEP_DESIRED$$

$$T_DEL = (T_DEL_MIN DQ_MAX - T_DEL_MAX DQ_MIN) / (QBAR_MAX - QBAR_MIN)$$

Call the QBAR CALC TSK

$$T_DEL_MIN = T_DEL_MAX$$

$$QBAR_MIN = QBAR_MAX$$

$$T_DEL_MAX = T_DEL$$

$$QBAR_MAX = QBAR_PRED$$

(6) Proceed to Step 3A

- 3A. Compute the desired ET Separation time and the desired pitch acceleration for the remainder of Mated Coast. Perform this step one time only.

$$TSEP_DESIRED = T_NAV + T_DEL$$

$$QDOT_TEMP = DELTA_Q_RAMP/T_DEL$$

$$QDOT_DESIRED = MIN(QDOT_TEMP, QDOT_MAX_MC)$$

Proceed to Step 4.

4. Set the Mode 2 indicator every guidance pass to insure RCS jet availability if an OMS/RCS return to normal occurs during contingency abort maneuvers. This flag is sent to the Abort OMS/ RCS Interconnect principal function.

$$\dot{M}ODE_2_INDICATOR = ON$$

Also, check to see if ET separation has occurred. If it has, proceed with the post-separation portion of the maneuver.

If $\dot{E}T_SEP_CMD = ON$, proceed to Step 7. Otherwise, proceed to Step 5.

5. During some mated-coast maneuvers (usually Region 3 or Region 4 maneuvers) it may be necessary to abandon the mated maneuver to the desired attitude and simply command ET separation immediately. This will occur if the current dynamic pressure exceeds a specified value and is increasing. If it does occur, command separation, configure the GRTLS DAP open-loop -Z timers to their Region 3 values and set a flag so that ground controllers have visibility of the emergency separation situation.

If $H_DOT < 0$ and $Q_BAR_A > QBAR_MAX_SEP$ and $\dot{M}M102 = OFF$ perform the following to command an immediate separation. Otherwise, proceed to Step 6.

$$\dot{E}T_SEP_MAN_INITIATE = ON$$

EMERG_SEP = ON

CONT_3EO_PR_DELAY = MINUS_Z_REG3

ETSEP_Y_DRIFT = CONT_Y_DRIFT

Exit this task.

6. Based on the value of the 3 engine out region index, branch to the appropriate portion of this task for the appropriate mated-coast maneuver requirements.

- (a) If REGION = 102, proceed to Step 13.
- (b) If REGION = 3 or REGION = 4, proceed to Step 15.
- (c) If REGION = 2, proceed to Step 22.
- (d) If REGION = 1, proceed to Step 27.

Otherwise, exit the task.

7. If an RTLS 2EO contingency near "VREL=0" is in progress, continue the mated coast +X RCS settling burn (by delaying setting CONT_RCS_PLUSX_ON to OFF) until an I-loaded period of time since ET separation has elapsed. This extended RCS +X burn improves ET separation clearances in the "VREL=0" region. For all other contingency scenarios (NEAR_VREL0_MODE = OFF), disable the +X RCS settling burn immediately. If the -Z post-sep translation has not been completed, check if a first stage three-engine out contingency abort is in progress. If so, check if the orbiter pitch or yaw rates exceed I-loaded maximum values after an I-loaded minimum -Z translation time has passed. If so, zero the GRTLS DAP -Z open loop timers to permit attitude control and post-sep maneuvering. This may be required for some 3 engine out cases in first stage because of the large aerodynamic moments on the orbiter after ET separation.

If (NEAR_VREL0_MODE = ON and $T_{NAV} - T_{ET_SEP} \geq DT_{RCS_PLUSX_SEP}$), or NEAR_VREL0_MODE = OFF, set CONT_RCS_PLUSX_ON = OFF.

If CONT_MINUS_Z_COMPL = ON, proceed to Step 8. Otherwise, continue with the following:

If REGION = 102 and $T_{NAV} - T_{ET_SEP} > DT_{MIN_Z_102}$ and either $|Q_{ORB}| > Q_{MINUS_Z_MAX}$ or $|R_{ORB}| > R_{MINUS_Z_MAX}$, perform the following.

Otherwise, exit the task.

Set CONT_3EO_PR_DELAY = 0

Set ETSEP_Y_DRIFT = 0

Exit this task.

8. If a significant amount of OMS propellant remains at ET separation, it may be necessary to dump OMS after ET separation. Because OMS remaining is an aft c.g. concern, this step inhibits any forward RCS dump that had been planned for intact RTLS. Also, the delay in the MPS LO2 dump through the 8-inch fill/drain line is zeroed.

If $(\text{MANUAL_OMS_DT} - \text{OMS_EQV_ON_TIME} > \text{OMS_TIME_DUMP_START})$, perform the following one time only. Otherwise, proceed to Step 10.

$\text{FWD_RCS_DUMP_ENABLE} = \text{OFF}$

$\text{RTLS_LO_F_D_DELAY} = 0$

Proceed to Step 9.

9. This step commands an interconnected OMS dump following completion of the open-loop -Z translation. The dump begins in major mode 601 (Nz and QBAR permitting) and continues through the OPS 601-2 transition. The dump is not commanded if ET separation occurred in first-stage (REGION = 102). This is because the very short time between the dump stop in first-stage, and dump restart post-sep (as short as 2-3 seconds) can violate OMS/RCS system constraints. Perform this step one time only.

If $\text{REGION} \neq 102$ and $\text{Q_BAR_A} < \text{QBAR_OMS_DUMP}$, perform the following. Otherwise, exit the task.

$\text{FCS_ACCEPT_ICNCT} = \text{ON}$

$\text{OMS/RCS_I/C_INH/ENA_CMD} = \text{ENA} = \text{ON}$

$\text{ORBITER_DUMP_ENA} = \text{ON}$

This task also commands a new set of normal acceleration limits for terminating the dump and interconnect in major mode 601. These limits are higher than those used in major mode 602 (initialized by I-loads in the Abort Control Sequence). The post-separation maneuver in MM601 utilizes forward pitch jets that, due to their proximity to the Nz accelerometers, can cause a pre-mature termination of the OMS dump in MM601 due to rotational acceleration being sensed as linear acceleration. The original I-load limits will be reassigned when the transition to MM 602 is commanded.

$\text{OMS_NZ_LIM} = \text{OMS_NZ_LIM_3EO}$

$\text{CONTINGENCY_NZ_LIM} = \text{CONTINGENCY_NZ_LIM_3EO}$

This step also disables the extended -Z translation for scenarios requiring a post-MECO OMS dump. This is done because the OMS/RCS interconnect sequence will inhibit the aft jets for a short period of time. Attempting a -Z burn during this period will introduce an undesirable pitch transient.

$\text{CONT_EXT_MINUSZ_ENA} = \text{OFF}$

$\text{DT_EXT_MINUSZ} = 0.0$

Exit this task.

10. This step begins the logic for the post-sep maneuver to the entry attitude. Before the maneuver is commanded, an entry maneuver counter must be decremented to zero.

If $ENTRY_MNVR_COUNTER \leq 0$, perform the remainder of this step. Otherwise, decrement the entry maneuver counter ($ENTRY_MNVR_COUNTER = ENTRY_MNVR_COUNTER - 1$) and exit this task.

When the entry maneuver counter decrements to zero, begin checking if the RCS jets are available. If an OMS/RCS interconnect has been commanded in Step 9, the RCS jets should become unavailable for several seconds while the interconnect takes place. Due to inter-process variable considerations, it is necessary to decrement an entry maneuver counter before RCS jet availability is checked here in guidance. As soon as the RCS jets become available, turn off the 3 engine out attitude freeze flag, reset the high-rate separation flag to OFF, reset the commanded body pitch rate to zero, and set an entry gains for use by flight control to use post-sep gains. To improve ET separation performance in the RTLS 2 EO Yellow region near $VREL=0$, turn on the contingency attitude hold flag following completion of -Z burn for an I-loaded duration.

If $RCS_1/2_ALL_JET_INHIBIT = OFF$ or $RCS_3/4/5_ALL_JET_INHIBIT = OFF$, perform the following. Otherwise, exit this task.

$FRZ_3EO = OFF$

$HIGH_RATE_SEP = OFF$

$WCB2 = 0$

If $CONT_2EO_MODE = 2$ and $NEAR_VREL0_MODE = ON$, perform the following. Otherwise, set $ENTRY_GAINS = ON$ and proceed to step 11.

If $CONT_ATT_HOLD = OFF$ and $CONT_ATT_HOLD_COMPL = OFF$, set
 $CONT_ATT_HOLD = ON$
 $T_CONT_ATT_HOLD_START = T_NAV$

If $T_NAV - T_CONT_ATT_HOLD_START \geq DT_CONT_ATT_HOLD$, set
 $CONT_ATT_HOLD = OFF$
 $CONT_ATT_HOLD_COMPL = ON$
 $ENTRY_GAINS = ON$

Proceed to Step 11.

11. An entry M50-to-commanded body quaternion is constructed in the following manner:
- a. Compute an entry angle-of-attack based on the current orbiter relative velocity.

$ALF_CMD = ALPRECS \ REL_VEL_MAG / 1000 + ALPRECI$

$ALF_CMD = MIDVAL(ALPRECL, ALF_CMD, ALPRECU)$

- b. Construct the angle of rotation from the VR frame to the desired angle of attack.

$$ROT = ALF_CMD + 90$$

- c. Construct the M50-to-commanded body quaternion to command wings level, zero sideslip, and the computed angle of attack. The M50-to-commanded body quaternion is formed by multiplying the rotation quaternion ($Q_{CB_VR}^+$) by the conjugate of the VR-to-M50 quaternion (Q_{M50_VR}).

$$Q_{CB_VR}^+ = QUAT_CALC(ROT, U\bar{Y}) \text{ where } U\bar{Y} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}, \text{ the right wing unit vector}$$

$$Q_{M50_VR}^+ = RV_TO_QLVLH(V\bar{RHO}, -R\bar{NAV})$$

$$Q_{GCB_I}^+ = QUAT_MULT(Q_{CB_VR}^+, Q_{VR_M50}^+)$$

- d. An error quaternion is constructed from which commanded-body-to-actual-body errors are computed. The body-to-M50 quaternion is the conjugate of the M50-to-body quaternion.

$$Q_{CB_B}^+ = QUAT_MULT(Q_{GCB_I}^+, Q_{I_B}^+)$$

$$E_{CB_B}^- = QUAT_ERR_ANG(Q_{CB_B}^+)$$

- 11A. This step commands a rapid pitch-up maneuver following ET-Sep for ECAL scenarios. The special maneuver is only commanded if the current alpha error is less than an I-Loaded limit.

If (ALPHA_N - ALF_CMD < ALF_ERR_ECAL) perform the following. Otherwise, proceed to Step 12.

$$E\dot{C}AL_PITCH_UP = ON$$

Proceed to Step 12.

12. This step determines when to command the transition from MM601 to MM602. If the current attitude and rates fall within certain I-loaded ranges and a minimum period of time since ET separation has elapsed, or if the dynamic pressure exceeds an I-loaded value, set the flag to command the auto transition to MM 602. Also, reassign the interconnect and OMS dump normal acceleration limits for MM 602 to the original I-load values.

If (|ALPHA_N-ALF_CMD| < ALPHA_602_ERR and
|E_CB_B(1)| < ROLL_602_ERR and
|BETA_N| < BETA_602_ERR and
|P_ORB| < PR_602_ERR and
|Q_ORB| < Q_602_ERR and
|R_ORB| < PR_602_ERR and
T_NAV - T_ET_SEP > DT_EXT_MINUSZ)

or

Q_BAR_A > QBAR_MAX_601, set C\dot{O}NT_SEP_CPLT = ON and

OMS_NZ_LIM = OMS_NZ_LIM_STD and
CONTINGENCY_NZ_LIM = CONTINGENCY_NZ_LIM_STD

Exit this task.

13. This step determines whether an OMS dump should be commanded for 3 E/O auto contingency situation in first stage.

If $ALT > ALT_MIN_102_DUMP$ and $T_NAV - T_GMTLO < T_DMP_LAST$, perform the following one time only.

ORBITER_DUMP_ENA = ON

Proceed to Step 14.

14. Check to see if the filtered SRB chamber pressures have fallen below an I-loaded value or the MET has exceeded an I-loaded value and a pre-SRB separation flag has been set to see if fast ET separation should be commanded in first stage. If these conditions are satisfied, set the ET_SEP_MAN_INITIATE flag and the GRTLS DAP open loop -Z timers.

If $[(PC4F < CNTPCSP \text{ and } PC5F < CNTPCSP) \text{ or } T_NAV - T_GMTLO \geq METCNTS]$ and $PRE_SEP = ON$, perform the following. Otherwise, exit this task.

ET_SEP_MAN_INITIATE = ON

CONT_3EO_PR_DELAY = MINUS_Z_REG102

ETSEP_Y_DRIFT = CONT_Y_DRIFT

Exit this task.

15. This step begins the mated-coast maneuver logic for Region 3 auto 3 E/O contingency maneuvers. The mated maneuver in Region 3 is a high qbar maneuver (normally a pitch down) to a specified angle of attack (near zero) with a slight pitch rate (nullifies the effect of flight path angle rotation) followed by ET separation. During the maneuver, the high dynamic pressure may cause aerodynamic moments to exceed the ability of the RCS jets to complete the pitchdown. If this occurs (see Step 21), the region will switch from 3 to 4 and instead of a pitchdown to near zero angle of attack, a new commanded angle of attack is commanded in the second alpha quadrant ($90^\circ < \alpha_{cmd} < 180^\circ$) and the commanded body pitch rate is reset to zero.

If $REGION = 4$, set $ALF_CMD = ALF_REG4$ and $WCB2 = 0$.
Otherwise, set $ALF_CMD = ALPHA_PPD \text{ DEG_PER_RAD}$ and
 $WCB2 = WCB2_3EO$.

Proceed to Step 16.

16. The commanded body quaternion is constructed by performing (a) through (e) below. A new quaternion is constructed each pass through this step. The quaternion is formed as follows: starting with the current attitude quaternion (Q_{B_I}), rotate beta degrees about a specified axis to cause beta to be zeroed. Then rotate about the body Y-axis until the commanded angle of attack is reached. The result is a quaternion with the desired angle of attack, zero sideslip, and current bank angle.

- a. Cross the right wing unit vector with the relative velocity vector in body coordinates and unitize the result.

$$\bar{U}B = \text{QUAT_XFORM}(Q_{B_I}, V_{\bar{RHO}})$$

$$V_{\bar{TEMP}} = \text{UNIT}(\bar{U}B \times U\bar{Y}) \text{ where } U\bar{Y} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

- b. Compute the quaternion that represents the minimum rotation required to zero sideslip. This is a single-axis rotation about a vector, $V_{\bar{TEMP}}$, in the orbiter X-Z plane.

$$Q_{\bar{C}B_B} = \text{QUAT_CALC}(\text{BETA}_N, V_{\bar{TEMP}})$$

- c. Compute the M50-to-commanded body quaternion for a zero beta attitude by multiplying the body-to-commanded body quaternion constructed in the previous step by the M50-to-body quaternion.

$$Q_{\bar{G}CB_I} = \text{QUAT_MULT}(Q_{\bar{C}B_B}, Q_{B_I})$$

- d. Construct a quaternion that represents a rotation about the body Y-axis. The magnitude of the rotation is the difference between the current and commanded angles of attack.

$$\text{ALF_ERR} = \text{ALF_CMD} - \text{ALPHA}_N$$

$$Q_{\bar{C}B_B} = \text{QUAT_CALC}(\text{ALF_ERR}, U\bar{Y})$$

- e. Construct the final M50-to-commanded body quaternion by multiplying the quaternion constructed in (d) above by the quaternion constructed in (c) above.

$$Q_{\bar{G}CB_I} = \text{QUAT_MULT}(Q_{\bar{C}B_B}, Q_{\bar{G}CB_I})$$

17. Check the 3 engine out region index to see if a Region 4 or Region 3 type of maneuver is being commanded.

If REGION = 4, proceed to Step 18. Otherwise, proceed to Step 20.

18. If the alpha error value is less than an I-loaded value or the current alpha is less than zero, and the current rates are within acceptable I-loaded values, set a region 4 pitch command. This flag is sent to the GRTLS DAP to establish a negative pitch rate just prior to structural release.

If $\dot{P}CH_CMD_REG4 = ON$, proceed to Step 19.

If $ALF_ERR < DELTA_ALF_REG4$ or $ALPHA_N < 0$
and $|P_ORB| < PR_REG4_MAX$ and $|Q_ORB| < Q_REG4_MAX$ and
 $|R_ORB| < PR_REG4_MAX$, perform the following. Otherwise, exit this task.

Set $\dot{P}CH_CMD_REG4 = ON$

Proceed to Step 19.

19. If a negative pitch rate has been established, set the $ET_SEP_MAN_INITIATE$ flag to command ET separation. Also set the appropriate open loop $-Z$ timers for Region 4.

If $Q_ORB < 0$, perform the following. Otherwise, exit this task.

$\dot{E}T_SEP_MAN_INITIATE = ON$

$CONT_3EO_PR_DELAY = MINUS_Z_REG4$

$ETSEP_Y_DRIFT = CONT_Y_DRIFT$

Exit this task.

20. This step determines if a Region 3 ET separation should be commanded at the current time. Normally, separation will be commanded when alpha, beta, and body rates are within acceptable limits. Control limitations may not permit all these parameters to be satisfied at the same time. The possibility of alpha overshoot requires separation be commanded independent of the other parameters if alpha error achieves, and then moves outside, the acceptable deadband. When separation is commanded, the open-loop $-Z$ timers are also set to their Region 3 values.

a. If $|ALF_ERR| < ALF_SEP_ERR$, set $\dot{A}LPHA_OK = ON$ and proceed to (b).
Otherwise, proceed to (c).

b. If $|BETA_N| < BETA_SEP_ERR$ and $|P_ORB| < PR_SEP_MAX$ and $|Q_ORB| < Q_SEP_MAX$ and $|R_ORB| < PR_SEP_MAX$, proceed to (d). Otherwise, exit this task.

c. If $\dot{A}LPHA_OK = ON$, proceed to (d). Otherwise, proceed to Step 21.

d. Perform the following:

$\dot{E}T_SEP_MAN_INITIATE = ON$

$CONT_3EO_PR_DELAY = MINUS_Z_REG3$

$ETSEP_Y_DRIFT = CONT_Y_DRIFT$

Exit this task.

21. If a I-loaded amount of time has elapsed since starting the region 3 maneuver and the GRTLS DAP pitch error signal is less than an I-loaded value, change the 3 engine out region index from 3 to 4 and begin the Region 4 maneuver.

If $T_NAV - T_3EO > T_CHK_REG4$ and $DPJET_MC < REG4_ERR$, set $REGION = 4$ and go back to Step 15. Otherwise, exit this task.

22. This step begins the mated-coast maneuver logic for Region 2 auto 3 E/O contingency maneuvers. The mated-coast maneuver in Region 2 is a maneuver to zero the sideslip angle, followed by a pitch rate maneuver and ET separation. If sideslip is already small, the maneuver to establish a specified pitch rate is begun immediately. The commanded body quaternion is constructed by performing (a) through (c) below. A new quaternion is constructed each pass through this step. The minimum required maneuver to zero sideslip is a maneuver of exactly beta degrees that holds the vehicle's bank angle and angle of attack at their current values. The current attitude quaternion is rotated beta degrees about a specified axis of rotation. This axis is constructed by taking the cross product of the relative velocity vector and the right wing unit vector (both expressed in body-axis coordinates).

- a. Cross the right wing unit vector with the relative velocity vector in body coordinates and unitize the result.

$$\bar{U}B = \text{QUAT_XFORM}(Q_B_I, V_RHO)$$

$$V_TEMP = \text{UNIT}(\bar{U}B \times \bar{U}Y) \text{ where } \bar{U}Y = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

- b. Compute the quaternion that represents the minimum rotation required to zero sideslip. This is a single-axis rotation about a vector, V_TEMP , in the orbiter X-Z plane.

$$Q_CB_B = \text{QUAT_CALC}(BETA_N, V_TEMP)$$

- c. Compute the M50-to-commanded body quaternion by multiplying the quaternion constructed in (b) above by the current attitude quaternion.

$$Q_GCB_I = \text{QUAT_MULT}(Q_CB_B, Q_B_I)$$

23. If the pitch rate phase of the maneuver has not yet started, a check is made of the current sideslip angle. If this angle exceeds a specified value, it will take too long to try to zero beta before the dynamic pressure builds to an unsafe level. Since the current dynamic pressure is small enough to permit an attitude independent type of ET separation, the region is changed from 2 to 1 and the Region 1 maneuver is begun immediately.

If $|BETA_N| > BETA_MAX$ and $HIGH_RATE_SEP = OFF$, set $REGION = 1$ and Proceed to Step 27. Otherwise, proceed to Step 24.

24. Begin the pitch rate phase of the Region 2 maneuver if the sideslip is below a specified value and the vehicle's roll and yaw rates are acceptably small.

If $[|BETA_N| < BETA_REG2 \text{ and } |P_ORB| < PR_MAX_REG2 \text{ and } |R_ORB| < PR_MAX_REG2]$ or $\dot{HIGH_RATE_SEP} = ON$, proceed to Step 25. Otherwise, exit this task.

25. Command a specified pitch rate, set the $HIGH_RATE_SEP$ flag, and store the current GMT as the time the zero-beta phase of the maneuver was completed. Perform this step one time only.

$\dot{HIGH_RATE_SEP} = ON$

$T_ZRBETA = T_NAV$

$WCB2 = CONT_HIGH_SEP_RATE$

Proceed to Step 25A.

- 25A. If a powered contingency abort was completed near $RTLS\ VREL=0$ ($\dot{NEAR_VREL0_MODE} = ON$), perform the following. Otherwise, proceed to Step 26.

If $TSEP_DESIRED - T_NAV < DT_SEP_CMD$, command ET separation by setting $\dot{ET_SEP_MAN_INITIATE} = ON$

If $TSEP_DESIRED - T_NAV < DT_SETL_BURN_STOP$, terminate the MPS settling burn by setting $\dot{SETTLING_BURN_ENA} = OFF$, $\dot{ARM_CONT_MPS_SETTLING_BURN} = OFF$ and $\dot{MATED_CG_TRIM} = OFF$

$ETSEP_Y_DRIFT = CONT_Y_DRIFT$

Exit this task.

26. Check to see if the pitch rate error is less than an I-loaded value or if an I-loaded amount of time has passed since completing the zero-beta phase. If so, set the $ET_SEP_MAN_INITIATE$ flag and the GRTLS DAP open loop -Z timers.

$QORB_ERR = Q_ORB - WCB2$

If $QORB_ERR < QORB_MIN_REG2$ or $T_NAV - T_ZRBETA > T_REG2_PITCH$, perform the following. Otherwise, exit this task.

$\dot{ET_SEP_MAN_INITIATE} = ON$

$CONT_3EO_PR_DELAY = MINUS_Z_REG2$

$ETSEP_Y_DRIFT = CONT_Y_DRIFT$

Exit this task.

27. This step begins the Region 1 attitude independent mated coast maneuver logic. Perform this step one time only. Otherwise, proceed to Step 28.

Set the GRTLS DAP open-loop -Z translation timers to their Region 1 values.

$$\text{CONT_3EO_PR_DELAY} = \text{MINUS_Z_REG1}$$

$$\text{ETSEP_Y_DRIFT} = \text{CONT_Y_DRIFT}$$

From an ET separation standpoint, the longer RTLS separation sequence is preferred to the fast separation sequence. But the rapid rate of descent and the maneuver time to entry attitude after separation require an early separation (i. e. fast sep) on some contingency aborts. To determine if an early separation is required, the predicted dynamic pressure is calculated REG1_MNVR_TIME seconds in the future.

$$\text{T_DEL} = \text{REG1_MNVR_TIME}$$

Call the QBAR CALC TSK

Next determine the time of minimum dynamic pressure.

If $\dot{H}_{\text{DOT}} \leq 0$, set $\text{T_QBAR_MIN} = 0$. Otherwise, set $\text{T_QBAR_MIN} = -\dot{H}_{\text{DOT}} / G$

Set the early separation flag if the time to minimum QBAR is below an I-loaded value and the predicted QBAR calculated above exceeds the Region 1 threshold.

If $\text{T_QBAR_MIN} < \text{T_APOGEE}$ and $\text{QBAR_PRED} > \text{QBAR_REG1}$, then set $\dot{\text{EARLY_SEP}} = \text{ON}$. Otherwise, set $\dot{\text{EARLY_SEP}} = \text{OFF}$.

Proceed to Step 28.

28. If ET separation has not yet been commanded, set a 3 E/O freeze flag to be sent to G/C Steer. This flag will command zero body rates through ET separation. Set this flag each pass through this step.

If $\dot{\text{ET_SEP_MAN_INITIATE}} = \text{OFF}$, set $\dot{\text{FRZ_3EO}} = \text{ON}$ and proceed to Step 29. Otherwise, exit this task.

29. ET separation is commanded when the body rates are within I-loaded limits and dynamic pressure has dropped to a safe value. If the early separation flag is not set, an additional constraint is to permit time for the mated coast RTLS separation sequence to complete.

If $|\dot{P}_{\text{ORB}}| < \text{P_MAX_REG1}$ and $|\dot{Q}_{\text{ORB}}| < \text{QR_MAX_REG1}$ and

$|\dot{R}_{\text{ORB}}| < \text{QR_MAX_REG1}$ and $(\dot{Q}_{\text{BAR_A}} < \text{QBAR_UPHILL_SEP}$ or

$\dot{H}_{\text{DOT}} \leq 0)$ and $(\dot{\text{EARLY_SEP}} = \text{ON}$ or $\text{T_NAV} > \text{T_3EO} + \text{T_RTLS_SEP}$),

set $\dot{\text{ET_SEP_MAN_INITIATE}} = \text{ON}$ and exit this task. Otherwise,

just exit this task.

B. Interface Requirements. The input and output parameters for the contingency 3 three-engine out guidance task are given in Tables 4.10.1-1 and 4.10.1-2.

C. Processing Requirements. The recommended execution rate for this task is 1.92 seconds from initiation until MECO_CONFIRM = ON, then 0.16 seconds until the principal function is terminated.

D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

ENTRY_GAINS = OFF

FRZ_3EO = OFF

OMS_NZ_LIM_STD = OMS_NZ_LIM

CONTINGENCY_NZ_LIM_STD = CONTINGENCY_NZ_LIM

CONT_3EO_PR_DELAY = 5.0

CONT_SEP_CPLT = OFF

EMERG_SEP = OFF

PCH_CMD_REG4 = OFF

ALPHA_OK = OFF

CONT_EXT_MINUSZ_ENA = ON

DT_EXT_MINUSZ = MINUS_Z_EXTEND

ECAL_PITCH_UP = OFF

CONT_ATT_HOLD = OFF

T_CONT_ATT_HOLD_START = 0

CONT_ATT_HOLD_COMPL = OFF

SETTLING_BURN_ENA = OFF

E. Supplemental Information.

$\bar{U}Y = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$, the right wing unit vector.

TSEP_DESIREDD is double precision.

Requirements for the following modules called by this task are documented in FSSR STS 83-0008, Ascent Flight Control Volume 1: QUAT_CALC, QUAT_MULT, QUAT_ERR_ANG, QUAT_XFORM, and RV_TO_QLVLH.

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs				
Definition	Symbol	Source	Precision	Units
Desired angle of attack for Region 4 contingency abort	ALF_REG4	I-LOAD	SP	deg
Maximum angle of attack error for Region 3 ET separation	ALF_SEP_ERR	I-LOAD	SP	deg
Maximum angle of attack error for MM602 transition	ALPHA_602_ERR	I-LOAD	SP	deg
NAV angle of attack	ALPHA_N	A/E ATT PROC	SP	deg
Desired angle of attack at end of PPD	ALPHA_PPD	I-LOAD	SP	rad
Current orbiter altitude above reference ellipsoid	ALT	ASC UPP RTLS UPP	SP	ft
Minimum altitude to initiate OMS dump in first stage	ALT_MIN_102_DUMP	I-LOAD	SP	ft
Maximum sideslip angle for MM602 transition	BETA_602_ERR	I-LOAD	SP	deg
Minimum sideslip angle for a transition from Region 2 to Region 1	BETA_MAX	I-LOAD	SP	deg
NAV-derived sideslip angle	BETA_N	A/E_ATT_PROC	SP	deg
Maximum sideslip angle for Region 2 negative pitch rate initiation	BETA_REG2	I-LOAD	SP	deg
Maximum sideslip angle for Region 3 ET separation	BETA_SEP_ERR	I-LOAD	SP	deg
Maximum SRB chamber pressure for ET separation in first stage	CNTPCSP	I-LOAD	SP	psia
Contingency 2 engine out mode index	CONT_2EO_MODE	PW CONT GUID	I	N/A
Contingency 3 engine out start discrete	CONT_3EO_START	CONT 3EO MODE SEL TSK	D	N/A
Contingency high ET separation pitch rate	CONT_HIGH_SEP_RATE	I-LOAD	SP	deg/sec
Contingency ET separation yaw drift timer	CONT_Y_DRIFT	I-LOAD	SP	sec
Constant recovery angle of attack (contingency)	ALPRECI	I-LOAD	SP	deg
Minimum recovery angle of attack (contingency)	ALPRECL	I-LOAD	SP	deg
Change in recovery angle of attack (contingency abort)	ALPRECS	I-LOAD	SP	deg
Maximum recovery angle of attack (contingency abort)	ALPRECU	I-LOAD	SP	deg

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs

Definition	Symbol	Source	Precision	Units
Contingency attitude hold time	DT_CONT_ATT_HOLD	I_LOAD	SP	sec
Counter to delay checking RCS jet availability after ET separation	ENTRY_MNVR_COUNTER	I-LOAD	I	N/A
Normal acceleration limit for OMS/RCS interconnect termination	CONTINGENCY_NZ_LIM	I-LOAD	SP	G
Normal acceleration limit for 3 E/O OMS/RCS interconnect termination	CONTINGENCY_NZ_LIM_3EO	I-LOAD	SP	G
Computed vertical acceleration	G	CONT 3EO MODE SEL TSK	SP	ft/sec ²
Normal acceleration limit for OMS dump termination	OMS_NZ_LIM	I-LOAD	SP	G
Normal acceleration limit for 3 E/O OMS dump termination	OMS_NZ_LIM_3EO	I-LOAD	SP	G
Dynamic pressure below which a post-separation OMS dump may start	QBAR_OMS_DUMP	I-LOAD	SP	lb/ft ²
Predicted dynamic pressure	QBAR_PRED	QBAR CALC TSK	SP	lb/ft ²
QBAR boundary for Region 1 ET separation	QBAR_REG1	I-LOAD	SP	lb/ft ²
Maximum QBAR for Region 1 ET separation with HDOT > 0	QBAR_UPHILL_SEP	I-LOAD	SP	lb/ft ²
Time required for post-sep maneuvering during Region 1	REG1_MNVR_TIME	I-LOAD	SP	sec
Time to apogee above which early ET separation may not occur	T_APOGEE	I-LOAD	SP	sec
Normal mated coast time for RTLS ET separation	T_RTLS_SEP	I-LOAD	SP	sec
ET separation manual initiate flag	ET_SEP_MAN_INITIATE	PW CONT GUID, SSME OPS, ET SEP SEQ	D	N/A
High rate ET separation flag	HIGH_RATE_SEP	PW CONT GUID	D	N/A
Contingency -Z maneuver complete discrete	CONT_MINUS_Z_COMPL	GRTLS DAP	D	N/A
Degree per radian	DEG_PER_RAD	CONSTANT	SP	deg/rad
Maximum angle of attack error for Region 4 negative pitch rate phase initiation	DELTA_ALF_REG4	I-LOAD	SP	deg
Pitch error signal, mated coast	DPJET_MC	GRTLS DAP	SP	deg/sec
Duration of RCS +X separation burn	DT_RCS_PLUSX_SEP	I-LOAD	SP	sec

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs

Definition	Symbol	Source	Precision	Units
Minimum angle-of-attack error required for ECAL post-sep pitch-up	ALF_ERR_ECAL	I-LOAD	SP	deg
Minimum -Z translation time for MM102	DT_MIN_Z_102	I-LOAD	SP	sec
ET separation commanded discrete	ET_SEP_CMD	ET SEP SEQ	D	N/A
Estimated altitude rate	H_DOT	ASCENT UPP RTLIS UPP	SP	fps
Delta time for commanding fast ET separation	DT_SEP_CMD	K-LOAD	SP	sec
Delta time for terminating MPS settling burn	DT_SETL_BURN_STOP	K-LOAD	SP	sec
Maximum dynamic pressure miss for ET separation time search	MAX_QBAR_MISS	I-LOAD	SP	psf
Maximum pitch acceleration for contingency Mated Coast	QDOT_MAX_MC	I-LOAD	SP	deg/ sec ²
Minimum time remaining for contingency Mated Coast	T_DEL_MIN	I-LOAD	SP	sec
Maximum time remaining for contingency Mated Coast	T_DEL_MAX	I-LOAD	SP	sec
Desired ET separation dynamic pressure	QBAR_SEP_DESIRE	PW CONT GUID	SP	psf
Minimum angle-of-attack for ET separation near RTLIS "VREL=0"	ALFA_SEP_MIN	PW CONT GUID	SP	deg
Desired pitch rate change during contingency Mated Coast	DELTA_Q_RAMP	PW CONT GUID	SP	deg/ sec
Manual OMS dump duration timer	MANUAL_OMS_DT	I-LOAD, OVERRIDE SPEC, UPLINK	SP	sec
Latest MET for ET separation in first stage	METCNTS	I-LOAD	SP	sec
Extended -Z timer for contingency abort	MINUS_Z_EXTEND	I-LOAD	SP	sec
-Z translation timer for Region 1 contingency abort	MINUS_Z_REG1	I-LOAD	SP	sec
-Z translation timer for contingency abort in MM102	MINUS_Z_REG102	I-LOAD	SP	sec
-Z translation timer for Region 2 contingency abort	MINUS_Z_REG2	I-LOAD	SP	sec

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs

Definition	Symbol	Source	Precision	Units
-Z translation timer for Region 3 contingency abort	MINUS_Z_REG3	I-LOAD	SP	sec
-Z translation timer for Region 4 contingency abort	MINUS_Z_REG4	I-LOAD	SP	sec
MM102 flag	MM102	MSC	D	N/A
Current duration of OMS only or OMS equivalent dump	OMS_EQV_ON_TIME	ABT CNTL SEQ	SP	sec
Minimum OMS dump duration at which to re-initiate OMS dump	OMS_TIME_DUMP_START	I-LOAD	SP	sec
GMT associated with current state	T_NAV	ASC UPP RTLS UPP	DP	sec
Time of liftoff in GMT	T_GMTLO	FCOS	DP	sec
Filtered chamber pressure, left SRB	PC4F	ASC DAP	SP	psia
Filtered chamber pressure, right SRB	PC5F	ASC DAP	SP	psia
Flag that denotes beginning of pre-SRB separation flight control	PRE_SEP	ASC DAP	D	N/A
Maximum roll/yaw rate for MM602 transition	PR_602_ERR	I-LOAD	SP	deg/sec
Maximum roll/yaw rate for Region 2 negative pitch rate initiation	PR_MAX_REG2	I-LOAD	SP	deg/sec
Maximum roll/yaw rate for Region 4 negative pitch rate phase initiation	PR_REG4_MAX	I-LOAD	SP	deg/sec
Maximum roll/yaw rate for Region 3 ET separation	PR_SEP_MAX	I-LOAD	SP	deg/sec
Maximum pitch rate for Region 1 ET separation	P_MAX_REG1	I-LOAD	SP	deg/sec
Roll rate, orbiter rate gyro	P_ORB	SF(ORB RGA)	SP	deg/sec
Near VREL=0 guidance mode flag	NEAR_VREL0_MODE	PW CONT GUID	D	N/A
M50-to-body quaternion	Q_B_I	A/E ATT PROC	SP	N/A
Dynamic pressure at which MM602 transition is required	QBAR_MAX_601	I-LOAD	SP	lb/ft ²
Dynamic pressure required for emergency ET separation	QBAR_MAX_SEP	I-LOAD	SP	lb/ft ²
Maximum pitch rate error for Region 2 ET separation	QORB_MIN_REG2	I-LOAD	SP	deg/sec
Maximum pitch/yaw rate for Region 1 ET separation	QR_MAX_REG1	I-LOAD	SP	deg/sec

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs

Definition	Symbol	Source	Precision	Units
Maximum pitch rate for MM602 transition	Q_602_ERR	I-LOAD	SP	deg/sec
Dynamic pressure	Q_BAR_A	ASCENT UPP RTL5 UPP	SP	lb/ft ²
Maximum pitch rate for MM102-to-MM602 transition	Q_MINUS_Z_MAX	I-LOAD	SP	deg/sec
Pitch rate, orbiter rate gyro	Q_ORB	SF (ORB RGA)	SP	deg/sec
Maximum pitch rate for Region 4 negative pitch rate phase initiation	Q_REG4_MAX	I-LOAD	SP	deg/sec
Maximum pitch rate for Region 3 ET separation	Q_SEP_MAX	I-LOAD	SP	deg/sec
RCS 1/2 manifold jet inhibit discrete	RCS_1/2_ALL_JET_INHIBIT	ABT OMS/RCS CONN	D	N/A
RCS 3/4/5 manifold jet inhibit discrete	RCS_3/4/5_ALL_JET_INHIBIT	ABT OMS/RCS CONN	D	N/A
Minimum pitch error signal for Region 3-to-Region 4 transition	REG4_ERR	I-LOAD	SP	deg/sec
Contingency 3 engine out region index	REGION	CONT 3EO MODE SEL TSK	I	N/A
Navigation earth-relative velocity magnitude	REL_VEL_MAG	ASC UPP RTL5 UPP	SP	ft/sec
Maximum roll error for MM602 transition	ROLL_602_ERR	I-LOAD	SP	deg
Yaw rate threshold for immediate MM602 transition	R_MINUS_Z_MAX	I-LOAD	SP	deg/sec
Current Shuttle position vector in M50 coordinates	R_NAV	ASC UPP RTL5 UPP	DP	ft
Yaw rate, orbiter rate gyro	R_ORB	SF (ORB RGA)	SP	deg/sec
Minimum Region 3 maneuver time before Region 3-to-Region 4 transition check	T_CHK_REG4	I-LOAD	SP	sec
Latest MET at which to initiate OMS dump in first stage	T_DMP_LAST	I-LOAD	SP	sec
Actual GMT time of external tank separation	T_ET_SEP	MSC	DP	sec
Maximum time for Region 2 negative pitch rate phase before ET separation	T_REG2_PITCH	I-LOAD	SP	sec
Earth relative velocity vector in M50 coordinates	V_RHO	ASC UPP RTL5 UPP	SP	ft/sec

Table 4.10.1-1. Contingency 3EO Guidance Task Inputs				
Definition	Symbol	Source	Precision	Units
Commanded body pitch rate during Region 3 maneuvers	WCB2_3EO	I-LOAD	SP	deg/sec

Table 4.10.1-2. Contingency 3EO Guidance Task Outputs				
Definition	Symbol	Destination	Precision	Units
Contingency MPS settling burn arm flag	ARM_CONT_MPS_SETTLING_BURN	ABT CNTL SEQ	D	N/A
ET separation -Z timer for 3E/O contingency aborts translation	CONT_3EO_PR_DELAY	GRTLS DAP	SP	sec
Contingency attitude hold discrete	CONT_ATT_HOLD	G/C STEER	D	N/A
MM602 transition discrete	CONT_SEP_CPLT	GRTLS DAP	D	N/A
Discrete enabling extended -Z translation for contingency aborts	CONT_EXT_MINUSZ_ENA	GRTLS DAP	D	N/A
RCS +X jets on discrete	CONT_RCS_PLUSX_ON	GRTLS DAP	D	N/A
Discrete indicating high level pitch-up is required for ECAL	ECAL_PITCH_UP	GC STEER	D	N/A
Time associated with predicated dynamic pressure	T_DEL	QBAR CALC TSK	SP	sec
Emergency ET separation discrete	EMERG_SEP	TLM	D	N/A
Discrete to switch to post-ET sep gains	ENTRY_GAINS	G/C STEER	D	N/A
ET separation manual initiate flag	ET_SEP_MAN_INITIATE	ET SEP SEQ	D	N/A
ET separation yaw axis jet inhibit timer	ETSEP_Y_DRIFT	GRTLS DAP	SP	sec
Interconnected dump constraint discrete	FCS_ACCEPT_ICNCT	ABT CNTL SEQ	D	N/A
Forward RCS dump enable discrete	FWD_RCS_DUMP_ENABLE	ASC RCS CMD SOP, OVERRIDE DISP	D	N/A
Attitude hold/zero-rate discrete	FRZ_3EO	G/C STEER	D	N/A
High rate ET separation flag	HIGH_RATE_SEP	G/C STEER	D	N/A
OMS/ RCS interconnect enable discrete	OMS/RCS_I/C_INH/ENA_CMD	OVERRIDE DISP, ABT CNTL SEQ	D	N/A
OMS dump enable discrete	ORBITER_DUMP_ENA	ABT CNTL SEQ, MSC, OVERRIDE SPEC	D	N/A
Region 4 negative pitch rate phase discrete	PCH_CMD_REG4	GRTLS DAP	D	N/A
Mode 2 indicator	MODE_2_INDICATOR	ABT OMS/ RCS CONN	D	N/A
M50-to-commanded body quaternion	Q_GCB_I	G/C STEER	SP	N/A

Table 4.10.1-2. Contingency 3EO Guidance Task Outputs				
Definition	Symbol	Destination	Precision	Units
Contingency 3 engine out region index	REGION	GRTLS DAP, G/C STEER, XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, MSC, TLM	I	N/A
RTLS LO2 fill/drain dump delay time	RTLS_LO_F_D_DELAY	MPS DUMP SEQ	SP	sec
Guidance convergence status indicator	S_UNCONV	ASC ADI PROC	D	N/A
Commanded body pitch rate	WCB2	G/C STEER	SP	deg/sec
Normal acceleration limit for OMS/RCS interconnect termination	CONTINGENCY_NZ_LIM	ABT CNTL SEQ	SP	G
Normal acceleration limit for OMS dump termination	OMS_NZ_LIM	ABT CNTL SEQ	SP	G
Flag indicating OMEs move to mated trim positions	MATED_CG_TRIM	OMS TVC CMD SOP	D	N/A
Desired pitch acceleration for mated coast	QDOT_DESIRED	G/C STEER	SP	deg/ sec ²
Settling burn start flag	SETTLING_BURN_ENA	ABT CNTL SEQ	D	N/A

4.10.2 Contingency 3EO Mode Select Task (CONT 3EO MODE SEL TSK)

The primary purpose of this task is to select an appropriate value for the 3 engine out region index each guidance cycle during powered flight and, if a contingency abort is necessary, set a 3 engine out contingency start flag to initiate a 3 engine out auto contingency maneuver. If a contingency abort is required, this task may also set the RTLS abort declared flag. The 3 engine out region index is passed to the XXXXXX TRAJ 1, XXXXXX TRAJ 2, and RTLS TRAJ 2 displays for the crew to be able to track their contingency abort status if all three engines were to fail at the current time. Each value of the index corresponds to a type of mated-coast maneuver to be executed in the case of a three-engine out contingency abort. The type of maneuver chosen is based on current and predicted values of dynamic pressure (qbar). The different values of the region index correspond to the following ET separation schemes.

<u>Region index</u>	<u>Type of mated-coast maneuver</u>
102 (1st stage only)	Separate during SRB tailoff
1	Attitude independent separation
2	Maneuver to $\beta = 0$ deg, establish -4 deg/sec pitch rate and separate
3	Maneuver to a targeted alpha, $\beta = 0$ deg and separate

During major mode 103, the inertial velocity is monitored. Below an I-loaded velocity, a MECO would constitute a contingency abort. Above a certain inertial velocity, the 3 engine out field is blanked, indicating that a MECO at this point would not require an OPS 6 contingency abort. Between the two velocities, an apogee altitude-velocity curve is constructed based on the current inertial velocity. If the apogee altitude is above this curve, a contingency abort capability is still required and a 3 engine out region index will be calculated. Otherwise, the 3 engine out field is blanked out and no further contingency abort calculations will be performed.

For an RTLS trajectory (SMODE = 5), a check is made on the downrange velocity to see if the vehicle is heading away from the landing site. If this is the case, a 3 engine out region index is calculated. If the vehicle is heading back towards the landing site, and the current range to the MECO R-V line is greater than an I-loaded value, a 3 engine out region index is calculated. Otherwise, an intact abort is possible and the 3 engine out field is blanked.

The 3 engine out region index is initialized to -1 upon transition to OPS 101. If this task is called prior to SRB separation, the 3 engine out region index is set to 102 and the 3 engine out contingency start flag is set. This will invoke the contingency portion of the three engine out guidance software and this task is no longer executed. After SRB separation, on every pass that the 3 engine out region index is calculated, a check is made to see if MECO confirmed has occurred. If so, a check is made to see if the major mode is 103. If so, an RTLS is automatically invoked to transition to major mode 601. A 3 engine out contingency start flag is then set to execute the contingency maneuver. Once this flag has been set, this task is no longer executed.

A. Detailed Requirements.

1. Check for three engines out in first stage.

If MM102 = ON, perform the following. Otherwise, proceed to Step 2.

CONT_3EO_START = ON

REGION = 102

Exit this task.

2. Store the current value of vertical acceleration. Also, check to see if this is an RTLS abort.

$G = G_GRAV + VI_MAG^{**2} / ABVAL (R_NAV)$

If SMODE = 5, proceed to Step 5.

If the inertial velocity is greater than an I-loaded value, set the 3 engine out region index to zero to indicate that a contingency abort capability is no longer required.

If VI_MAG > VI_3EO_MAX, perform the following. Otherwise, proceed to Step 3.

REGION = 0

This will blank the 3 engine out contingency region field on the XXXXXX TRAJ 1, XXXXXX TRAJ 2, and RTLS TRAJ 2 displays.

Exit this task.

3. If the inertial velocity is greater than an I-loaded value, construct an altitude-velocity curve and compute an apogee altitude based on the current altitude and altitude rate.

If VI_MAG > VI_3EO_MIN, perform the following. Otherwise, proceed to Step 6.

$ALT_REF = C1_3EO VI_MAG^2 + C2_3EO VI_MAG + C3_3EO$

$ALT_APOGEE = ALT - H_DOT^2 / (2 G)$

Proceed to Step 4.

4. If the apogee altitude is less than the corresponding altitude from the altitude-velocity line, set the 3 engine out region index to zero indicating that a contingency abort capability is no longer needed.

If ALT_APOGEE < ALT_REF, perform the following. Otherwise, proceed to Step 6.

REGION = 0

This will blank the 3 engine out contingency region field on the XXXXXX TRAJ 1, XXXXXX TRAJ 2, and RTLS TRAJ 2 displays.

Exit this task.

5. If the vehicle is heading back towards the landing site, compare the range difference of the predicted range and the range to runway with a minimum acceptable range difference for an intact RTLS abort.

If $V_HORIZ_DNRNG < 0$ and $DELTA_R > DEL_R_USP$, perform the following.
Otherwise, proceed to Step 6.

REGION = 0

This will blank the 3 engine out contingency region field on the RTLS TRAJ 2 display.

6. If the REGION index has been set to zero (REGION = 0), exit this task. This indicates that the vehicle has enough energy to not require an OPS 6 contingency abort maneuver. Otherwise, proceed to Step 7.
7. If $H_DOT \leq 0$, set $Q_BAR_MIN = Q_BAR_A$ and proceed to Step 8. Otherwise, calculate the minimum dynamic pressure as follows:

$$T_DEL = -H_DOT/G$$

Call the QBAR CALC TSK

$$Q_BAR_MIN = QBAR_PRED$$

Proceed to Step 8.

8. Check the minimum QBAR and the HIGH_RATE_SEP flag to determine if a high dynamic pressure type of ET separation (Region 3) is required.

If $Q_BAR_MIN > QBAR_REG3$ and $HIGH_RATE_SEP = OFF$, perform the following.
Otherwise, proceed to step 9.

REGION = 3

Proceed to Step 10.

9. Check if a high rate type ET separation (Region 2) is possible, based on the current state of the vehicle. If the conditions for a Region 2 maneuver are not met, Region 1 is selected.

If $(H_DOT < HDOT_REG2$ and $ALPHA_N > ALPHA_REG2$ and $Q_BAR_A > QBAR_REG1)$ or $HIGH_RATE_SEP = ON$, set
REGION = 2 and proceed to Step 10. Otherwise, set
REGION = 1 and proceed to Step 10.

10. This step commands the 3 E/O auto contingency maneuver. If this step is reached and MECO confirmed has occurred, the contingency 3 E/O start flag is set. Along with the start flag, if the current major mode is 103, RTLS abort is automatically declared. This permits all 3 E/O auto contingency maneuvers to be performed in major mode 601 (utilizing the GRTLS DAP for flight control).

If $\dot{M}E\dot{C}O_CONFIRMED = ON$, perform the following. Otherwise, exit this task.

If $\dot{M}M103 = ON$, set $\dot{R}T\dot{L}S_ABORT_DECLARED = ON$. This will cause a transition to MM601.

$\dot{C}O\dot{N}T_3EO_START = ON$

Exit this task.

- B. Interface Requirements. The input and output parameters for the contingency three-engine out mode select task are given in Tables 4.10.2-1 and 4.10.2-2.
- C. Processing Requirements. None.
- D. Initialization Requirements. Upon transition to OPS 101 initialize the following parameters.

$\dot{C}O\dot{N}T_3EO_START = OFF$

REGION = -1

ALT_APOGEE = 0

ALT_REF = 0

Table 4.10.2-1. Contingency 3EO Mode Select Task Inputs				
Definition	Symbol	Source	Precision	Units
NAV angle of attack	ALPHA_N	A/E ATT PROC	SP	deg
Minimum angle of attack for region 2 type ET separation	ALPHA_REG2	I-LOAD	SP	deg
Current orbiter altitude above reference ellipsoid	ALT	ASC UPP RTLS UPP	SP	ft
Coefficient required to construct apogee altitude-velocity curve	C1_3EO	I-LOAD	SP	sec ² /ft
Coefficient required to construct apogee altitude-velocity curve	C2_3EO	I-LOAD	SP	sec
Coefficient required to construct apogee altitude-velocity curve	C3_3EO	I-LOAD	SP	ft
Range to the RTLS TRAJ MECO cutoff tic	DELTA_R	XXXXXX TRAJ DIP	SP	nmi
Delta range (underspeed) to MECO cutoff tic boundary that requires CONT 3E/O GUID	DEL_R_USP	I-LOAD	SP	nmi
Acceleration due to gravity	G_GRAV	I-LOAD	SP	ft/sec ²
Estimated altitude rate	H_DOT	ASC UPP RTLS UPP	SP	fps
MECO confirmation discrete	M \dot{E} CO_CONFIRMED	SSME OPS	D	N/A
MM 102 flag	M \dot{M} 102	MSC	D	N/A
MM 103 flag	M \dot{M} 103	MSC	D	N/A
Qbar boundary for region 1 type ET separation	QBAR_REG1	I-LOAD	SP	lb/ft ²
High qbar boundary for Region 3 type ET separation	QBAR_REG3	I-LOAD	SP	lb/ft ²
Dynamic pressure	Q_BAR_A	ASC UPP RTLS UPP	SP	lb/ft ²
Current Shuttle position vector in M50	R_N \bar{A} V	RTLS UPP ASC UPP	DP	ft
PEG mode indicator	SMODE	RTLS INIT TSK ASC GUID TSK	I	N/A
Inertial velocity above which contingency abort capability is not required	VI_3EO_MAX	I-LOAD	SP	ft/sec
Inertial velocity below which contingency abort capability is required	VI_3EO_MIN	I-LOAD	SP	ft/sec
Current vehicle inertial velocity	VI_MAG	ASC UPP, RTLS UPP	SP	ft/sec
Downrange horizontal earth relative velocity	V_HORIZ_DNRNG	RTLS UPP	SP	ft/sec
Predicted dynamic pressure	QBAR_PRED	QBAR CALC TSK	SP	lb/ft ²
Maximum HDOT for Region 2 maneuvers	HDOT_REG2	I-LOAD	SP	ft/sec

Table 4.10.2-1. Contingency 3EO Mode Select Task Inputs				
Definition	Symbol	Source	Precision	Units
High rate ET separation flag	HIGH_RATE_SEP	CONT MODE 2 TSK, CONT MODE 3 TSK	BD	N/A

Table 4.10.2-2. Contingency 3EO Mode Select Task Outputs				
Definition	Symbol	Destination	Precision	Units
Contingency 3 engine out start discrete	CONT_3EO_START	CONT 3E/O GUID TSK, XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, MSC, GRTLS DAP, TLM, G/C STEER, ET SEP SEQ, ABT CNTL SEQ, A/E ATT PROC, HORIZ SIT DISP, HORIZ SIT SPEC	D	N/A
Contingency 3 engine out region index	REGION	XXXXXX TRAJ 1 DISP, XXXXXX TRAJ 2 DISP, RTLS TRAJ 2 DISP, MSC, TLM, CONT 3EO GUID TSK, G/C STEER, GRTLS DAP	I	N/A
RTLS abort declared discrete	RTLS_ABORT_ DECLARED	MSC, XXXXXX TRAJ DIP, MPS DUMP SEQ, SSME OPS, ET SEP SEQ, ABT CNTL SEQ, MPS TVC CMD SOP, MEDS FC GNC XFER	D	N/A
Predicted 3 E/O apogee altitude	ALT_APOGEE	TLM	SP	ft
Reference altitude for 3 E/O contingency aborts	ALT_REF	TLM	SP	ft
Computed vertical acceleration	G	QBAR CALC TSK, CONT 3EO GUID TSK	SP	ft/sec ²
Time associated with predicted dynamic pressure	T_DEL	QBAR CALC TSK	SP	sec

4.10.3 QBAR Calculation Task (QBAR CALC TSK)

This task calculates the predicted dynamic pressure on the vehicle at a given delta time in the future based on the current vehicle state. A ballistic trajectory is assumed with no aerodynamic forces. The same exponential atmosphere used by the Ascent/ RTLS User Parameter Processors is used here to determine density. This task utilizes the vertical acceleration computed in the CONT 3EO MODE SEL TSK.

A. Detailed Requirements.

1. Propagate the current altitude, altitude rate, and squared relative velocity forward T_DEL seconds into the future using simple equations of motion. Also initialize the altitude table lookup index.

$$H_DOT_PRED = H_DOT + G T_DEL$$

$$ALT_PRED = ALT + H_DOT T_DEL + 0.5 G T_DEL^{**2}$$

$$REL_VEL_PRED2 = REL_VEL_MAG^{**2} - H_DOT^{**2} + H_DOT_PRED^{**2}$$

$$I = 1$$

2. Search the altitude table until the table value exceeds the predicted altitude.

If $ALT_PRED < ALT_TAB_I$ or $I = IMAX$, then proceed to Step 3.

Otherwise, set $I = I + 1$ and repeat this step.

3. Compute the density and dynamic pressure using the index from Step 2 and the base density and scale height tables.

$$RHO_A = RHO_B_I \quad EXP(-ALT_PRED / ALT_S_I)$$

$$QBAR_PRED = 0.5 \quad RHO_A \quad REL_VEL_PRED2$$

B. Interface Requirements. The input and output parameters for the qbar calculation task are given in Tables 4.10.3-1 and 4.10.3-2.

C. Processing Requirements. None.

D. Initialization Requirements. None.

Table 4.10.3-1. QBAR Calculation Task Inputs				
Definition	Symbol	Source	Precision	Units
Altitude above reference ellipsoid	ALT	ASC UPP RTLS UPP	SP	ft
Exponential altitude scale height table	ALT_S ₁ (I =1,7)	I-LOAD	SP	ft
Altitude region table	ALT_TAB ₁ (I =1,7)	I-LOAD	SP	ft
Number of altitude regions	IMAX	K-LOAD	I	N/A
Computed vertical acceleration	G	CONT 3EO MODE SEL TSK	SP	ft/sec ²
Estimated altitude rate	H_DOT	ASC UPP RTLS UPP	SP	ft/sec
Magnitude of vehicle relative velocity	REL_VEL_MAG	ASC UPP RTLS UPP	SP	ft/sec
Exponential atmosphere base density table	RHO_B ₁ (I = 1,7)	I-LOAD	SP	slug/ft ³
Time associated with predicted dynamic pressure	T_DEL	CONT 3EO MODE SEL TSK, CONT 3EO GUID TSK	SP	sec

Table 4.10.3-2. QBAR Calculation Task Outputs				
Definition	Symbol	Destination	Precision	Units
Predicted dynamic pressure	QBAR_PRED	CONT 3EO MODE SEL TSK, CONT 3EO GUID TSK	SP	lb/ft ²

4.10.4 Parameter Tables for Contingency 3 E/O Guidance

The IDD inputs and outputs are listed in Table 4.10.4-1 and Table 4.10.4-2 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 4.10.4-3. K-loads are listed in Table 4.10.4-4. Constants are listed in Table 4.10.4-5. The input/ output variable cross-references are listed below.

Contingency 3 E/O Guidance Input Variable Cross-Reference

MSID	Local Name	Source Name
V95H0185C, 6C, 7C	$R_{\bar{N}AV}$	R_AVGG (1), (2), (3)
V94L0510C	VI_MAG	V_INERTIAL_MAG
V90X8158X	$MM\dot{1}02$	MM_102/MM_CODE_102
V90X8156X	$MM\dot{1}03$	MM_103/MM_CODE_103
V95W0200C	T_NAV	T_STATE
V90W8320C	OMS_EQV_ON_TIME	T1
V95L0190C, 1C, 2C	$V_{\bar{N}AV}$	V_AVGG (1), (2), (3)
V95U0507C, 8C, 9C	\bar{R}_{LS_M50}	R_M50_AT_LIFTOFF(1)(2)(3)

Contingency 3 E/O Guidance Output Variable Cross-Reference

MSID	Local Name	Destination Name
V90J0108C	REGION	CONT_3EO_REGION

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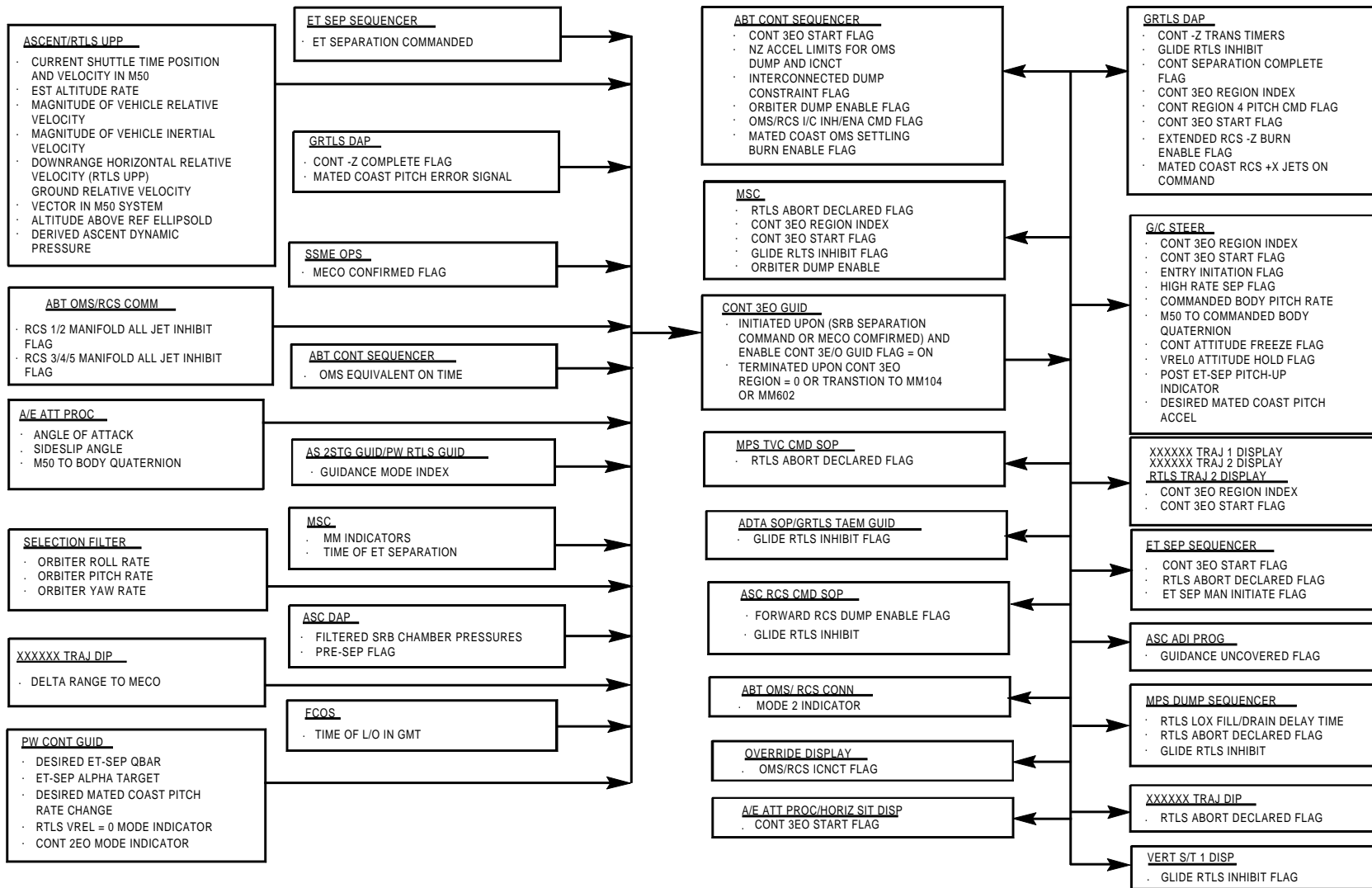


FIGURE 4.10-3. Contingency 3 E/O Guidance Principal Function Data Flow

TABLE 4.10.4-1. INPUT FUNCTIONAL PARAMETERS FOR CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALFA_SEP_MIN	V90H3297C	MINIMUM ANGLE-OF-ATTACK FOR ET SEP	PW CONT GUID	DEG	SPL		92504G	
ALPHA_N	V90H2246C	NAV DERIVED ANGLE OF ATTACK	A/E ATT PROC	DEG	SPL		93017G	*
ALT	V95H0175CA	CURR ORB ALT ABOVE REF ELLIPSOID	RTLS UPP	FT	SPL		93017G	*
ALT	V95H0175CB	CURR ORB ALT ABOVE REF ELLIPSOID	ASC UPP	FT	SPL		93017G	*
BETA_N	V90H2249C	INERTIAL SIDESLIP ANGLE	A/E ATT PROC	DEG	SPL		93017G	*
CONT_2EO_MODE	V90J2077C	CONTINGENCY 2-ENG OUT MODE INDEX	PW CONT GUID		HXS		93017G	*
CONT_MINUS_Z_COMPL	V90X7002X	CONTINGENCY MINUS Z COMPLETE FLAG	GRTLS DAP		BD		90705H	
DELTA_Q_RAMP	V90R3295C	DESIRED MC PITCH RATE CHANGE	PW CONT GUID	DEG/S	SPL		92504G	
DELTA_R	V90H6981C	RANGE TO RTLS MECO TARGET LINE	XXXXXX TRAJ DIP	NM			90705H	
DPJET_MC	V90R0917C	CONT GRTLS DAP PITCH ERR SIGNAL	GRTLS DAP	DEG/S	SPL		93017G	*
ET_SEP_CMD	V90X8250X	ET SEPARATION CMD FLAG	ET SEP SEQ		BD		93017G	*
ET_SEP_MAN_INITIATE	V90X8584XA	ET SEP MAN INITIATE FLAG	SSME OPS		BD		90964	
ET_SEP_MAN_INITIATE	V90X8584XB	ET SEP MAN INITIATE FLAG	PW CONT GUID		BD		90964	
ET_SEP_MAN_INITIATE	V90X8584XD	ET SEP MAN INITIATE FLAG	ET SEP SEQ		BD		90964	
HIGH_RATE_SEP	V90X6989X	HIGH RATE ET SEPARATION FLAG	PW CONT GUID		BD		90705H	
H_DOT_ELLIPSOID/H_DOT	V95L0265CA	EST ALTITUDE RATE	RTLS UPP	FT/S	SPL		93017G	*
H_DOT_ELLIPSOID/H_DOT	V95L0265CE	EST ALTITUDE RATE	ASC UPP	FT/S			93012D	
MANUAL_OMS_DT	V99U9717C	MANUAL OMS DUMP TIMER	UL	S	SPL	S	92175D	
MANUAL_OMS_DT	V99U9717CA	MANUAL OMS DUMP TIMER	OVERRIDE SPEC	S			92175D	
MECO_CONFIRMED	V90X8561X	MECO CONFIRMED FLAG	SSME OPS		BD		93017G	*
MM_CODE_102/MM_102	V90X8158X	MAJOR MODE 102 FLAG	MSC				93012D	
MM_CODE_103/MM_103	V90X8156X	MAJOR MODE 103 FLAG	MSC				93012D	
NEAR_VREL0_MODE	V90X3238X	NEAR RTLS VREL=0 CONTINGENCY FLAG	PW CONT GUID		BD		92504G	
PC4F	V90P0907C	FILTERED LEFT PRESS SRB CHAMBER	ASC DAP		PSIA		90705H	
PC5F	V90P0908C	FILTERED RIGHT PRESS SRB CHAMBER	ASC DAP		PSIA		90705H	
PRE_SEP	V90X0906X	PRE-SEP INDICATOR	ASC DAP		BD		90705H	
P_ORB	V90R5301CA	SELECTED RGA ROLL RATE	SF	DEG/S			93017G	*
QBAR_SEP_DESIRED	V90P3296C	DESIRED ET SEP DYNAMIC PRESSURE	PW CONT GUID	LB/FT2	SPL		92504G	
Q_BAR_A	V95P0500C	DERIVED ASCENT DYNAMIC PRESS	ASC UPP	LB/FT2	SPL		93017G	*
Q_BAR_A	V95P0500CA	DERIVED ASCENT DYNAMIC PRESS	RTLS UPP	LB/FT2	SPL		93017G	*
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	*
Q_ORB/Q	V90R5321CA	SELECTED RGA PITCH RATE	SF	DEG/S			93017G	*
REL_VEL_MAG	V95L0151CA	GND REL VEL MAGNITUDE IN M50 SYS	RTLS UPP	FT/S	SPL		93017G	*
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S			93017G	*
R_AVGG(1)	V95H0185CA	X-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(1)	V95H0185CB	X-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CA	Y-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(2)	V95H0186CB	Y-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CA	Z-COMP OF CUR SHUTTLE POS VCTR M50	RTLS UPP	FT	DPL		93017G	*
R_AVGG(3)	V95H0187CB	Z-COMP OF CUR SHUTTLE POS VCTR M50	ASC UPP	FT	DPL		93017G	*
R_M50_AT_LIFTOFF(1)	V95U0507C	X-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(2)	V95U0508C	Y-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	
R_M50_AT_LIFTOFF(3)	V95U0509C	Z-M50 POS OF NB AT LIFTOFF	ASC UPP	FT			90705H	

TABLE 4.10.4-1. INPUT FUNCTIONAL PARAMETERS FOR CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6)

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE	P R E C	LAST CR	R E V
R_ORB	V90R5341CA	SELECTED RGA YAW RATE	SF	DEG/S			93017G	*
SMODE	V94J3779CA	GUIDANCE MODE INDICATOR	ASC 2STG GUID		HXS		93012D	
SMODE	V94J3779CB	GUIDANCE MODE INDICATOR	PW RTLS GUID		HXS		93012D	
T1	V90W8320C	OMS EQUIVALENT ON TIME	ABT CNTL SEQ	S	SPL		93017G	*
T_ET_SEP	V90W8621C	TIME OF ET SEPARATION	MSC	S			90705H	
T_GMTLO	V90W4380C	TIME OF LIFTOFF IN GMT	FCOS	S			93012D	
T_STATE	V95W0200CC	TIME TAG ASSOC WITH CURRENT STATE	RTLS UPP	S			93017G	*
T_STATE	V95W0200CD	TIME TAG ASSOC WITH CURRENT STATE	ASC UPP	S			93017G	*
V_AVGG(1)	V95L0190CA	X-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(1)	V95L0190CB	X-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CA	Y-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(2)	V95L0191CB	Y-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CA	Z-COMP OF CUR SHUTTLE VEL VCTR M50	RTLS UPP	FT/S	SPL		93017G	*
V_AVGG(3)	V95L0192CB	Z-COMP OF CUR SHUTTLE VEL VCTR M50	ASC UPP	FT/S	SPL		93017G	*
V_HORIZ_DNRNG	V90L0474C	DOWNRANGE HORIZ EARTH REL VEL	RTLS UPP	FT/S			90705H	
V_INERTIAL_MAG	V95L0510CA	MAG OF VEHICLE INERTIAL VELOCITY	ASC UPP	FT/S			93090E	
V_INERTIAL_MAG	V95L0510CB	MAG OF VEHICLE INERTIAL VELOCITY	RTLS UPP	FT/S			93090E	
V_RHO(1)	V95L0215CA	X-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(1)	V95L0215CE	X-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(2)	V95L0216CA	Y-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(2)	V95L0216CE	Y-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
V_RHO(3)	V95L0217CA	Z-COMP OF RELATIVE VEL IN M50	RTLS UPP	FT/S			93090E	
V_RHO(3)	V95L0217CE	Z-COMP OF RELATIVE VEL IN M50	ASC UPP	FT/S			93090E	
	V90X8290X	RCS 1/2 ALL JET INHIBIT FLAG	ABT OMS/RCS CONN		BD		90705H	
	V90X8291X	RCS 3/4/5 ALL JET INHIBIT FLAG	ABT OMS/RCS CONN		BD		90705H	

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

TABLE 4.10.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
ALT_APOGEE	V90H0923C	PREDICTED 3 E/O APOGEE ALTITUDE	DL FMT 21/1	FT	SPL		93017G	*
ALT_REF	V90H0922C	REFERENCE ALTITUDE FOR 3 E/O	DL FMT 21/1	FT	SPL		93017G	*
ARM_CONT_MPS_SETTLING_BURN	V90X3234XA	CONT MPS SETTling BURN ARM FLAG	ABT CNTL SEQ		BD		92672B	
CONTINGENCY_NZ_LIM	V97U9837C	NORMAL ACCEL LIMIT FOR ICNCT	ABT CNTL SEQ	G			91036B	
CONT_3EO_PR_DELAY	V90W0919C	CONT 3 E/O PITCH/ROLL DELAY TIME	GRTLS DAP	SEC			90705H	
CONT_3EO_REGION	V90J0108C	CONTINGENCY 3 E/O REGION INDEX	DL FMT 21/1 G/C STEER GRTLS DAP MSC RTLS TRAJ 2 DISP XXXXXX TRAJ 1 DISP XXXXXX TRAJ 2 DISP				93017G	*
CONT_3EO_START	V90X0909X	CONTINGENCY 3 E/O START FLAG	A/E ATT PROC ABT CNTL SEQ ASC BRG DISP DL FMT 21/1 ET SEP SEQ G/C STEER GRTLS DAP HORIZ SIT DISP HORIZ SIT SPEC MSC RTLS TRAJ 2 DISP XXXXXX TRAJ 1 DISP XXXXXX TRAJ 2 DISP		BD		93017G	*
CONT_ATT_HOLD	V90X3298X	CONTINGENCY ATTITUDE HOLD FLAG	G/C STEER		BD		92504G	
CONT_EXT_MINUSZ_ENA	V90X3235X	CONTINGENCY EXTENDED -Z BURN FLAG	GRTLS DAP		BD		92504G	
CONT_RCS_PLUSX_ON	V90X3236X	CONTINGENCY +X RCS BURN FLAG	GRTLS DAP		BD		92504G	
CONT_SEP_CPLT	V90X0918X	CONTINGENCY SEP COMPLETE FLAG	GRTLS DAP		BD		90705H	
ECAL_PITCH_UP	V90X3237X	ECAL PITCH UP COMMAND	G/C STEER		BD		92504G	
EMERG_SEP	V90X0910X	CONTINGENCY EMERGENCY SEP FLAG	DL FMT 21/1		BD		93017G	*
ENTRY_GAINS	V90X0911X	MNVR TO ENTRY ATTITUDE FLAG	G/C STEER		BD		90705H	
ETSEP_Y_DRIFT	V97U1086C	ETSEP YAW AXIS OPEN LOOP TIME	GRTLS DAP	SEC			90705H	
ET_SEP_MAN_INITIATE	V90X8584XC	ET SEP MAN INITIATE FLAG	ET SEP SEQ		BD		90964	
FCS_ACCEPT_ICNCT	V90X8296XC	INTERCONNECTED DUMP CONSTRAINT	ABT CNTL SEQ				90964	
FRZ_3EO	V90X0912X	CONTINGENCY 3 E/O FREEZE FLAG	G/C STEER		BD		90705H	
FWD_RCS_DUMP_ENABLE	V93X6948XD	FWD RCS DUMP ENABLE	ASC RCS CMD SOP OVERRIDE DISP		BD		90964	

TABLE 4.10.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C	LAST CR	R E V
GLIDE_RTLS_INHIBIT	V90X2090XD	RTLS CONTINGENCY FLAG	ADTA SOP ASC RCS CMD SOP DL FMT 21/1 ENT BRG SPEC GRTLS DAP GRTLS TAEM GUID MEDS FC GNC XFER MPS DUMP MSC VERT SIT1 DISP		BD		93017G	*
HIGH_RATE_SEP	V90X6989XA	HIGH RATE ET SEPARATION FLAG	G/C STEER		BD		90964	
MATED.CG.TRIM	V90X3120XA	MATED COAST C.G. TRIM	OMS TVC CMD SOP		BD		92504G	
MODE_2_INDICATOR	V90X8308XA	MODE 2 INDICATOR	ABT OMS/RCS CONN		BD		90705H	
OMS_NZ_LIM	V99U9697C	NORMAL ACCEL LIMIT FOR OMS DUMP	ABT CNTL SEQ	G			90705H	
ORBITER_DUMP_ENA	V93X6980XC	ORBITER DUMP ENABLE	ABT CNTL SEQ MSC OVERRIDE SPEC		BD		90964	
PCH_CMD_REG4	V90X0913X	PITCH CMD CONT REGION 4 FLAG	GRTLS DAP		BD		90705H	
QDOT_DESIRED	V90A3239C	DESIRED MATED COAST PITCH ACCEL	G/C STEER	DEG/S2	SPL		92504G	
Q_CB_M50(1)/Q_GCB_1	V90U1949CD	M50-TO-CMD BODY QUATERNION ELE 1	G/C STEER				90964	
Q_CB_M50(2)/Q_GCB_2	V90U1950CD	M50-TO-CMD BODY QUATERNION ELE 2	G/C STEER				90964	
Q_CB_M50(3)/Q_GCB_3	V90U1951CD	M50-TO-CMD BODY QUATERNION ELE 3	G/C STEER				90964	
Q_CB_M50(4)/Q_GCB_4	V90U1952CD	M50-TO-CMD BODY QUATERNION ELE 4	G/C STEER				90964	
RTLS_ABORT_DECLARED	V90X8637XC	RTLS ABORT DECLARED	ABT CNTL SEQ ASC BRG DISP ASC BRG SPEC ET SEP SEQ MEDS FC GNC XFER MPS DUMP MPS TVC CMD SOP MSC SSME OPS XXXXXX TRAJ DIP		BD		93167A	*
RTLS_LO_F_D_DELAY	V97U9743C	RTLS LO2 FILL/DRAIN DELAY TIME	MPS DUMP	SEC	SPL		90705H	
SETTLING_BURN_ENA	V90X3240X	SETTLING BURN ENABLE FLAG	ABT CNTL SEQ		BD		92504G	
S_UNCONV	V90X2084XD	PEG UNCONVERGED DSCR IND	ASC ADI PROC		BD		90964	
WCB2	V90R6980CA	COMMANDED BODY PITCH RATE	G/C STEER	DEG/S			90964	
	V93X5348XD	OMS/RCS INTERCONNECT INH/ENA CMD	ABT CNTL SEQ OVERRIDE DISP		BD		90964	
	V99M1855PG	CONT MNVR DISCRETES	DL FMT 21/1				93017G	*

TABLE 4.10.4-2. OUTPUT FUNCTIONAL PARAMETERS FROM CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6)

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 4.10.4-3. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALF_ERR_ECAL	V97U8477C	DEG	F	S	D	P	G4.6	00	A3E	92504G	
ALF_REG4	V97U8501C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
ALF_SEP_ERR	V97U8502C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
ALPHA_602_ERR	V97U8503C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
ALPHA_PPD	V97U4310C	RAD	F	S	D	P	G4.5 G4.6	00	ZF1	93087E	
ALPHA_REG2	V97U8540C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
ALPRECI	V99U5047C	DEG	F	S	M	P	G4.204 G4.6	00	GCA	90705H	
ALPRECL	V99U5049C	DEG	F	S	M	P	G4.204 G4.6	00	GCA	90705H	
ALPRECS	V99U5046C	DEG	F	S	M	P	G4.204 G4.6	00	GCA	90705H	
ALPRECU	V99U5048C	DEG	F	S	M	P	G4.204 G4.6	00	GCA	90705H	
ALT_MIN_102_DUMP	V97U8504C	FT	F	S	D	P	G4.6	00	A3E	90705H	
ALT_S(1)	V97U5706C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(2)	V97U5707C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(3)	V97U5708C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(4)	V97U5709C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(5)	V97U5710C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(6)	V99U6878C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_S(7)	V99U6879C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(1)	V97U5712C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(2)	V97U5713C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(3)	V97U5714C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	

TABLE 4.10.4-3. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
ALT_TAB(4)	V97U5715C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(5)	V97U5716C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(6)	V99U6874C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ALT_TAB(7)	V99U6875C	FT	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
BETA_602_ERR	V97U8505C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
BETA_MAX	V97U8506C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
BETA_REG2	V97U8507C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
BETA_SEP_ERR	V97U8508C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
C1_3EO	V97U8543C	SEC**2/FT	F	S	M	P	G4.6	00	A3E	90705H	
C2_3EO	V97U8542C	SEC	F	S	M	P	G4.6	00	A3E	90705H	
C3_3EO	V97U8541C	FT	F	S	M	P	G4.6	00	A3E	90705H	
CNTPCSP	V97U8509C	PSIA	F	S	D	P	G4.6	00	A3E	90705H	
CONTINGENCY_NZ_LIM	V97U9837C	G	F	S	M	C	G4.192 G4.6	00	QTO	90705H	
CONTINGENCY_NZ_LIM_3EO	V97U8602C	G	F	S	M	P	G4.6	00	A3E	90705H	
CONT_HIGH_SEP_RATE	V97U8434C	DEG/SEC	F	S	D	P	G4.175 G4.5 G4.6	00	ACG	92504G	
CONT_Y_DRIFT	V97U6299C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
DELTA_ALF_REG4	V97U8510C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
DEL_R_USP	V97U8544C	NMI	F	S	D	P	G4.6	00	A3E	90705H	
DT_CONT_ATT_HOLD	V97U6300C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
DT_MIN_Z_102	V97U8511C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
DT_RCS_PLUSX_SEP	V97U8500C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
ENTRY_MNVR_COUNTER	V97U8605C	ND	I	S	D	P	G4.6	00	A3E	90705H	
G_GRAV	V97U8600C	FT/SEC**2	F	S	D	P	G4.6	00	A3E	90705H	
HDOT_REG2	V97U8606C	FT/SEC	F	S	D	P	G4.6	00	A3E	90705H	
MANUAL_OMS_DT	V99U9717C	SEC	F	S	M	C	G4.192 G4.6 G5.21 G6.47	00	QRP	90705H	
MAX_QBAR_MISS	V97U6295C	LB/FT**2	F	S	D	P	G4.6	00	A3E	92504G	
METCNTS	V97U8512C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
MINUS_Z_EXTEND	V97U8478C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
MINUS_Z_REG1	V97U8514C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
MINUS_Z_REG102	V97U8515C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
MINUS_Z_REG2	V97U8516C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
MINUS_Z_REG3	V97U8517C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
MINUS_Z_REG4	V97U8518C	SEC	F	S	D	P	G4.6	00	A3E	90705H	

TABLE 4.10.4-3. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
OMS_NZ_LIM	V99U9697C	G	F	S	M	C	G4.192 G4.6	01 03	QTO QTO	90705H	
OMS_NZ_LIM_3EO	V97U8603C	G	F	S	M	P	G4.6	00	A3E	90705H	
OMS_TIME_DUMP_START	V97U8519C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
PR_602_ERR	V97U8520C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
PR_MAX_REG2	V97U8521C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
PR_REG4_MAX	V97U8522C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
PR_SEP_MAX	V97U8523C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
P_MAX_REG1	V97U8524C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_MAX_601	V97U8525C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_MAX_SEP	V97U8526C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_OMS_DUMP	V97U8607C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_REG1	V97U8545C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_REG3	V97U8546C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QBAR_UPHILL_SEP	V97U8551C	LB/FT**2	F	S	D	P	G4.6	00	A3E	90705H	
QDOT_MAX_MC	V97U6296C	DEG/SEC**2	F	S	D	P	G4.6	00	A3E	92504G	
QORB_MIN_REG2	V97U8527C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
QR_MAX_REG1	V97U8528C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
Q_602_ERR	V97U8529C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
Q_MINUS_Z_MAX	V97U8530C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
Q_REG4_MAX	V97U8531C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
Q_SEP_MAX	V97U8532C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
REG1_MNVR_TIME	V97U8547C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
REG4_ERR	V97U8533C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	
RHO_B(1)	V97U5765C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(2)	V97U5766C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(3)	V97U5767C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(4)	V97U5768C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(5)	V97U5769C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(6)	V99U6876C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
RHO_B(7)	V99U6877C	SLUG/FT**3	F	S	D	C	G4.19 G4.20 G4.6	00	PAE	90705H	
ROLL_602_ERR	V97U8534C	DEG	F	S	D	P	G4.6	00	A3E	90705H	
R_MINUS_Z_MAX	V97U8535C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	

TABLE 4.10.4-3. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) I-LOADS

FSSR NAME	MSID	ENG UNITS	DT	PR	D	S	PR FCTN	MC	CAT	LAST CR	R E V
T_APOGEE	V97U8548C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
T_CHK_REG4	V97U8536C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
T_DEL_MAX	V97U6298C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
T_DEL_MIN	V97U6297C	SEC	F	S	D	P	G4.6	00	A3E	92504G	
T_DMP_LAST	V97U8537C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
T_REG2_PITCH	V97U8538C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
T_RTLS_SEP	V97U8604C	SEC	F	S	D	P	G4.6	00	A3E	90705H	
VI_3EO_MAX	V97U8549C	FT/SEC	F	S	D	P	G4.6	00	A3E	90705H	
VI_3EO_MIN	V97U8550C	FT/SEC	F	S	D	P	G4.6	00	A3E	90705H	
V_RTLS_CNTG	V98U7974C	FT/SEC	F	S	D	P	G4.4 G4.5 G4.6	00	ZF1	90705H	
WCB2_3EO	V97U8539C	DEG/SEC	F	S	D	P	G4.6	00	A3E	90705H	

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

TABLE 4.10.4-4. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) K-LOADS

FSSR NAME DESCRIPTION	MSID	MC	KLOAD VALUE	ENG UNITS	DT	P R	S	PR FCTN	LAST CR	R E V
DT_SEP_CMD DELTA TIME FOR FAST ETSEP COMMAND	V97U6285C	00	+1.44	E+00 SEC	F		S	P G4.6	92504G	
DT_SETL_BURN_STOP DELTA TIME TO SETTLING BURN STOP	V97U6286C	00	+5.0	E-01 SEC	F		S	P G4.6	92504G	
IMAX NO OF ALTITUDE REGIONS	V97U5729C	00	+7	ND	I		S	C G4.19 G4.20 G4.6	90705H	

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

TABLE 4.10.4-5. CONTINGENCY THREE ENGINES OUT GUIDANCE (G4.6) 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	

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

4.11 GUIDANCE AND TARGETING SEQUENCING

The following paragraphs describe briefly the sequencing of principal functions needed to perform guidance and targeting during MM's 104 and 105. Each major mode is divided into three time periods:

1. From entry into the major mode until orbit insertion guidance is started 15 seconds before the desired ignition time.
2. From the start of orbit insertion guidance until the OMS ignition is enabled when the BURN_ENABLE discrete is set to ON.
3. From ignition enabled to the next major mode.

During the first period (before guidance is initiated), AS MNVR DIP is executed cyclically. If either of the S_AOA or S_ATO abort discrettes is ON or is set to ON during this period, AOA/ATO TGT is executed on the first or next guidance cycle before AS MNVR DIP is executed.

During the second period, the guidance and targeting software is sequenced as follows:

1. ASC UPP is executed first.
2. A/E ATT PROC and ORB INS GUID are executed next: either one may be executed first.
3. If either the S_AOA or S_ATO abort discrete is set to ON during this period, AOA/ATO TGT is executed next on the first pass in which the discrete is ON.
4. The AS MNVR DIP is then executed.

In the third period (BURN_ENABLE = ON to the next major mode), the sequencing is the same as in the second period, except that AOA/ATO TGT will not be performed. If either of the abort discrettes is set to ON during this period, and MM = 104, AOA/ATO TGT will be performed on the first guidance cycle of MM 105.

Entry to the next major mode is accomplished by crew action after engine cutoff.

If S_AOA is ON upon entry into MM 105 or is turned on before the BURN_ENABLE discrete is set to ON, AOA/ATO TGT and AS MNVR DIP are executed in the sequences described above. Transfer to OPS 3 can then occur.

In MM 106, only AS MNVR DIP is executed cyclically.

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4.12 ASCENT UPLINKED PARAMETERS MEMORY LOCATION REQUIREMENTS

Table 4.12–1 and Table 4.12–2 describe the detailed requirements for grouping specific uplinked parameters (mostly I-loads) in adjacent locations in memory. For each table, all of the parameters listed are required to be in one block of contiguous memory in the sequence specified. The uplink description headings are included for information only. These parameters are reconfigurable on day of launch due to the measured wind and atmosphere environment, mission rendezvous and/or other mission requirements. The justification for grouping these parameters in contiguous memory locations is to facilitate memory dumps of the parameters for validation of the uplink.

Note: Ordering of the parameters within these tables must match, within each item, the ordering of the corresponding PASS/BFS One Shot items noted in the One Shot Item No. column. (Reference: ICD-2-1S001 Table 11)

Table 4.12-1. Ascent Rendezvous I-load Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
LAUNCH TARGETING LOAD				
T_GMTLO_REF	V99U7442C	UL	ASC UPP, RTLS UPP	N/A
IY_MIN_EF(1)	V96U9388C	UL	AOA/ATO TGT	N/A
IY_MIN_EF(2)	V96U9389C	UL	AOA/ATO TGT	N/A
IY_MIN_EF(3)	V96U9390C	UL	AOA/ATO TGT	N/A
IYD(1)	V97U4413C	UL	ASC 2STG GUID, RTLS UPP, ORB INS GUID, A/E ATT PROC	N/A
IYD(2)	V97U4414C	UL	ASC 2STG GUID, RTLS UPP, ORB INS GUID, A/E ATT PROC	N/A
IYD(3)	V97U4415C	UL	ASC 2STG GUID, RTLS UPP, ORB INS GUID, A/E ATT PROC	N/A
IYD_NOM(1)	V96U9385C	UL	ASC 2STG GUID	N/A
IYD_NOM(2)	V96U9386C	UL	ASC 2STG GUID	N/A
IYD_NOM(3)	V96U9387C	UL	ASC 2STG GUID	N/A
DELTA_PSI	V99U7440C	UL	ASC 1STG GUID, ASC UPP	N/A
DELTA_NODE_PHASE	V97U0932C	UL	ASC UPP	N/A
T_GMTLO_PHASE	V97U0931C	UL	ASC UPP	N/A
LAUNCH TARGETING LOAD OMS TGT				
IYD_OMS1 (1)	V97U4855C	UL	ASC MNVR DIP	N/A
IYD_OMS1 (2)	V97U4856C	UL	ASC MNVR DIP	N/A
IYD_OMS1 (3)	V97U4857C	UL	ASC MNVR DIP	N/A
IYD_OMS2 (1)	V97U4858C	UL	ASC MNVR DIP	N/A
IYD_OMS2 (2)	V97U4859C	UL	ASC MNVR DIP	N/A
IYD_OMS2 (3)	V97U4860C	UL	ASC MNVR DIP	N/A
DTIG_OMS(1)	V97U4367C	UL	ASC MNVR DIP	N/A

Table 4.12-1. Ascent Rendezvous I-load Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
HTGT_OMS(1)	V97U4411C	UL	ASC MNVR DIP	N/A
THETA_OMS(1)	V97U4803C	UL	ASC MNVR DIP	N/A
C1_OMS(1)	V97U4326C	UL	ASC MNVR DIP	N/A
C2_OMS(1)	V97U4342C	UL	ASC MNVR DIP	N/A
DTIG_OMS(2)	V97U4368C	UL	ASC MNVR DIP	N/A
HTGT_OMS(2)	V97U4412C	UL	ASC MNVR DIP	N/A
THETA_OMS(2)	V97U4804C	UL	ASC MNVR DIP	N/A
C1_OMS(2)	V97U4327C	UL	ASC MNVR DIP	N/A
C2_OMS(2)	V97U4343C	UL	ASC MNVR DIP	N/A

Table 4.12-2. Misc Uplinked Parameter Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
OMS ASSIST, ABORT DUMP TIMERS, MASSES, AND VELOCITIES				
OMS_ASSIST	V97U1247C	UL	MSC, ABT CNTL SEQ	14
* FILLER (ONE HALF WORD)				14
ASSIST_OMS_DT	V97U1248C	UL	ABT CNTL SEQ, ASC 2STG GUID	14
ATO_OMS_DT	V97U9798C	UL	ABT CNTL SEQ	14
RTLS_ICNCT_SEL	V99U9991C	UL	ABT CNTL SEQ	14
* FILLER (ONE HALF WORD)				14
RTLS_OMS_DT	V97U9780C	UL	ABT CNTL SEQ	14
MANUAL_OMS_DT	V99U9717C	UL	ABT CNTL SEQ, CONT 3E/O GUID, OVERRIDE DISP	14
TAL_ICNCT_SEL	V99U9992C	UL	ABT CNTL SEQ	14
* FILLER (ONE HALF WORD)				14
TAL_OMS_DT	V97U9786C	UL	ABT CNTL SEQ	14
ENTRY_OMS_FUEL_ BURN_TIME	V99U9571C	UL	ABT CNTL SEQ, OVERRIDE DISP	14
OMS_RCS_INTERCON_ INIT_FU_TIME	V99U9716C	UL	ABT CNTL SEQ	14
OMS_RCS_INTERCON_ TERM_FU_TIME	V99U9952C	UL	ABT CNTL SEQ	14
RTLS_POST_MECO_ RCS_PROP_RCS_X_DT	V97U9785C	UL	OVERRIDE DISP	14

Table 4.12-2. Misc Uplinked Parameter Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
AFT_RCS_DUMP_TIMER	V99U9574C	UL	OVERRIDE DISP	14
FRCS_DUMP_TIMER_OPS1	V97U3751C	UL	OVERRIDE DISP	14
FRCS_DUMP_TIMER_OPS3	V97U3752C	UL	OVERRIDE DISP	14
CONT_OMS_RCS_ ICNCT_TERM_FU_TIME	V99U9718C	UL	ABT CNTL SEQ	N/A
M_EMPTY	V97U8376C	UL	PW CONT GUID	N/A
M	V97U4429C	UL	ASC 1STG GUID	12
MASS_LOW_LEVEL	V97U4432C	UL	ASC 2STG GUID, PW RTLS GUID	12
MASS_OMS_INIT	V97U4434C	UL	AOA/ATO TGT	12
MASS_ORB	V97U4435C	UL	AOA/ATO TGT, ASC MNVR DIP	12
MBO_MIN(1)	V97U4861C	UL	ASC MNVR DIP	12
MBO_MIN(2)	V97U4862C	UL	ASC MNVR DIP	12
MBOD(1)	V97U4438C	UL	PW RTLS GUID	12
MBOD(2)	V97U4439C	UL	PW RTLS GUID	12
EPS_K2	V97U4837C	UL	AOA/ ATO TGT	13
V_LIN	V97U4819C	UL	AOA/ ATO TGT	13
V_ZERO	V97U4825C	UL	AOA/ ATO TGT	13
V_MSSN_CNTN	V96U9392C	UL	AOA/ATO TGT	13
VARIABLE INTACT ABORT THROTTLE LIMIT VELOCITIES				
V_KMAX_DOWN	V97U0603C	UL	ASC 1STG GUID, ASC 2STG GUID, PW RTLS GUID	13
V_KMAX_UP	V97U0604C	UL	ASC 1STG GUID, ASC 2STG GUID, PW RTLS GUID	13
ASCENT PSEUDO AND ATO MECO TARGETS LOAD				
GAMD	V97U4394C	UL	ASC 2STG GUID	16
VDMAG	V97U4828C	UL	ASC 2STG GUID	16
GAMD_ATO	V97U4395C	UL	AOA/ATO TGT	16
VD_ATO	V97U4826C	UL	AOA/ATO TGT	16
RTLS GUIDANCE PARAMETERS LOAD				
TARGET2(1)	V99U8902C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET4(1)	V99U8904C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET6(1)	V99U8906C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET9(1)	V99U8909C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET10(1)	V99U8910C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET11(1)	V99U8911C	UL	ASC 2STG GUID, PW RTLS GUID	17
TARGET12(1)	V99U8912C	UL	ASC 2STG GUID, PW RTLS GUID	17

Table 4.12-2. Misc Uplinked Parameter Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
TARGET14(1)	V98U8497C	UL	ASC 2STG GUID, PW RTLS GUID	17
GRNZC1	V97U0254C	UL	GRTLS TAEM GUID	18
NZSW1	V97U0324C	UL	GRTLS TAEM GUID	18
THROTTLE LEVELS				
THROT(1)	V97U4808C	UL	ASC 1STG GUID	19
THROT(2)	V97U4809C	UL	ASC 1STG GUID	19
THROT(3)	V97U4810C	UL	ASC 1STG GUID	19
THROT(4)	V97U4811C	UL	ASC 1STG GUID	19
THROTTLE VELOCITIES and TREF ADJUST				
QPOLY(1)	V97U4640C	UL	ASC 1STG GUID	19
QPOLY(2)	V97U4641C	UL	ASC 1STG GUID	19
QPOLY(3)	V97U4642C	UL	ASC 1STG GUID	19
QPOLY(4)	V97U4643C	UL	ASC 1STG GUID	19
TREF_ADJUST	V99U7566C	UL	ASC 1STG GUID	19
**FILLER (TWO HALF WORDS)				N/A
GPS SOP TIME ADJUSTMENT LOAD				
T_GPS_TO_GMT_ADJ	V91W0035C	UL	GPS SOP	4
RNP MATRIX TIME PARAMETERS LOAD				
LAUNCH_YEAR	V97U5383C	UL	RNP MAT COMP	4
RNP_DAY	V97U5384C	UL	RNP MAT COMP	4
WIND TABLE				
WNDE_TAB(1)	V99U6349C	UL	ASC 1STG GUID	2
WNDE_TAB(2)	V99U6350C	UL	ASC 1STG GUID	2
WNDE_TAB(3)	V99U6351C	UL	ASC 1STG GUID	2
WNDE_TAB(4)	V99U6352C	UL	ASC 1STG GUID	2
WNDE_TAB(5)	V99U6353C	UL	ASC 1STG GUID	2
WNDE_TAB(6)	V99U6354C	UL	ASC 1STG GUID	2
WNDE_TAB(7)	V99U6355C	UL	ASC 1STG GUID	2
WNDE_TAB(8)	V99U6356C	UL	ASC 1STG GUID	2
WNDN_TAB(1)	V99U6357C	UL	ASC 1STG GUID	2
WNDN_TAB(2)	V99U6358C	UL	ASC 1STG GUID	2
WNDN_TAB(3)	V99U6359C	UL	ASC 1STG GUID	2
WNDN_TAB(4)	V99U6360C	UL	ASC 1STG GUID	2
WNDN_TAB(5)	V99U6361C	UL	ASC 1STG GUID	2

Table 4.12-2. Misc Uplinked Parameter Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
WNDN_TAB(6)	V99U6362C	UL	ASC 1STG GUID	2
WNDN_TAB(7)	V99U6363C	UL	ASC 1STG GUID	2
WNDN_TAB(8)	V99U6364C	UL	ASC 1STG GUID	2
GUIDANCE POLYNOMIAL LOADS (PSI)				
PSI(01)	V97U4516C	UL	ASC 1STG GUID	2
PSI(02)	V97U4520C	UL	ASC 1STG GUID	2
PSI(03)	V97U4524C	UL	ASC 1STG GUID	2
PSI(04)	V97U4528C	UL	ASC 1STG GUID	2
PSI(05)	V97U4532C	UL	ASC 1STG GUID	2
PSI(06)	V97U4536C	UL	ASC 1STG GUID	2
PSI(07)	V97U4540C	UL	ASC 1STG GUID	2
PSI(08)	V97U4544C	UL	ASC 1STG GUID	2
PSI(09)	V97U4548C	UL	ASC 1STG GUID	2
PSI(10)	V97U4552C	UL	ASC 1STG GUID	2
PSI(11)	V97U4556C	UL	ASC 1STG GUID	2
PSI(12)	V97U4560C	UL	ASC 1STG GUID	2
PSI(13)	V97U4564C	UL	ASC 1STG GUID	2
PSI(14)	V97U4568C	UL	ASC 1STG GUID	2
PSI(15)	V97U4572C	UL	ASC 1STG GUID	2
PSI(16)	V97U4576C	UL	ASC 1STG GUID	2
PSI(17)	V97U4580C	UL	ASC 1STG GUID	2
PSI(18)	V97U4584C	UL	ASC 1STG GUID	2
PSI(19)	V97U4588C	UL	ASC 1STG GUID	2
PSI(20)	V97U4592C	UL	ASC 1STG GUID	2
PSI(21)	V97U4596C	UL	ASC 1STG GUID	2
PSI(22)	V97U4600C	UL	ASC 1STG GUID	2
PSI(23)	V97U4604C	UL	ASC 1STG GUID	2
PSI(24)	V97U4608C	UL	ASC 1STG GUID	2
PSI(25)	V97U4612C	UL	ASC 1STG GUID	2
PSI(26)	V97U4616C	UL	ASC 1STG GUID	2
PSI(27)	V97U4620C	UL	ASC 1STG GUID	2
PSI(28)	V97U4624C	UL	ASC 1STG GUID	2
PSI(29)	V97U4628C	UL	ASC 1STG GUID	2
PSI(30)	V97U4632C	UL	ASC 1STG GUID	2

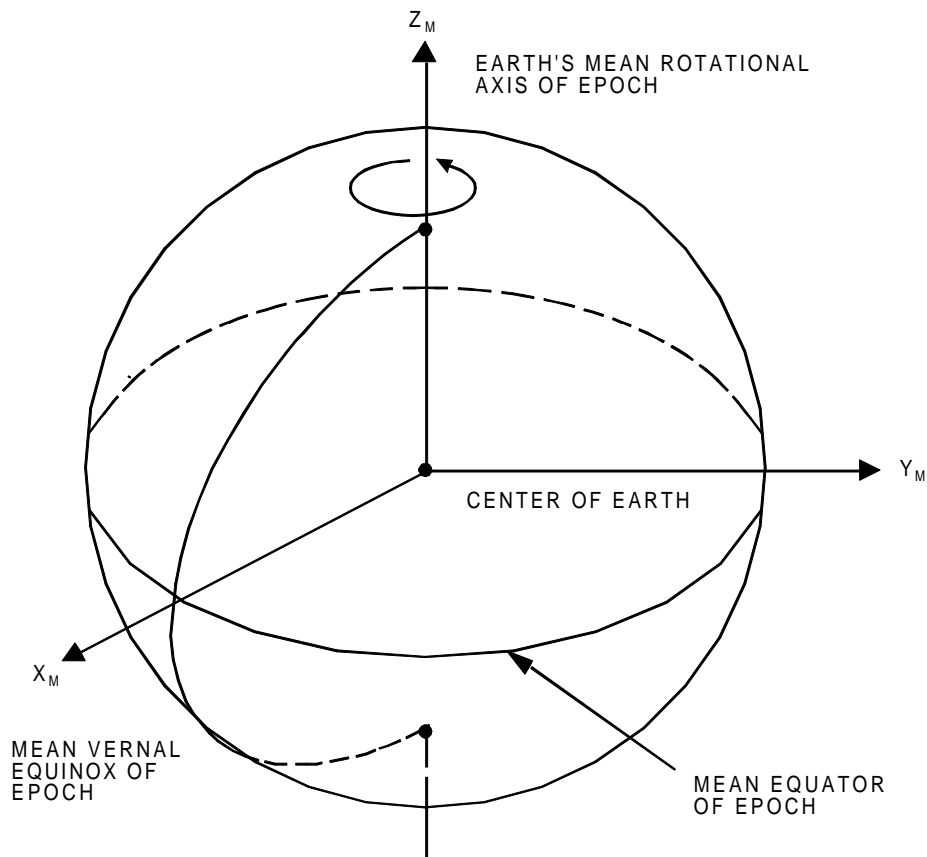
Table 4.12-2. Misc Uplinked Parameter Grouping In Memory For DOL Verification Dump				
FSSR Name	MSID	Source	Destination	One Shot Item No.
GUIDANCE POLYNOMIAL LOADS (THET 1)				
THET(1,01)	V97U4667C	UL	ASC 1STG GUID	3
THET(1,02)	V97U4671C	UL	ASC 1STG GUID	3
THET(1,03)	V97U4675C	UL	ASC 1STG GUID	3
THET(1,04)	V97U4679C	UL	ASC 1STG GUID	3
THET(1,05)	V97U4683C	UL	ASC 1STG GUID	3
THET(1,06)	V97U4687C	UL	ASC 1STG GUID	3
THET(1,07)	V97U4691C	UL	ASC 1STG GUID	3
THET(1,08)	V97U4695C	UL	ASC 1STG GUID	3
THET(1,09)	V97U4699C	UL	ASC 1STG GUID	3
THET(1,10)	V97U4703C	UL	ASC 1STG GUID	3
THET(1,11)	V97U4707C	UL	ASC 1STG GUID	3
THET(1,12)	V97U4711C	UL	ASC 1STG GUID	3
THET(1,13)	V97U4715C	UL	ASC 1STG GUID	3
THET(1,14)	V97U4719C	UL	ASC 1STG GUID	3
THET(1,15)	V97U4723C	UL	ASC 1STG GUID	3
THET(1,16)	V97U4727C	UL	ASC 1STG GUID	3
THET(1,17)	V97U4731C	UL	ASC 1STG GUID	3
THET(1,18)	V97U4735C	UL	ASC 1STG GUID	3
THET(1,19)	V97U4739C	UL	ASC 1STG GUID	3
THET(1,20)	V97U4743C	UL	ASC 1STG GUID	3
THET(1,21)	V97U4747C	UL	ASC 1STG GUID	3
THET(1,22)	V97U4751C	UL	ASC 1STG GUID	3
THET(1,23)	V97U4755C	UL	ASC 1STG GUID	3
THET(1,24)	V97U4759C	UL	ASC 1STG GUID	3
THET(1,25)	V97U4763C	UL	ASC 1STG GUID	3
THET(1,26)	V97U4767C	UL	ASC 1STG GUID	3
THET(1,27)	V97U4771C	UL	ASC 1STG GUID	3
THET(1,28)	V97U4775C	UL	ASC 1STG GUID	3
THET(1,29)	V97U4779C	UL	ASC 1STG GUID	3
THET(1,30)	V97U4783C	UL	ASC 1STG GUID	3
<p>* There will be a one half word gap after discrete parameters because of single precision full-word alignment requirements enforced by the compiler. This gap is filled with a "filler" initialized to zero.</p> <p>** There will be a two half word gap after TREF_ADJUST because of double precision scalar even-full-word alignment requirements enforced by the compiler. This gap is filled with a "filler" initialized to zero.</p>				

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.
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 System	An inertial or quasi-inertial system. That is, any system whose rates of rotation about all axes, relative to any inertial system, are zero.
Rotating System	A reference frame which 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.
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.



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.

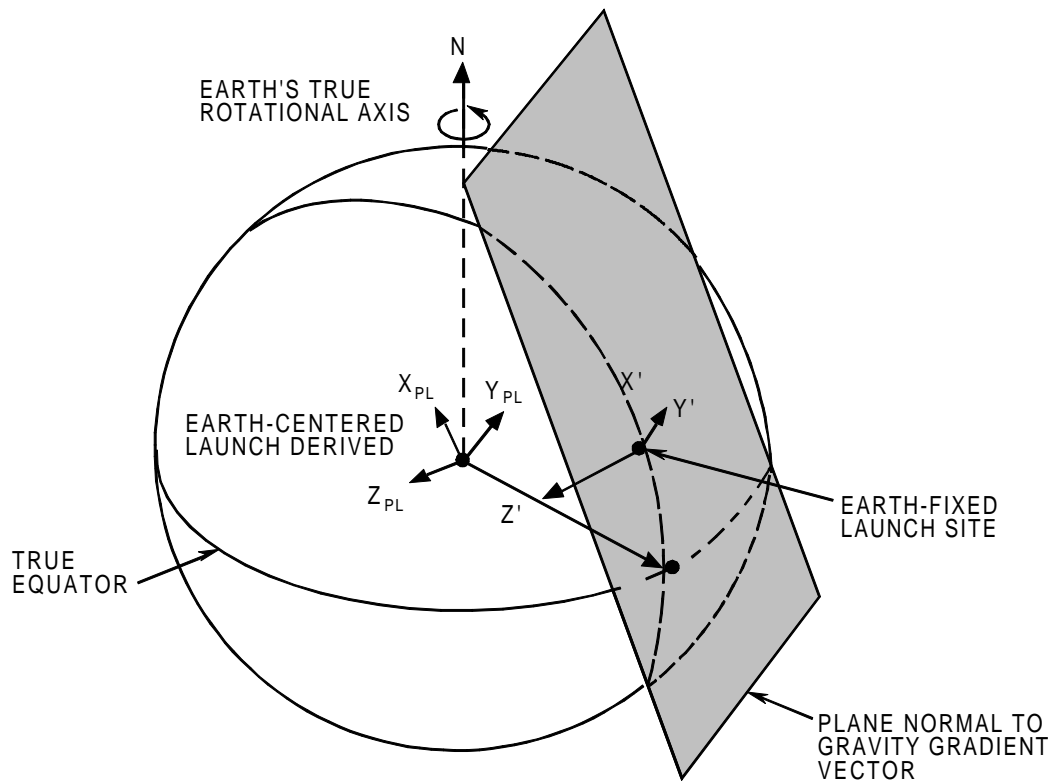
THE X_M AXIS IS DIRECTED TOWARD THE MEAN VERNAL EQUINOX OF EPOCH.

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, Cartesian, Coordinate System



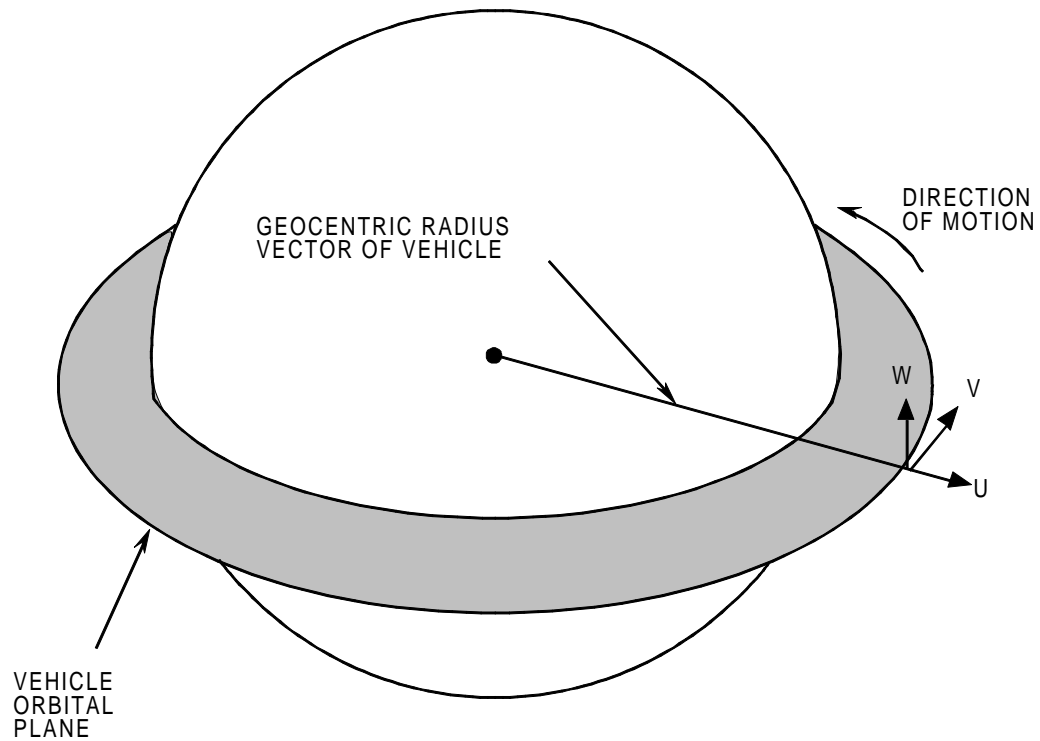
NAME: BOOST REFERENCE COORDINATE SYSTEM.
ORIGIN: AT THE CENTER OF THE EARTH.

ORIENTATION AND DIRECTIONS:

- THE Z_{PL} AXIS IS PARALLEL TO THE GRAVITY GRADIENT (Z') WHICH PASSES THROUGH THE LAUNCH SITE AND IS POSITIVE IN THE DIRECTION OF GRAVITY. THE Z_{PL} AXIS IS FIXED AT A SPECIFICALLY STATED TIME.
- THE X_{PL} AXIS IS PARALLEL TO X' WHICH IS ALONG THE LAUNCH SITE MERIDIAN AND IS POSITIVE NORTHWARD.
- THE Y_{PL} AXIS IS PARALLEL TO THE Y' AND COMPLETES A STANDARD RIGHT-HANDED SYSTEM; I.E., POSITIVE EAST.
- THE $X_{PL} - Y_{PL}$ PLANE IS NORMAL TO THE LAUNCH SITE GRAVITY GRADIENT VECTOR.

CHARACTERISTICS: INERTIAL, RIGHT-HANDED, CARTESIAN.

FIGURE 5.1-2. Boost Reference Coordinate System



NAME: U, V, W COORDINATE SYSTEM.

ORIGIN: POINT OF INTEREST.

ORIENTATION: THE U-V PLANE IS THE INSTANTANEOUS ORBIT PLANE AT EPOCH.

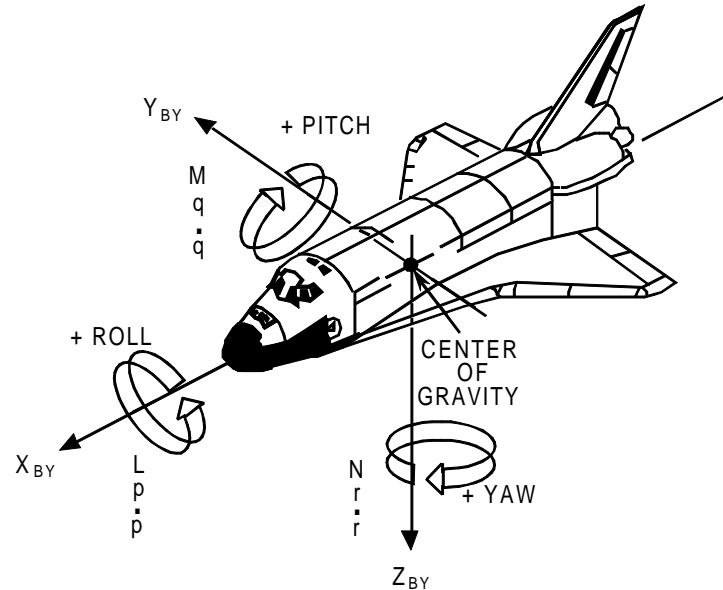
THE U AXIS LIES ALONG THE GEOCENTRIC RADIUS VECTOR TO THE VEHICLE AND IS POSITIVE RADIALLY OUTWARD.

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.

CHARACTERISTICS: 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 5.1-3. U,V,W Coordinate System



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 5.1-4. Body Axis Coordinate System

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5.2 HAL PROGRAMMING LANGUAGE SYNTAX DEFINITIONS

The syntax notations commonly used throughout the document are defined as follows:

$\bar{A} \cdot \bar{B}$	Vector dot product
$\bar{A} \times \bar{B}$	Vector cross product
ABVAL(\bar{A})	Magnitude of vector \bar{A}
UNIT(\bar{A})	Unit vector of vector \bar{A}
EXP(A)	e^A
SIGN(A)	(+1) for a positive or zero value of A, and (-1) for a negative value of A
ABS(A)	Absolute value of A
MIDVAL(A,B,C)	Value of the argument which is between the other two
ROUND(A)	Nearest integral value of A
ARCOS(A)	Arc cosine of A
ARCSIN(A)	Arc sine of A
ARCTAN2(A, B)	Arc tangent of A/B in the proper quadrant
ARCTAN(A)	Arc tangent of A
COS(A)	Cosine of A
LOG(A)	Natural log of A
SIN(A)	Sine of A
SQRT(A)	Square root of A
TAN(A)	Tangent of A
SUM(A)	Sum of all elements of A
MAX(A)	Maximum of all elements of A
MIN(A)	Minimum of all elements of A
SGN(A)	+1, 0, or -1 for A positive, zero, or negative, respectively
INTEGER(A ₁ , A ₂ , A _N)	Array of integers formed from elements of A where A may be any type; e.g., integers, scalar, Boolean, etc.

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SCALAR(A ₁ , A ₂ ,A _N)	Array of scalars formed from elements of A where A may be any type; e.g., integers, scalar, Boolean, etc.
VECTOR(A ₁ , A ₂ , A ₃)	Vector (3) formed by elements of A where A may be integer or scalar type only.
MATRIX(A ₁ , A ₂ ,A _q)	Matrix formed by elements of A where A may be integer, scalar, vector, or matrix-type only.
MOD(A,B)	Remainder of A / B; i.e., MOD(A, B) = A – B truncate (A/B)
TRUNCATE(A)	Rounded low value of A

5.3 ABBREVIATIONS AND ACRONYMS

The abbreviations and acronyms commonly used throughout this document are defined as follows:

AOA	Abort–once–around
ARCS	Aft reaction control system
ATO	Abort–to–orbit
ATR	Current estimated acceleration
c.g.	Center–of–gravity
C/O	Cutoff
CPDS	Computer program development specification
CRT	Cathode ray tube display
DAP	Digital autopilot
DIP	Display interface processing
ΔV	Delta velocity
EI	Entry interface
ET	External tank
FDI	Fault detection and identification
FPL	Full power level (109%)
G	Acceleration due to gravity
G/C	Guidance to control
GN&C	Guidance, navigation, and control
L/O	Lift–off
LTVCON	Linear terminal velocity constraint
M50	Mean of 1950
MECO	Main engine cutoff
MM	Major mode
MPL	Minimum power level (65%)
MPS	Main propulsion system
MSC	Mode, sequencing, and control
OME	Orbital maneuvering engine
OMS	Orbital maneuvering system

OPS	Operational sequence
PBI	Pushbutton indicator
PEG	Powered explicit guidance
PFG	Powered flight guidance
PRO	Crew initiated action
\bar{q}	Dynamic pressure
r	Apogee radius magnitude
RCS	Reaction control system
RPL	Rated power level (100%)
RTLS	Return-to-launch-site
SOP	Subsystem operating program
SRB	Solid rocket booster
SSME	Space Shuttle main engine
TB	Burn time
TGO	Time-to-go
TIG	Time of ignition
TVC	Thrust vector control
UPP	User parameter processor
VGO	Velocity-to-be-gained

APPENDIX A DETAILED FLOW CHARTS

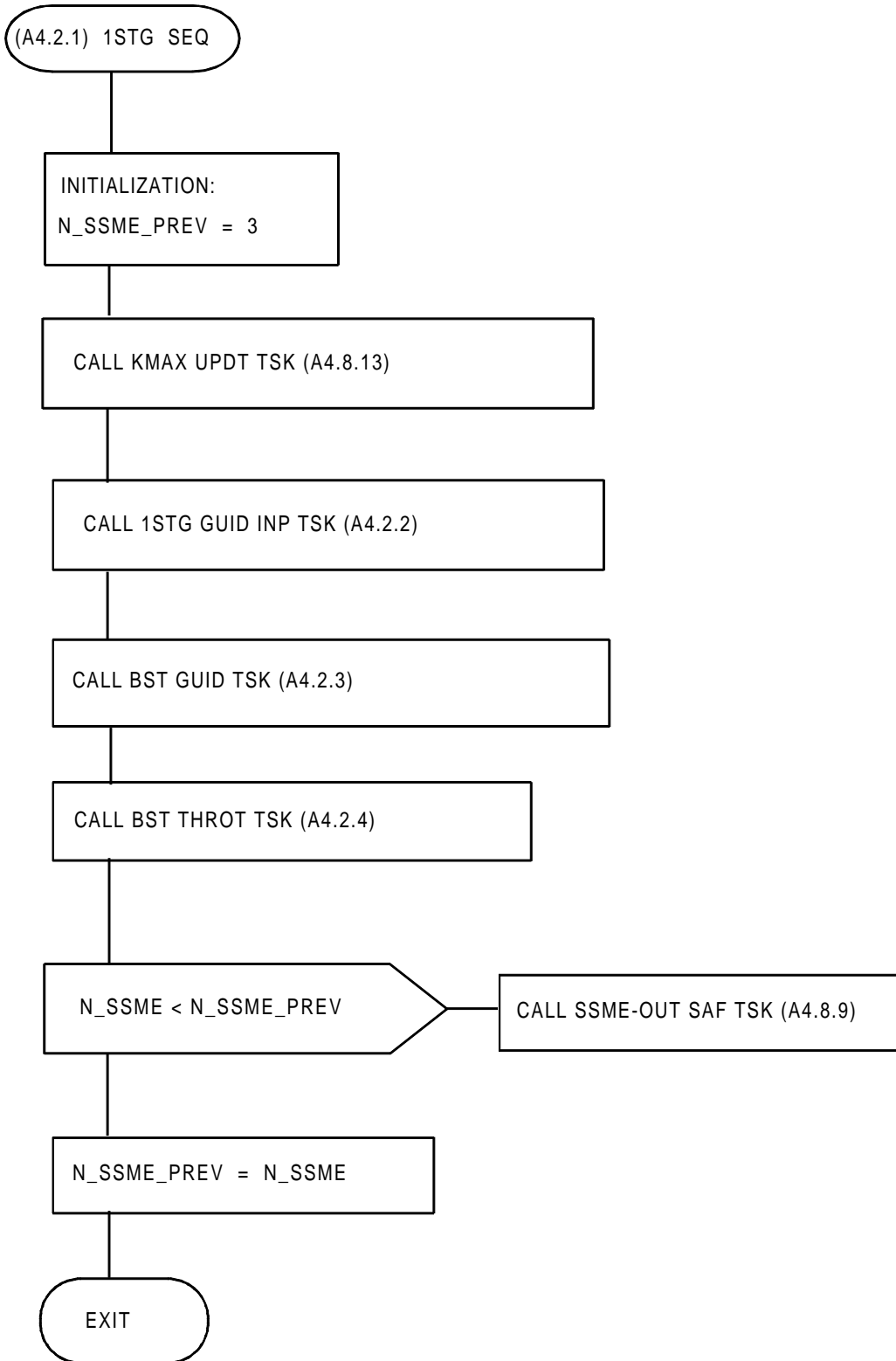


FIGURE A4.2.1. 1STG SEQ Flow Diagram

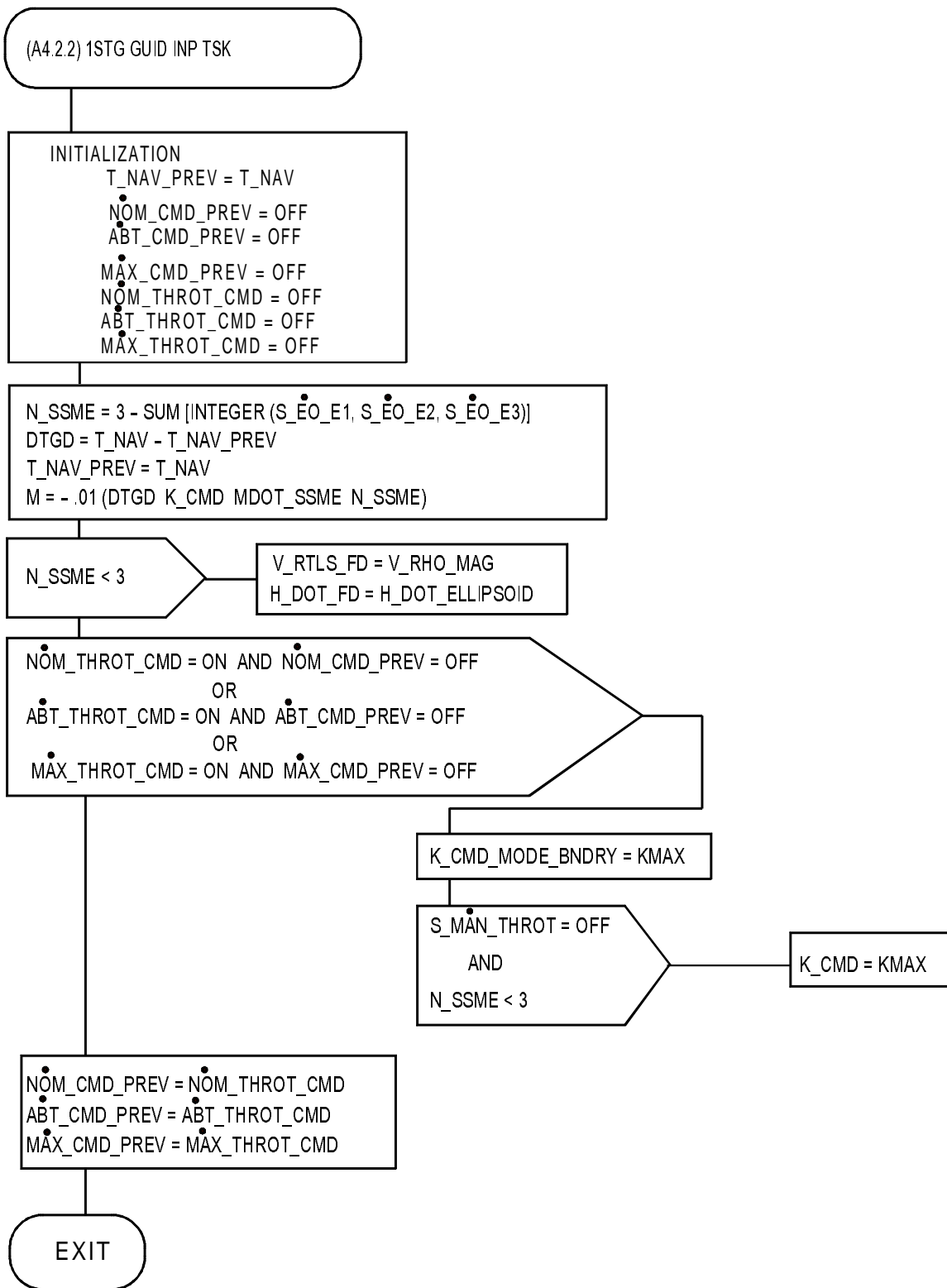


FIGURE A4.2.2. 1STG GUID INP TSK Flow Diagram

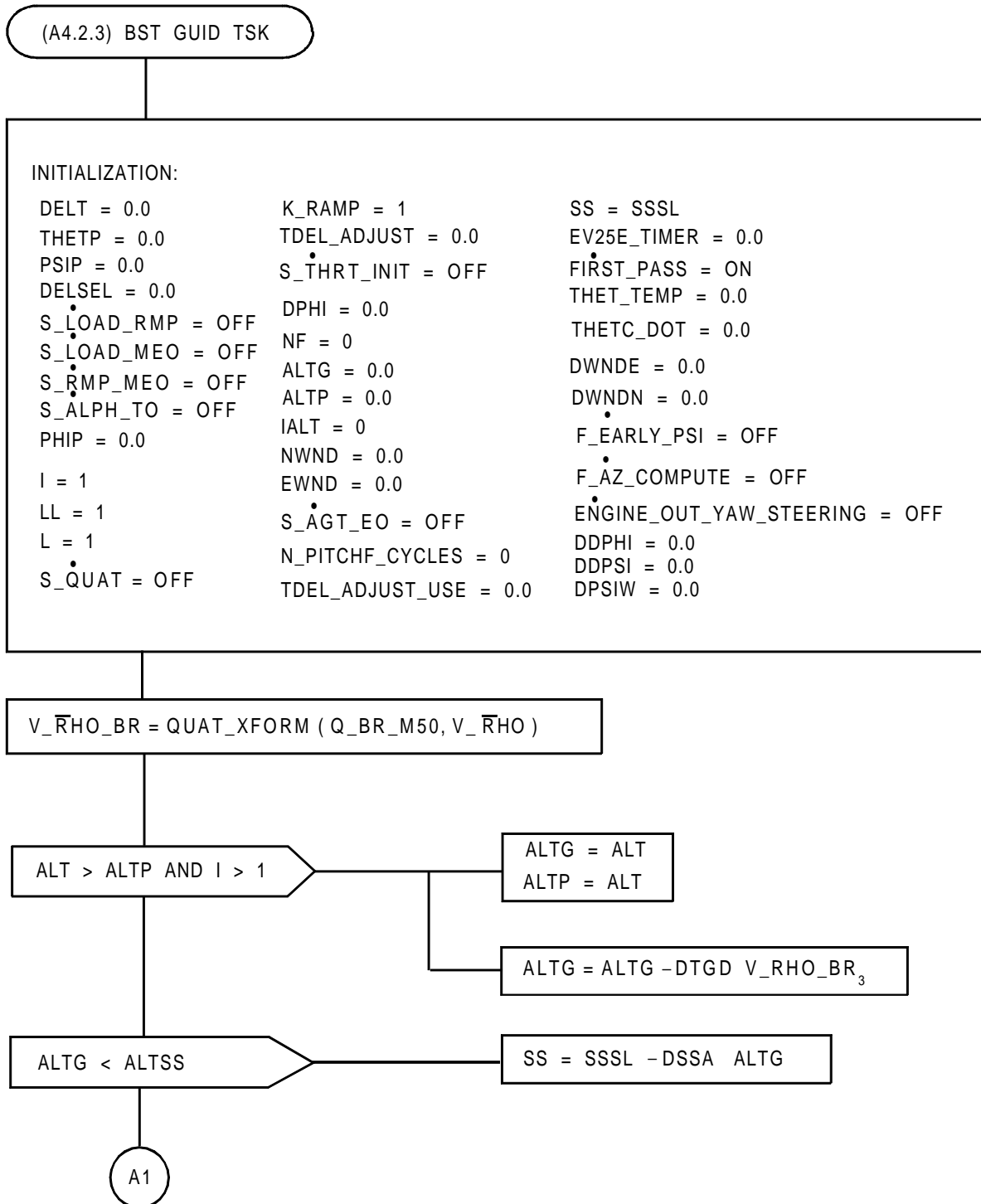


FIGURE A4.2.3.(1) BST GUID TSK Flow Diagram (Sheet 1 of 12)

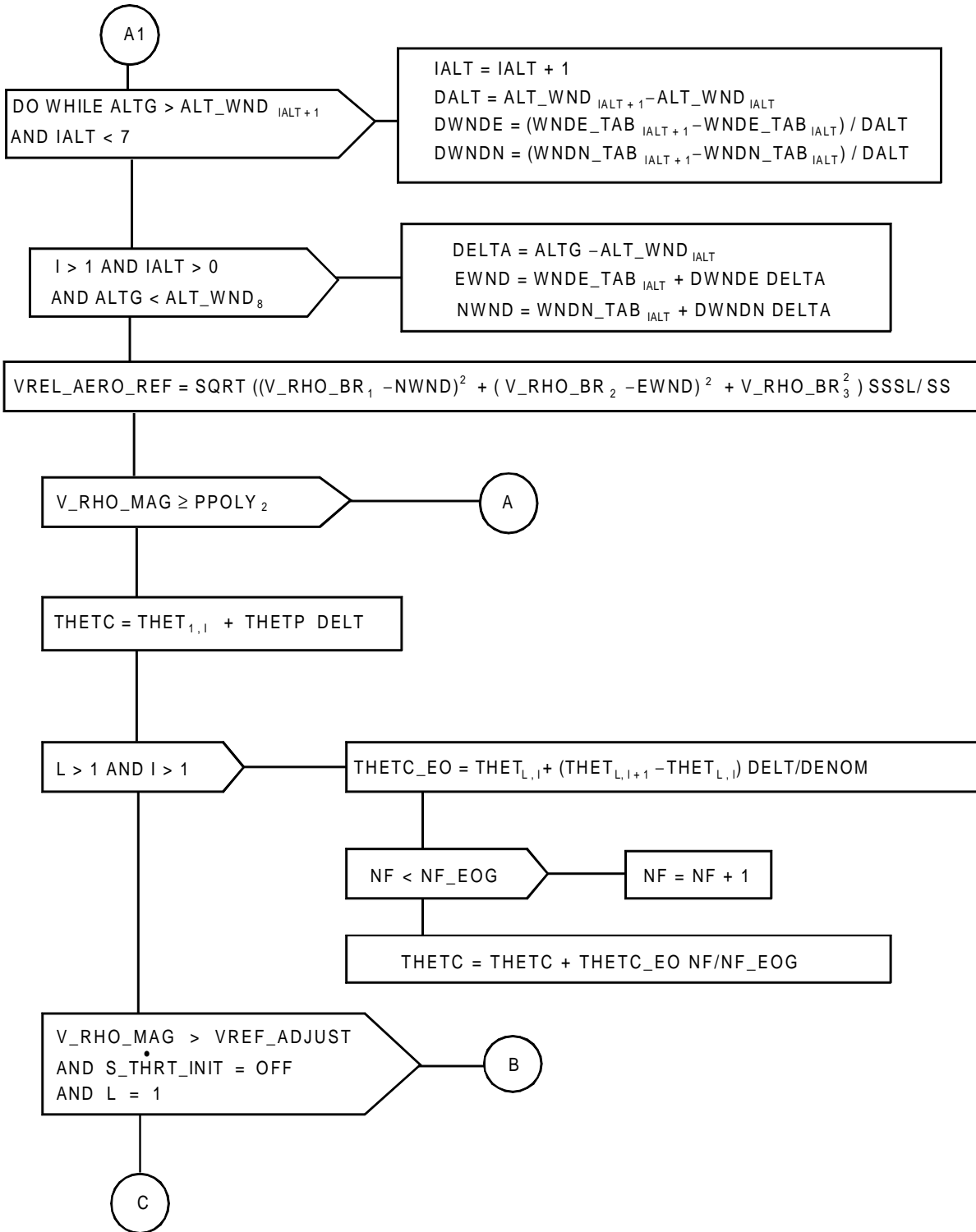


FIGURE A4.2.3.(2) BST GUID TSK Flow Diagram (Sheet 2 of 12)

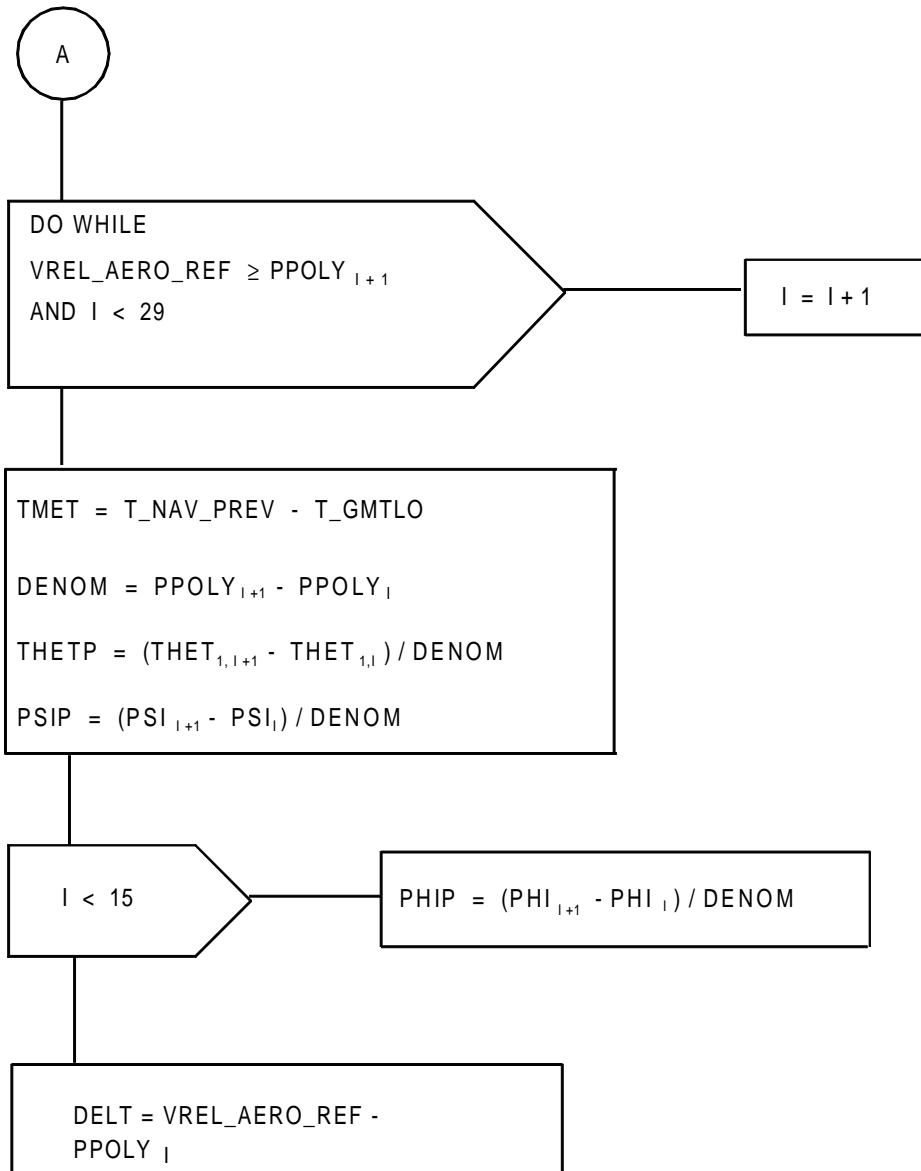


FIGURE A4.2.3.(3) BST GUID TSK Flow Diagram (Sheet 3 of 12)

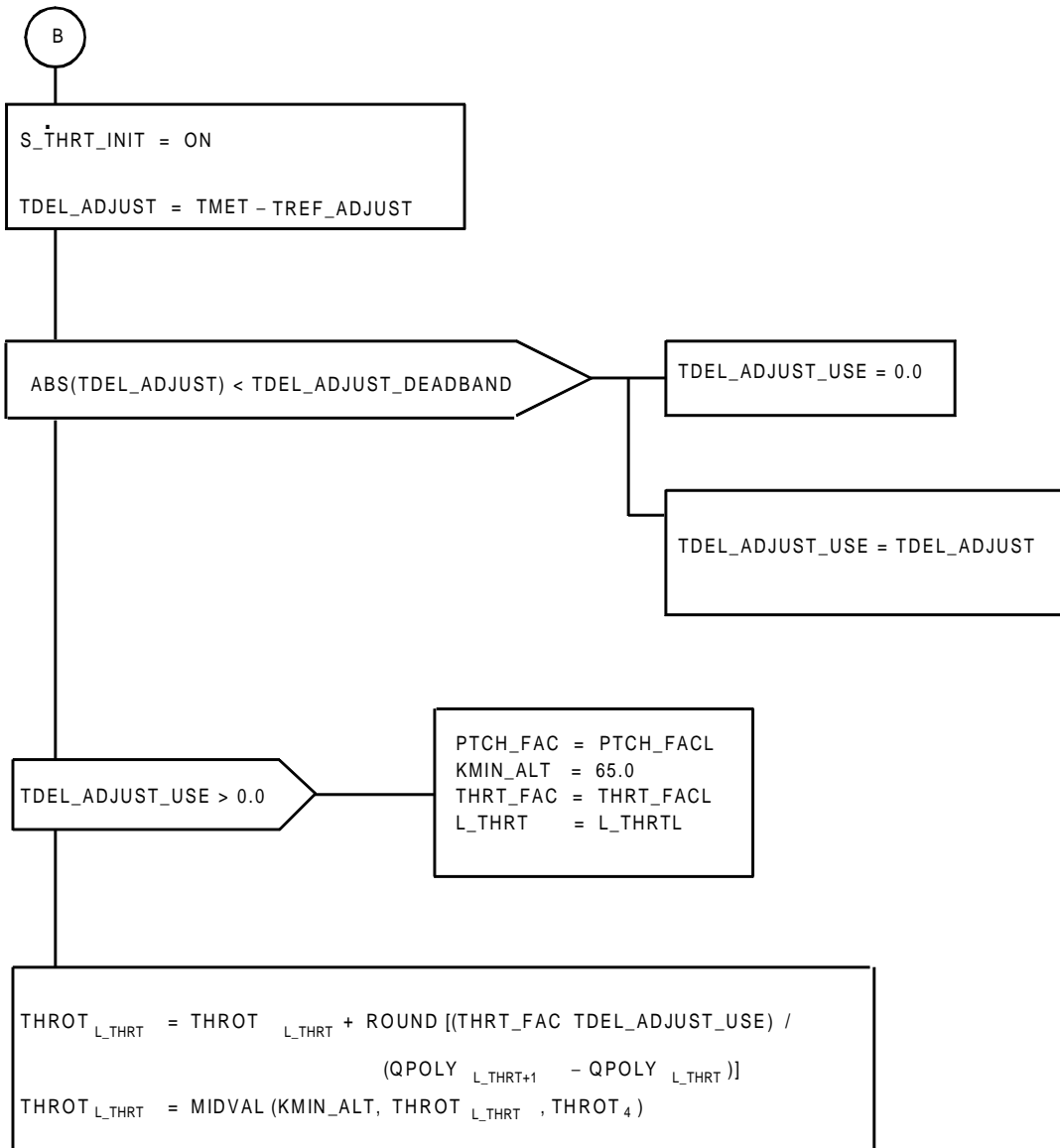


FIGURE A4.2.3.(4) BST GUID TSK Flow Diagram (Sheet 4 of 12)

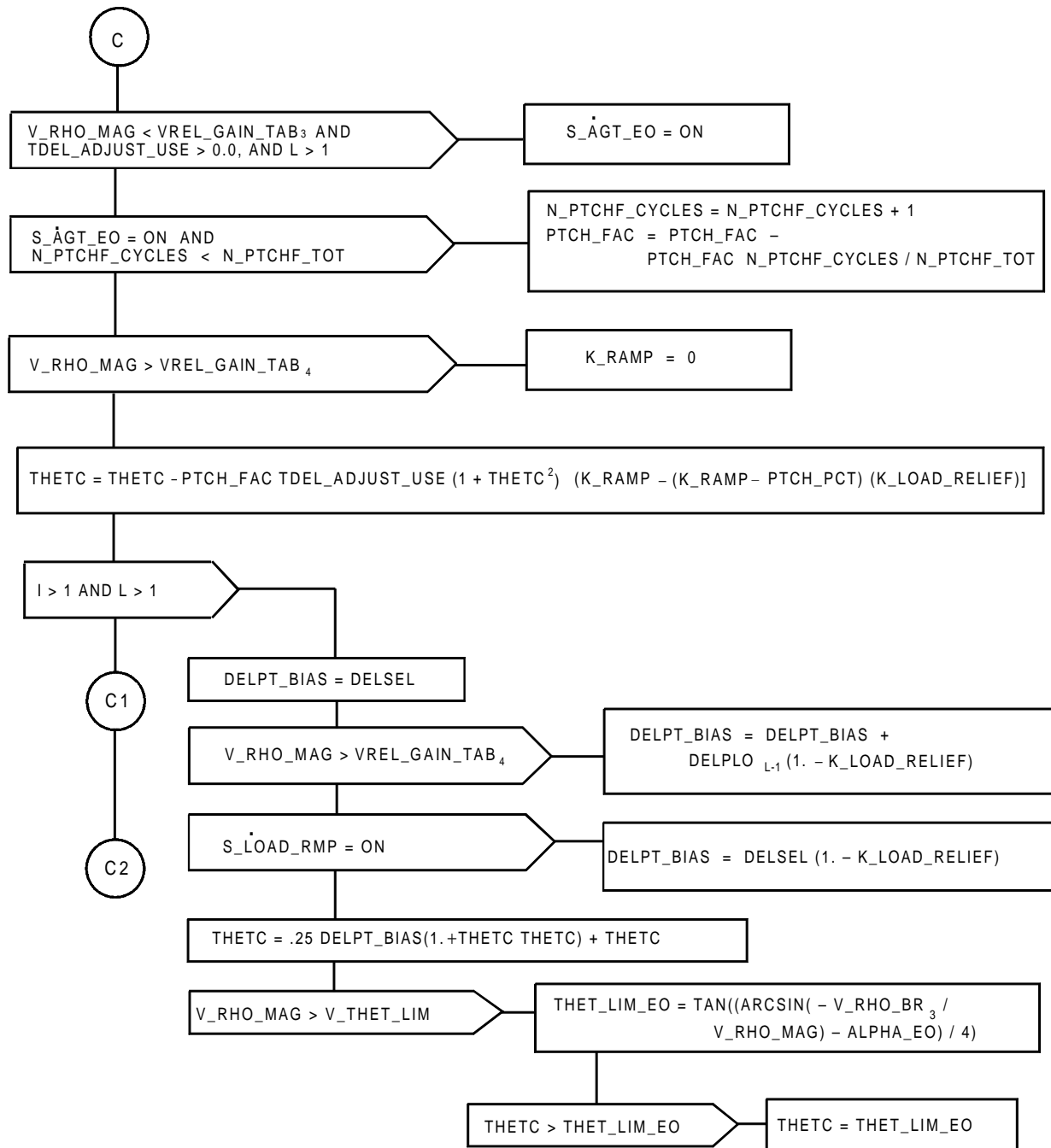


FIGURE A4.2.3.(5) BST GUID TSK Flow Diagram (Sheet 5 of 12)

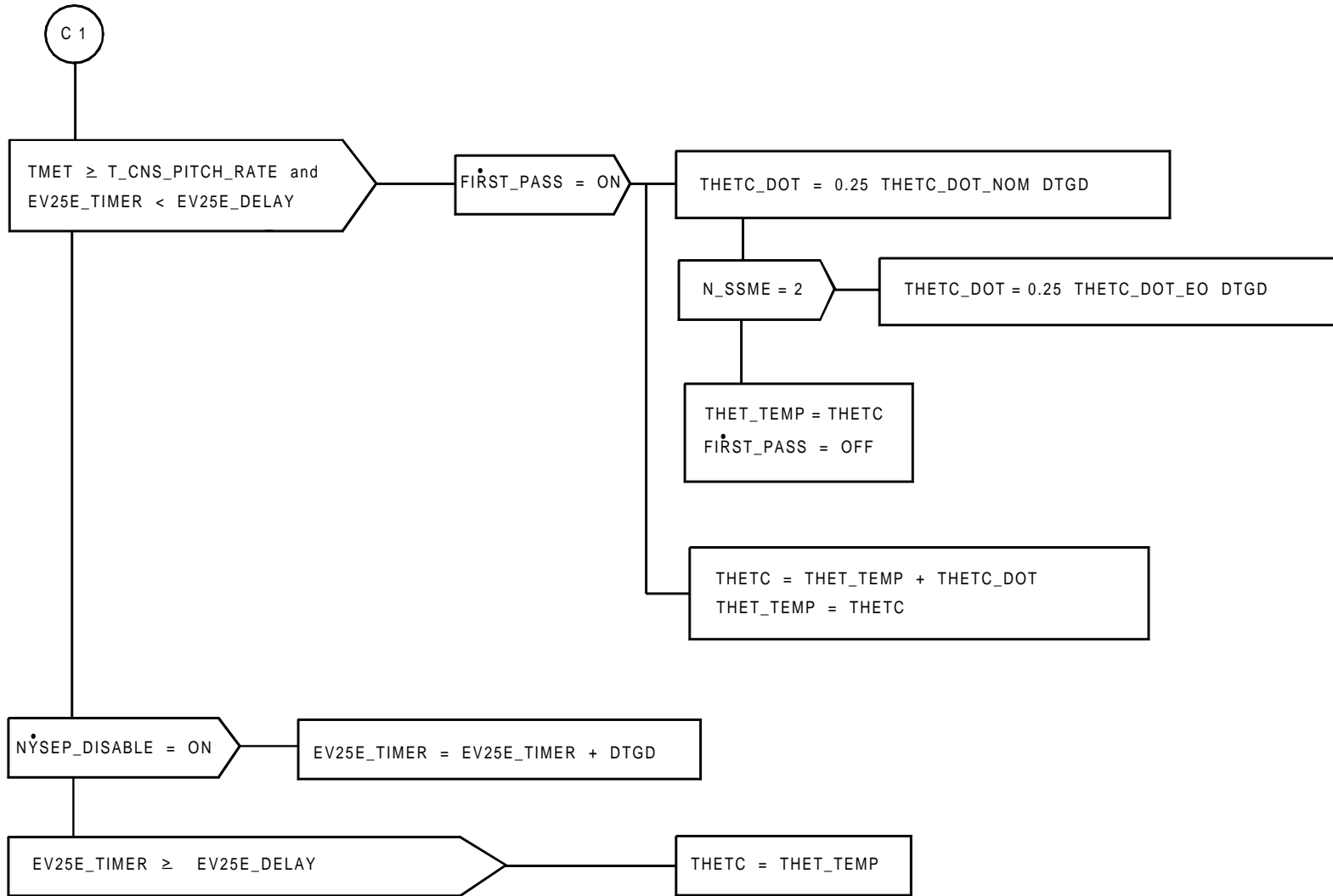


FIGURE A4.2.3.(6) BST GUID TSK Flow Diagram (Sheet 6 of 12)

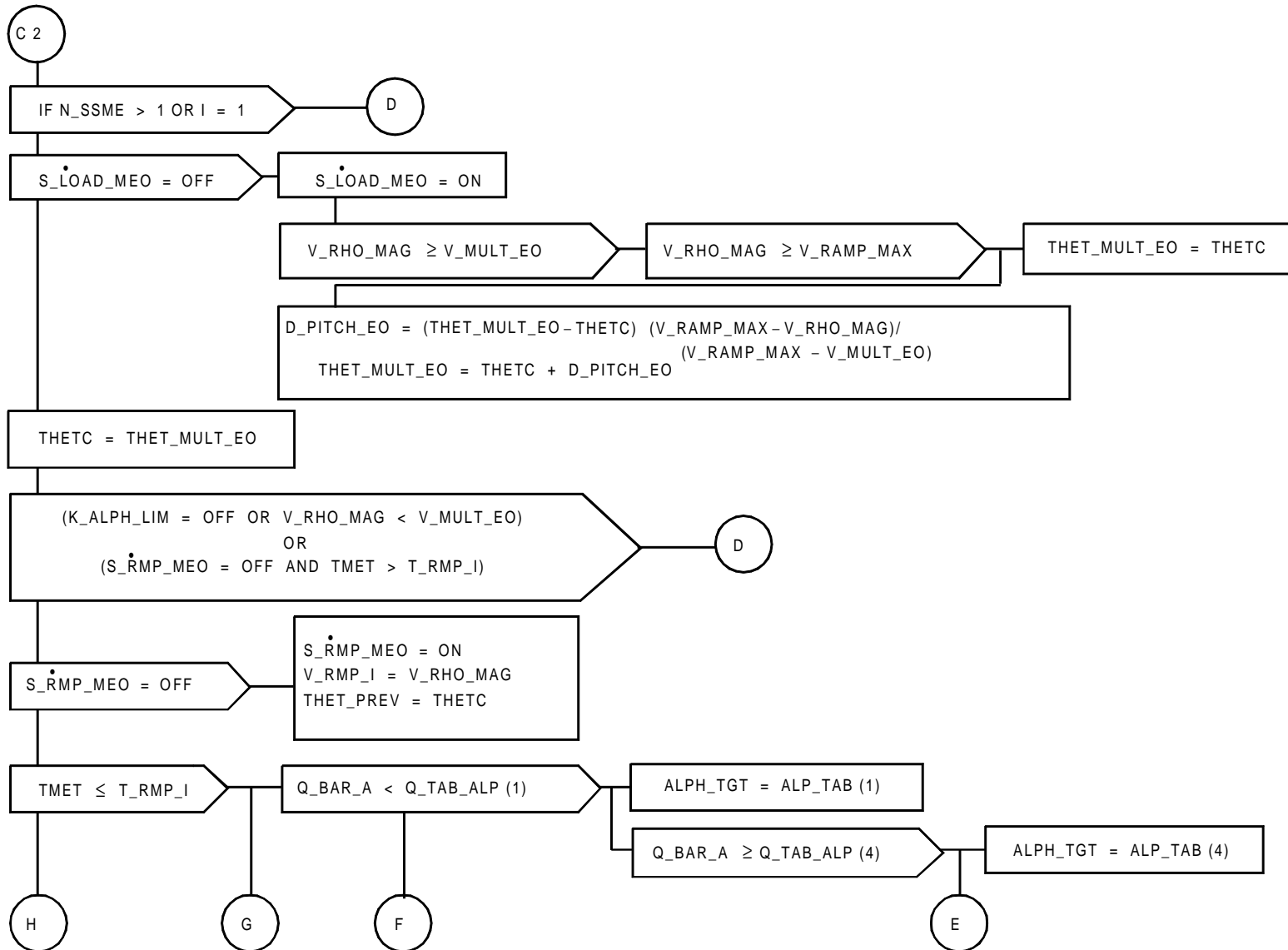


FIGURE A4.2.3.(7) BST GUID TSK Flow Diagram (Sheet 7 of 12)

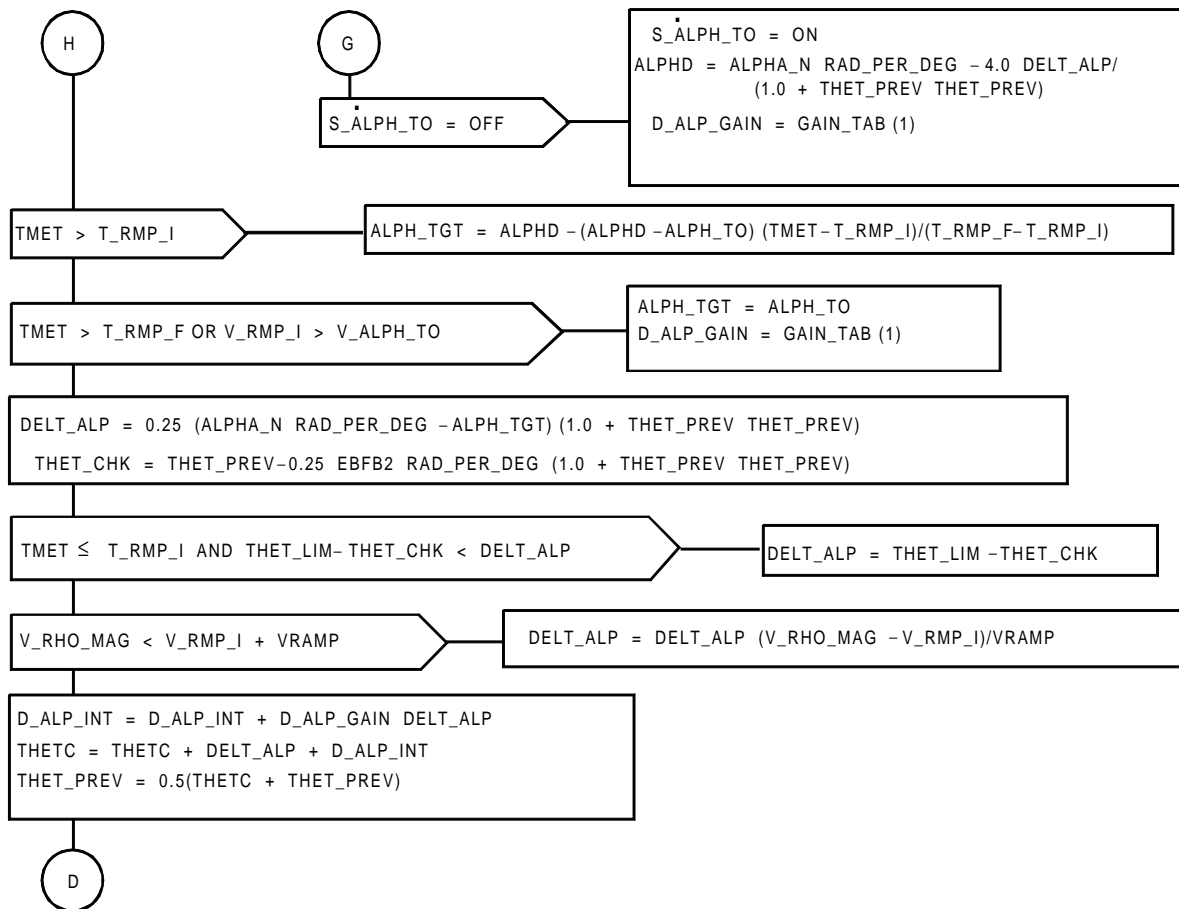


FIGURE A4.2.3.(8) BST GUID TSK Flow Diagram (Sheet 8 of 12)

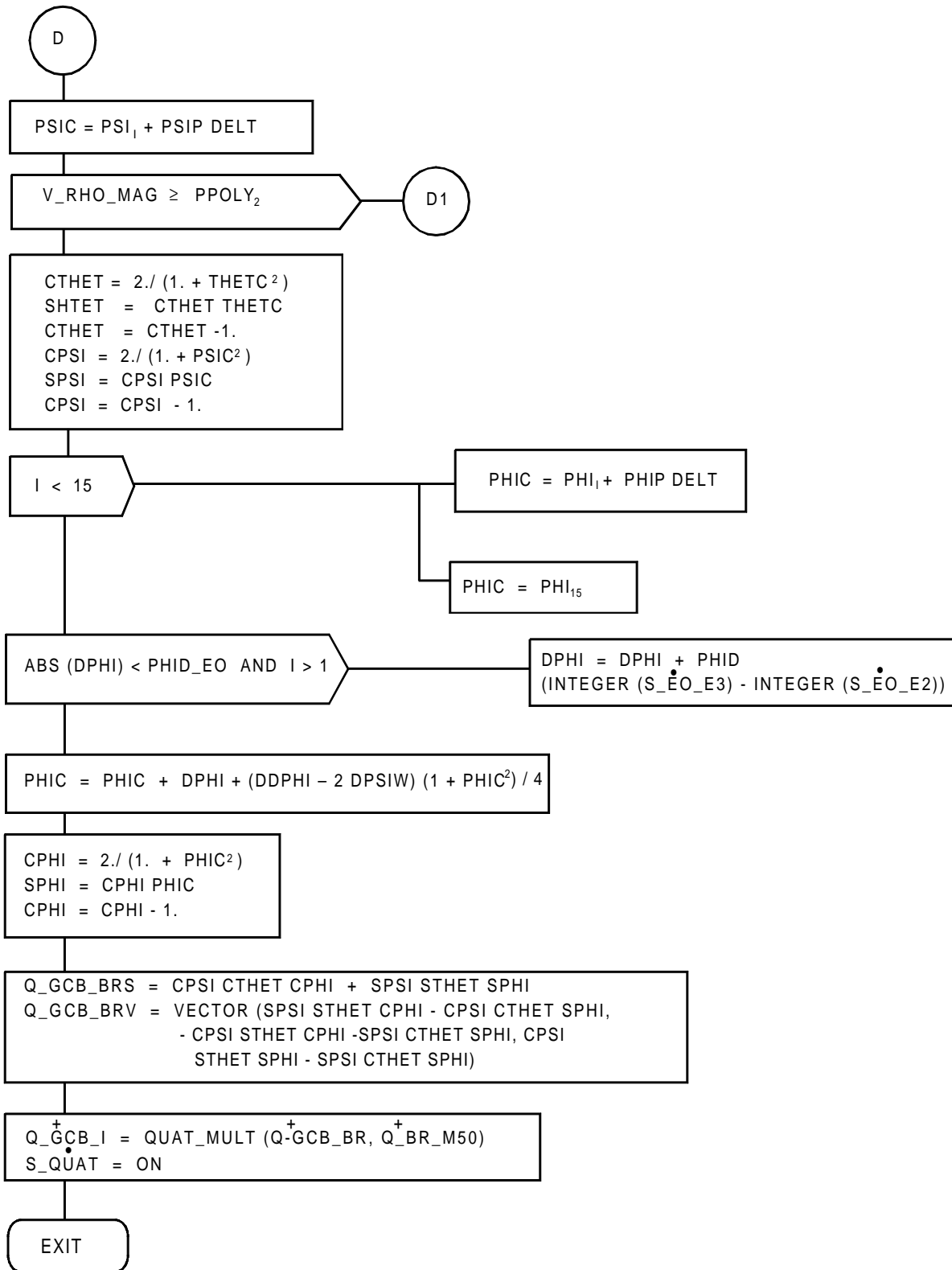


FIGURE A4.2.3.(9) BST GUID TSK Flow Diagram (Sheet 9 of 12)

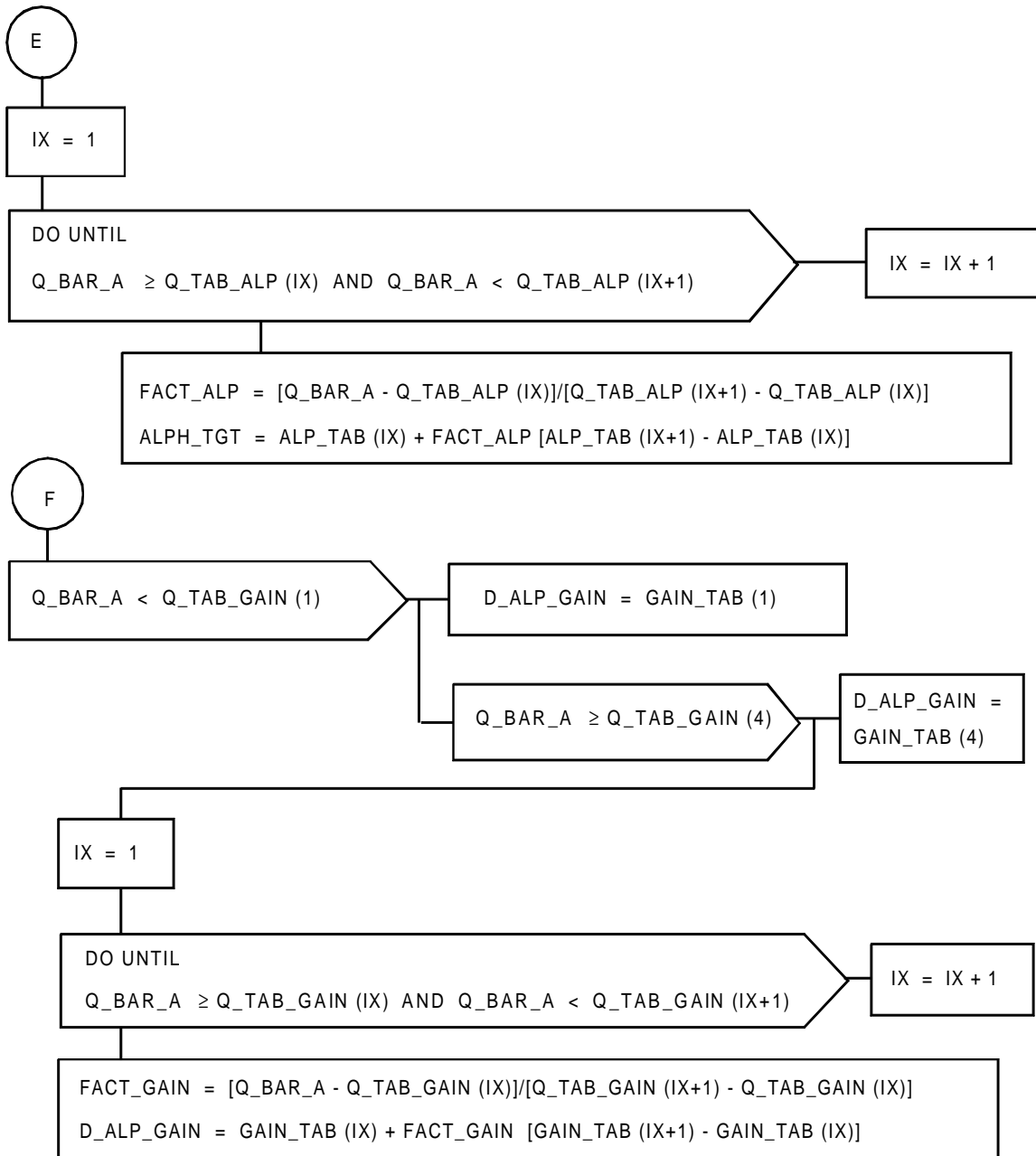


FIGURE A4.2.3.(10) BST GUID TSK Flow Diagram (Sheet 10 of 12)

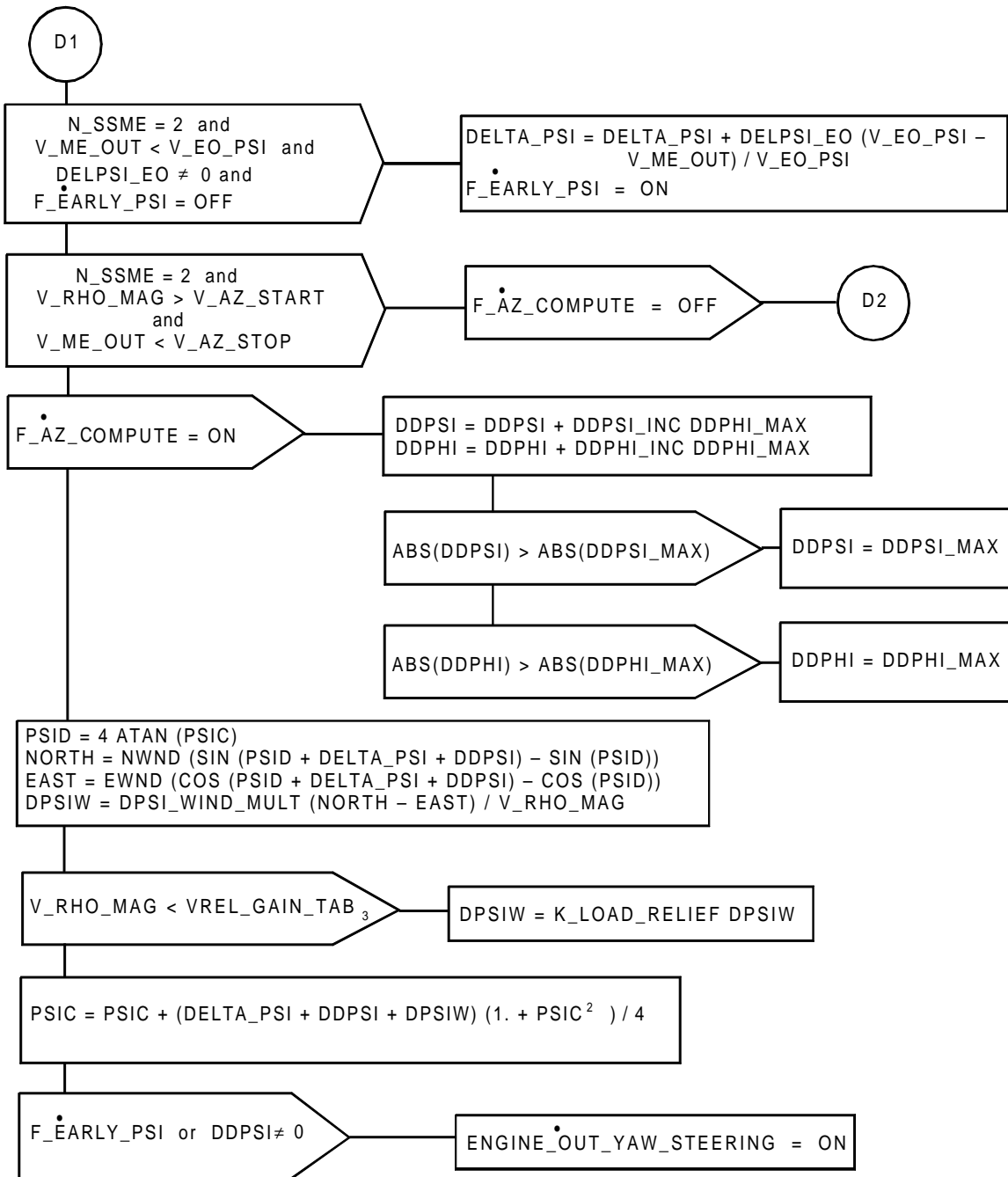


FIGURE A4.2.3.(11) BST GUID TSK Flow Diagram (Sheet 11 of 12)

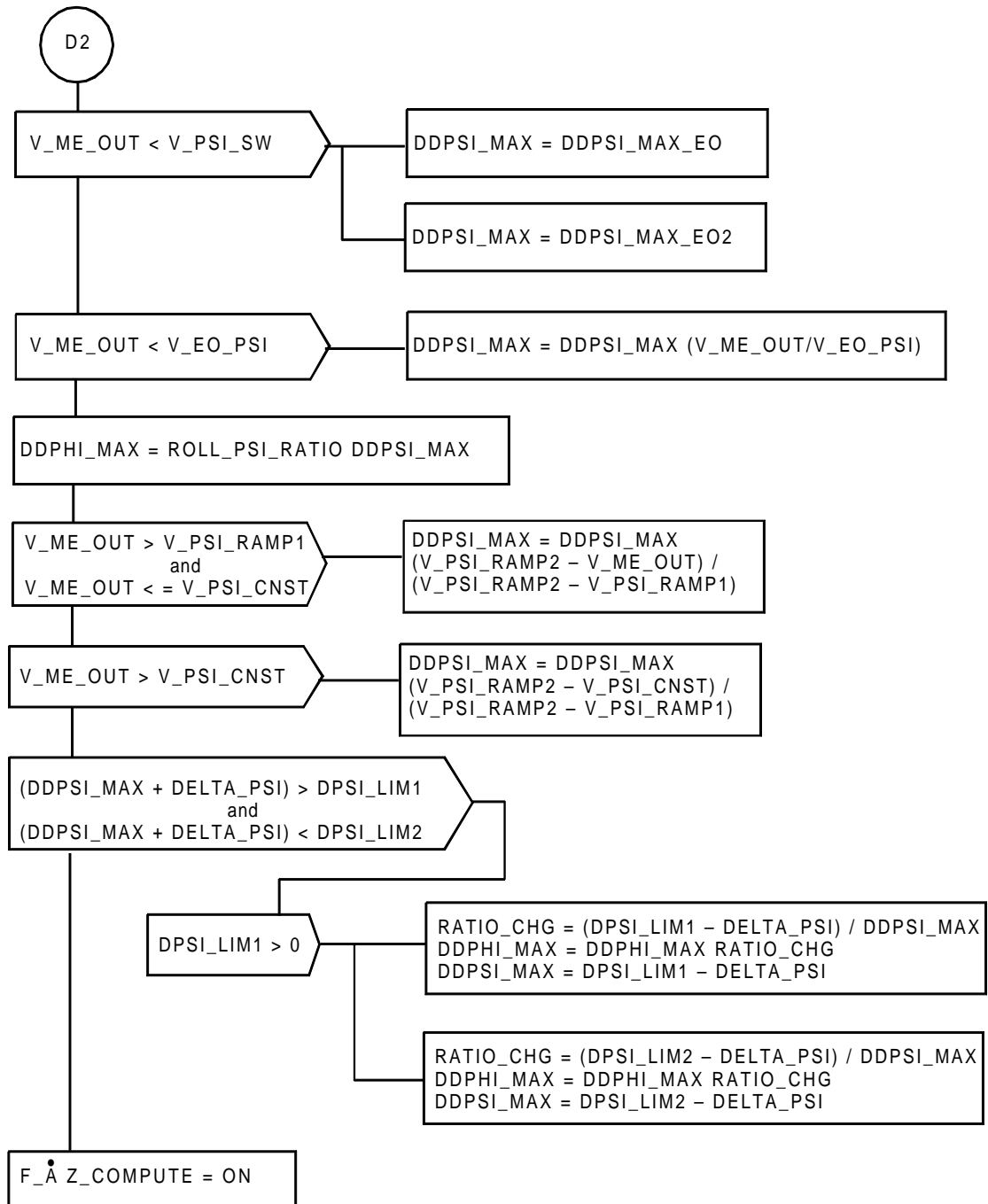


FIGURE A4.2.3.(12) BST GUID TSK Flow Diagram (Sheet 12 of 12)

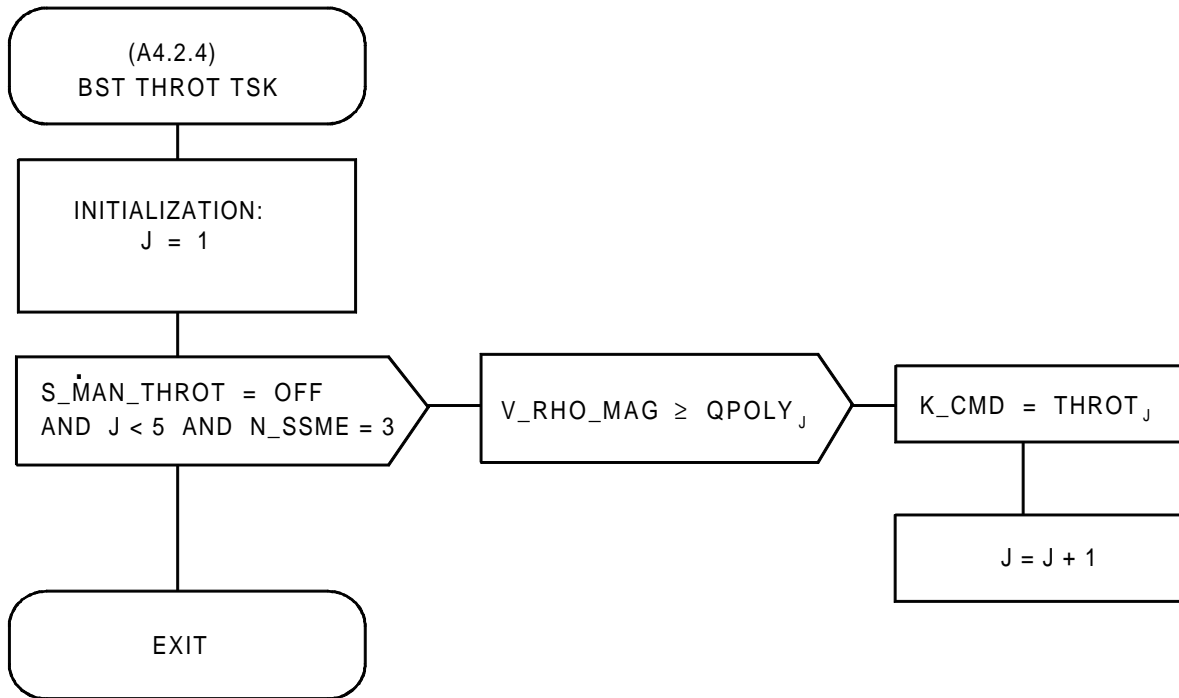


FIGURE A4.2.4. BST THROT TSK Flow Diagram

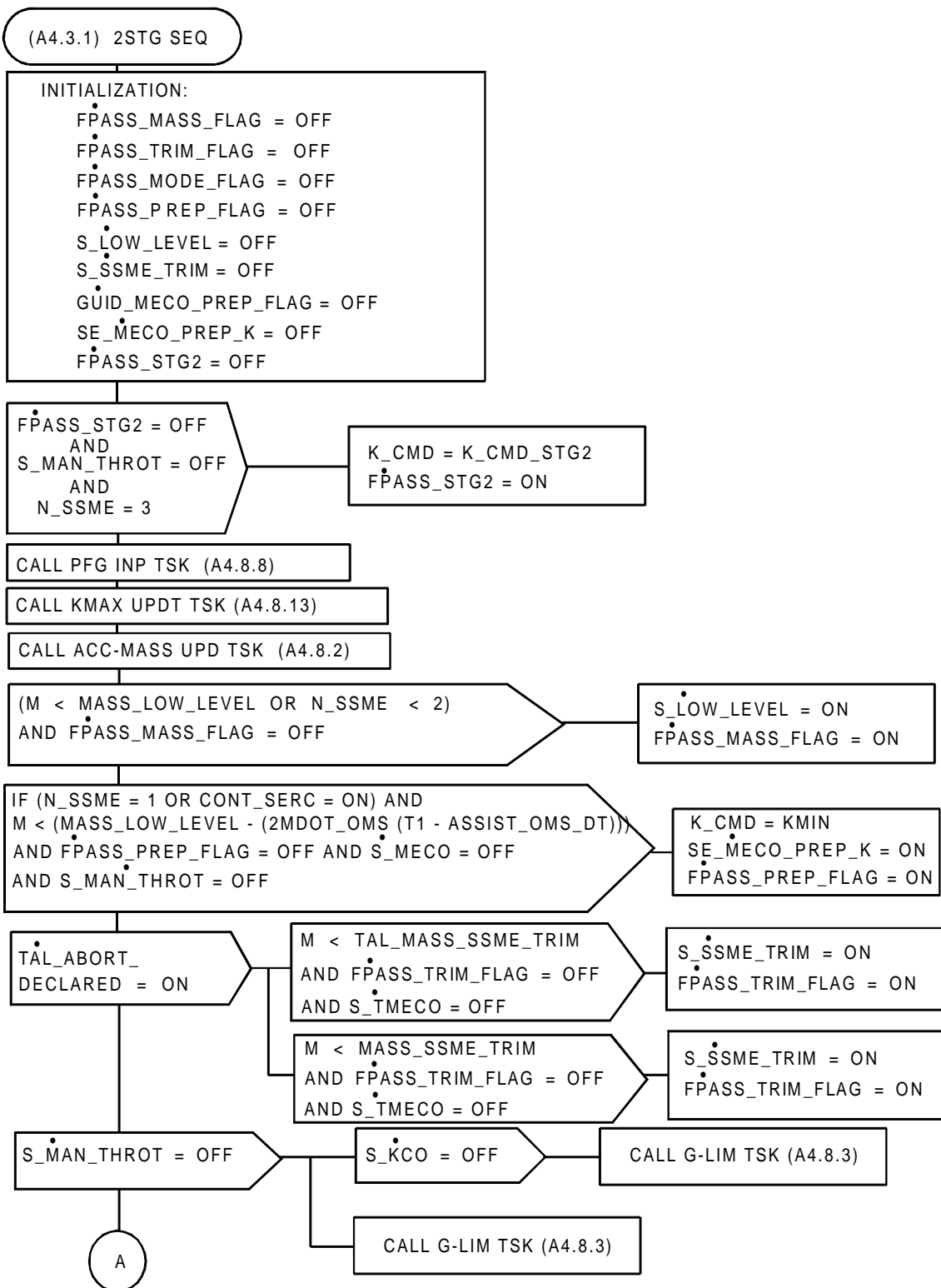


FIGURE A4.3.1.(1) 2STG SEQ Flow Diagram (Sheet 1 of 2)

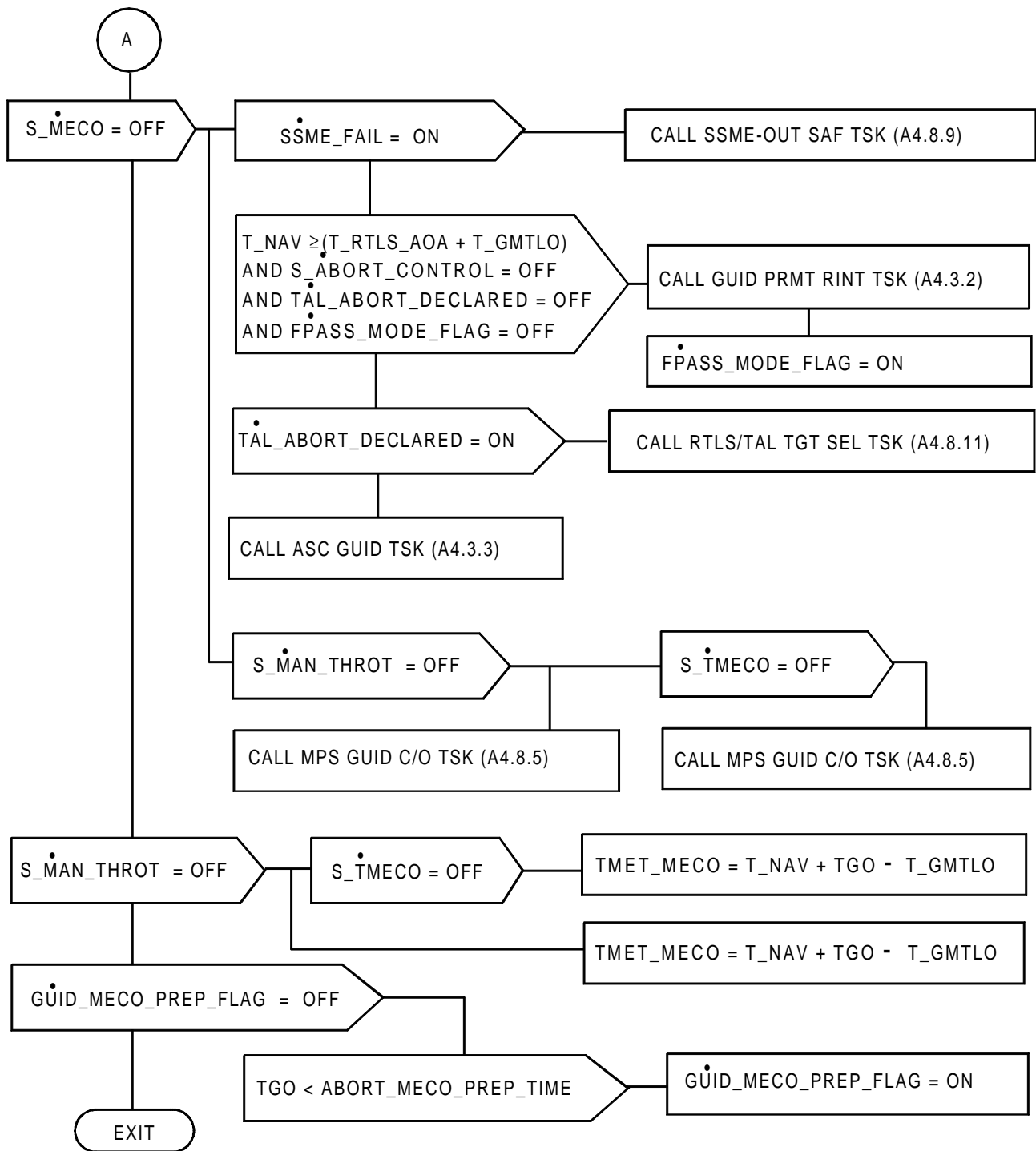


FIGURE A4.3.1.(2) 2STG SEQ Flow Diagram (Sheet 2 of 2)

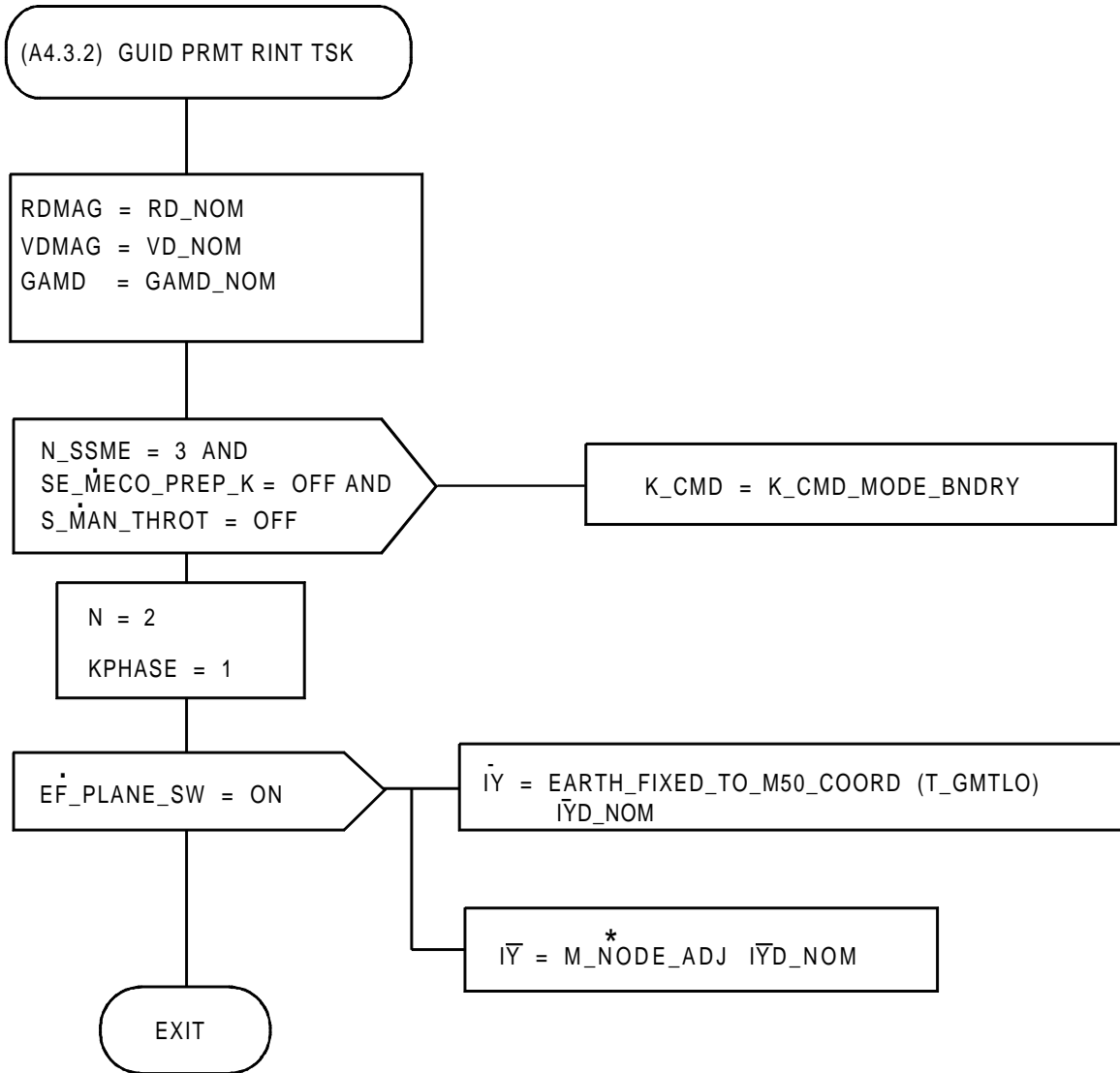


FIGURE A4.3.2. GUID PRMT RINT TSK Flow Diagram

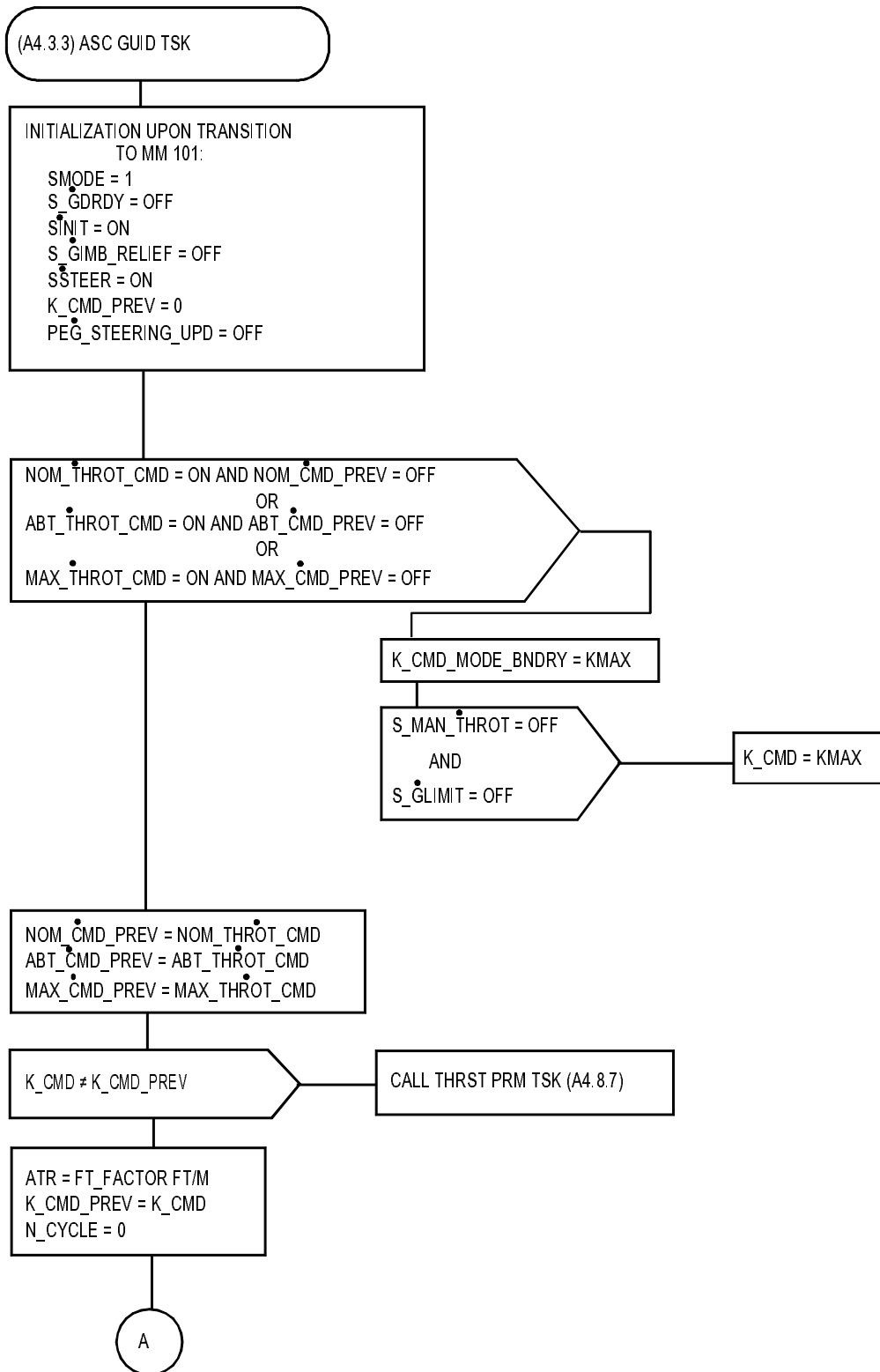


FIGURE A4.3.3.(1) ASC GUID TSK Flow Diagram (Sheet 1 of 2)

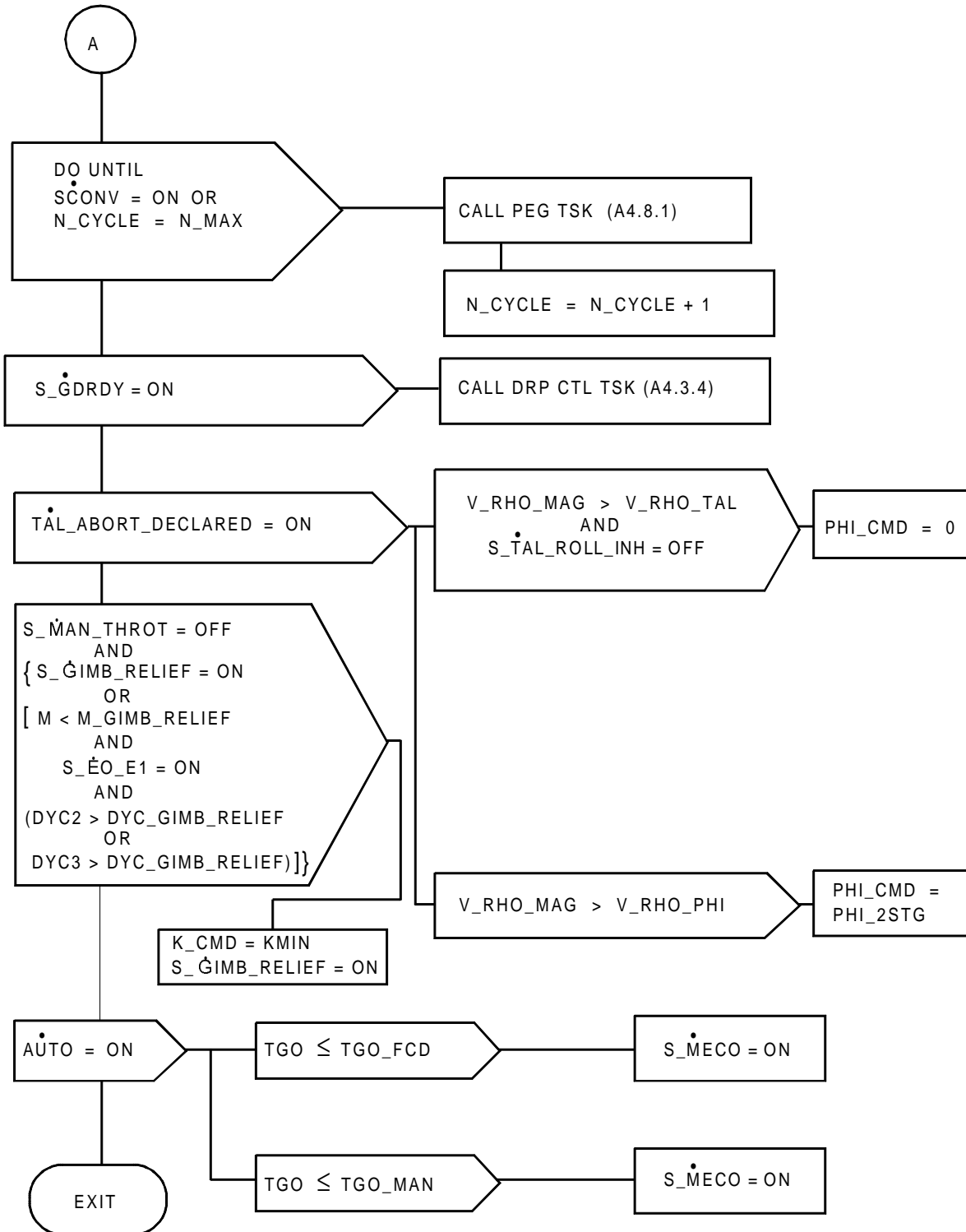


FIGURE A4.3.3.(2) ASC GUID TSK Flow Diagram (Sheet 2 of 2)

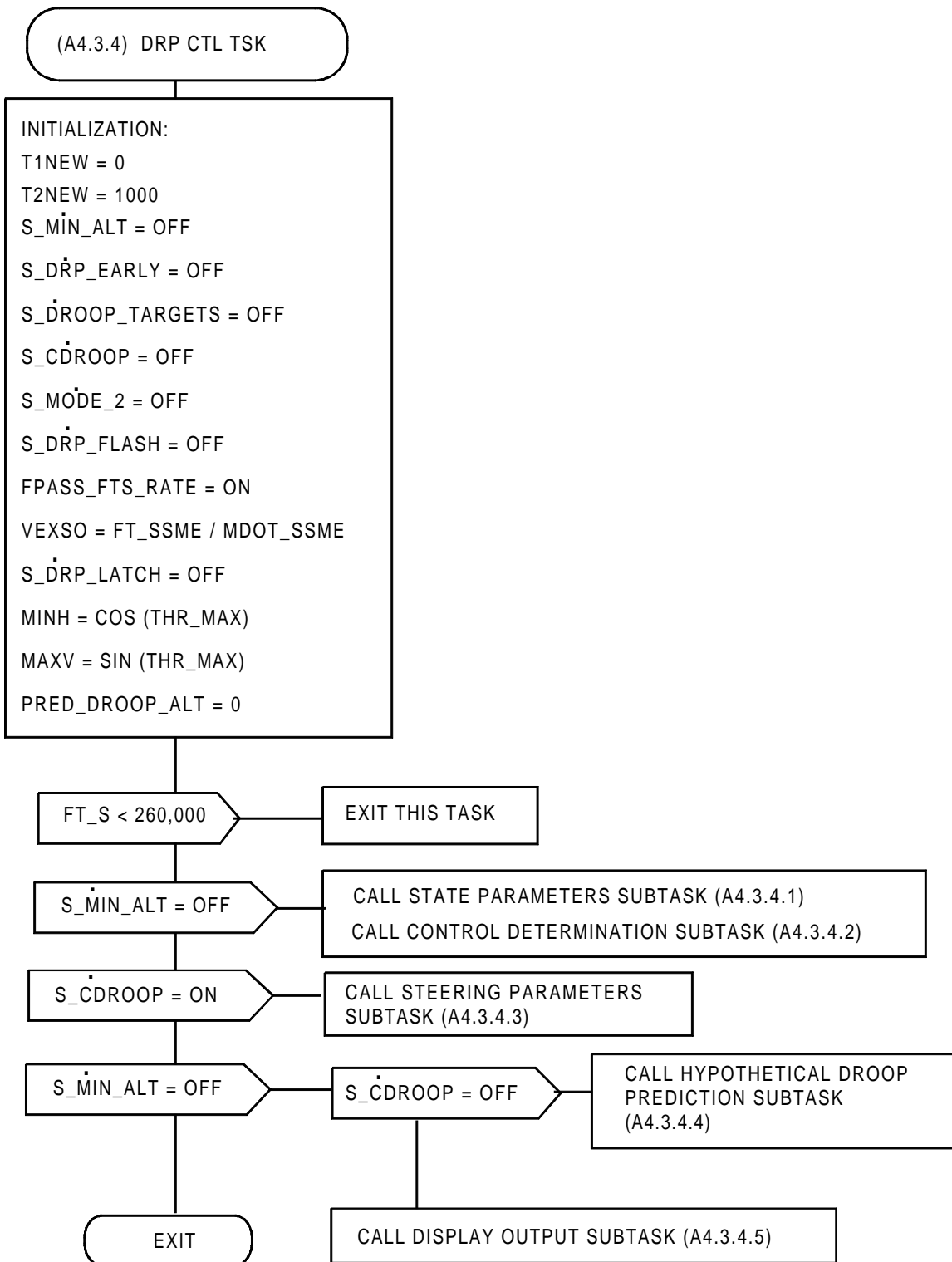


FIGURE A4.3.4.(1) DRP CTL TSK Flow Diagram (Sheet 1 of 9)

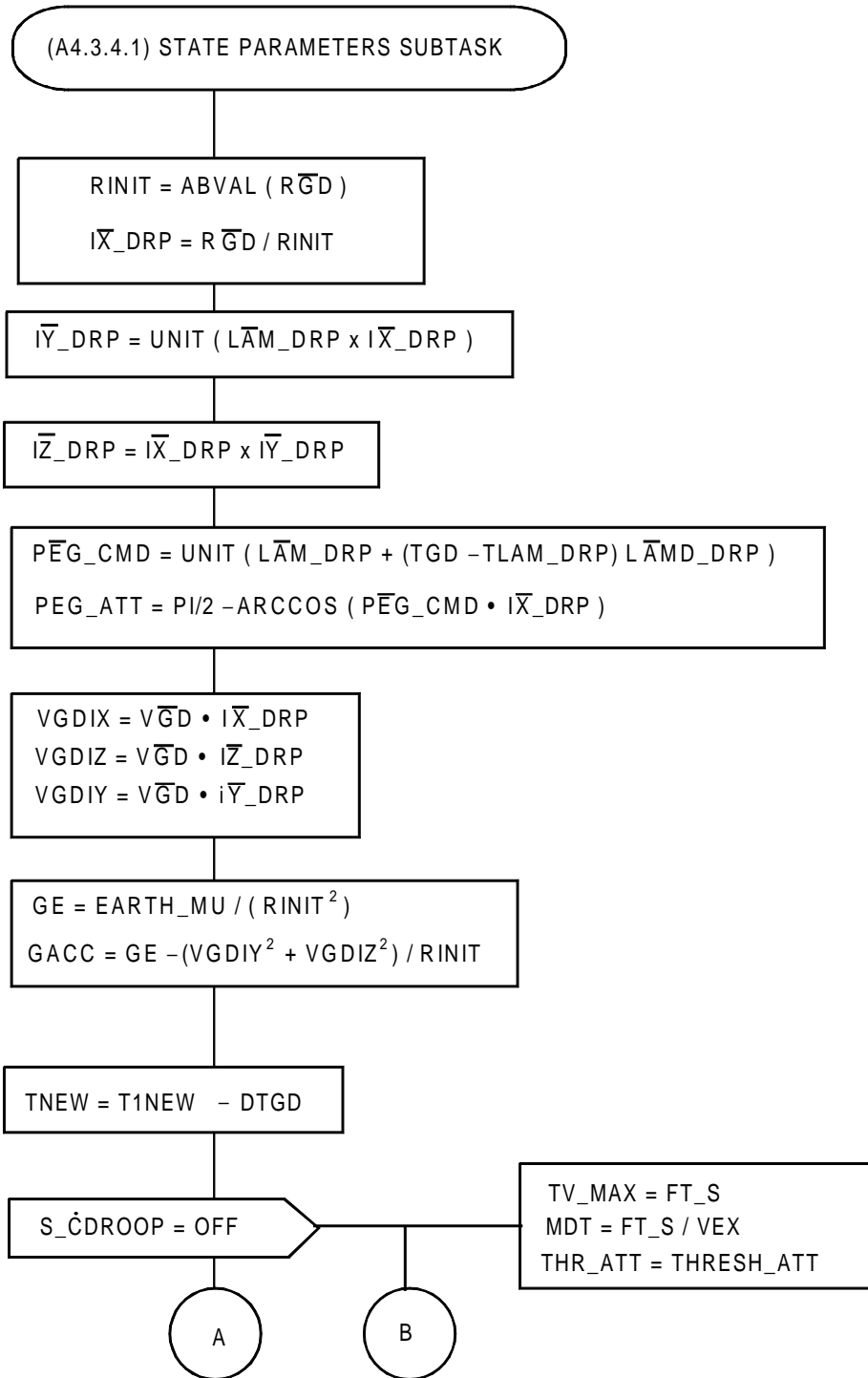


FIGURE A4.3.4.(2) DRP CTL TSK Flow Diagram (Sheet 2 of 9)

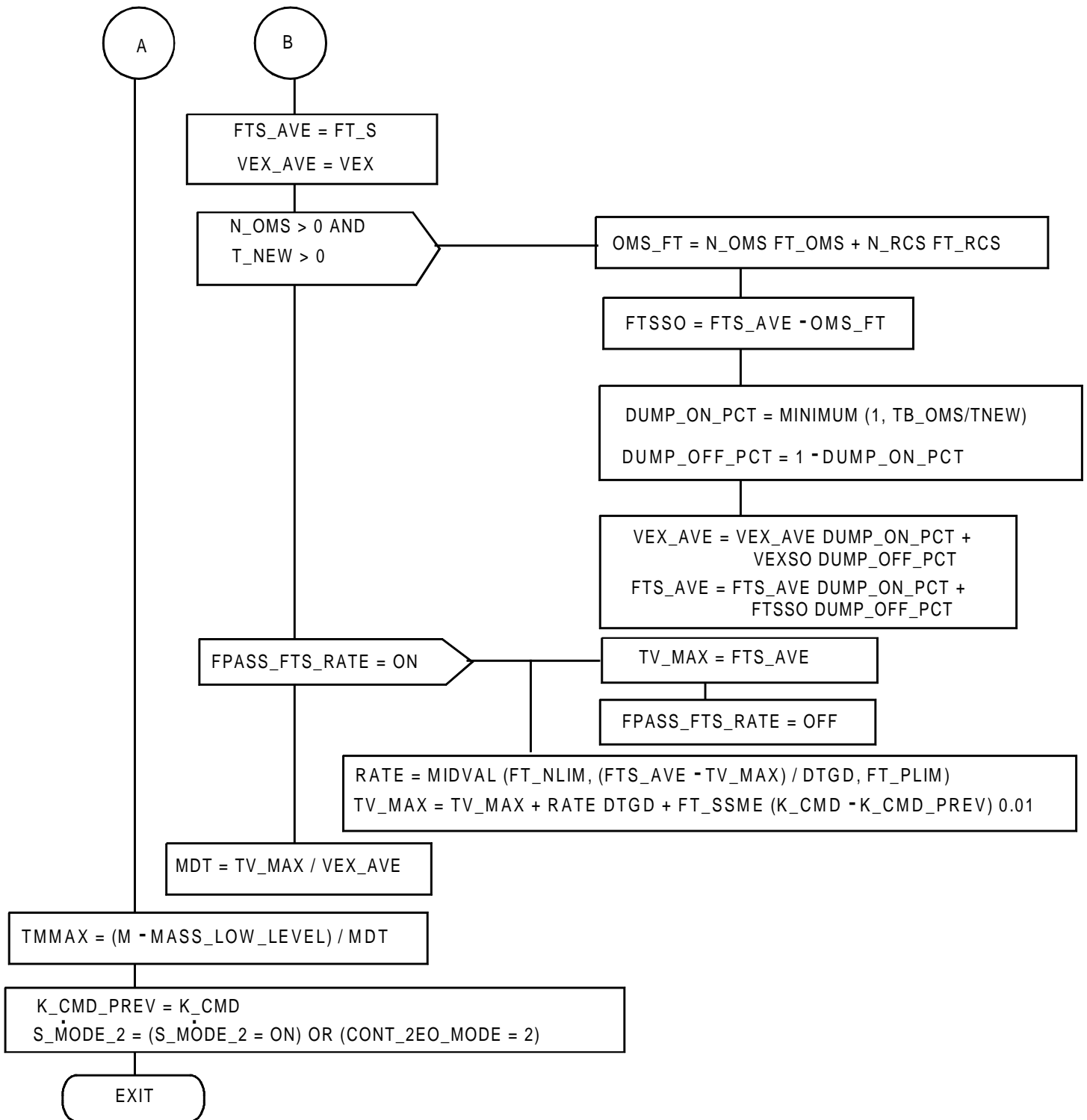


FIGURE A4.3.4.(3) DRP CTL TSK Flow Diagram (Sheet 3 of 9)

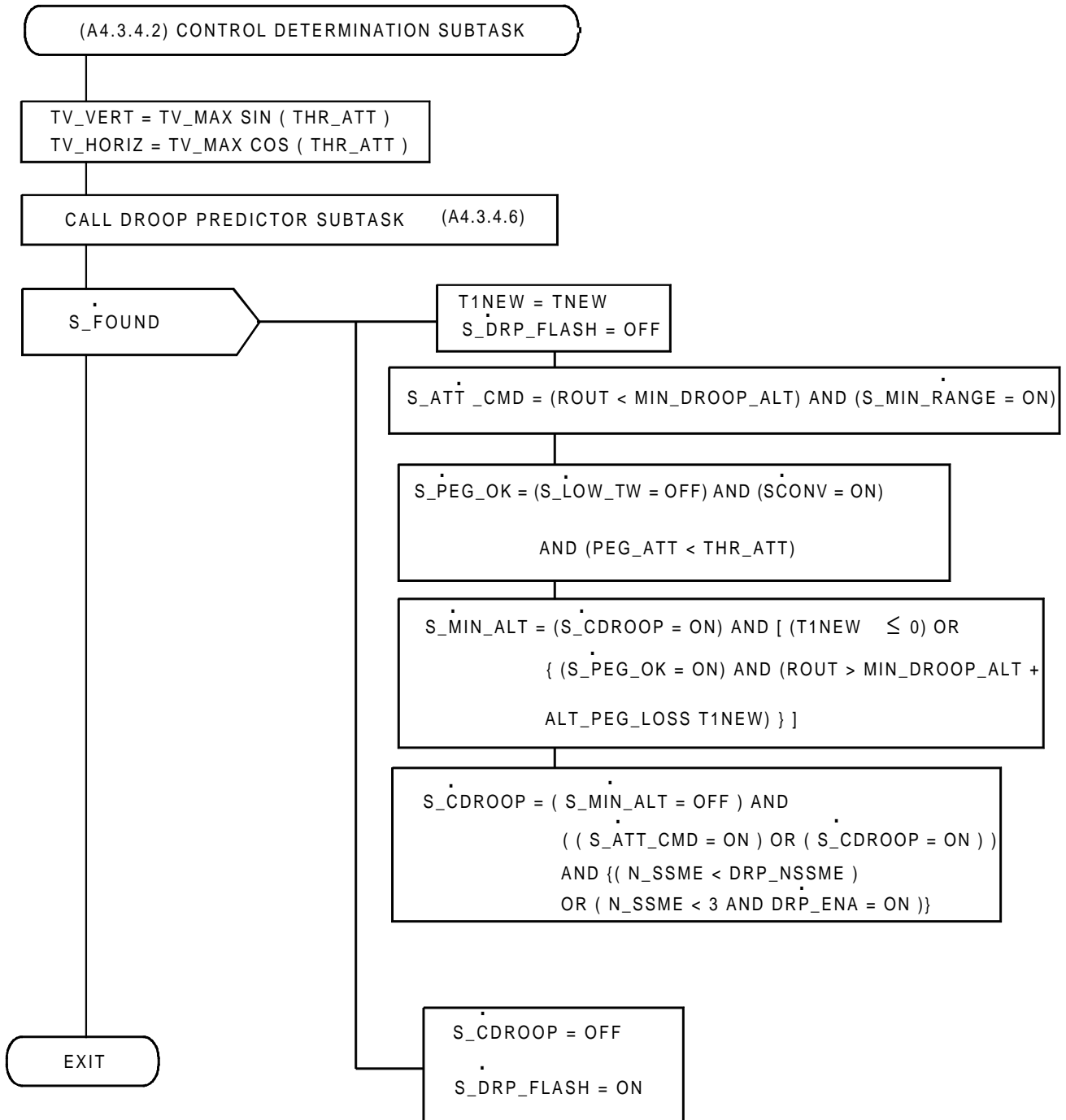


FIGURE A4.3.4.(4) DRP CTL TSK Flow Diagram (Sheet 4 of 9)

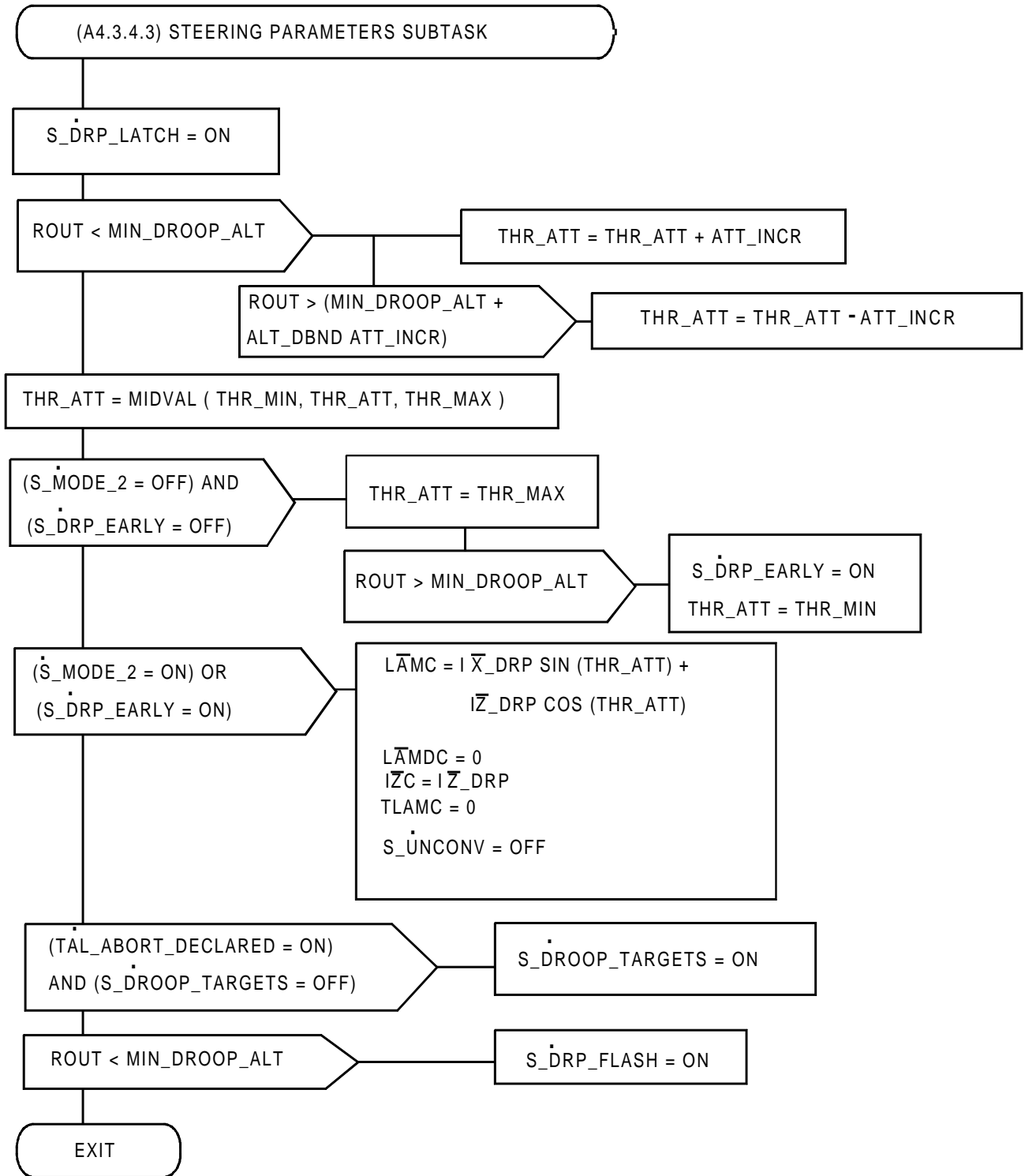


FIGURE A4.3.4.(5) DRP CTL TSK Flow Diagram (Sheet 5 of 9)

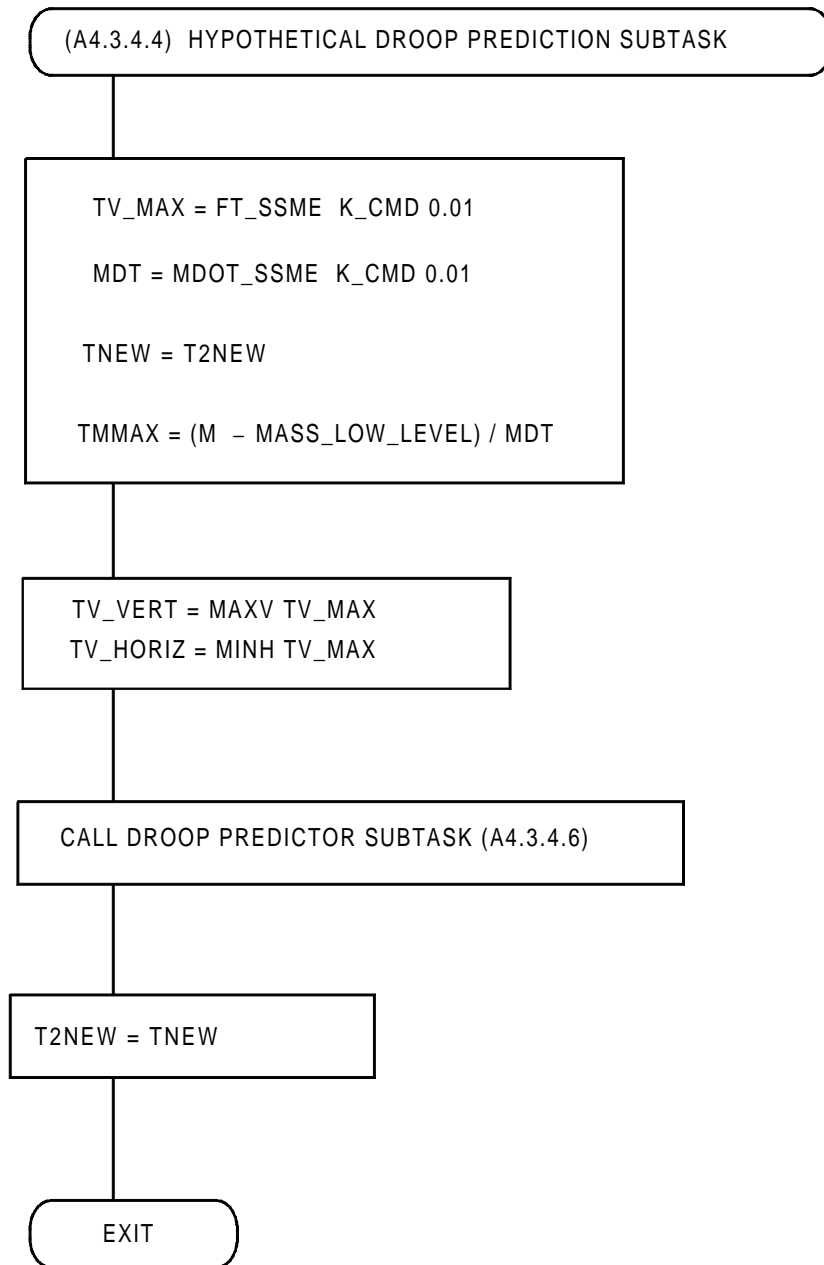


FIGURE A4.3.4.(6) DRP CTL TSK Flow Diagram (Sheet 6 of 9)

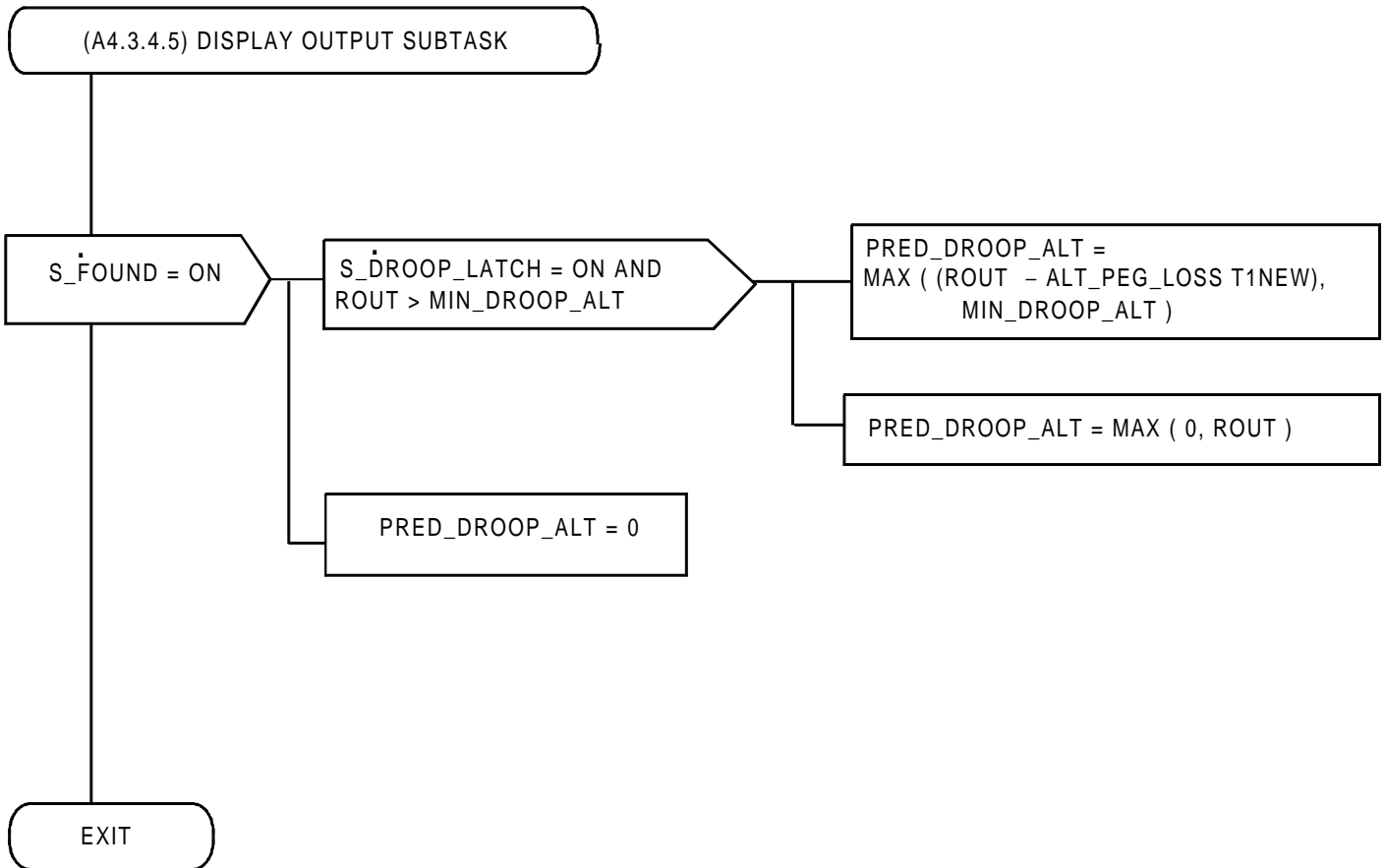


FIGURE A4.3.4.(7) DRP CTL TSK Flow Diagram (Sheet 7 of 9)

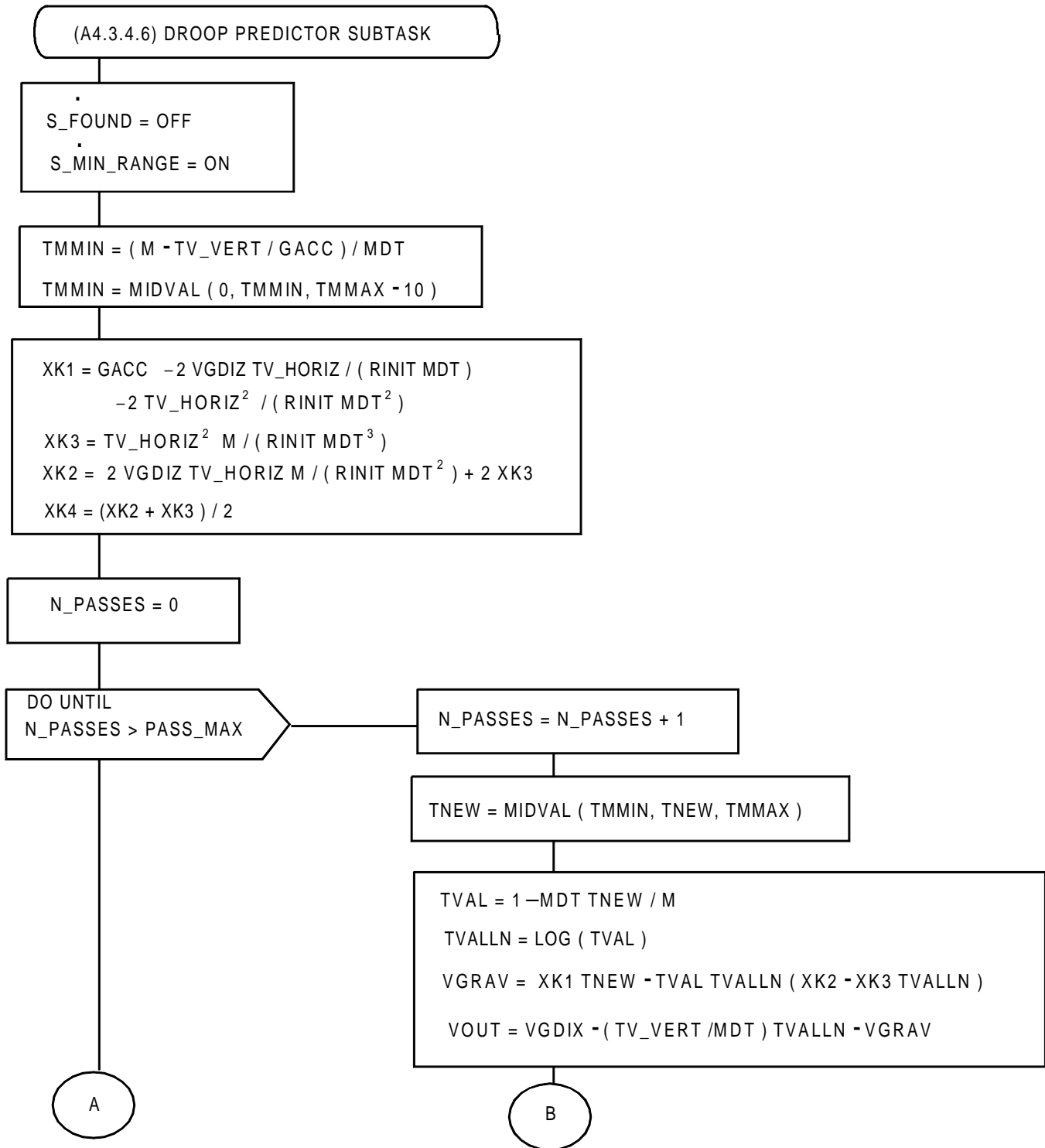


FIGURE A4.3.4.(8) DRP CTL TSK Flow Diagram (Sheet 8 of 9)

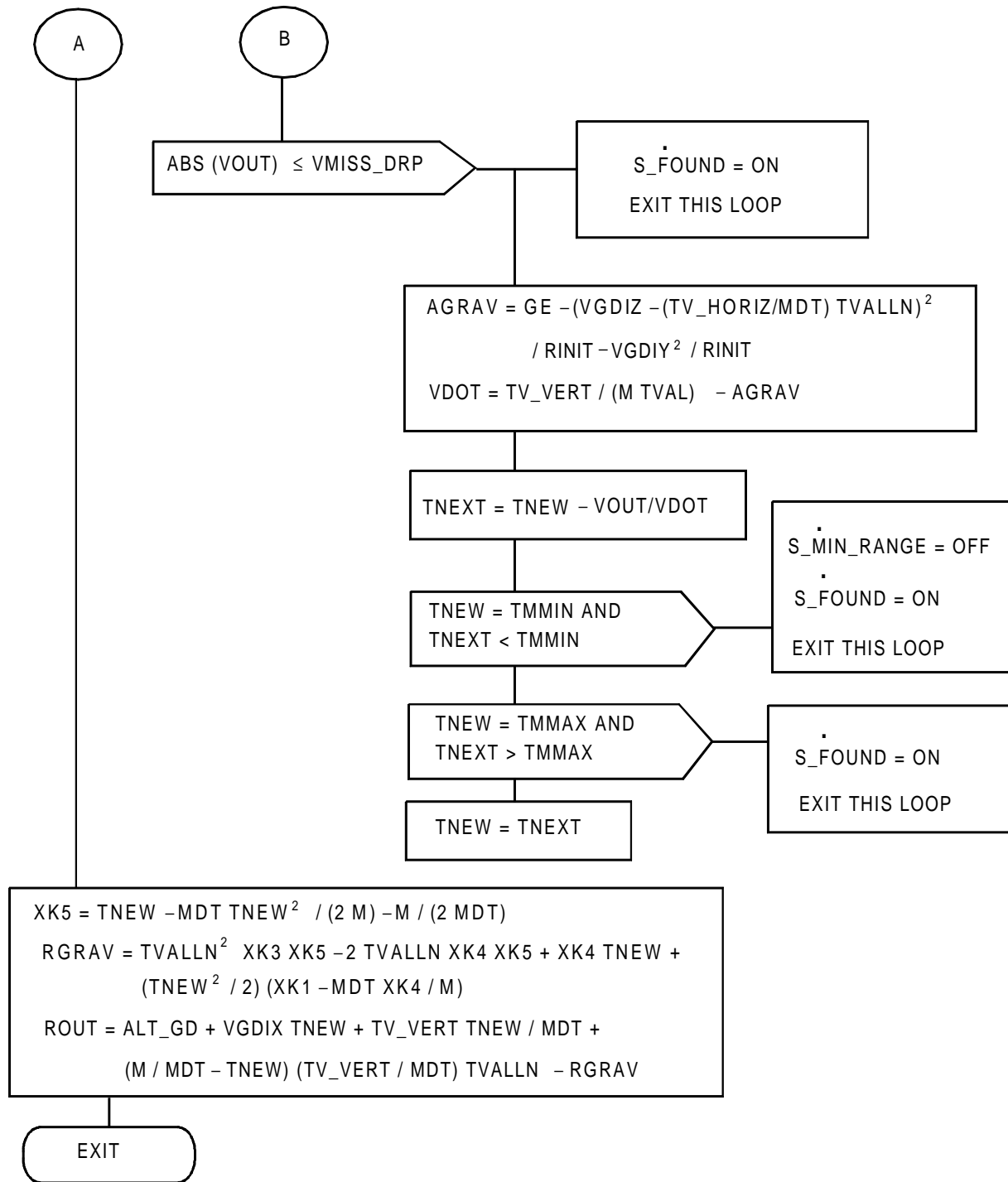


FIGURE A4.3.4.(9) DRP CTL TSK Flow Diagram (Sheet 9 of 9)

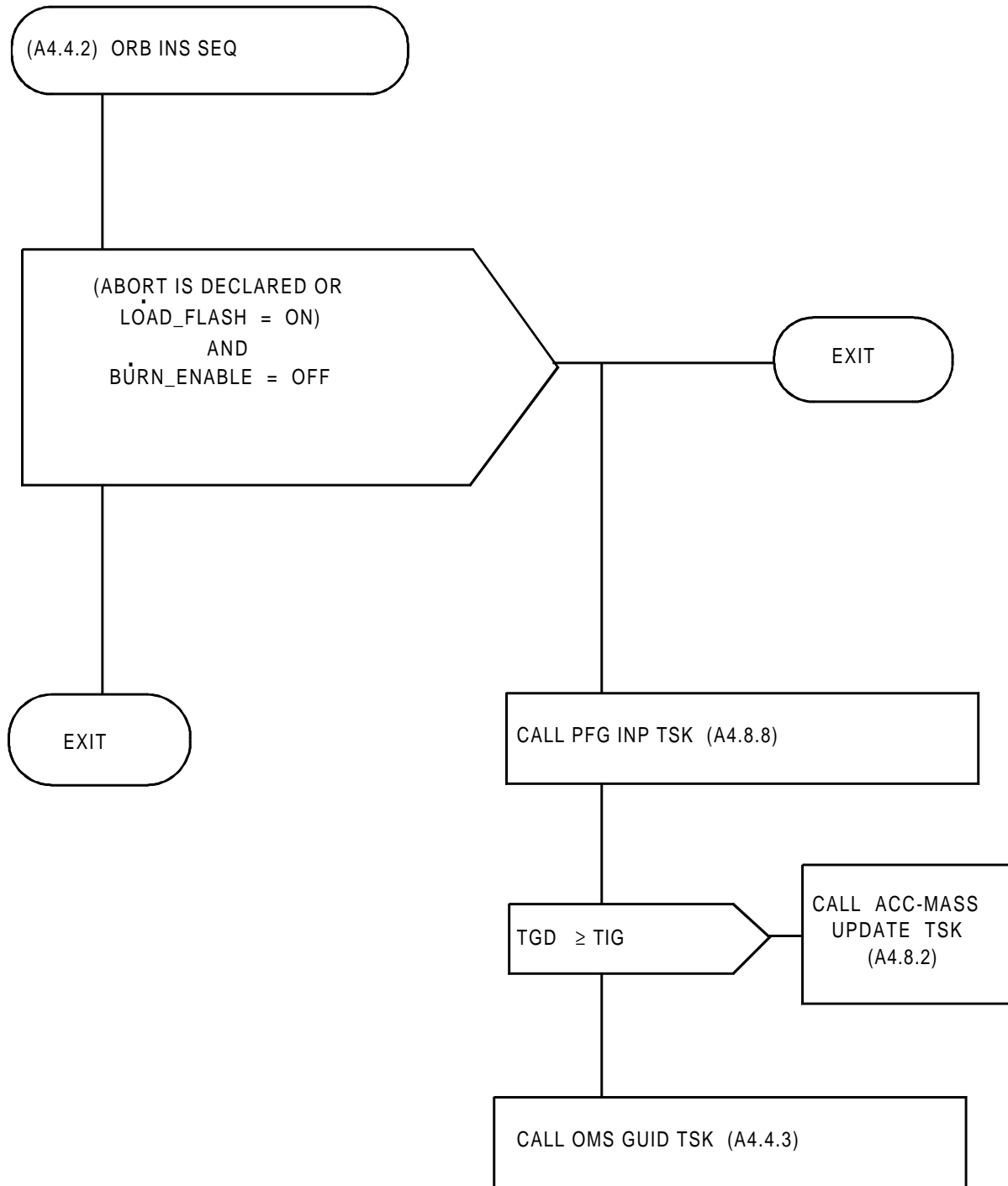


FIGURE A4.4.2. ORB INS SEQ Flow Diagram

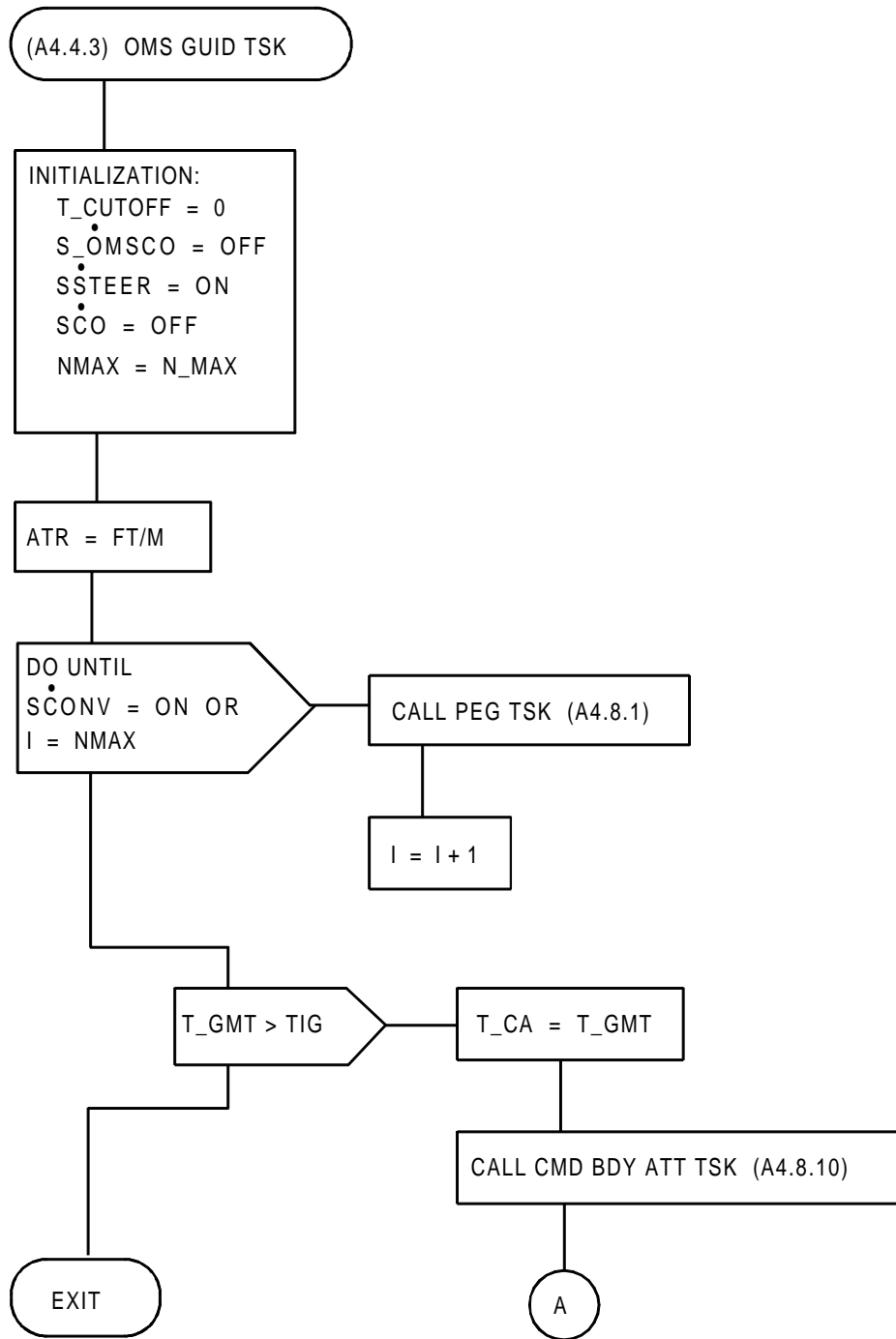


FIGURE A4.4.3.(1) OMS GUID TSK Flow Diagram (Sheet 1 of 2)

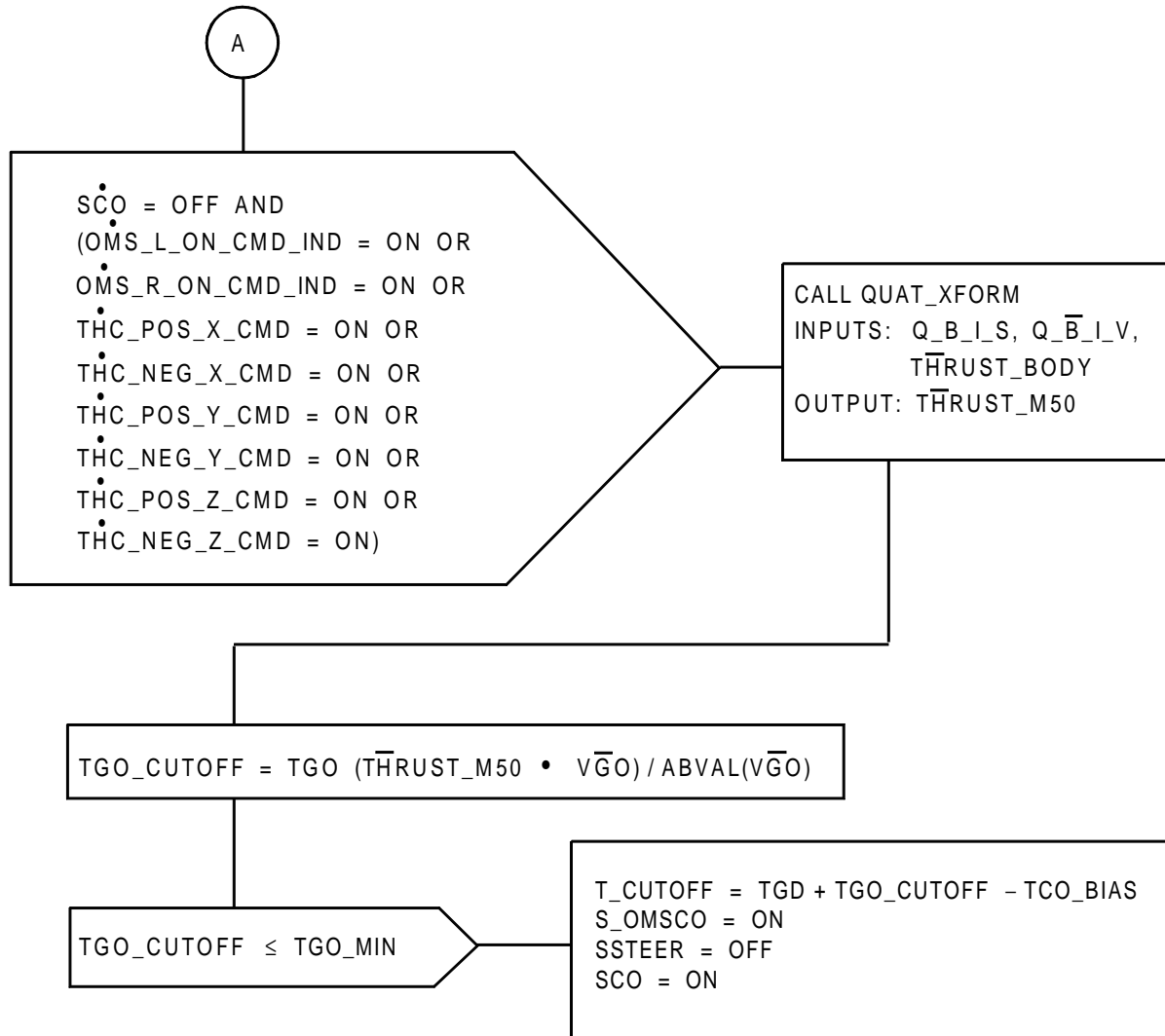


FIGURE A4.4.3.(2) OMS GUID TSK Flow Diagram (Sheet 2 of 2)

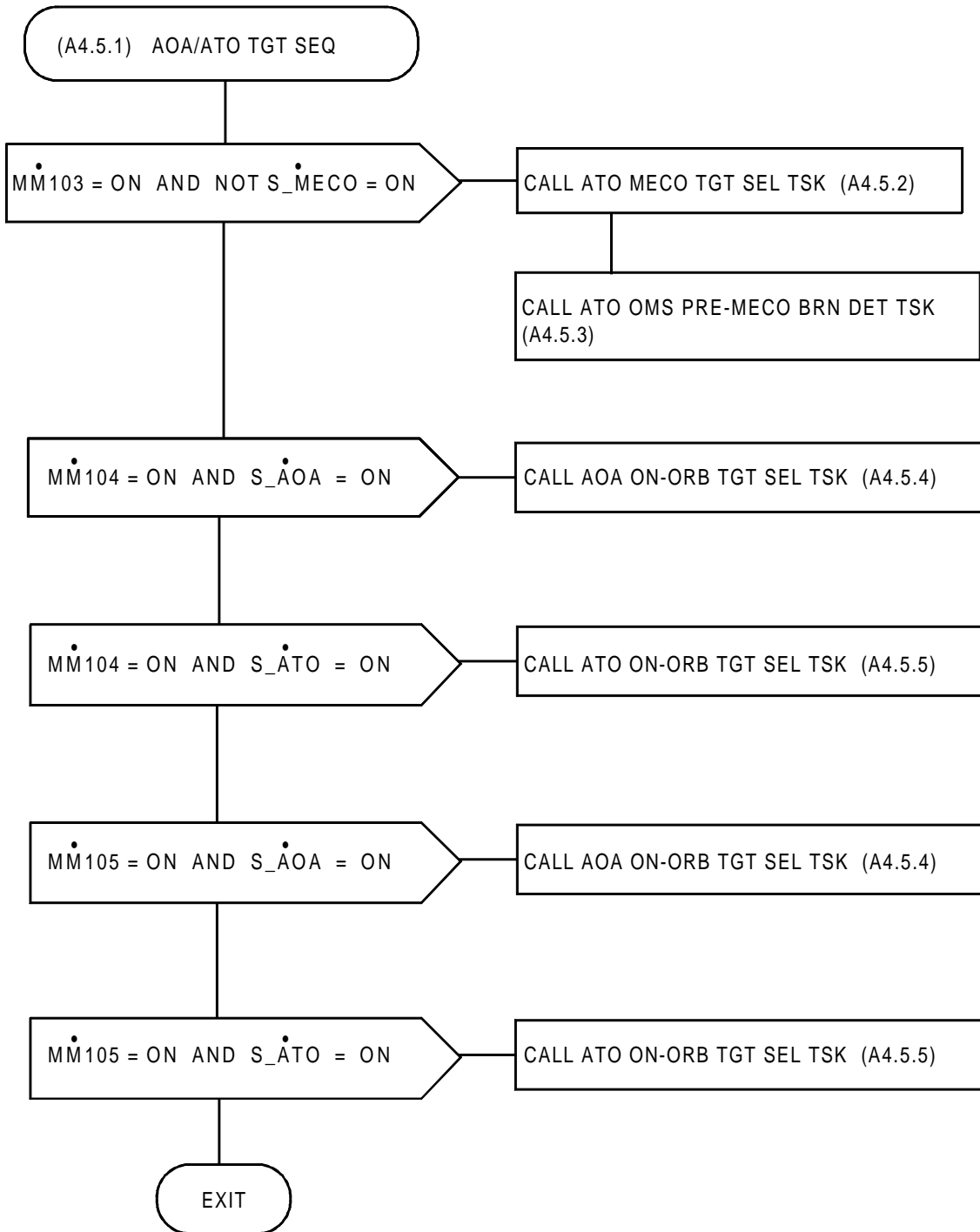


FIGURE A4.5.1. AOA/ATO TGT SEQ Flow Diagram

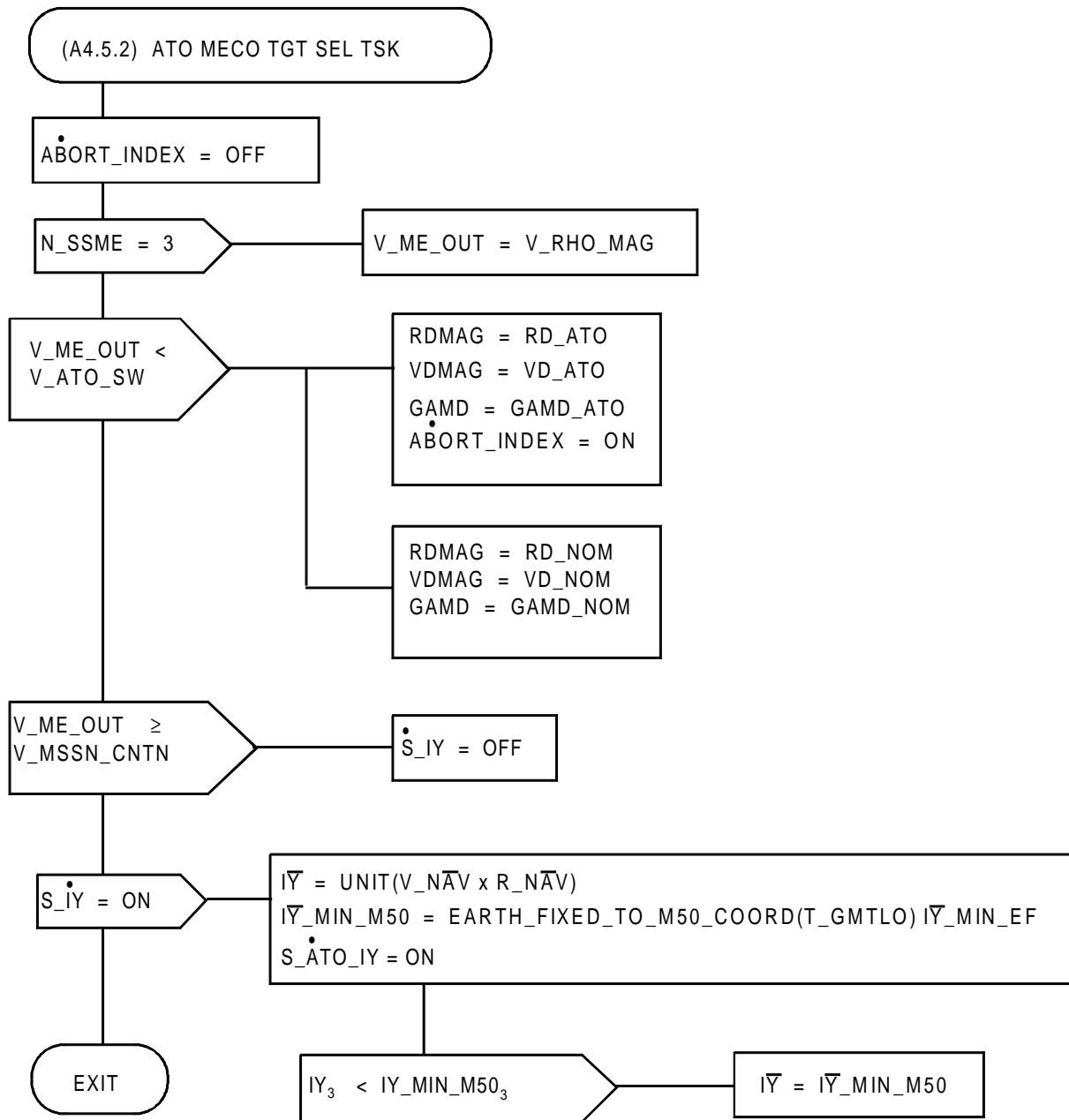


FIGURE A4.5.2. ATO MECO TGT SEL TSK Flow Diagram

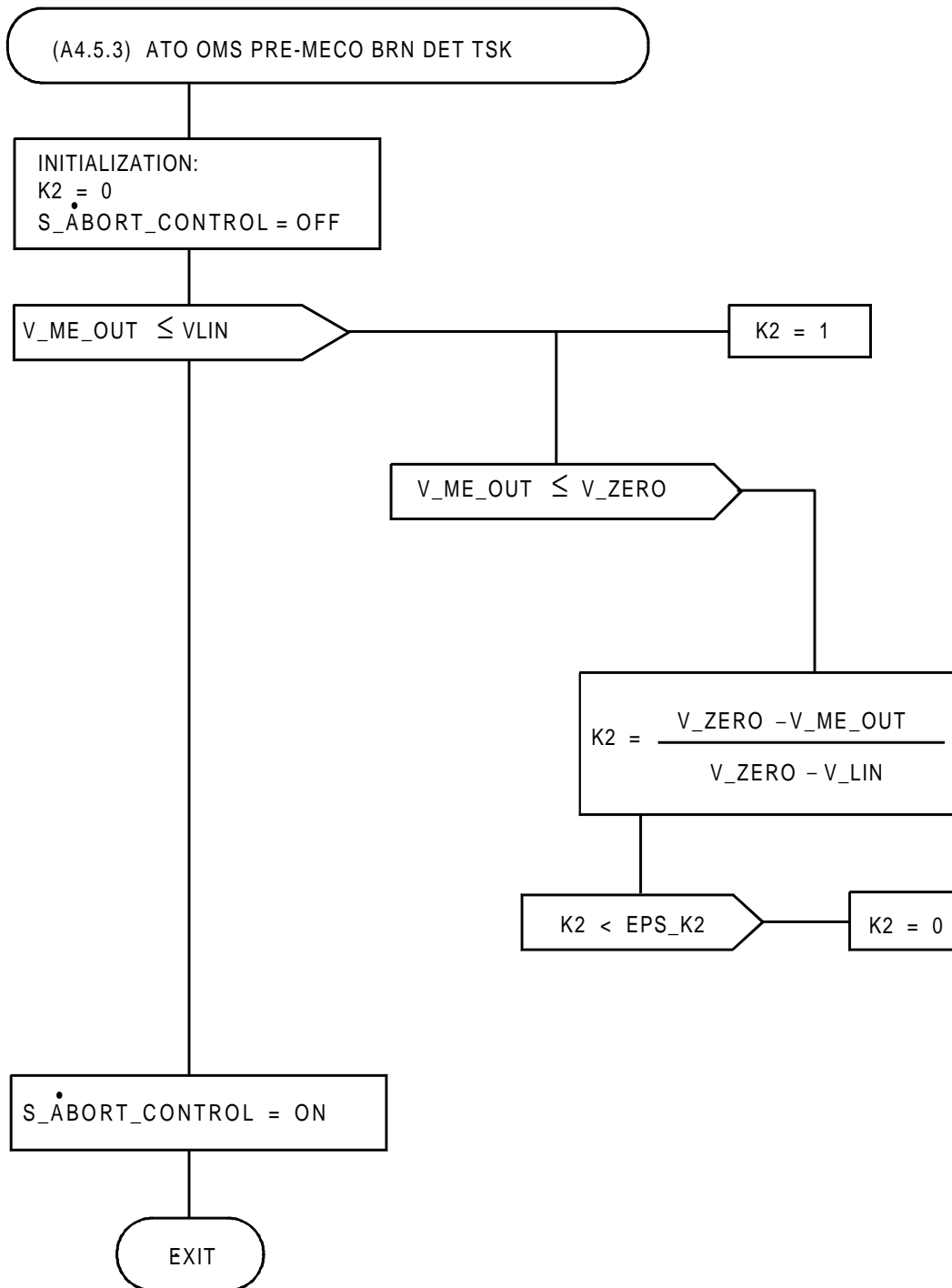


FIGURE A4.5.3. ATO OMS PRE-MECO BRN DET TSK Flow Diagram

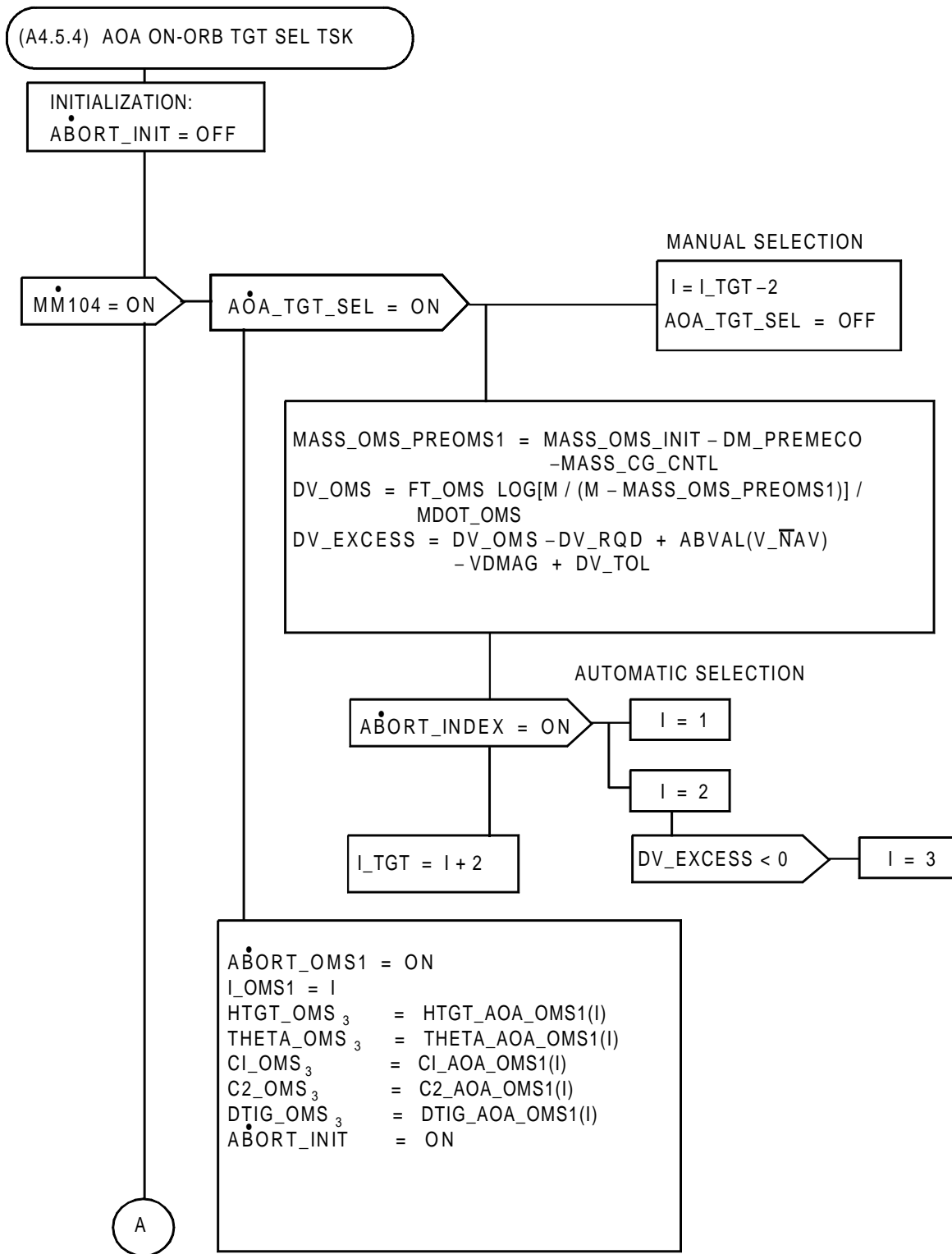


FIGURE A4.5.4.(1) AOA ON-ORB TGT SEL TSK Flow Diagram (Sheet 1 of 3)

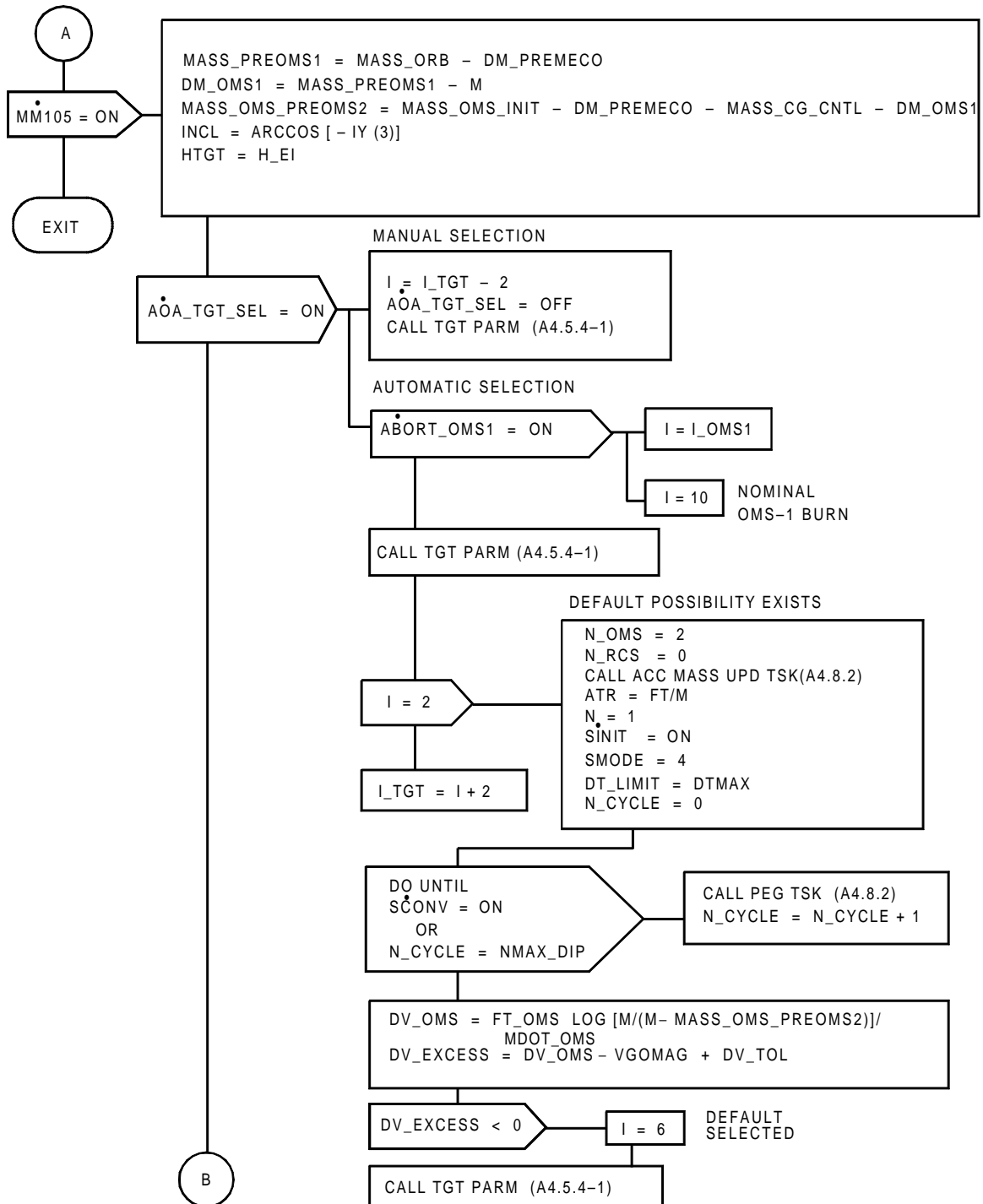


FIGURE A4.5.4.(2) AOA ON-ORB TGT SEL TSK Flow Diagram (Sheet 2 of 3)

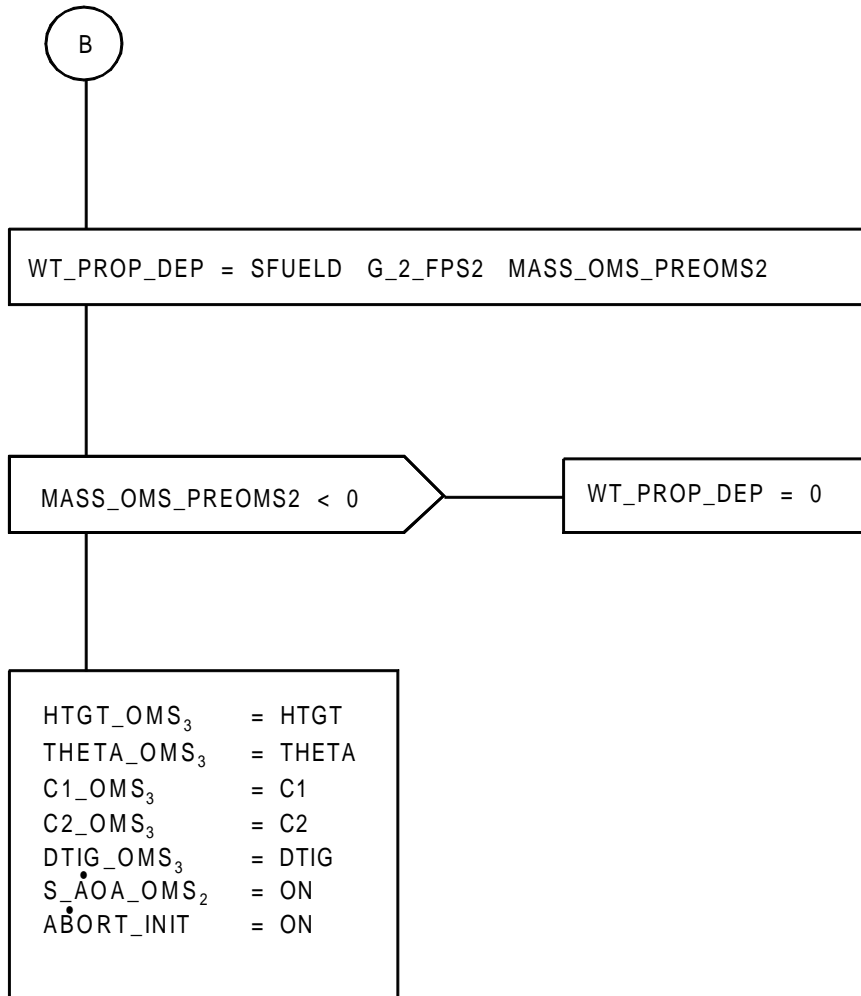


FIGURE A4.5.4.(3) AOA ON-ORB TGT SEL TSK Flow Diagram (Sheet 3 of 3)

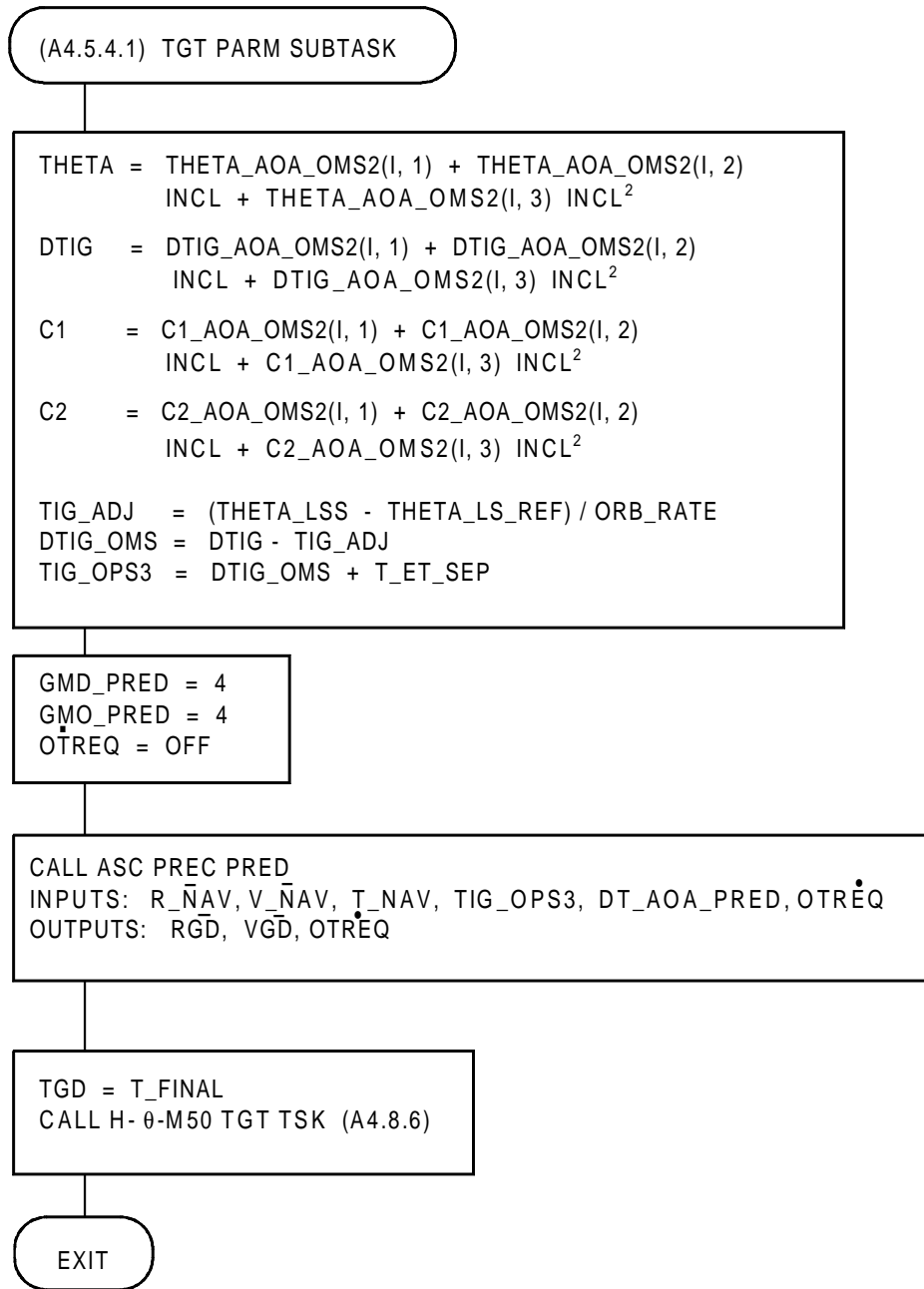


FIGURE A4.5.4.1. TGT PARM SUBTASK Flow Diagram

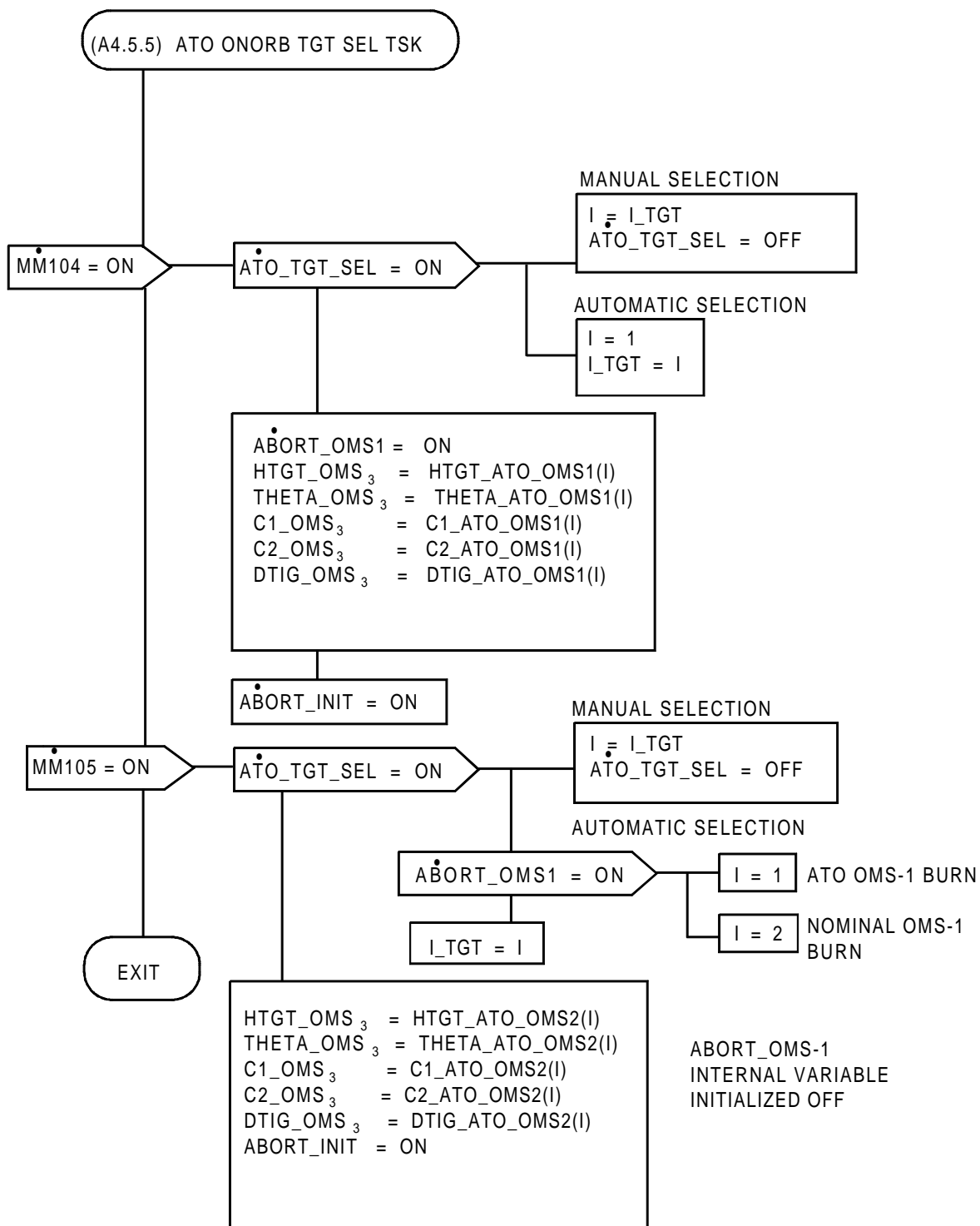


FIGURE A4.5.5. ATO ON-ORB TGT SEL TSK Flow Diagram

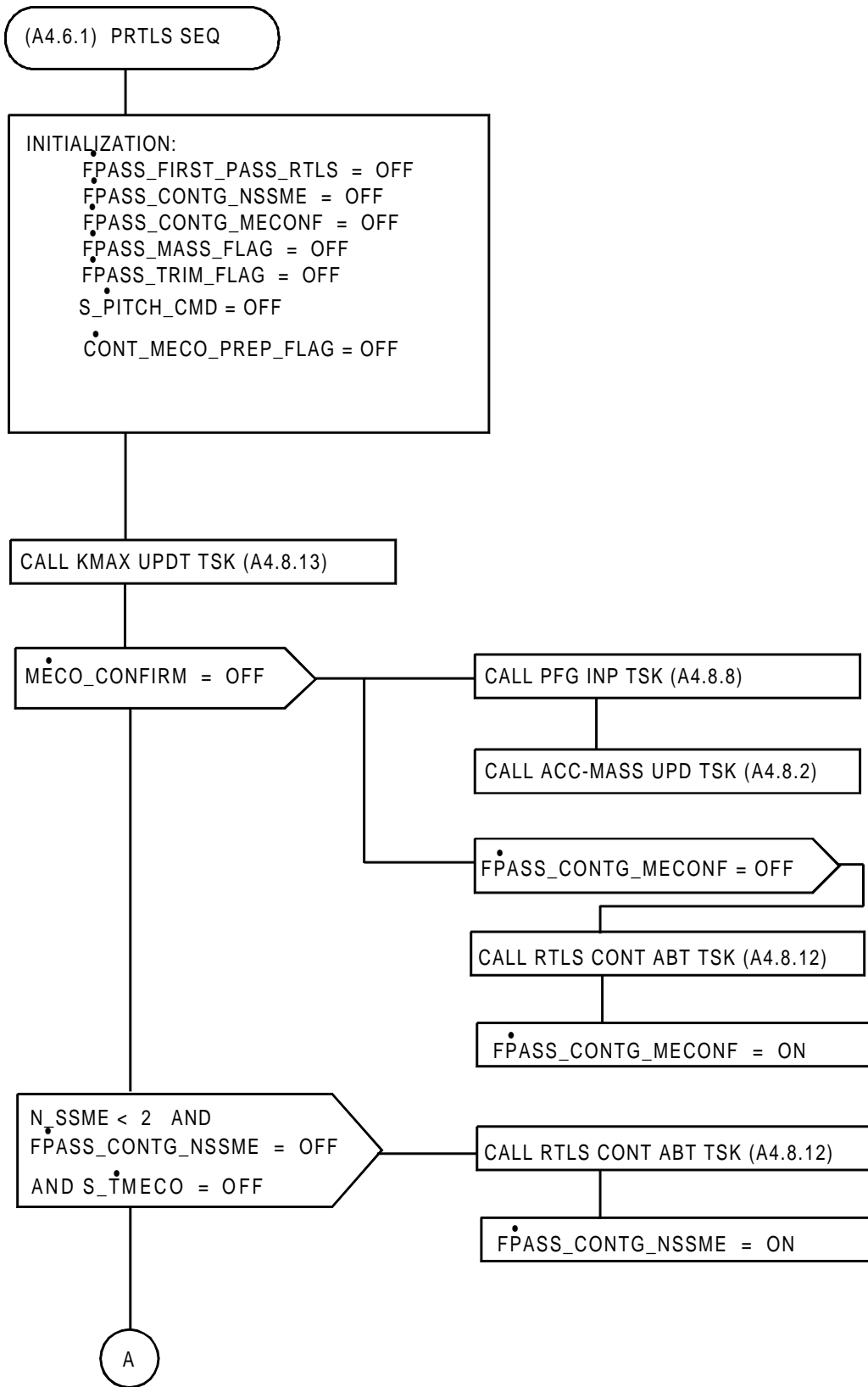


FIGURE A4.6.1.(1) PRTL SEQ Flow Diagram (Sheet 1 of 4)

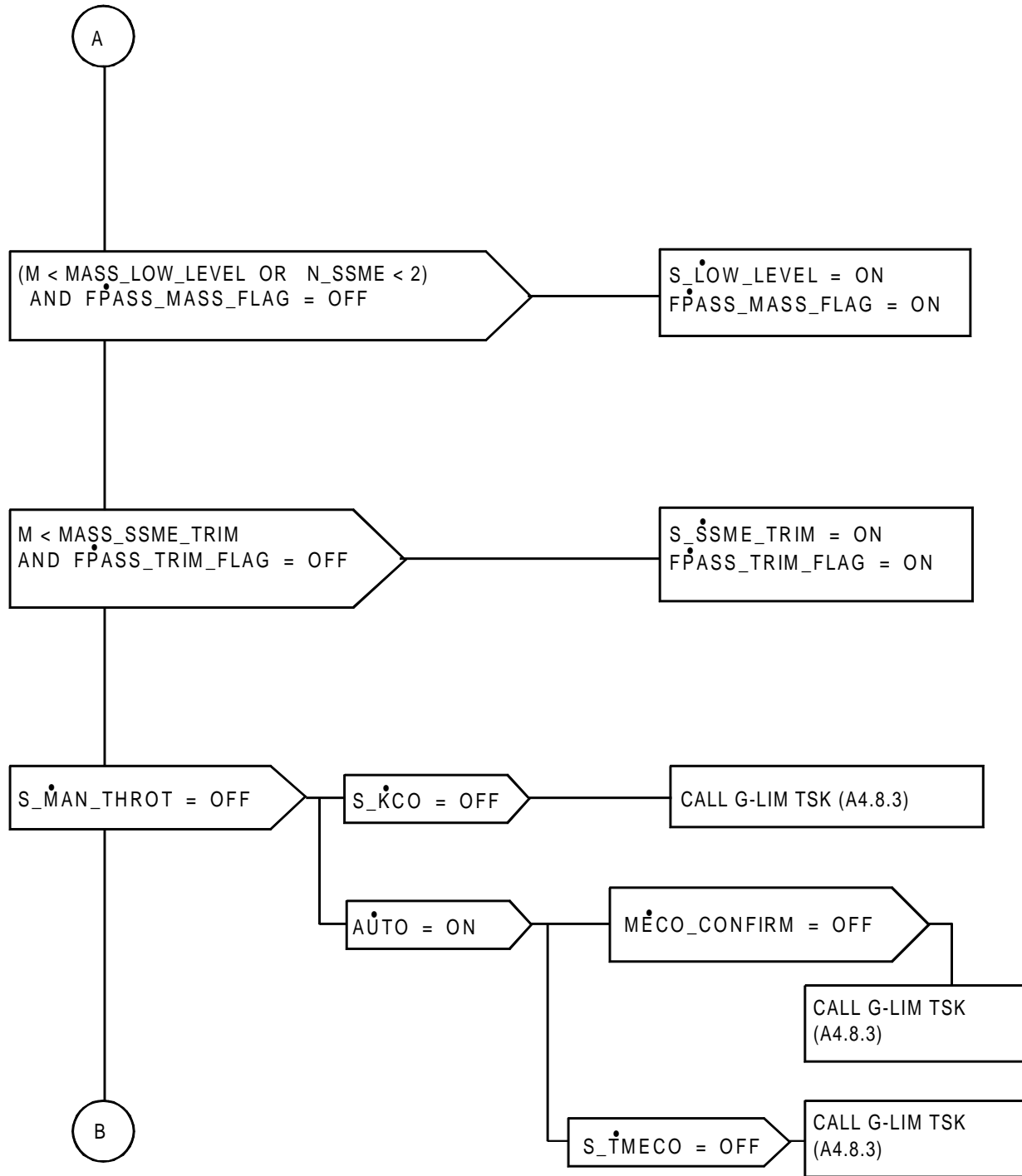


FIGURE A4.6.1.(2) PRTLs SEQ Flow Diagram (Sheet 2 of 4)

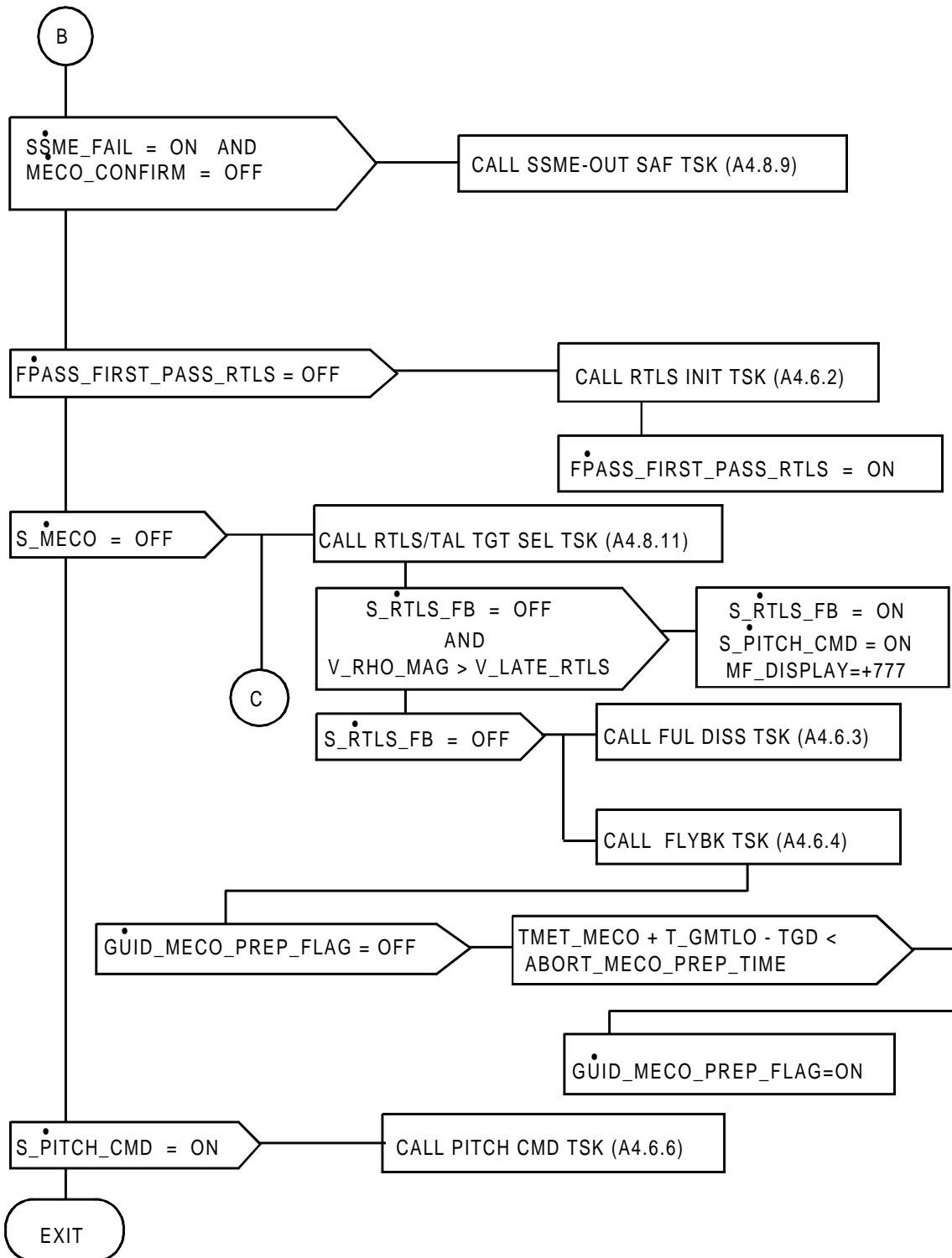


FIGURE A4.6.1.(3) PRTL SEQ Flow Diagram (Sheet 3 of 4)

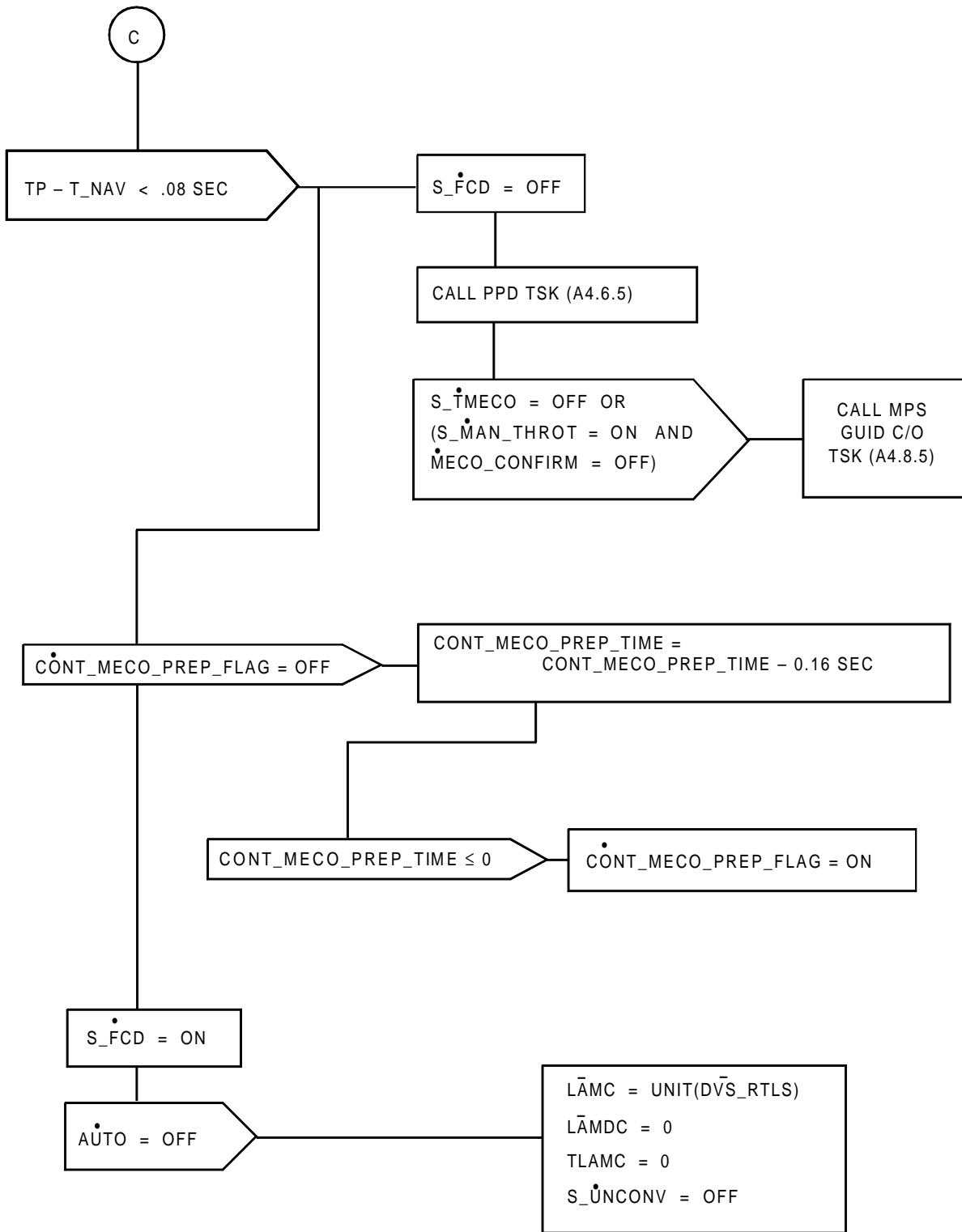


FIGURE A4.6.1.(4) PRTL SEQ Flow Diagram (Sheet 4 of 4)

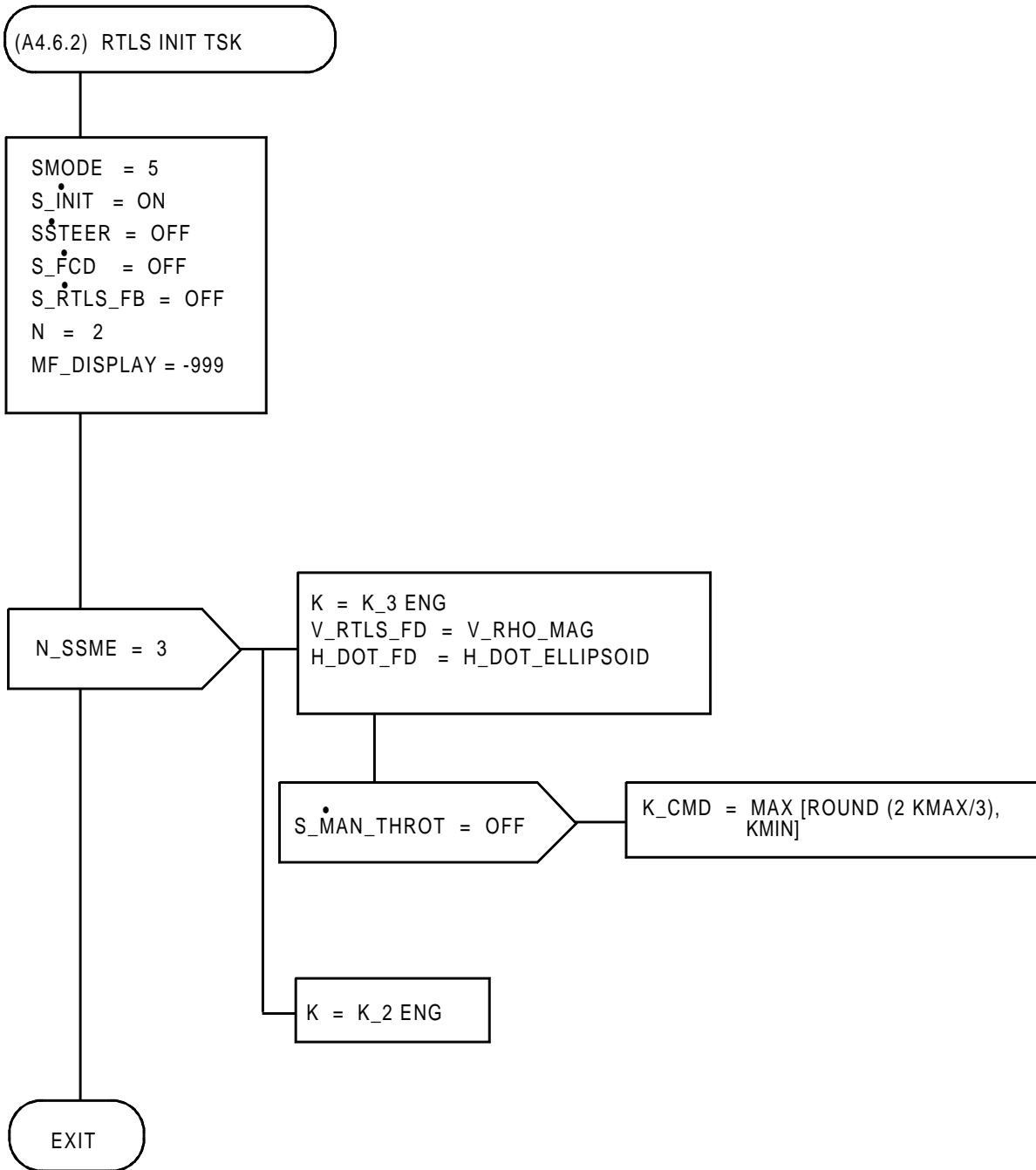


FIGURE A4.6.2. RTLS INIT TSK Flow Diagram

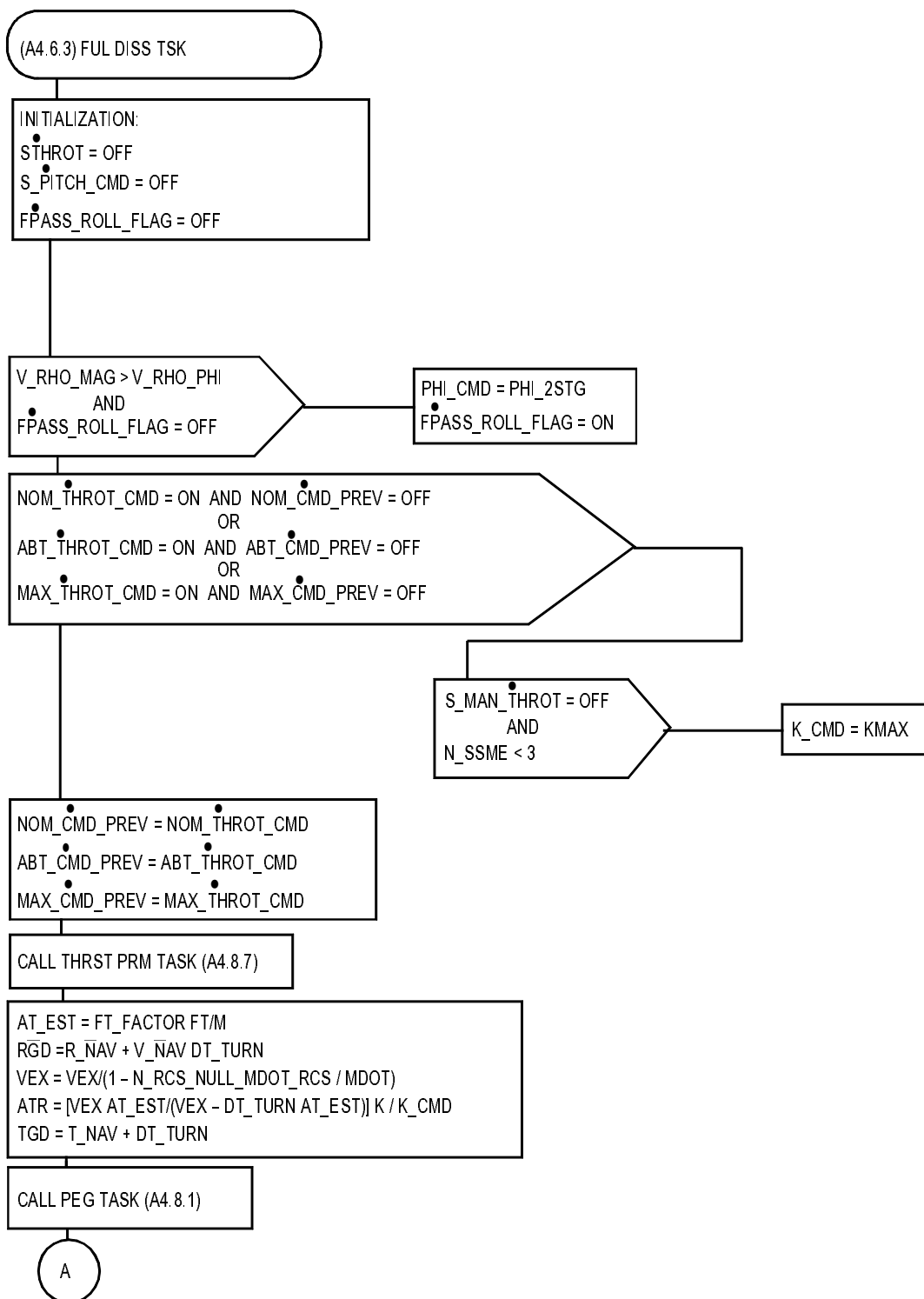


FIGURE A4.6.3.(1) FUL DISS TSK Flow Diagram (Sheet 1 of 2)

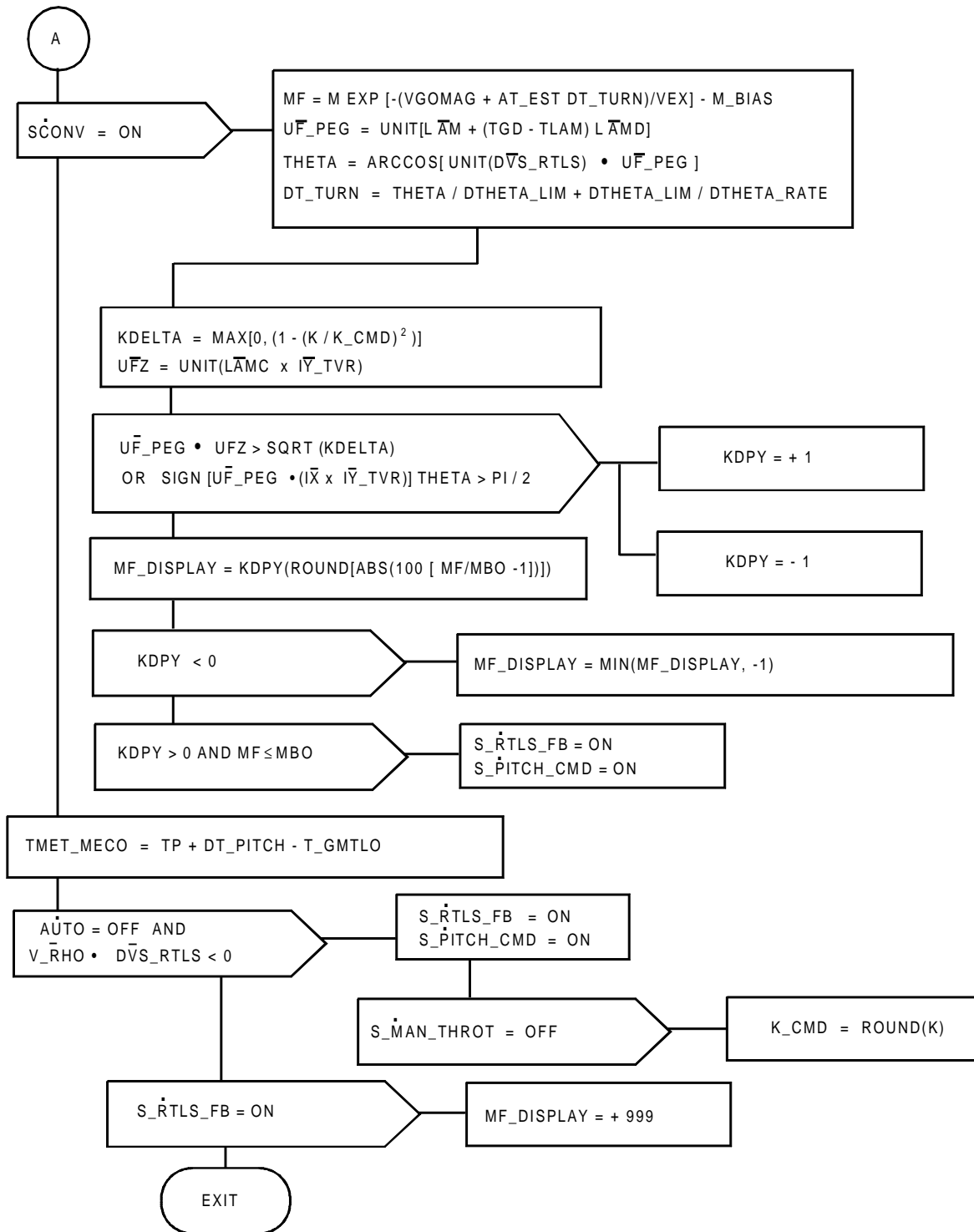


FIGURE A4.6.3.(2) FUL DISS TSK Flow Diagram (Sheet 2 of 2)

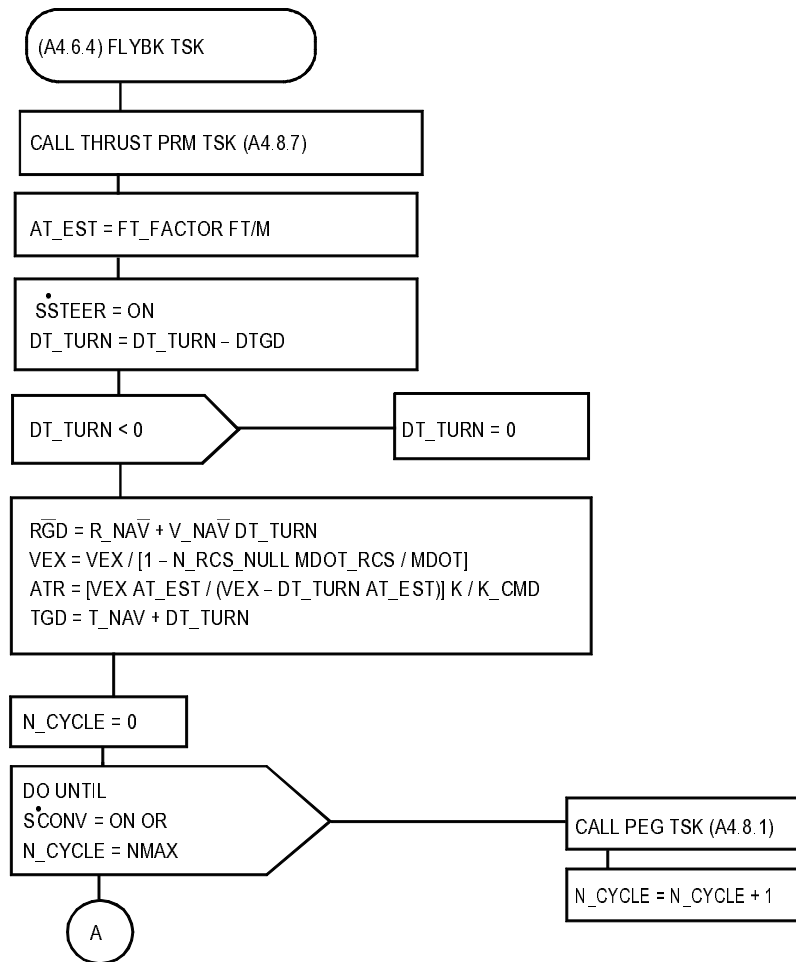


FIGURE A4.6.4.(1) FLYBK TSK Flow Diagram (Sheet 1 of 2)

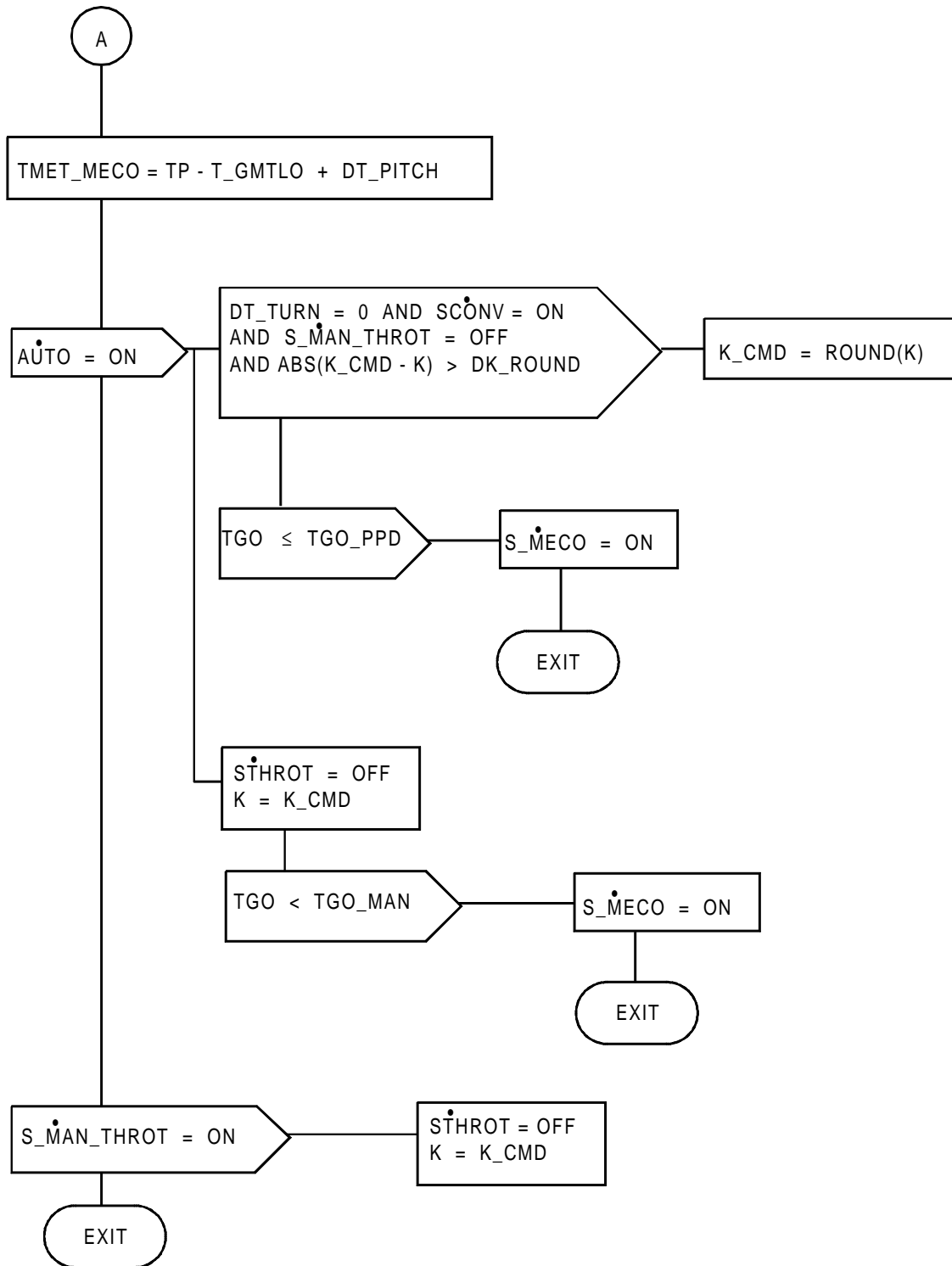


FIGURE A4.6.4.(2) FLYBK TSK Flow Diagram (Sheet 2 of 2)

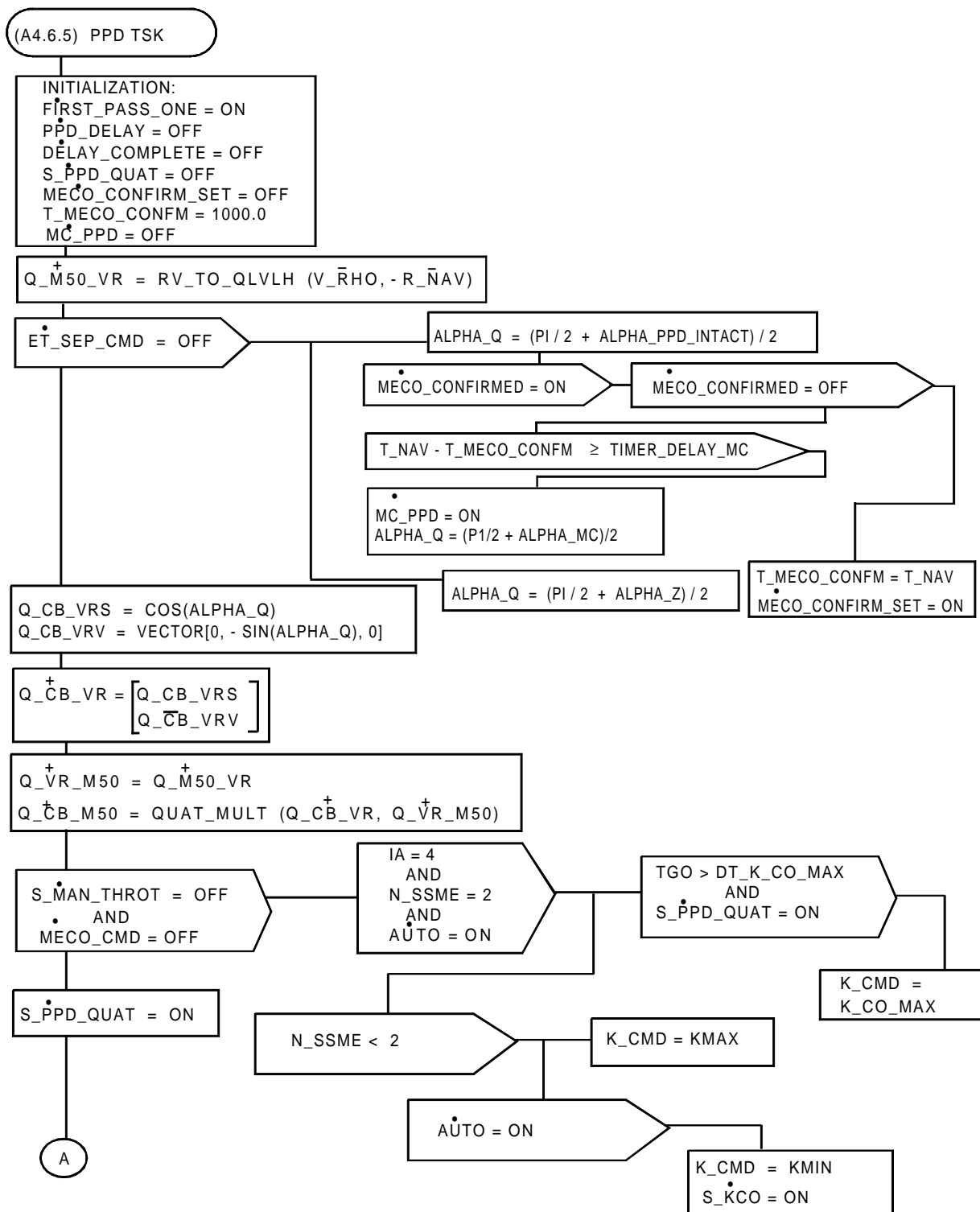


FIGURE A4.6.5.(1) PPD TSK Flow Diagram (Sheet 1 of 2)

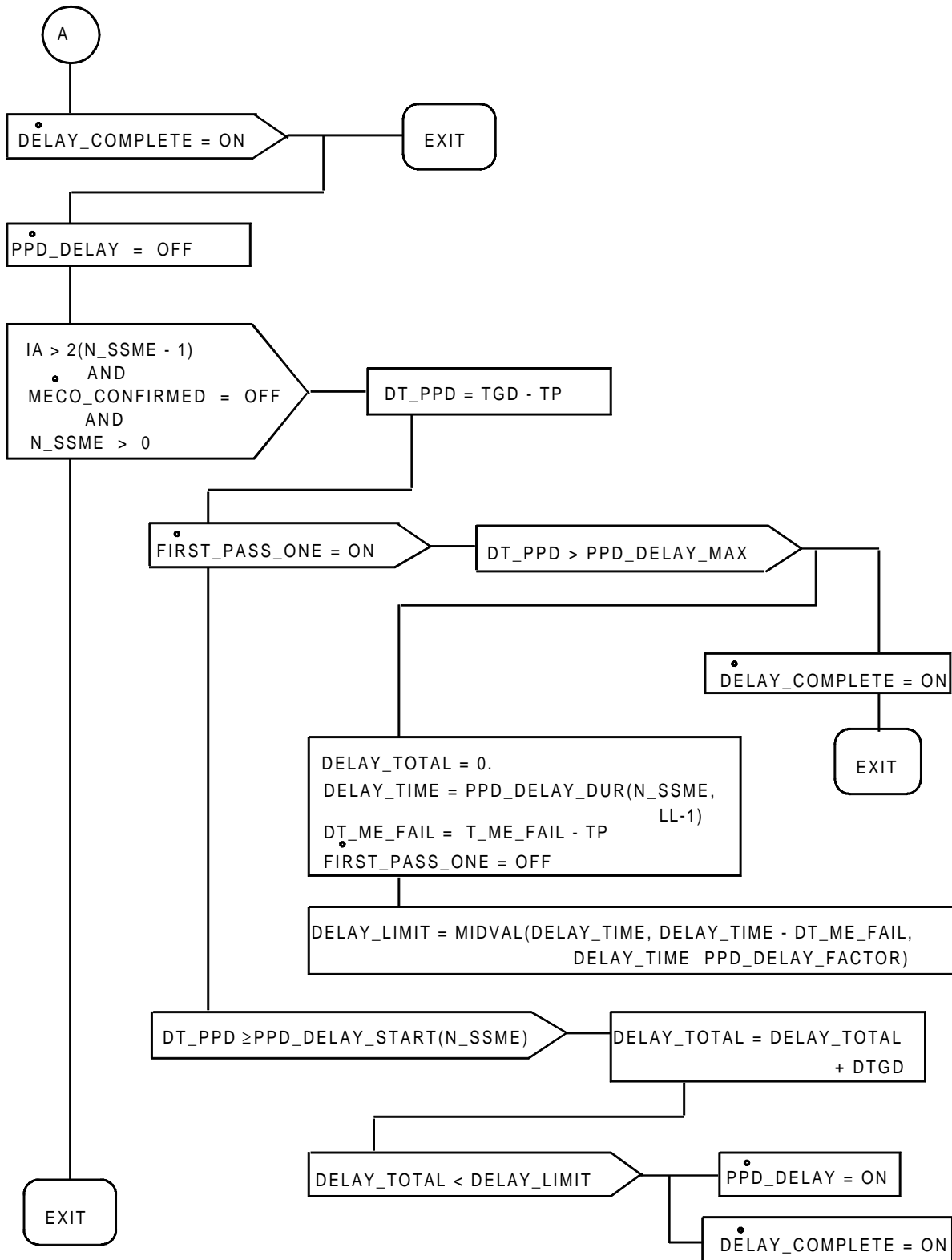


FIGURE A4.6.5.(2) PPD TSK Flow Diagram (Sheet 2 of 2)

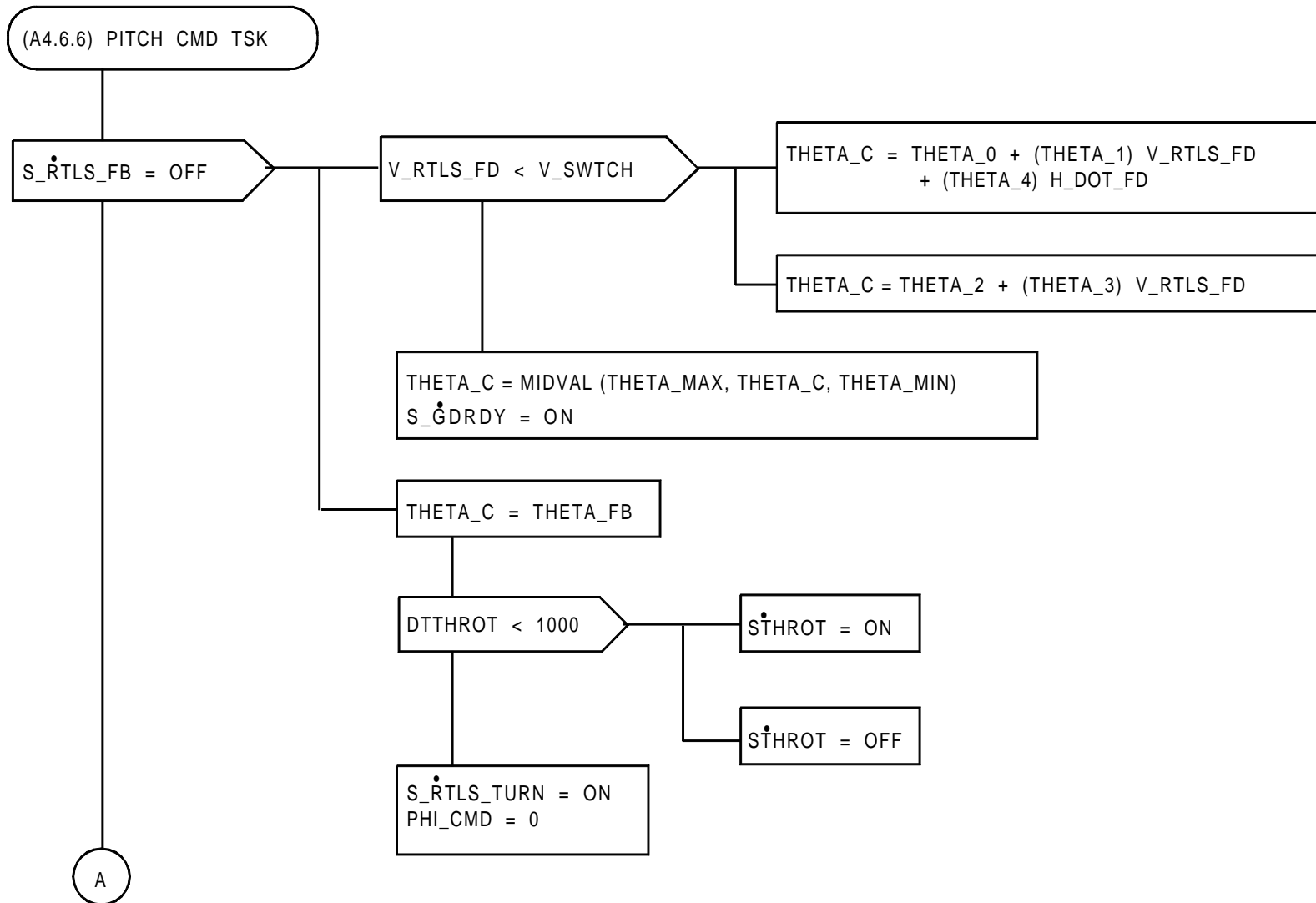


FIGURE A4.6.6.(1) PITCH CMD TSK Flow Diagram (Sheet 1 of 2)

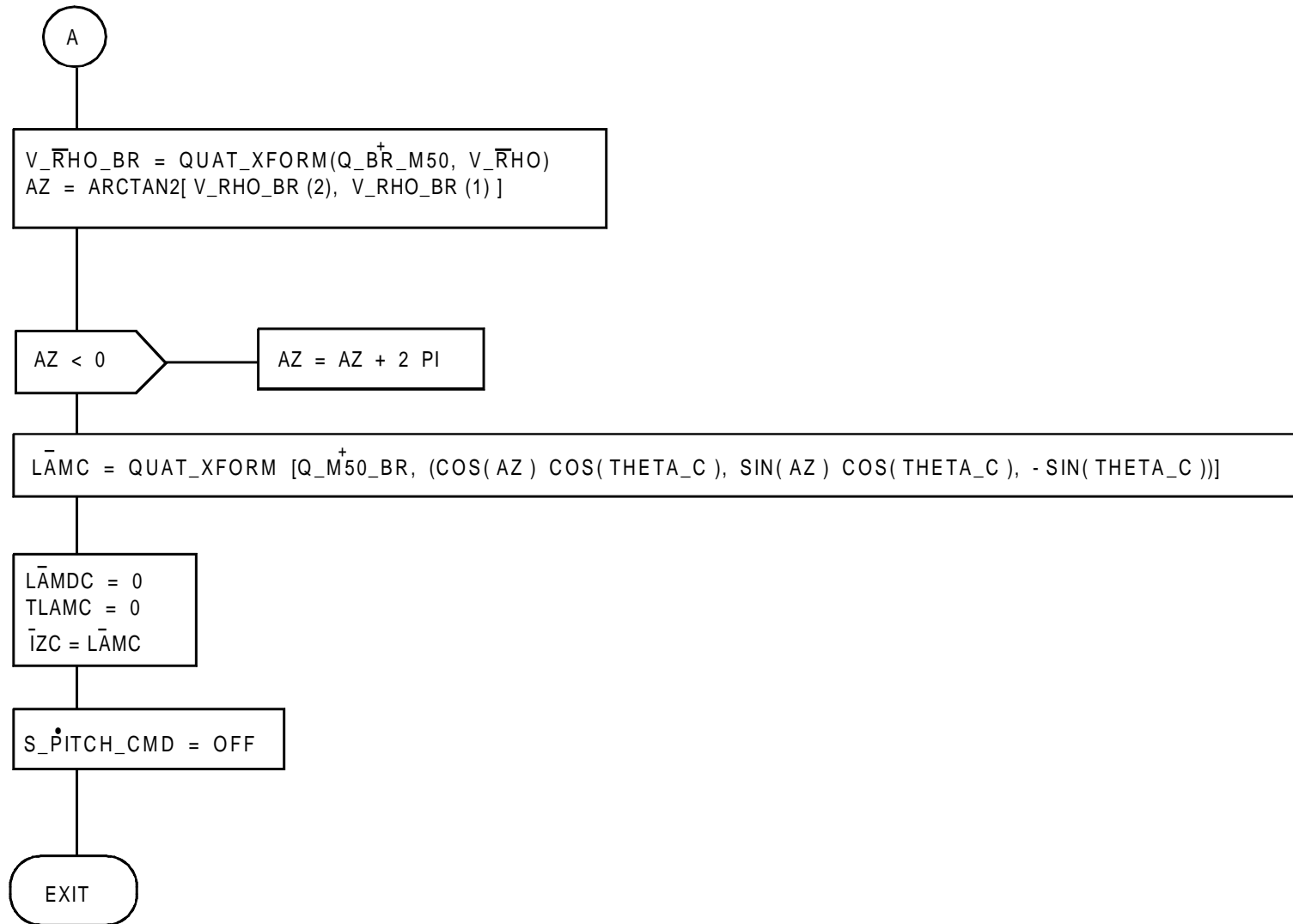


FIGURE A4.6.6.(2) PITCH CMD TSK Flow Diagram (Sheet 2 of 2)

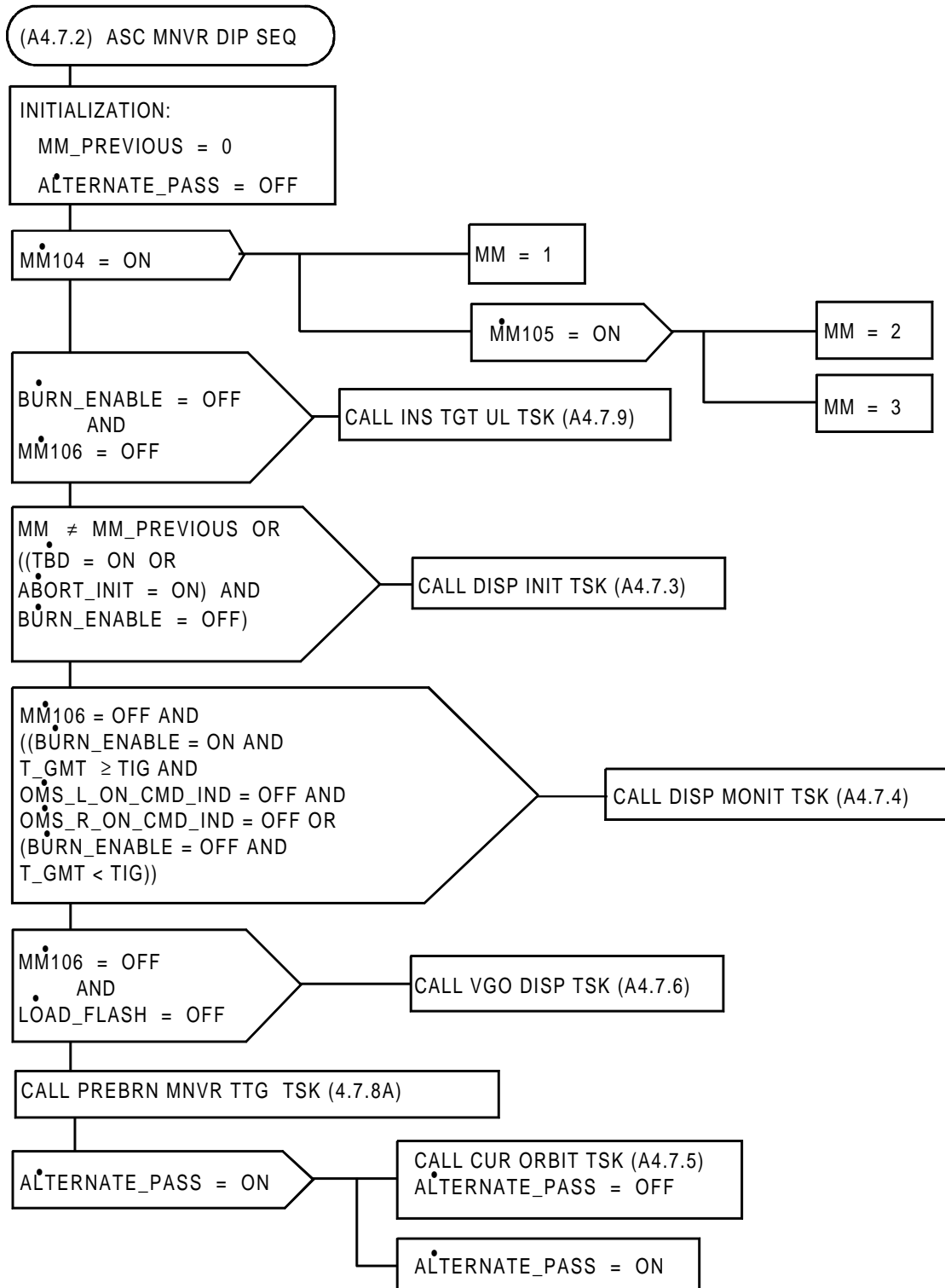


FIGURE A4.7.2. ASC MNVR DIP SEQ Flow Diagram

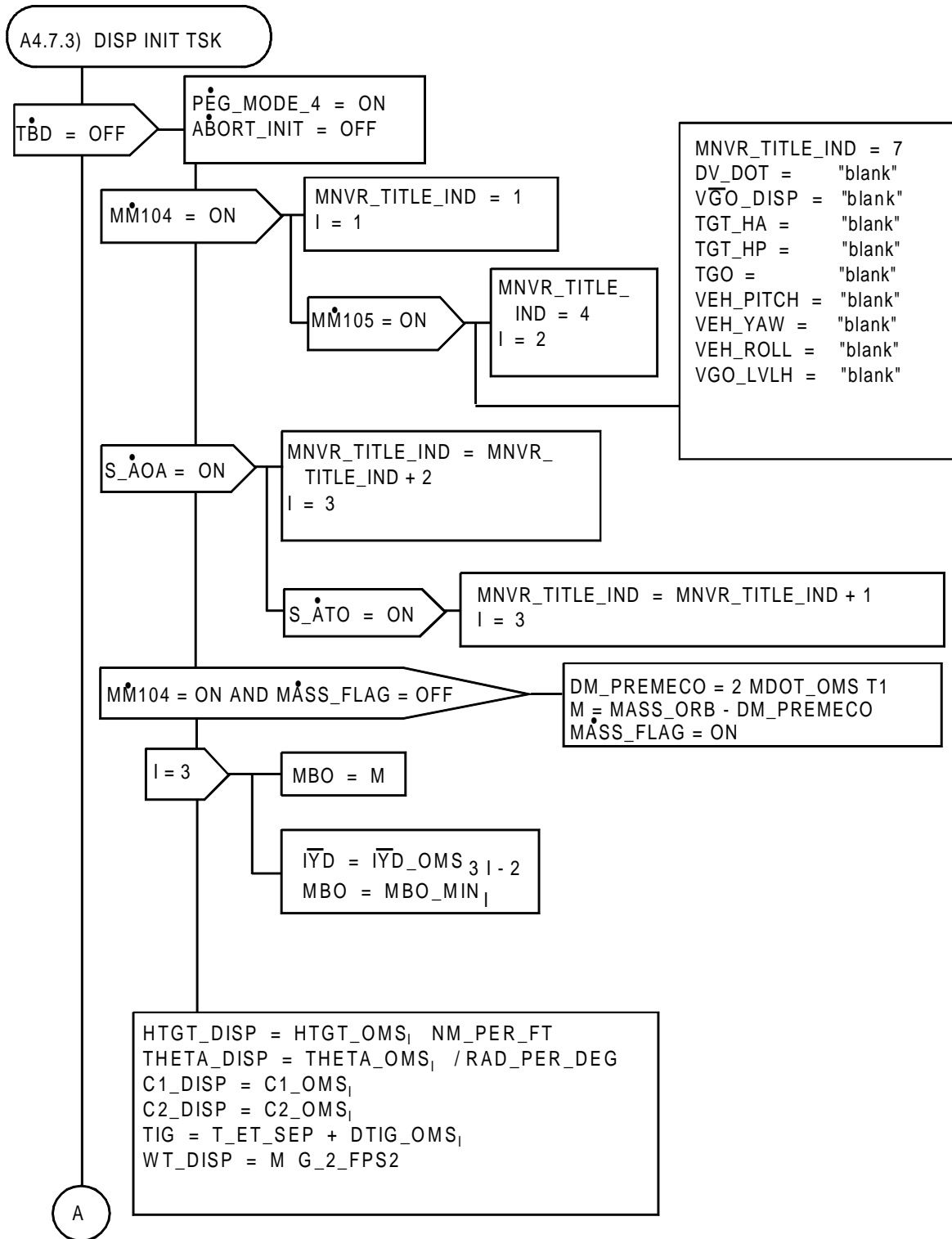


FIGURE A4.7.3.(1) DISP INIT TSK Flow Diagram (Sheet 1 of 2)

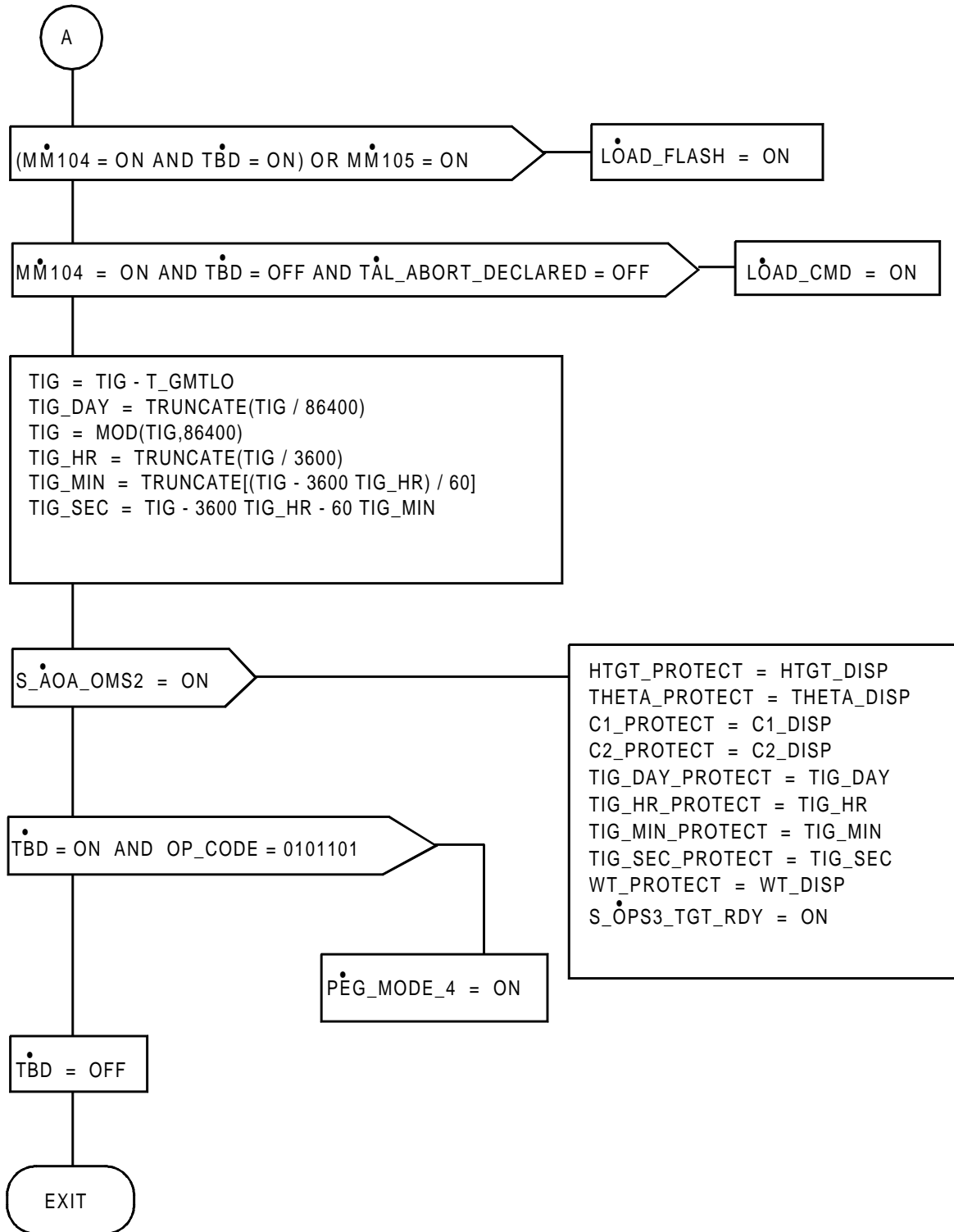
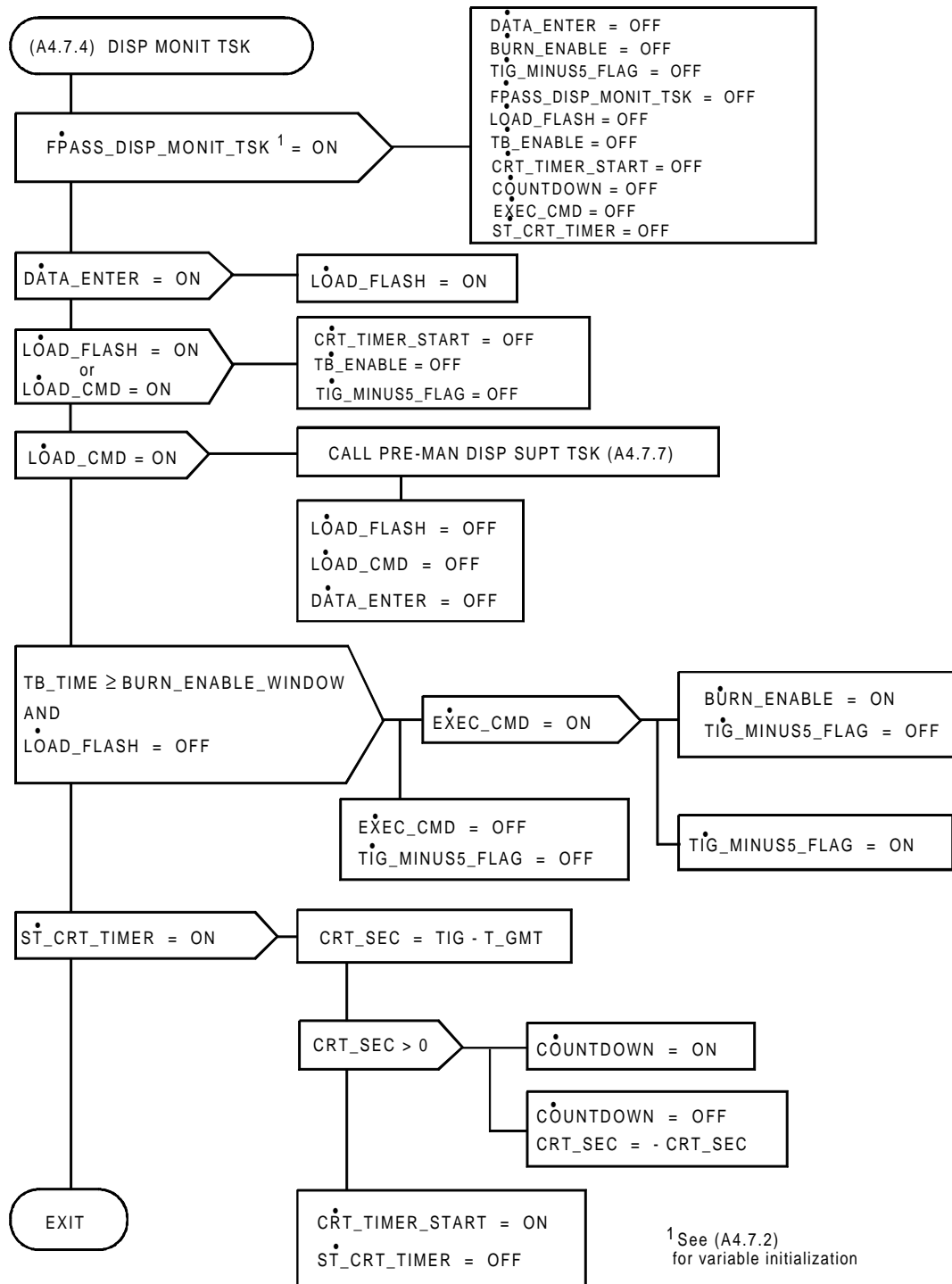


FIGURE A4.7.3.(2) DISP INIT TSK Flow Diagram (Sheet 2 of 2)



¹ See (A4.7.2) for variable initialization

FIGURE A4.7.4. DISP MONIT TSK Flow Diagram

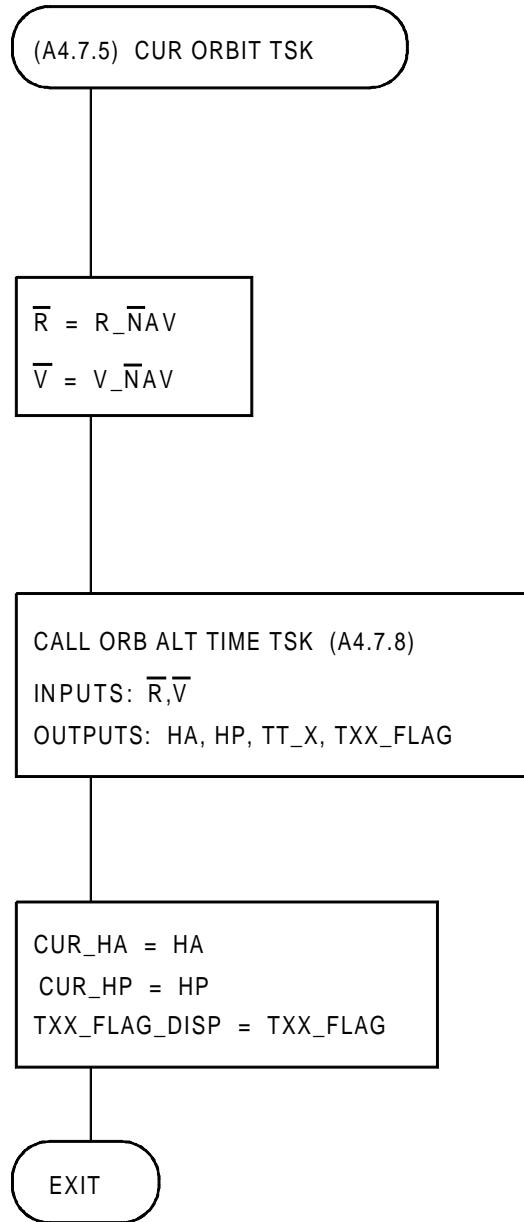
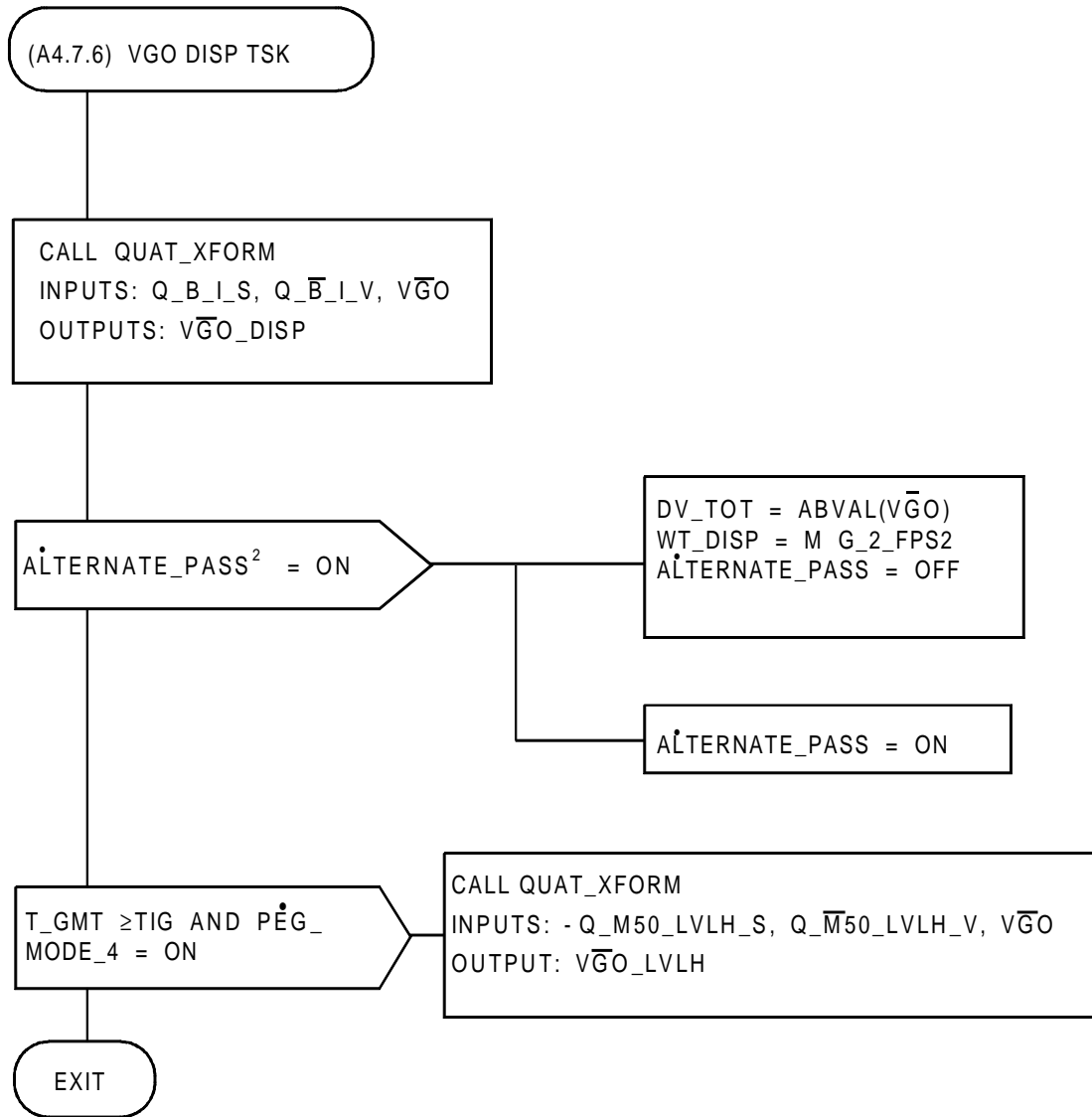


FIGURE A4.7.5. CUR ORBIT TSK Flow Diagram



²Internal variable

FIGURE A4.7.6. VGO DISP TSK Flow Diagram

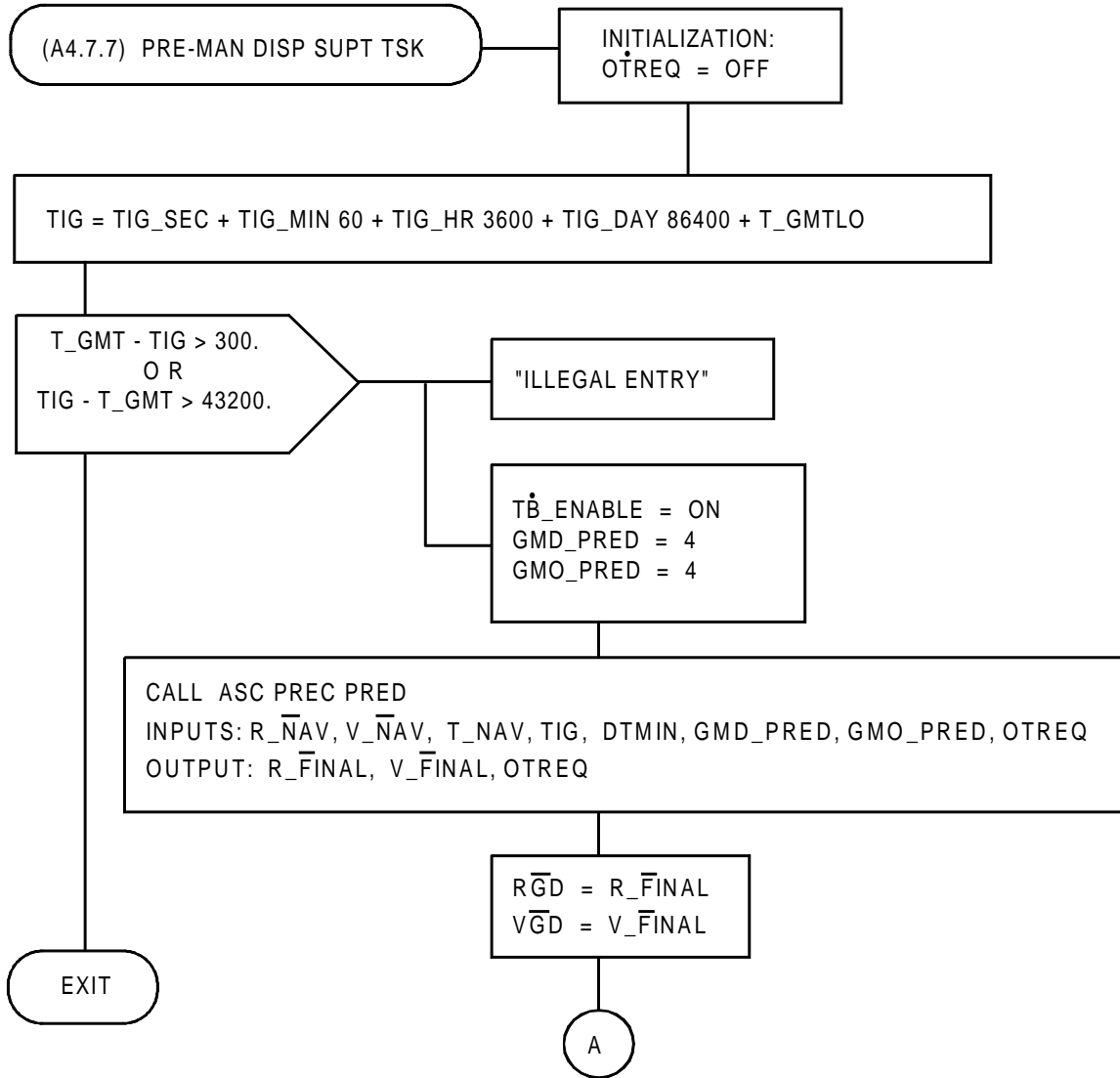


FIGURE A4.7.7.(1) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 1 of 6)

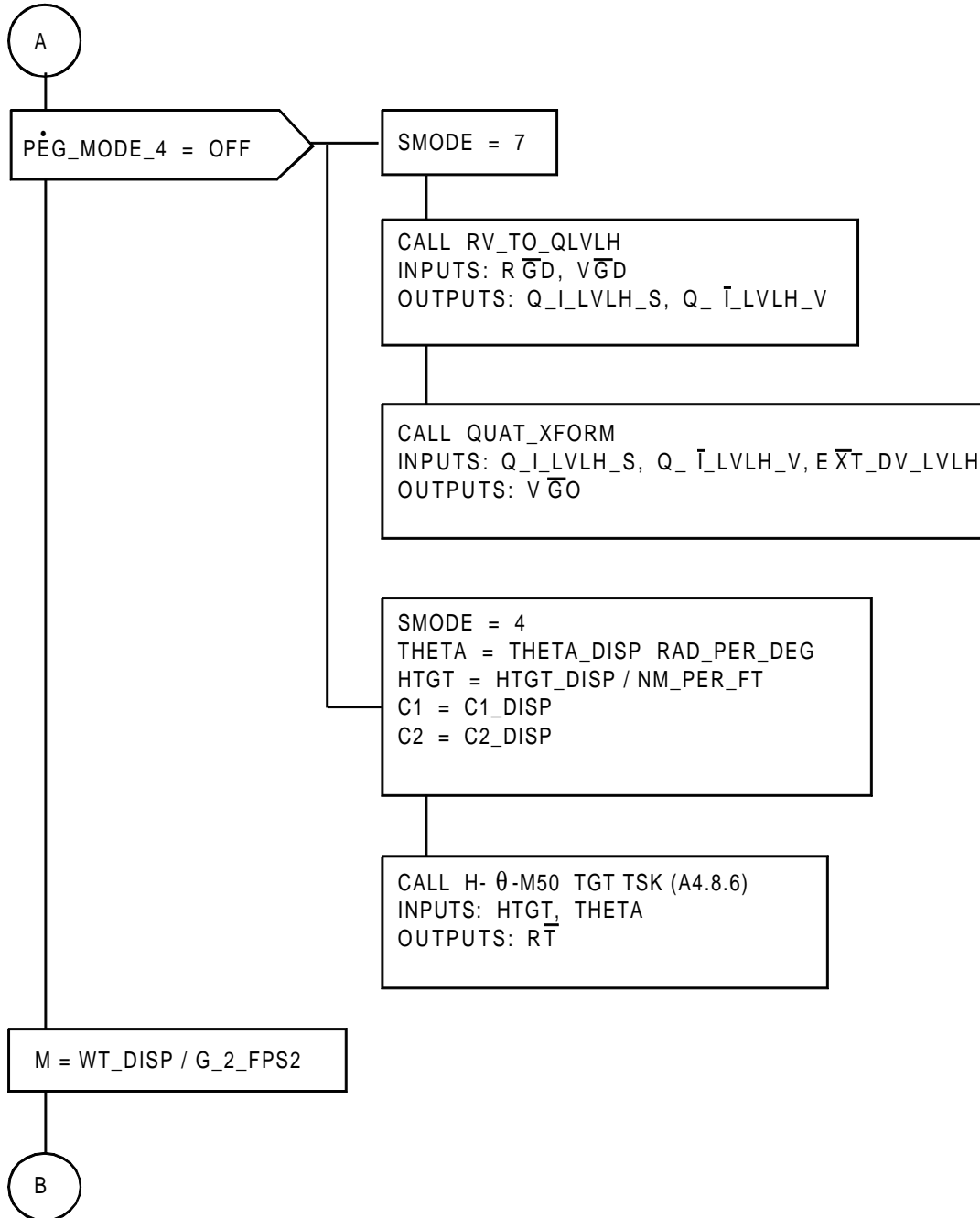


FIGURE A4.7.7.(2) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 2 of 6)

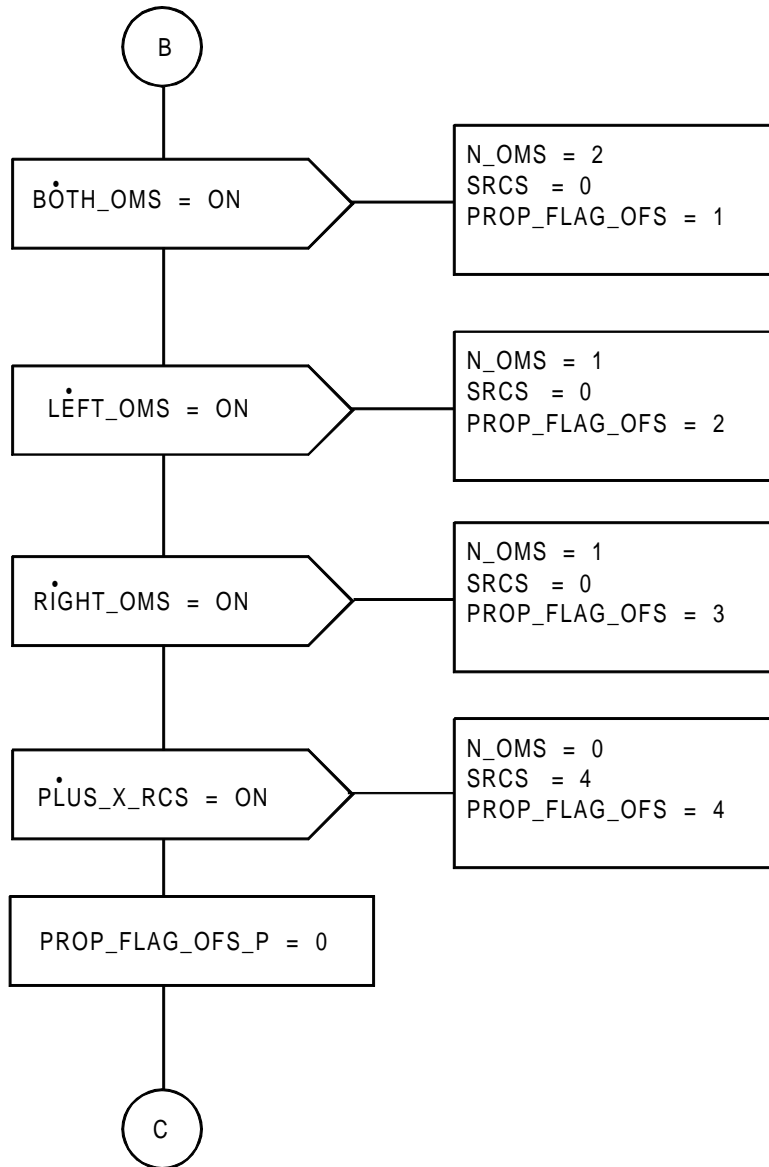


FIGURE A4.7.7.(3) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 3 of 6)

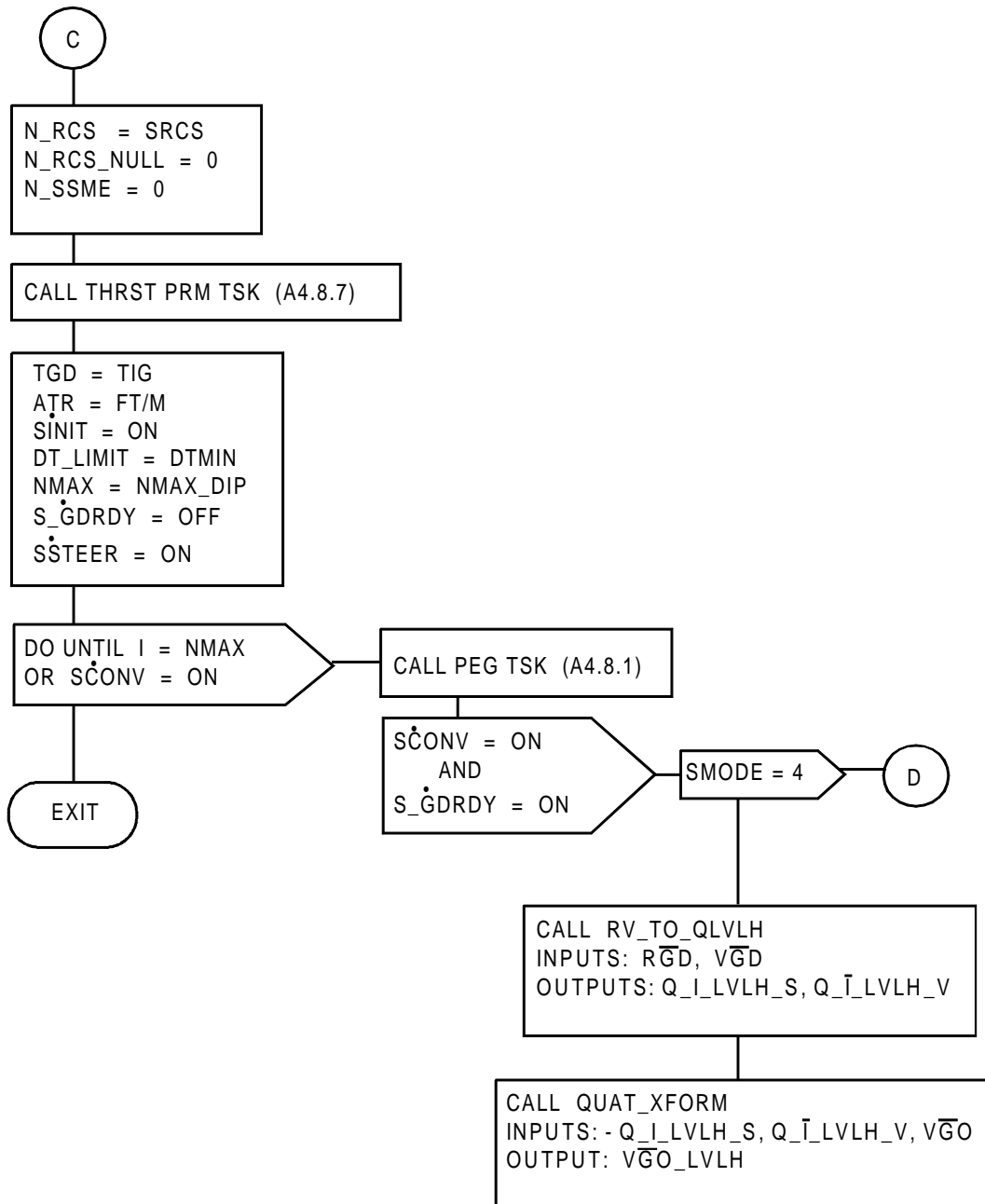


FIGURE A4.7.7.(4) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 4 of 6)

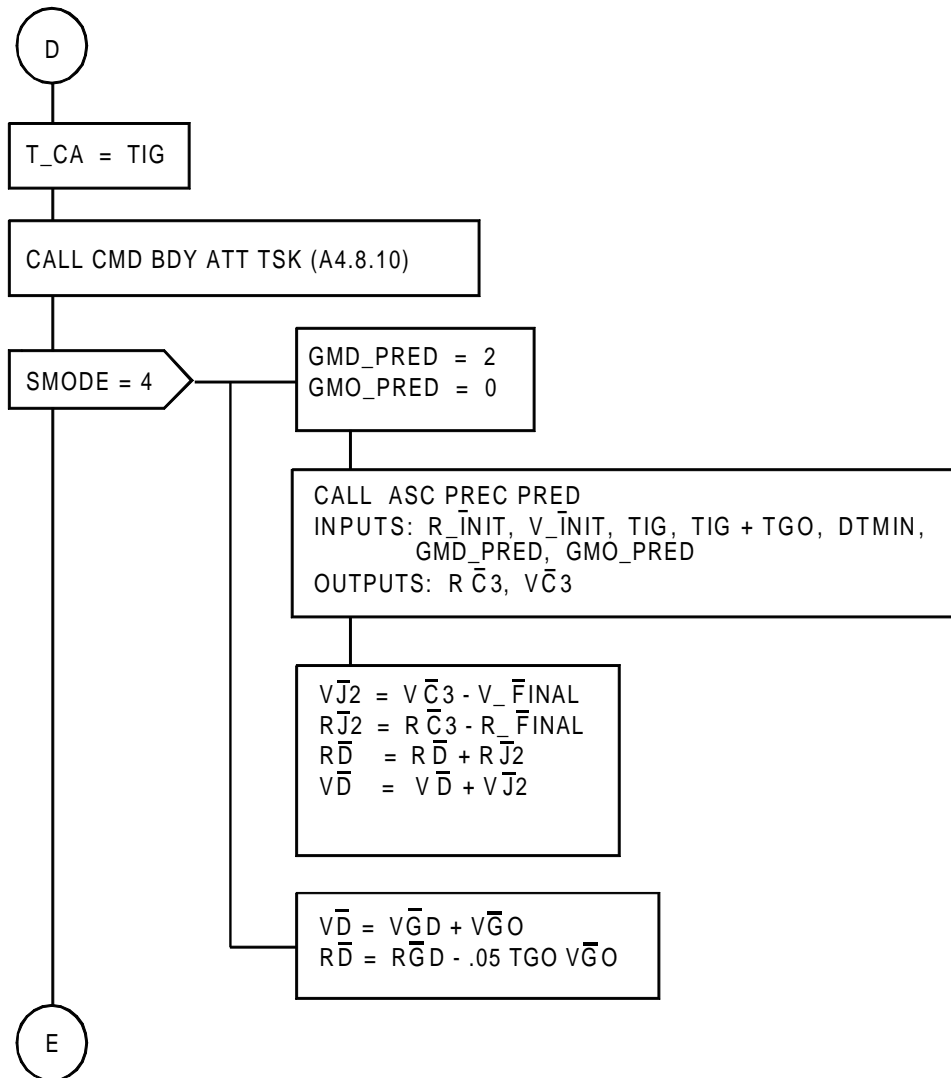


FIGURE A4.7.7.(5) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 5 of 6)

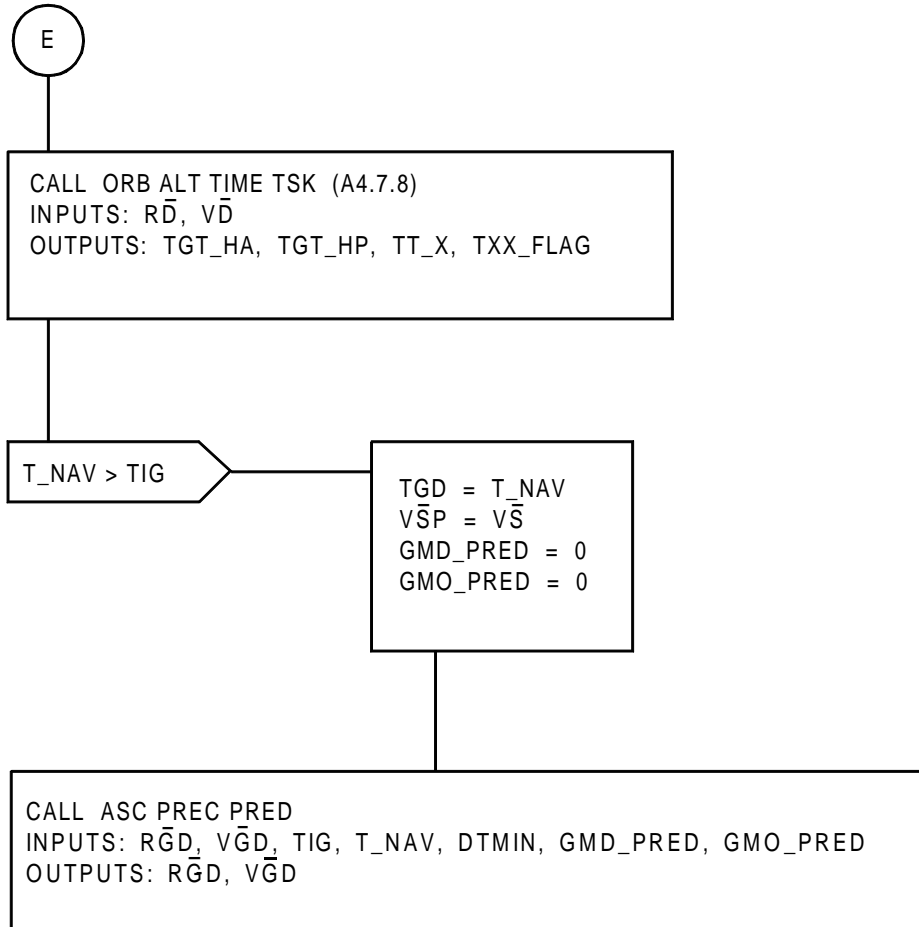


FIGURE A4.7.7.(6) PRE-MAN DISP SUPT TSK Flow Diagram (Sheet 6 of 6)



FIGURE A4.7.8.(1) ORB ALT TIME TSK Flow Diagram (Sheet 1 of 2)

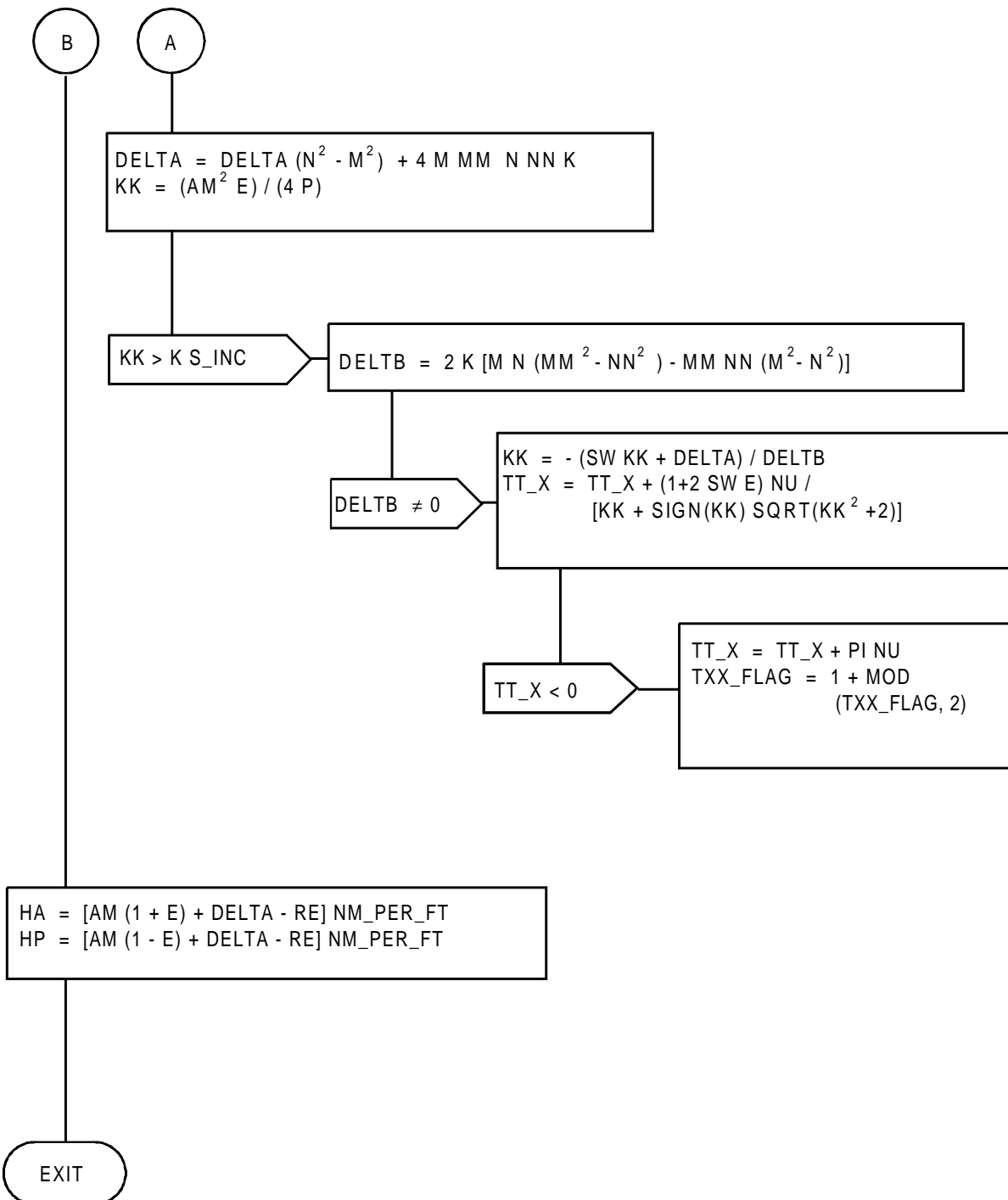


FIGURE A4.7.8.(2) ORB ALT TIME TSK Flow Diagram (Sheet 2 of 2)

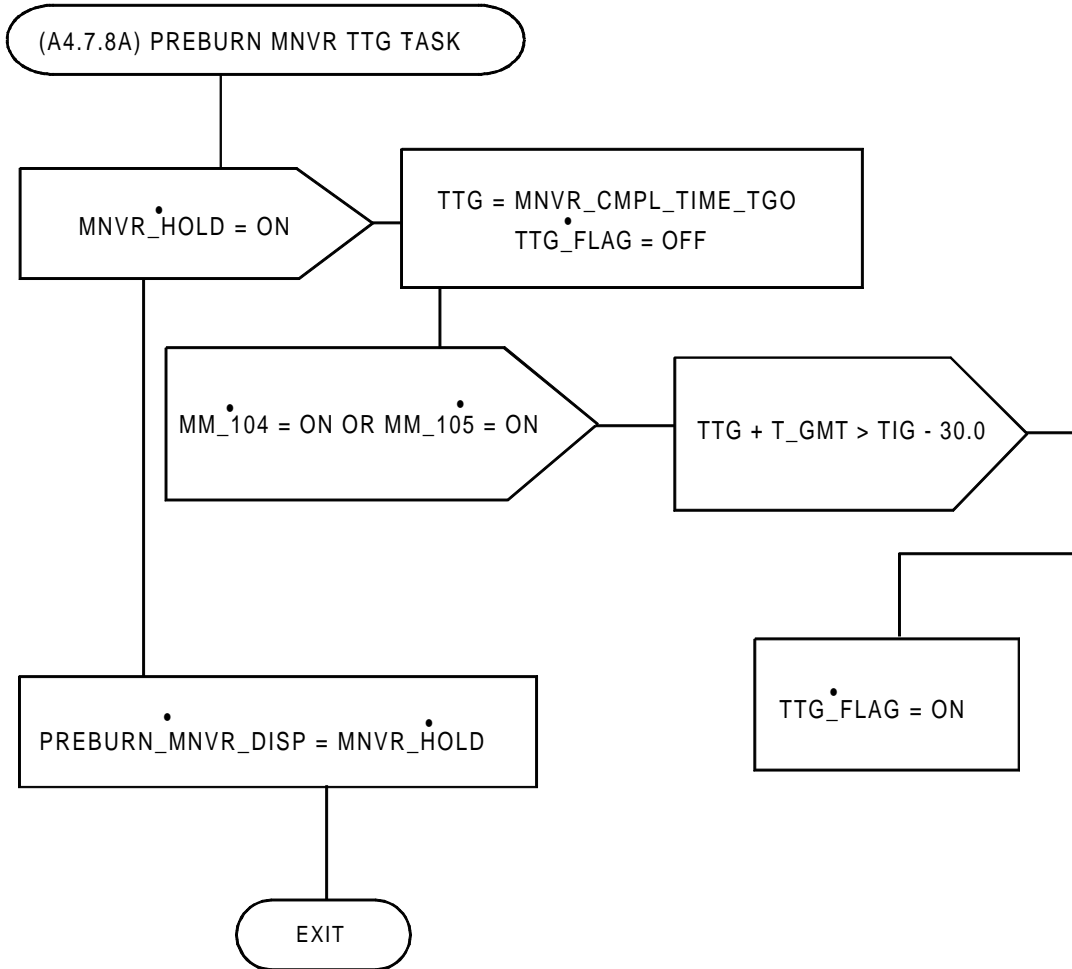


FIGURE A4.7.8A PREBRN MNVR TTG TSK FLOW DIAGRAM

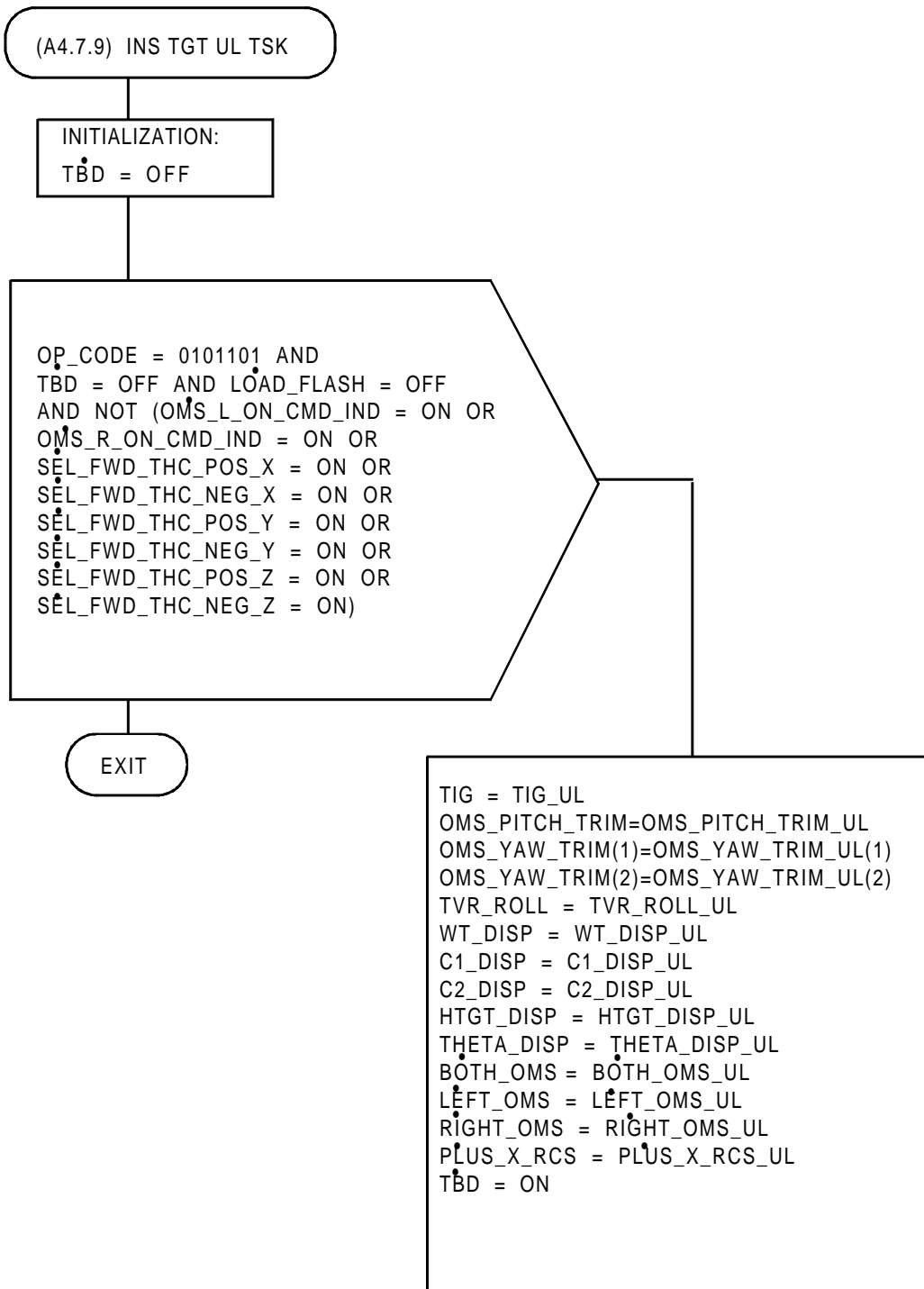


FIGURE A4.7.9. INS TGT UL TSK Flow Diagram

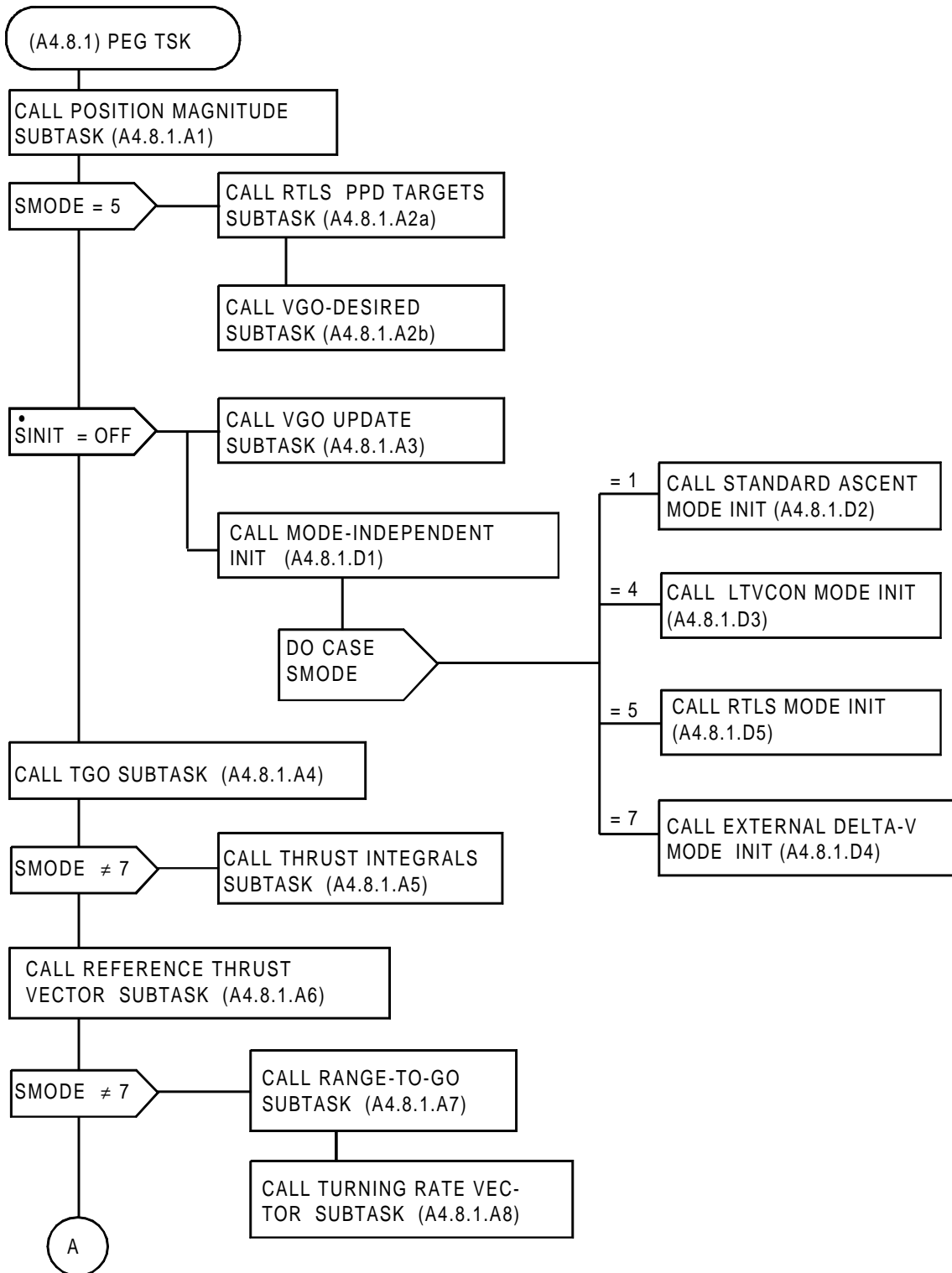


FIGURE A4.8.1.(1) PEG TSK Flow Diagram (Sheet 1 of 3)

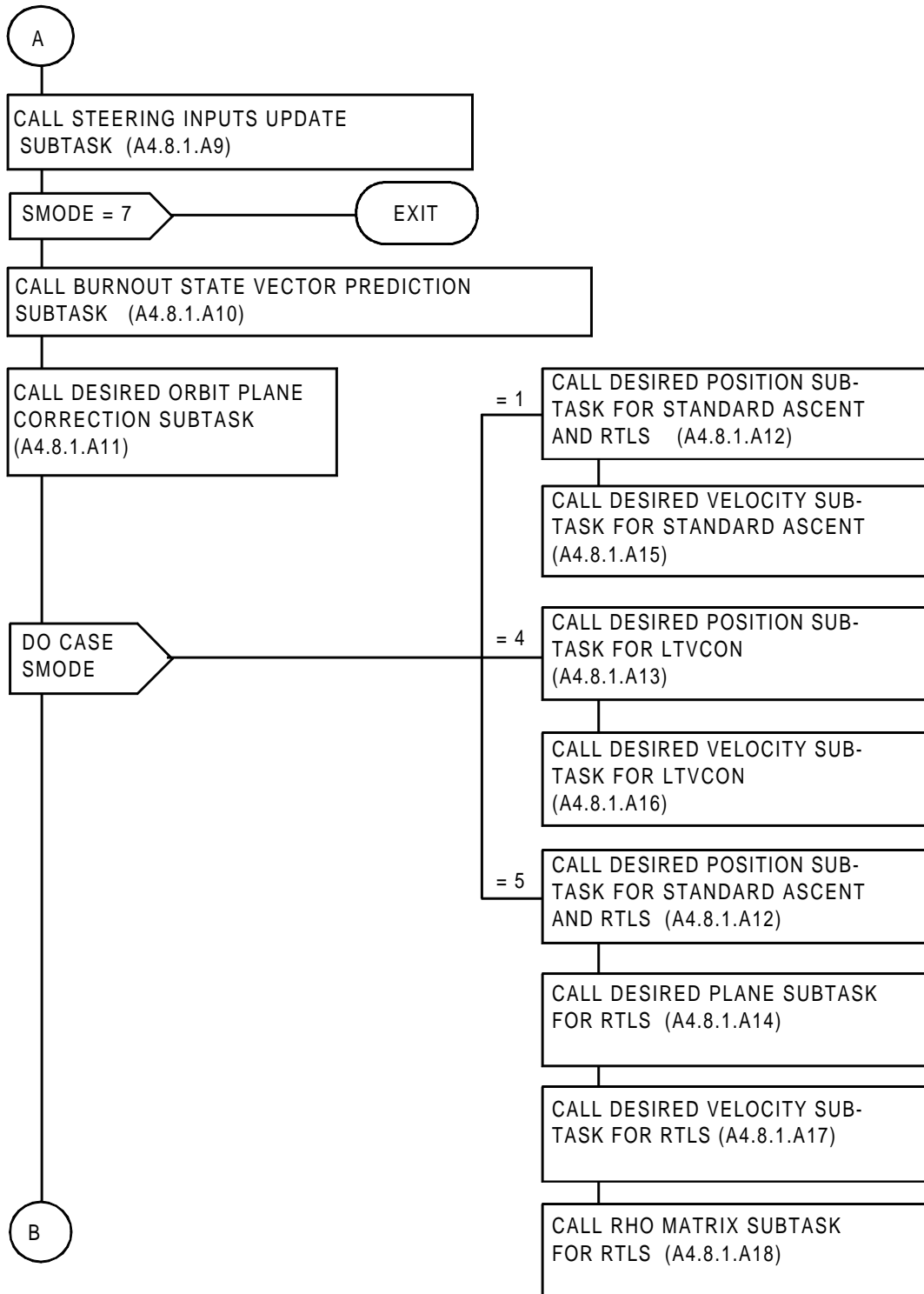


FIGURE A4.8.1.(2) PEG TSK Flow Diagram (Sheet 2 of 3)

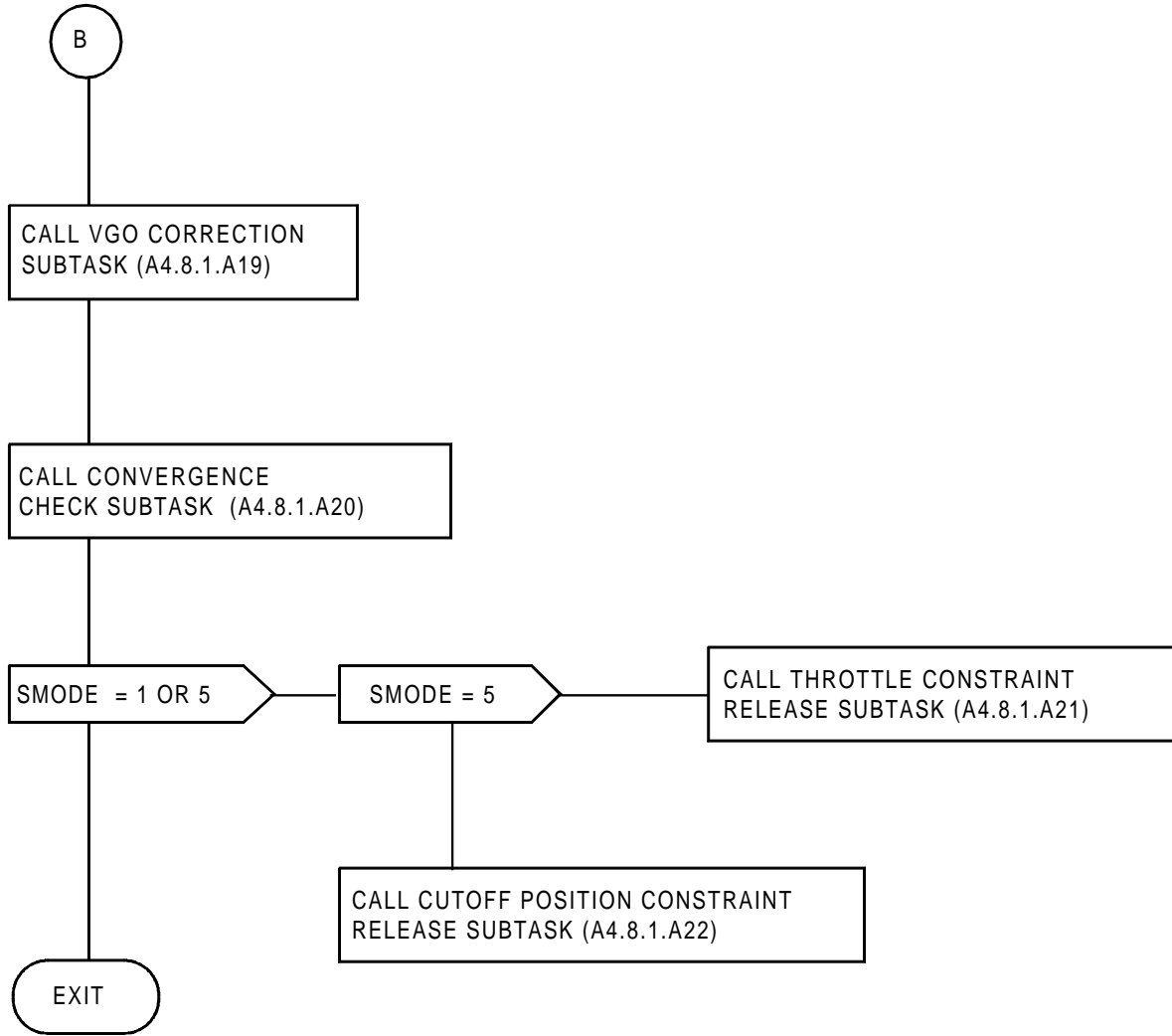


FIGURE A4.8.1.(3) PEG TSK Flow Diagram (Sheet 3 of 3)

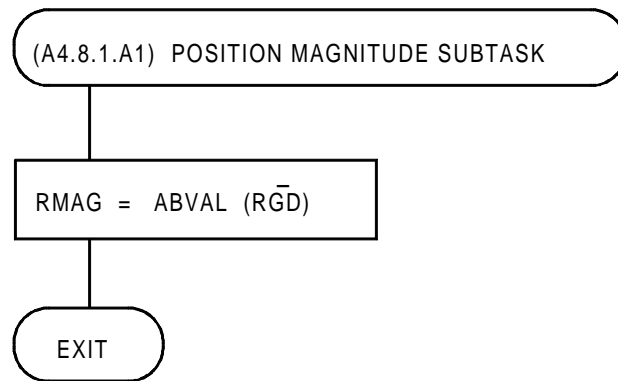


FIGURE A4.8.1.A1. PEG TSK (POSITION MAGNITUDE SUBTASK) Flow Diagram

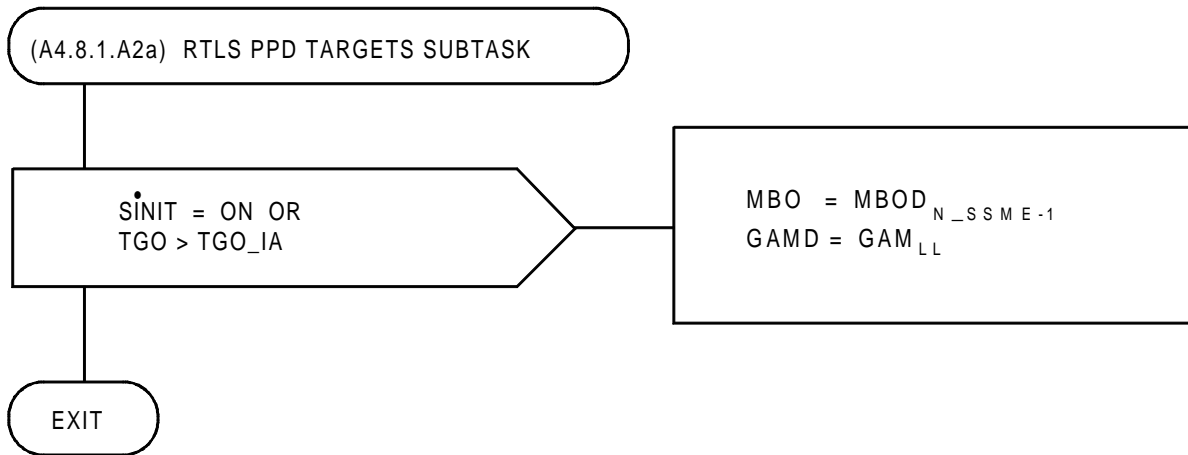


FIGURE A4.8.1.A2a. PEG TSK (RTLS PPD TARGETS SUBTASK) Flow Diagram

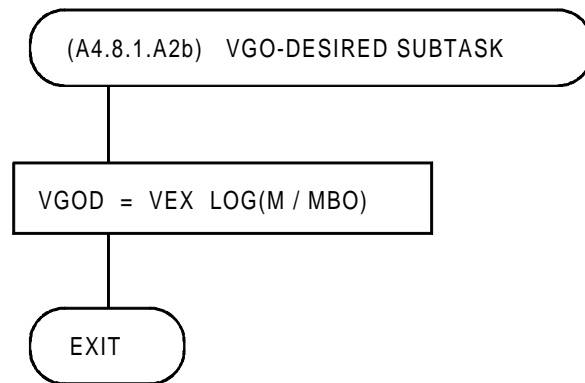


FIGURE A4.8.1.A2b. PEG TSK (VGO-DESIRED SUBTASK) Flow Diagram

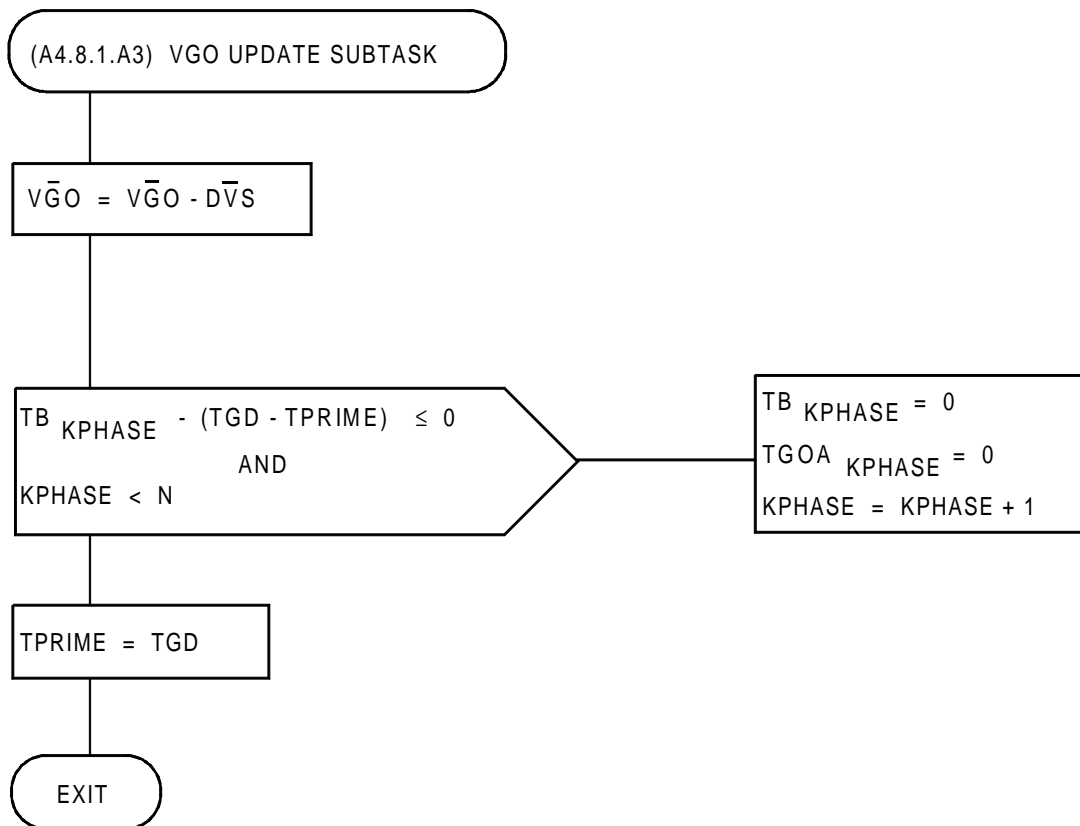


FIGURE A4.8.1.A3. PEG TSK (VGO UPDATE SUBTASK) Flow Diagram

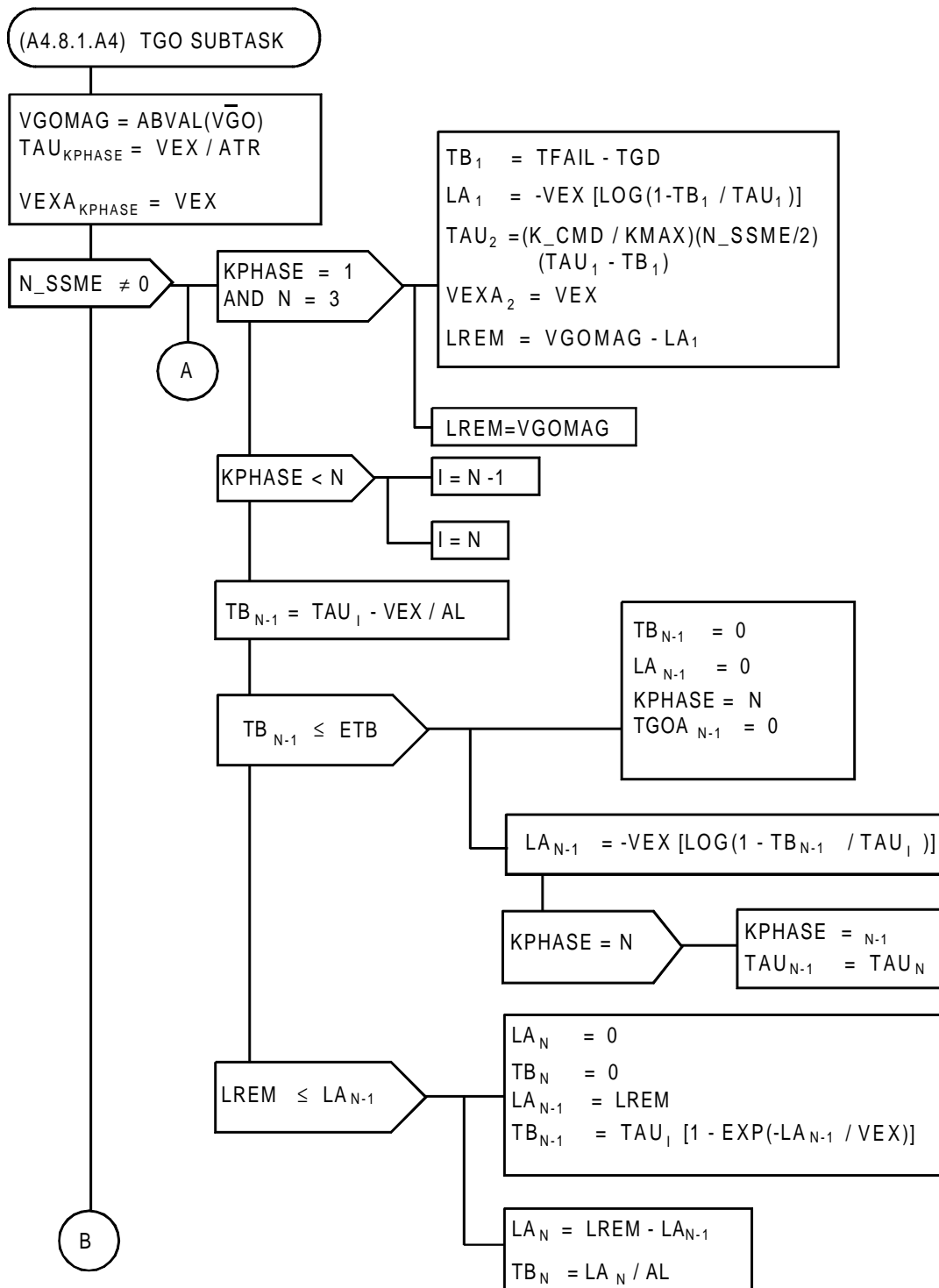


FIGURE A4.8.1.A4.(1) PEG TSK (TGO SUBTASK) Flow Diagram (Sheet 1 of 3)

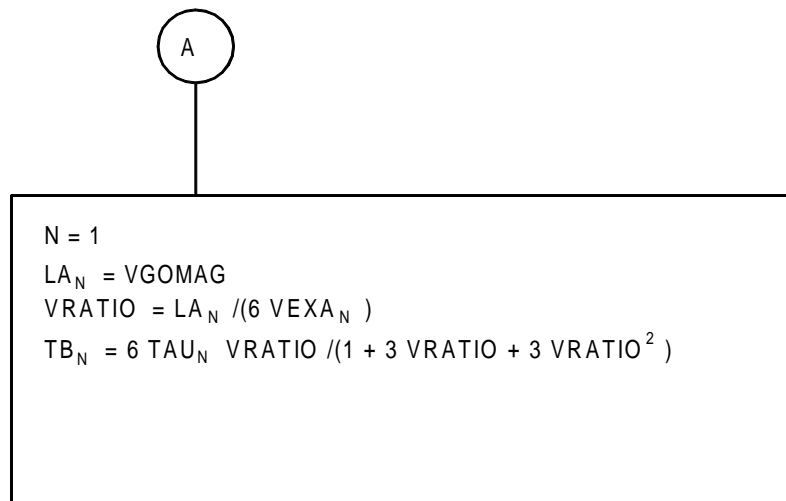


FIGURE A4.8.1.A4.(2) PEG TSK (TGO SUBTASK) Flow Diagram (Sheet 2 of 3)

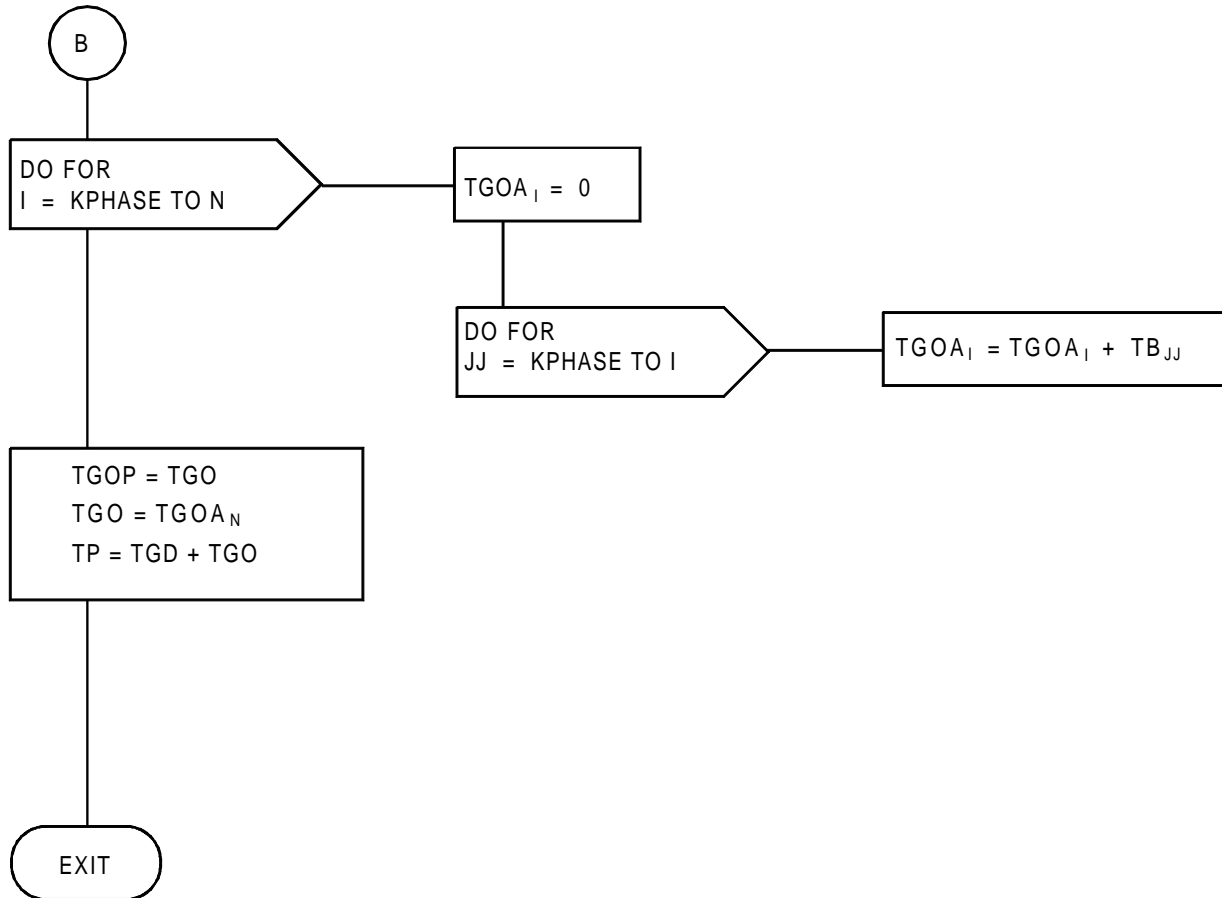


FIGURE A4.8.1.A4.(3) PEG TSK (TGO SUBTASK) Flow Diagram (Sheet 3 of 3)

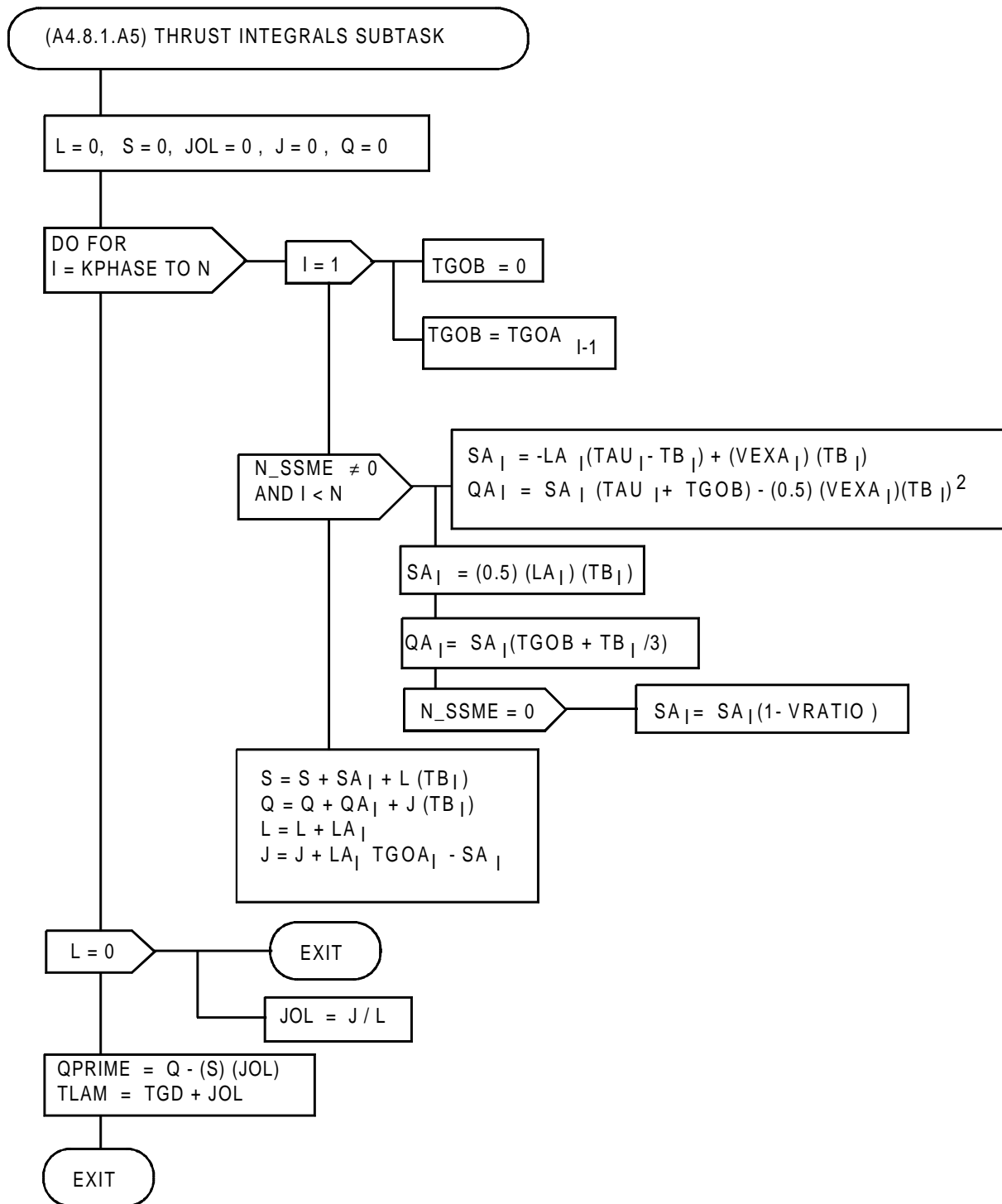


FIGURE A4.8.1.A5. PEG TSK (THRUST INTEGRALS SUBTASK) Flow Diagram

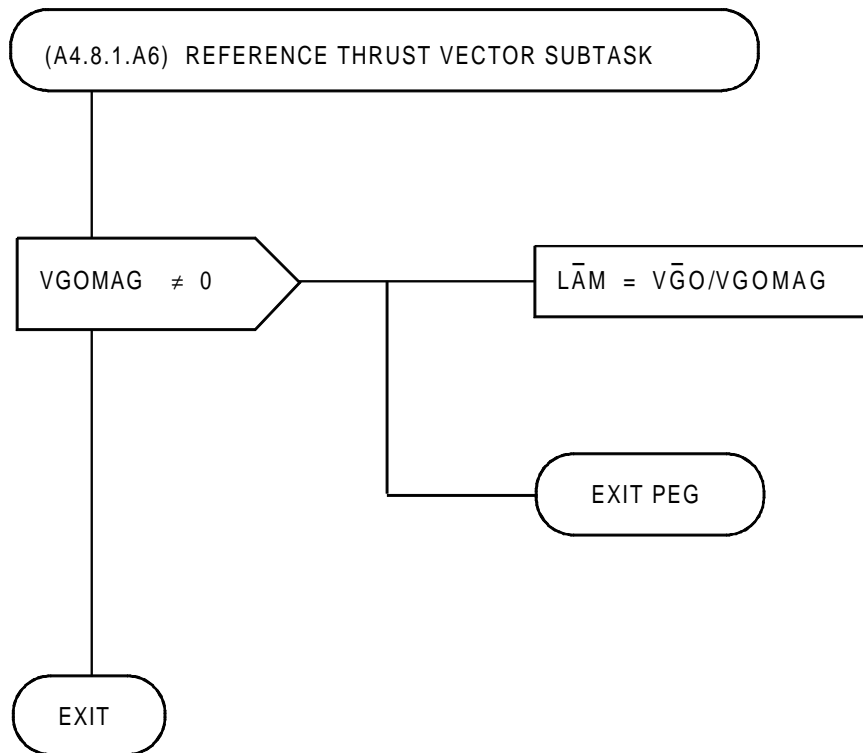


FIGURE A4.8.1.A6. PEG TSK (REFERENCE THRUST VECTOR SUBTASK) Flow Diagram

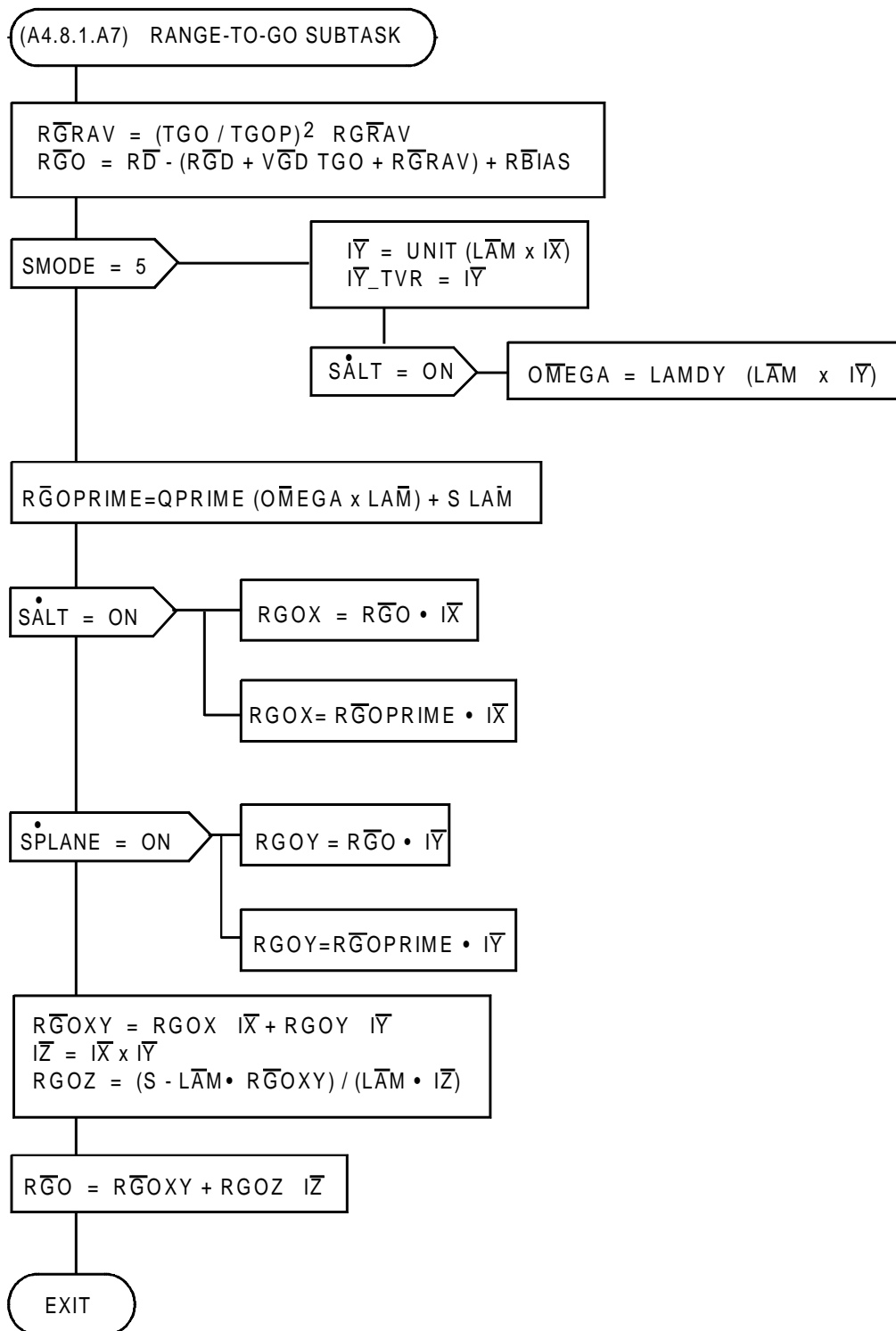


FIGURE A4.8.1.A7. PEG TSK (RANGE-TO-GO-SUBTASK) Flow Diagram

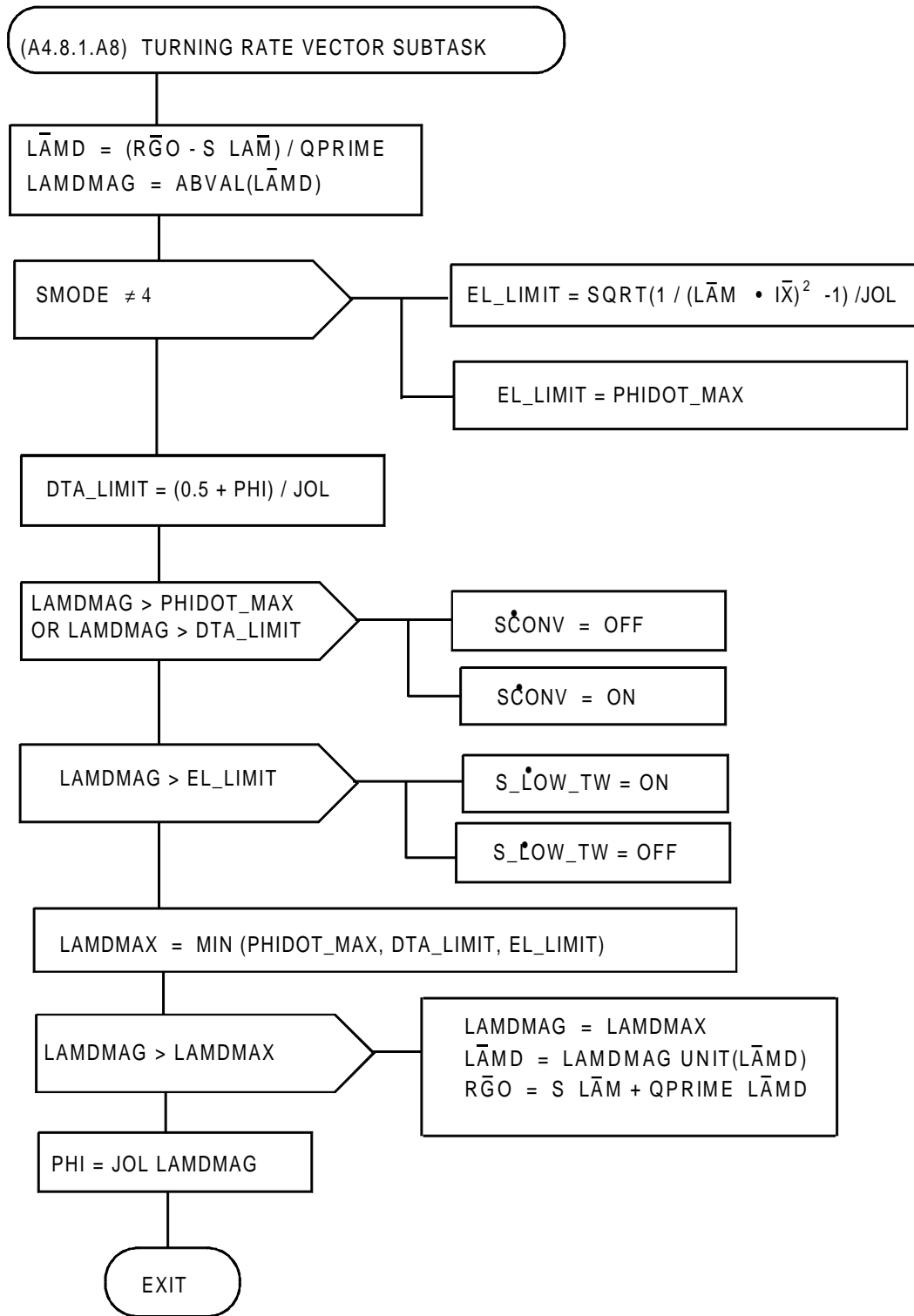


FIGURE A4.8.1.A8. PEG TSK (TURNING RATE VECTOR SUBTASK) Flow Diagram

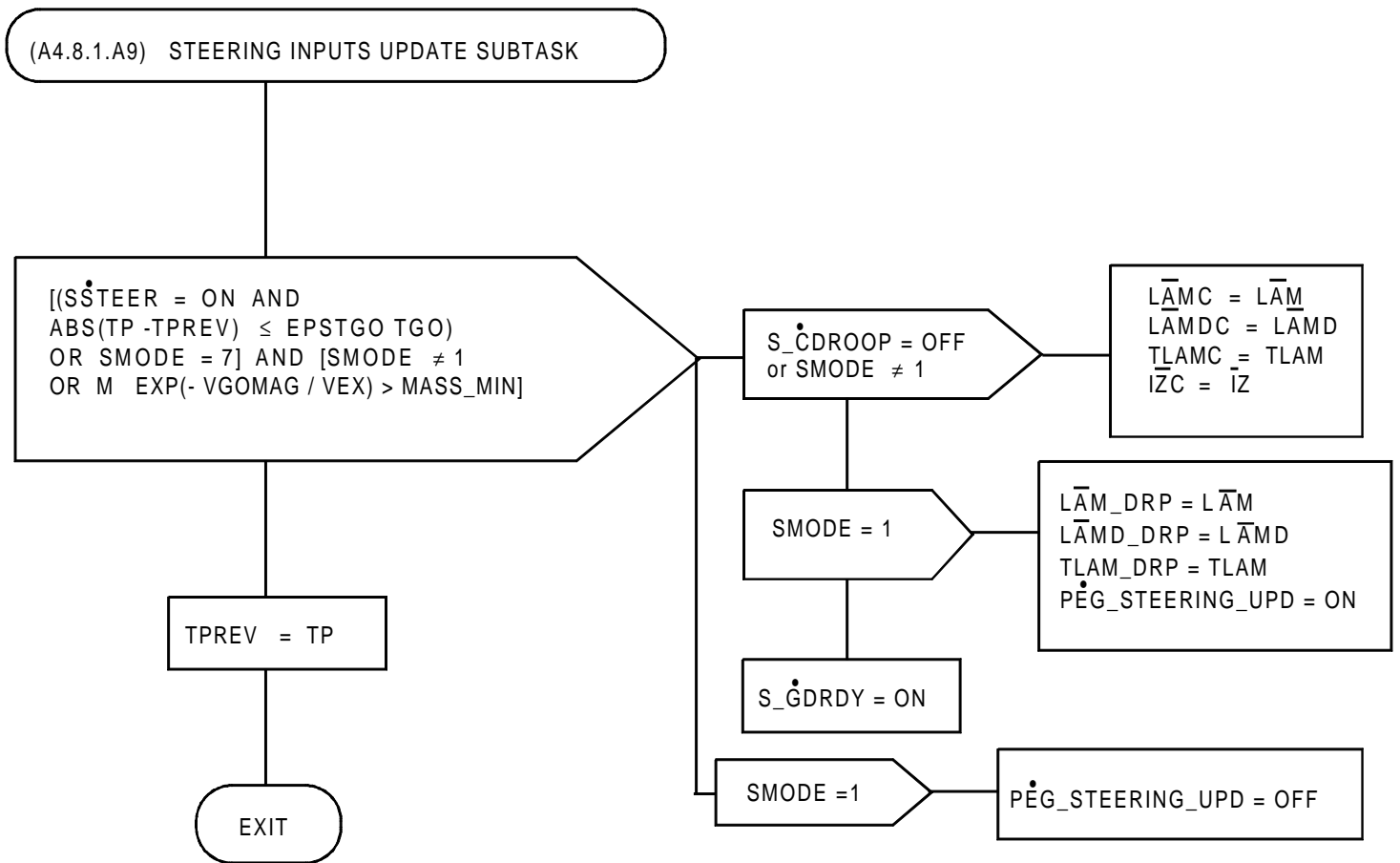


FIGURE A4.8.1.A9. PEG TSK (STEERING INPUTS UPDATE SUBTASK) Flow Diagram

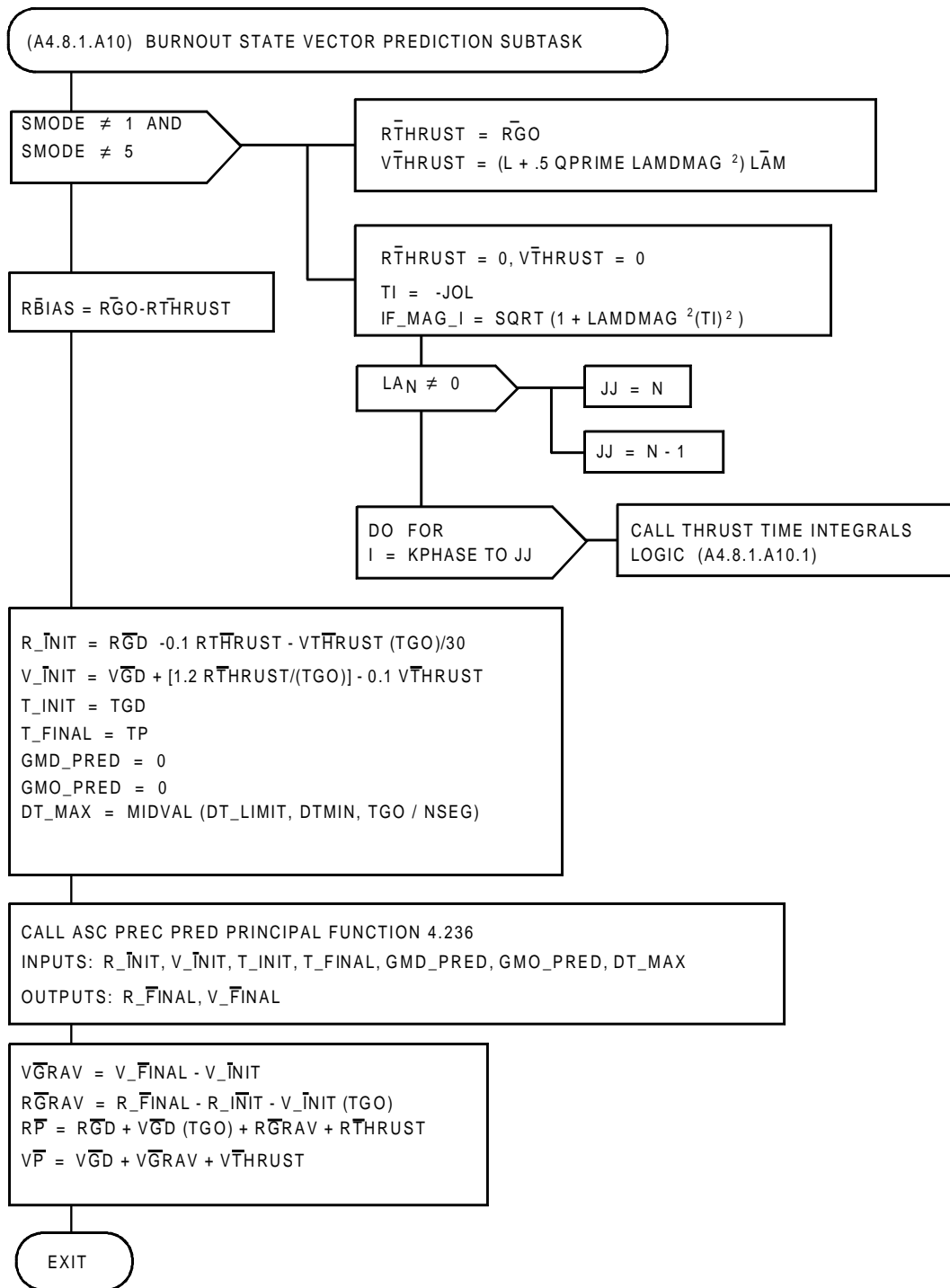


FIGURE A4.8.1.A10.(1) PEG TSK (BURNOUT STATE VECTOR PREDICTION SUBTASK)
 Flow Diagram (Sheet 1 of 2)

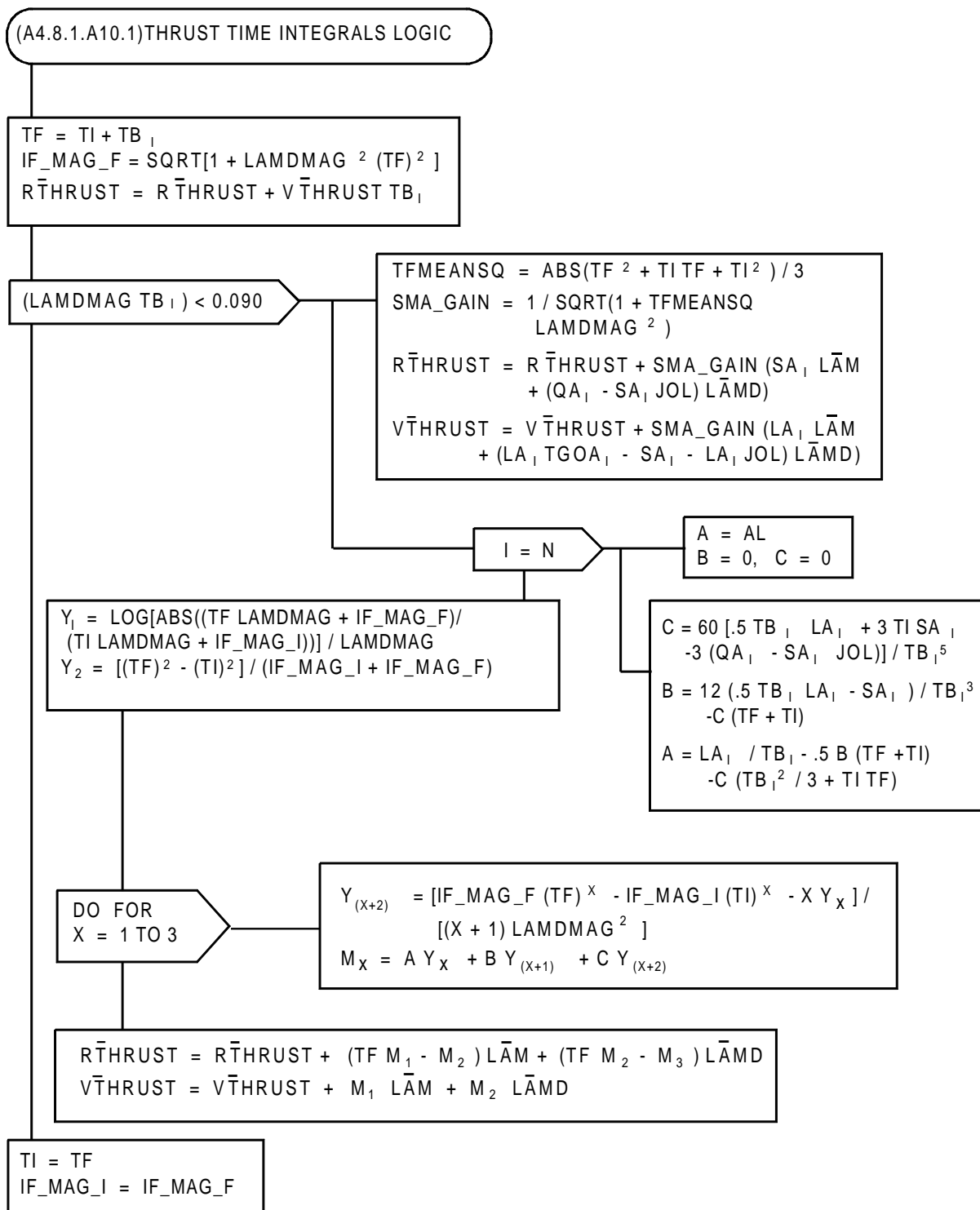


FIGURE A4.8.1.A10.(2) PEG TSK (BURNOUT STATE VECTOR PREDICTION SUBTASK)
Flow Diagram (Sheet 2 of 2)

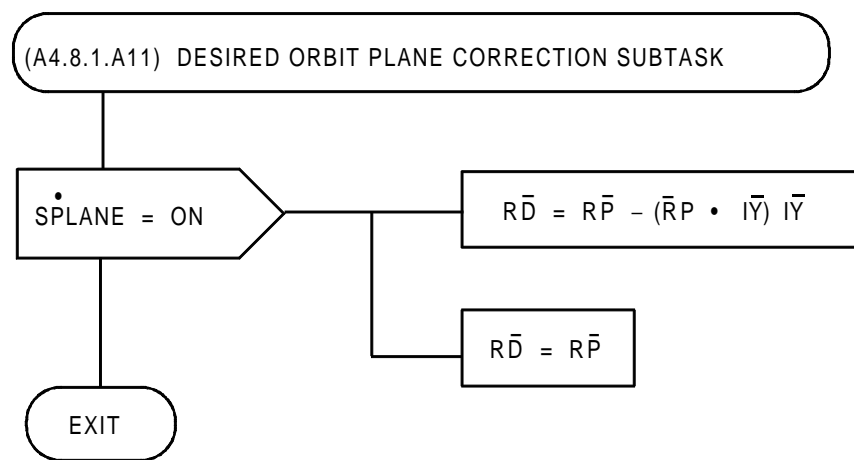


FIGURE A4.8.1.A11. PEG TSK (DESIRED ORBIT PLANE CORRECTION SUBTASK) Flow Diagram

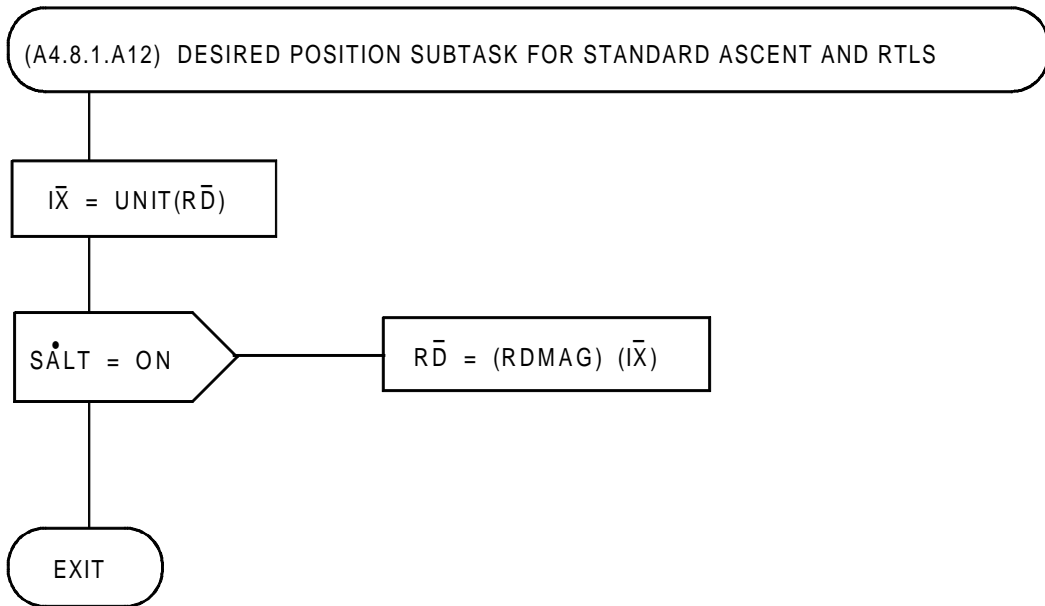


FIGURE A4.8.1.A12. PEG TSK (DESIRED POSITION SUBTASK FOR STANDARD ASCENT AND RTLS) Flow Diagram

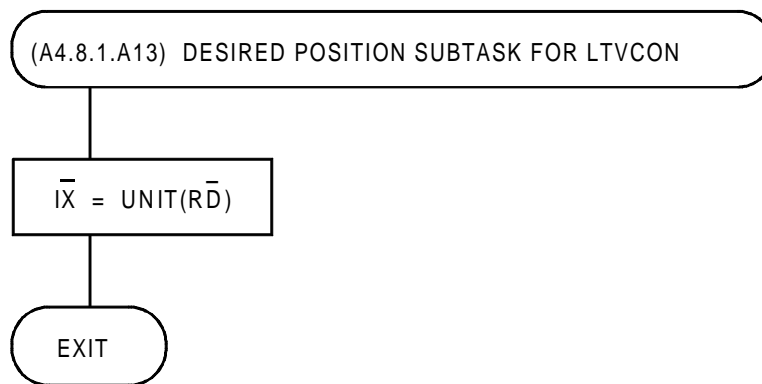


FIGURE A4.8.1.A13. PEG TSK (DESIRED POSITION SUBTASK FOR LTVCON) Flow Diagram

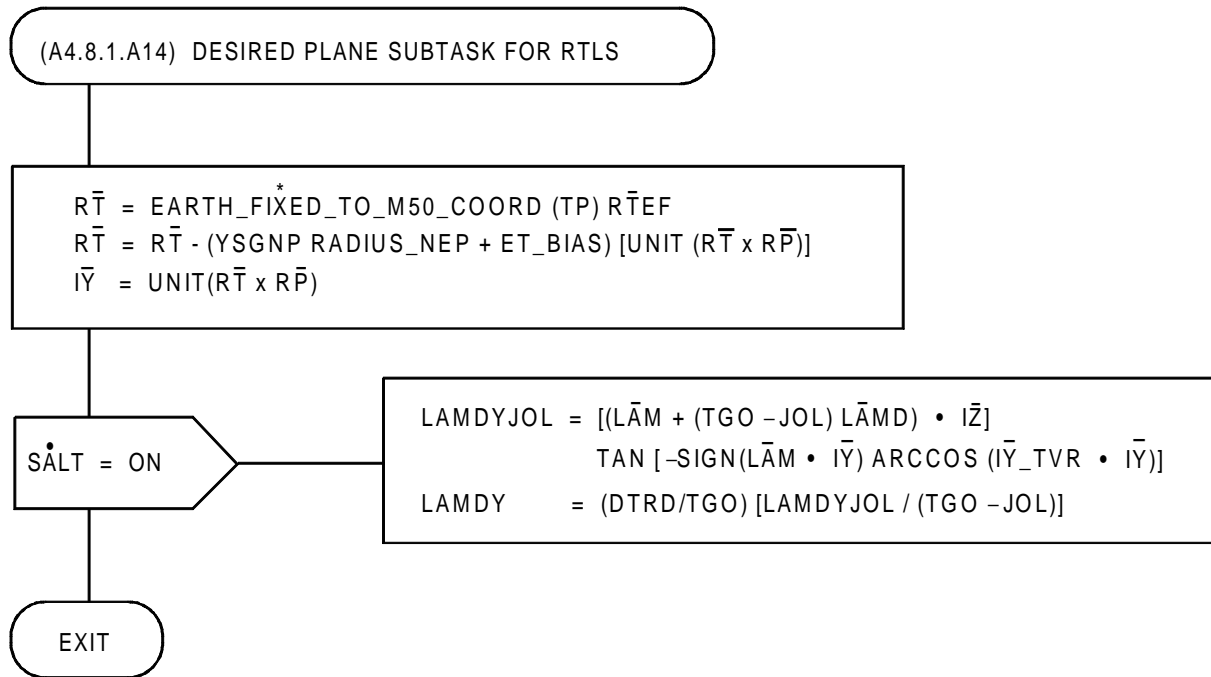


FIGURE A4.8.1.A14. PEG TSK (DESIRED PLANE SUBTASK FOR RTLS) Flow Diagram

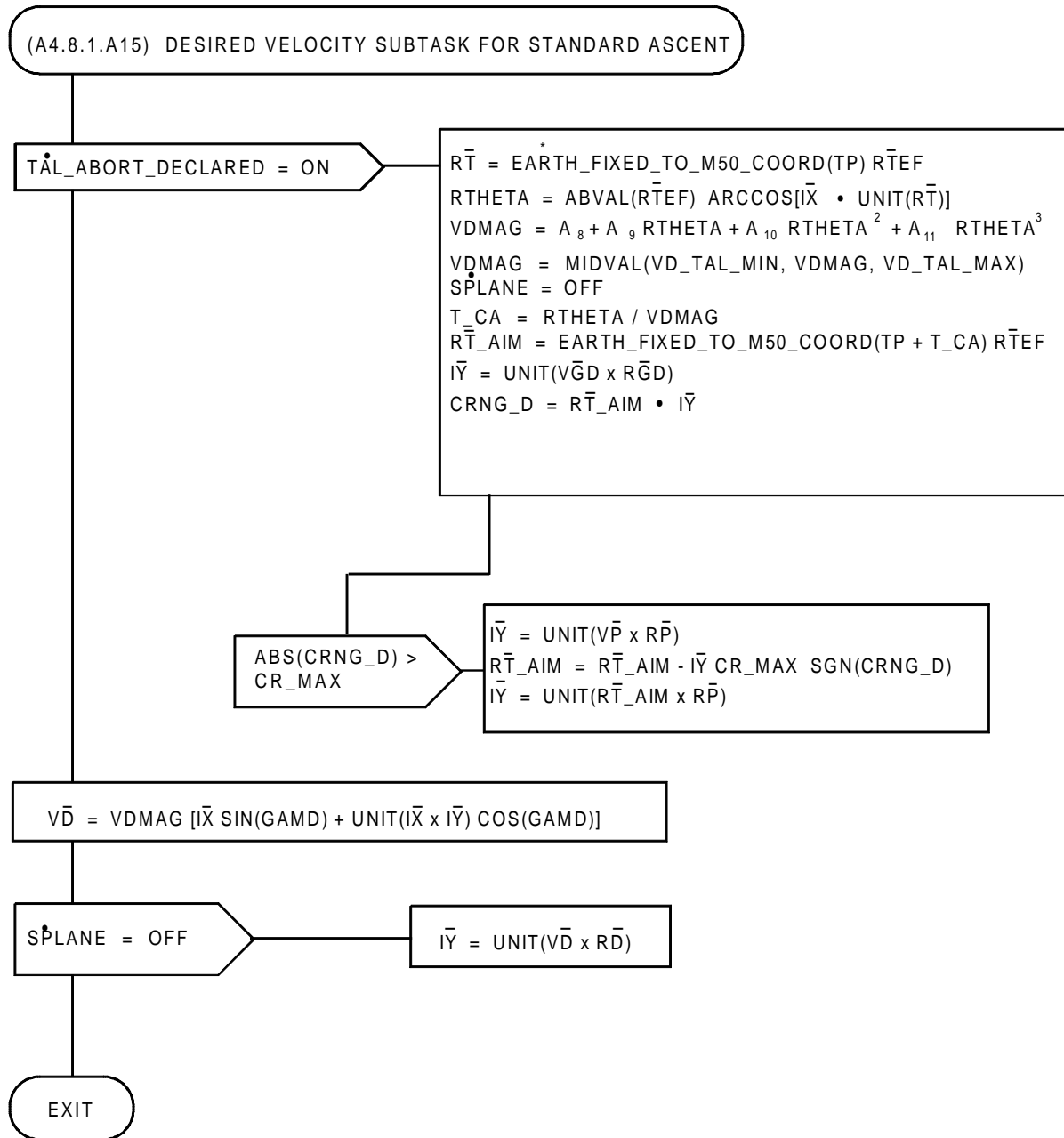


FIGURE A4.8.1.A15. PEG TSK (DESIRED VELOCITY SUBTASK FOR STANDARD ASCENT)
 Flow Diagram

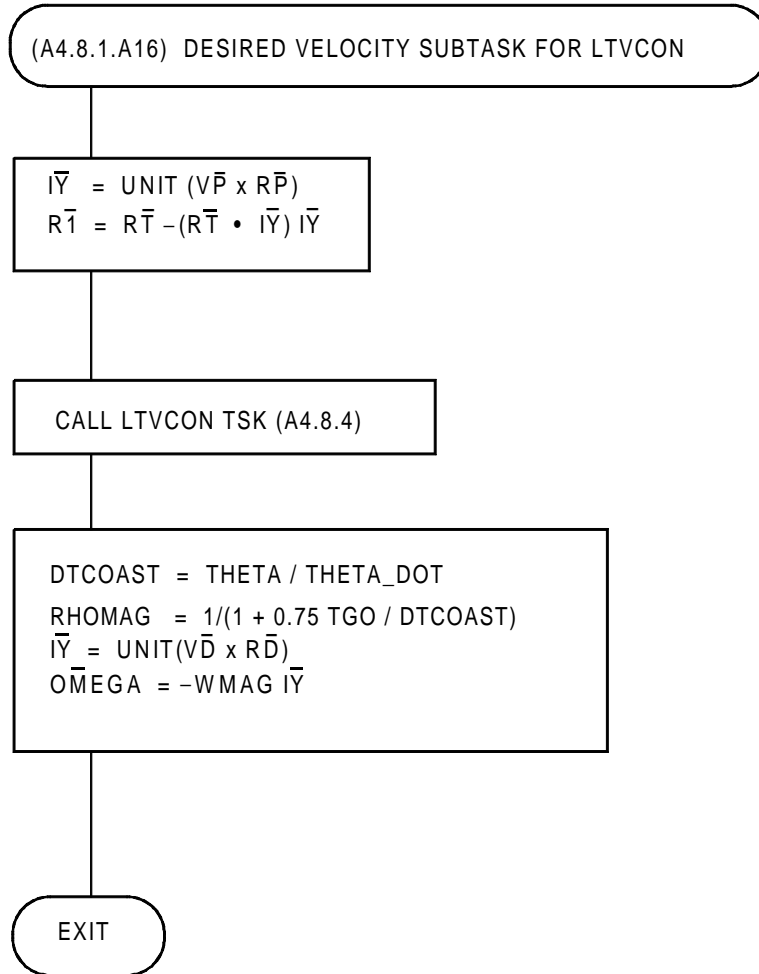


FIGURE A4.8.1.A16. PEG TSK (DESIRED VELOCITY SUBTASK FOR LTVCON) Flow Diagram

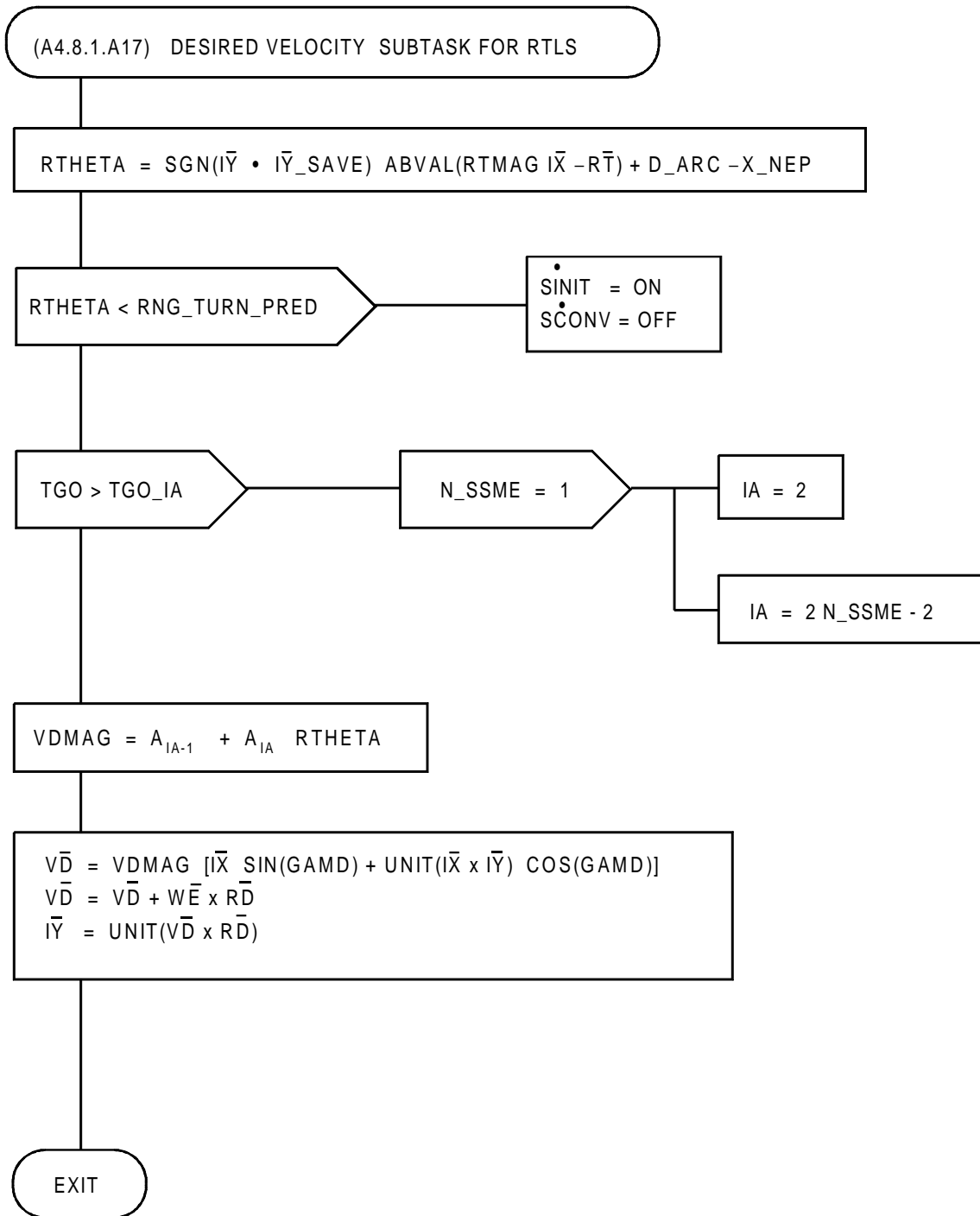


FIGURE A4.8.1.A17. PEG TASK (DESIRED VELOCITY SUBTASK FOR RTLS) Flow Diagram

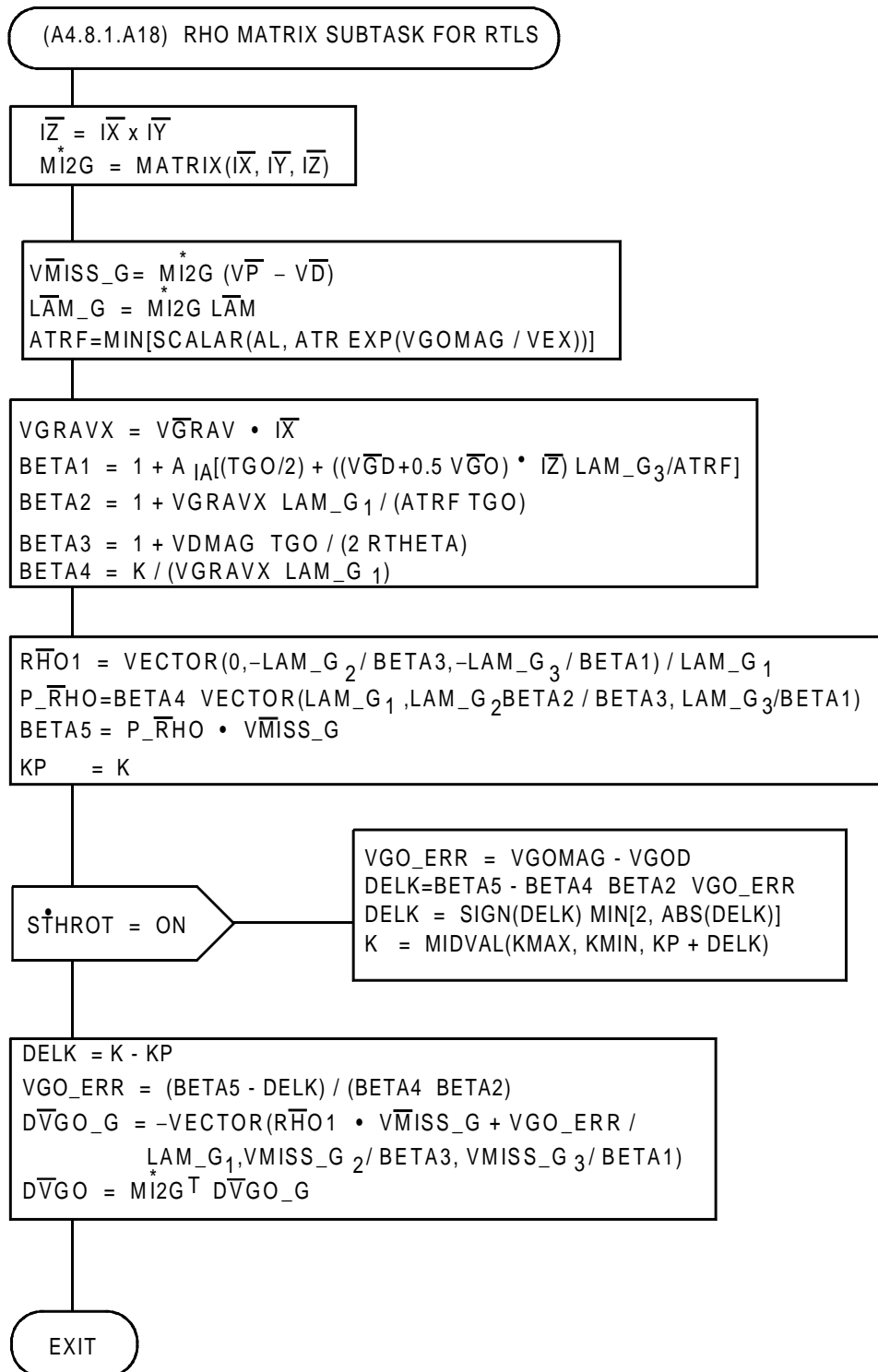


FIGURE A4.8.1.A18. PEG TSK (RHO MATRIX SUBTASK FOR RTLS) Flow Diagram

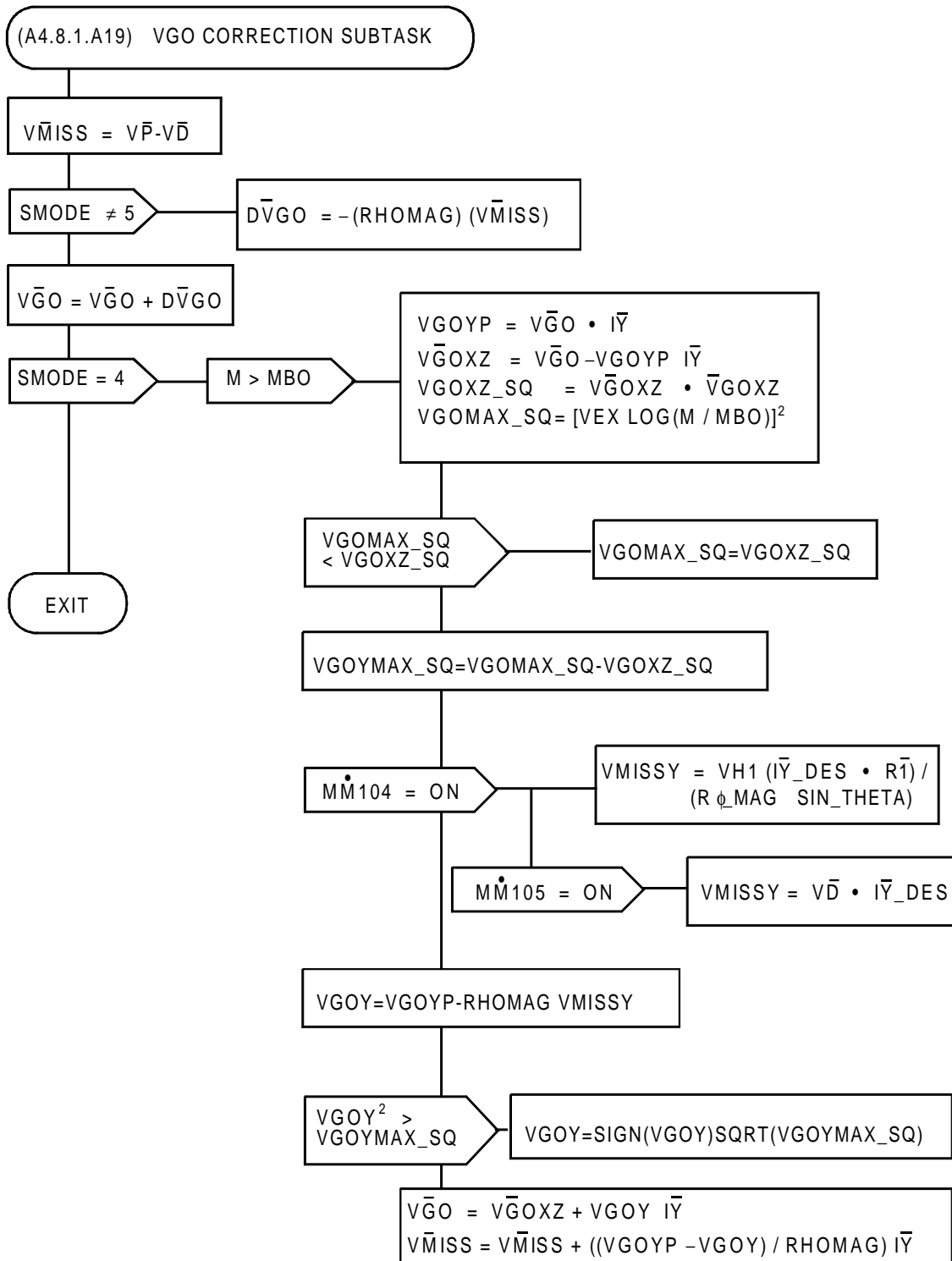


FIGURE A4.8.1.A19. PEG TSK (VGO CORRECTION SUBTASK) Flow Diagram

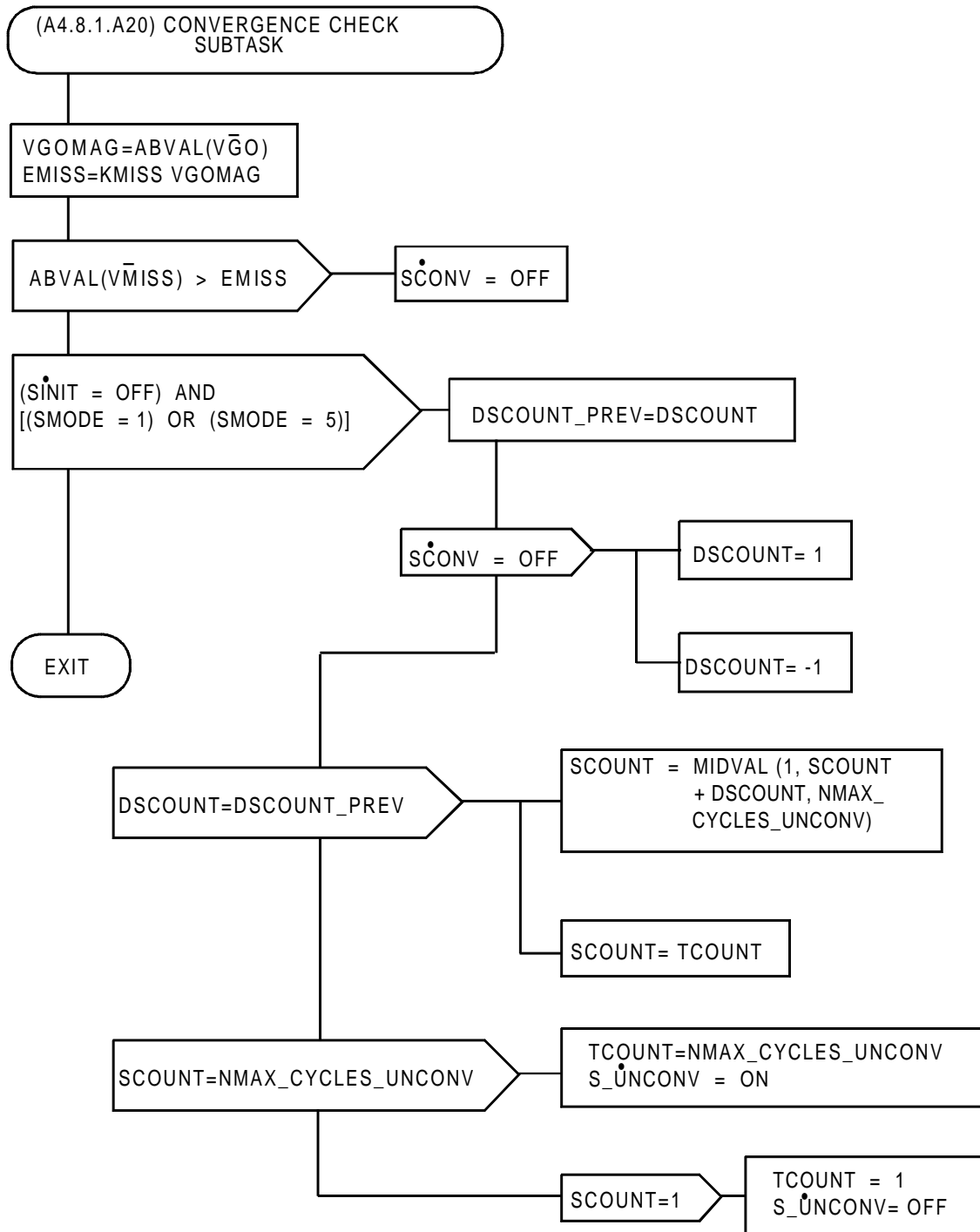


FIGURE A4.8.1.A20. PEG TSK (CONVERGENCE CHECK SUBTASK) Flow Diagram

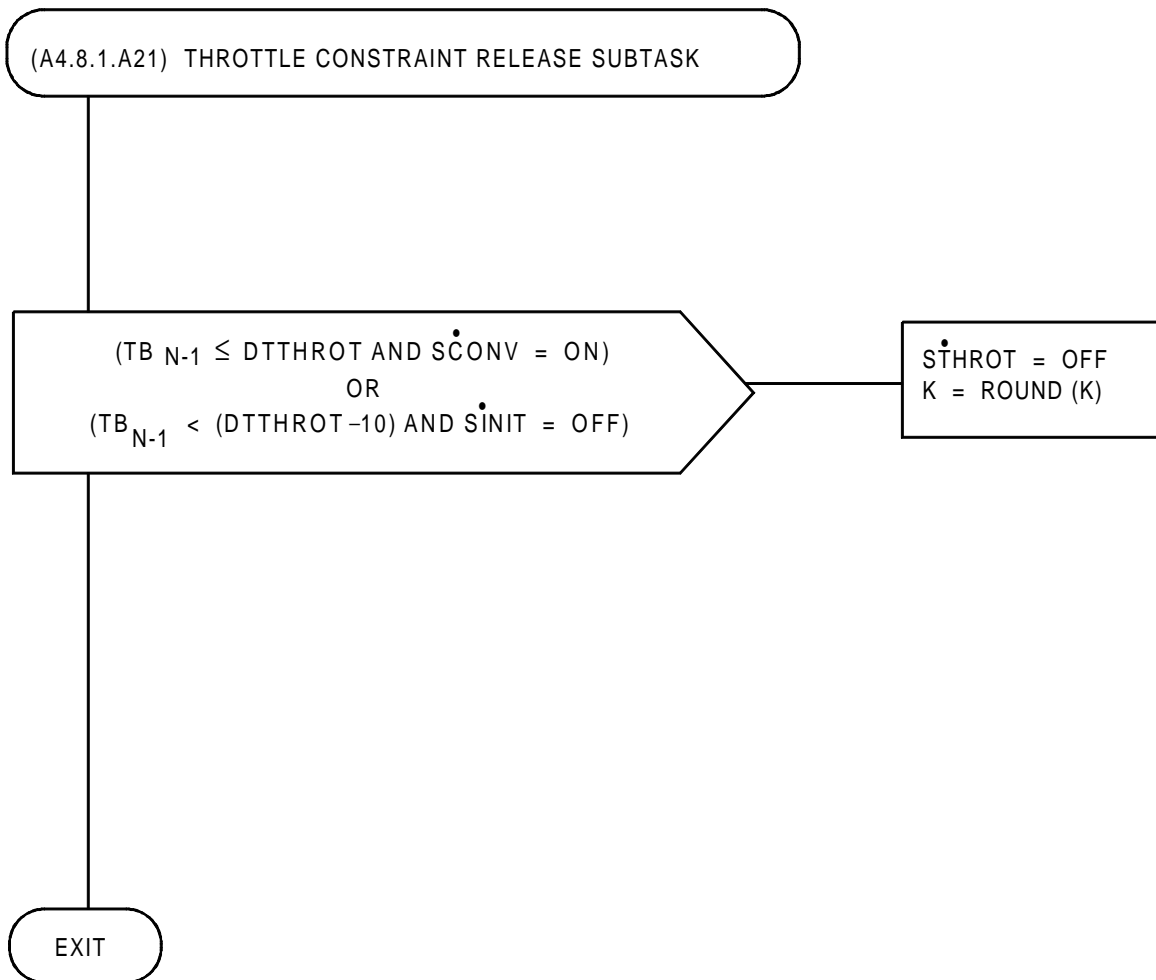


FIGURE A4.8.1.A21. PEG TSK (THROTTLE CONSTRAINT RELEASE SUBTASK) Flow Diagram

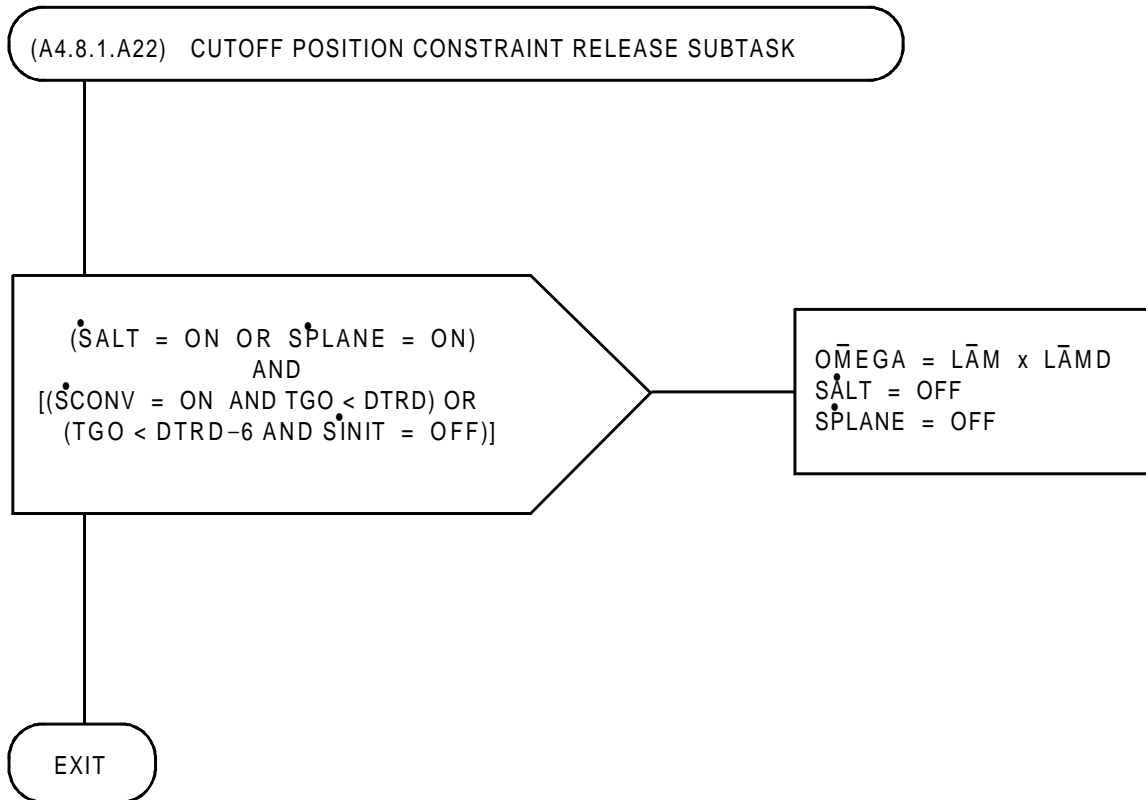


FIGURE A4.8.1.A22. PEG TSK (CUTOFF POSITION CONSTRAINT RELEASE SUBTASK)
Flow Diagram

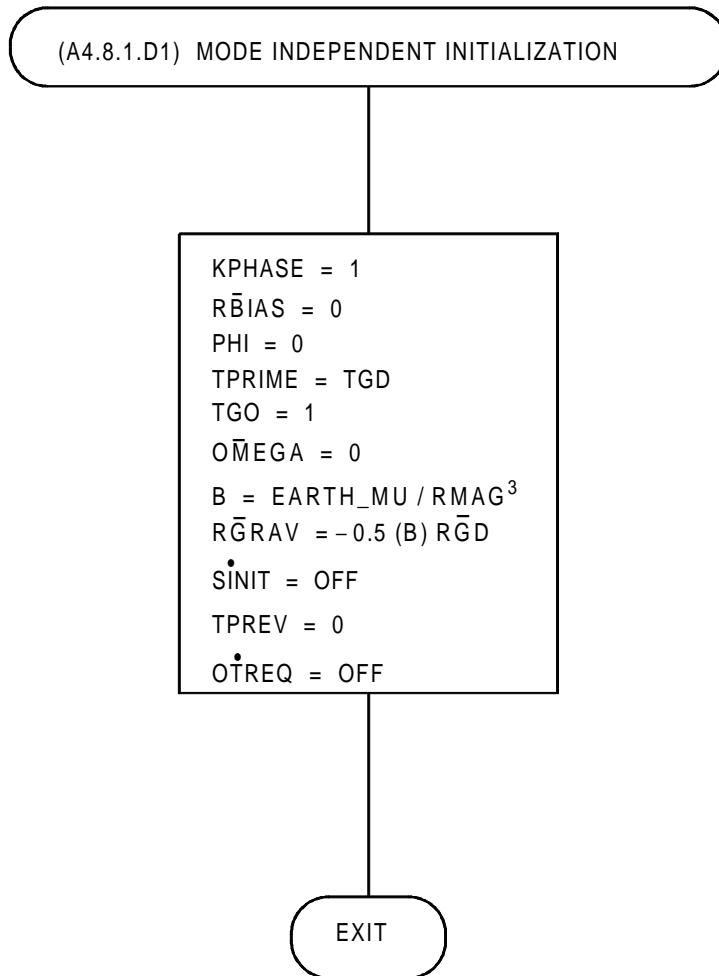


FIGURE A4.8.1.D1. PEG TSK (MODE INDEPENDENT INITIALIZATION) Flow Diagram

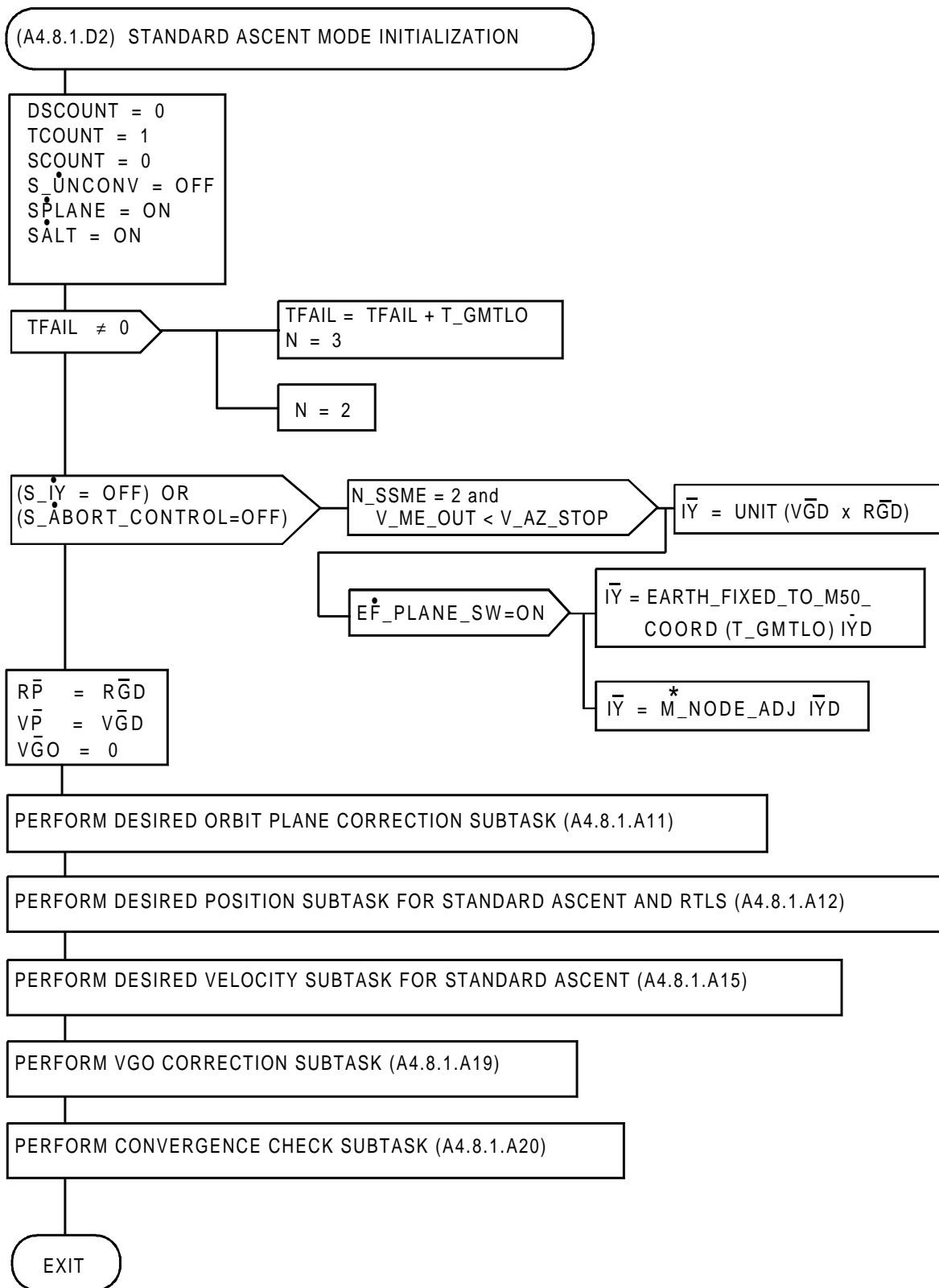


FIGURE A4.8.1.D2. PEG TSK (STANDARD ASCENT MODE INITIALIZATION) Flow Diagram

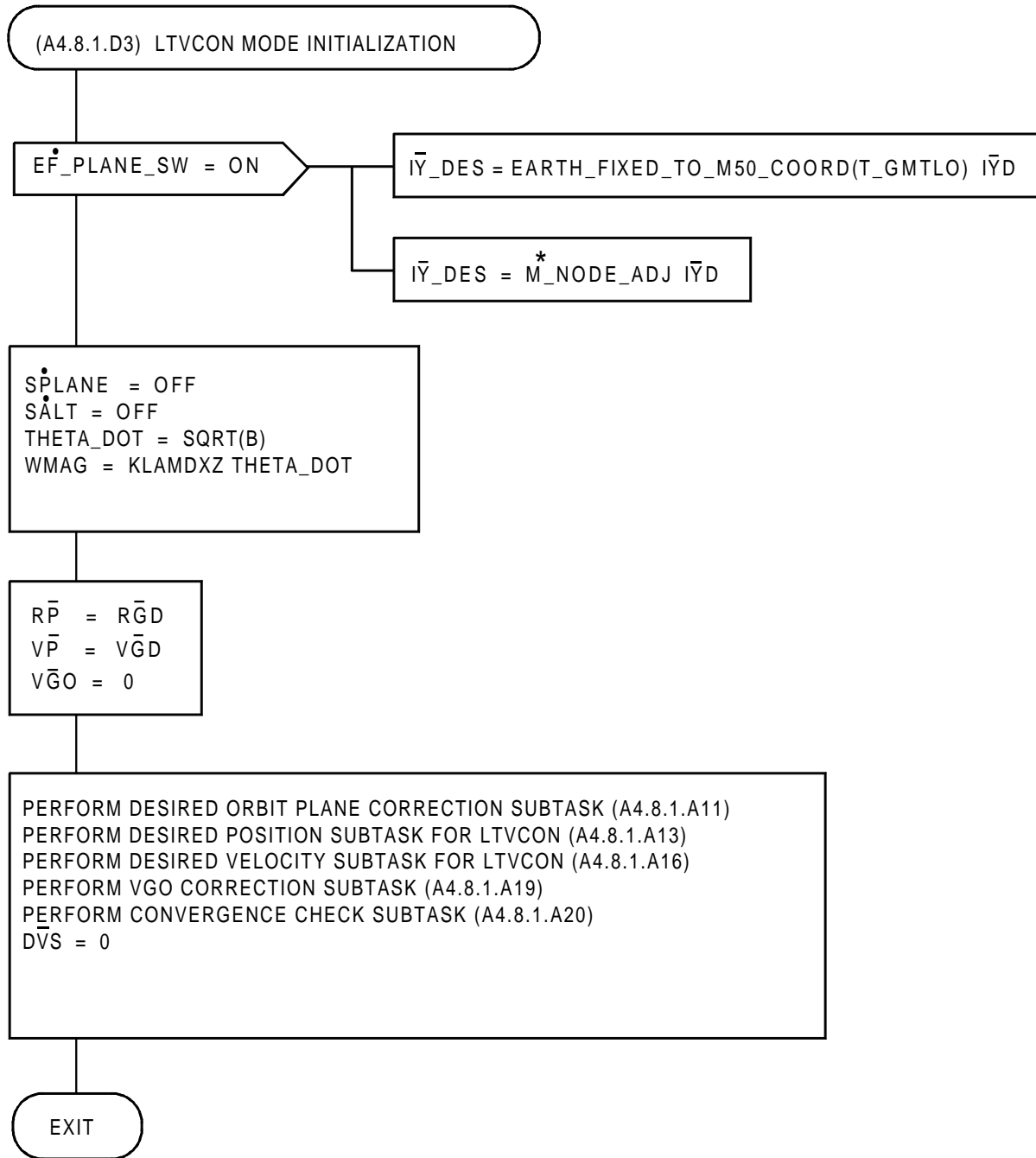


FIGURE A4.8.1.D3. PEG TSK (LTVCON MODE INITIALIZATION) Flow Diagram

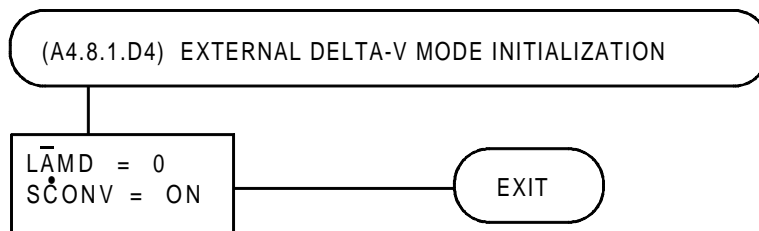


FIGURE A4.8.1.D4. PEG TSK (EXTERNAL DELTA-V MODE INITIALIZATION) Flow Diagram

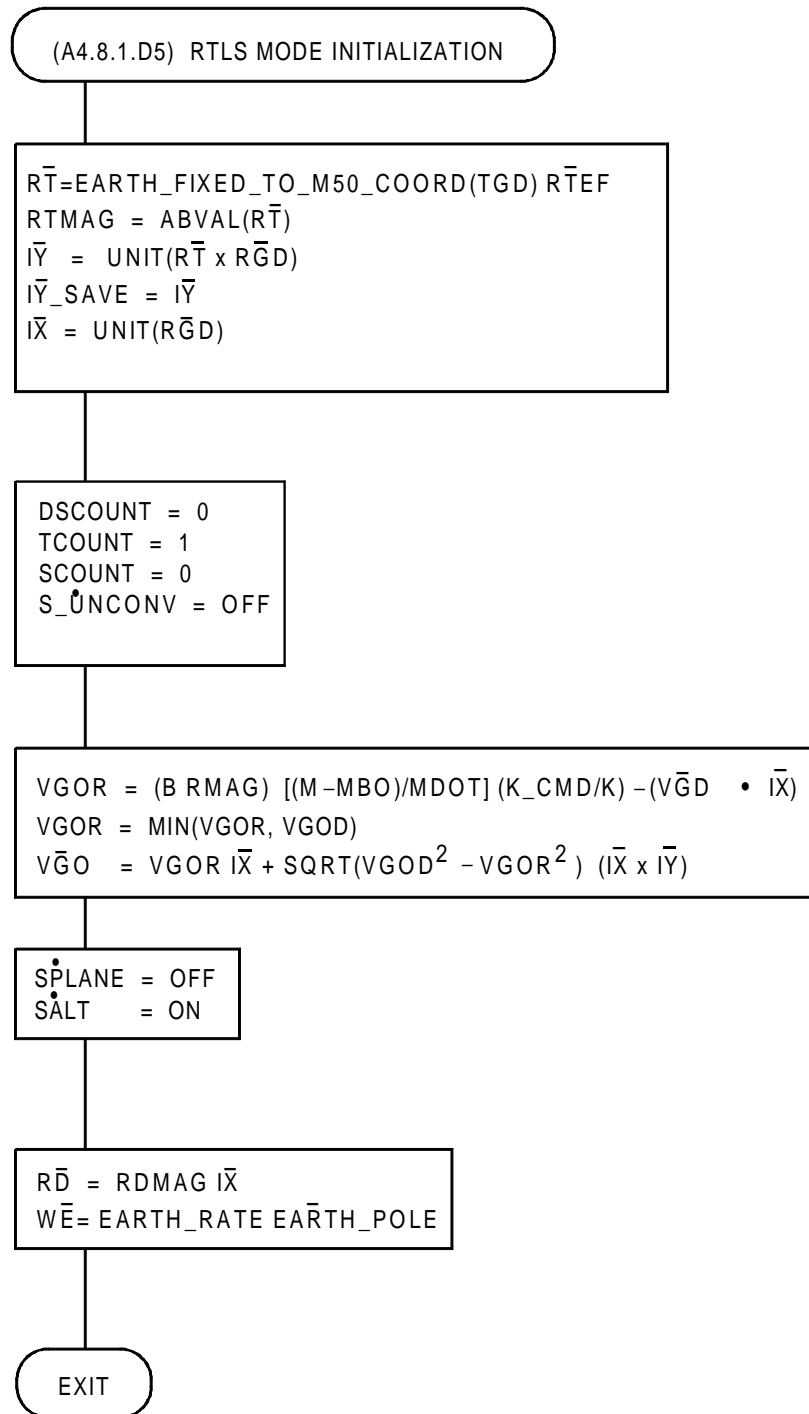


FIGURE A4.8.1.D5. PEG TSK (RTLS MODE INITIALIZATION) Flow Diagram

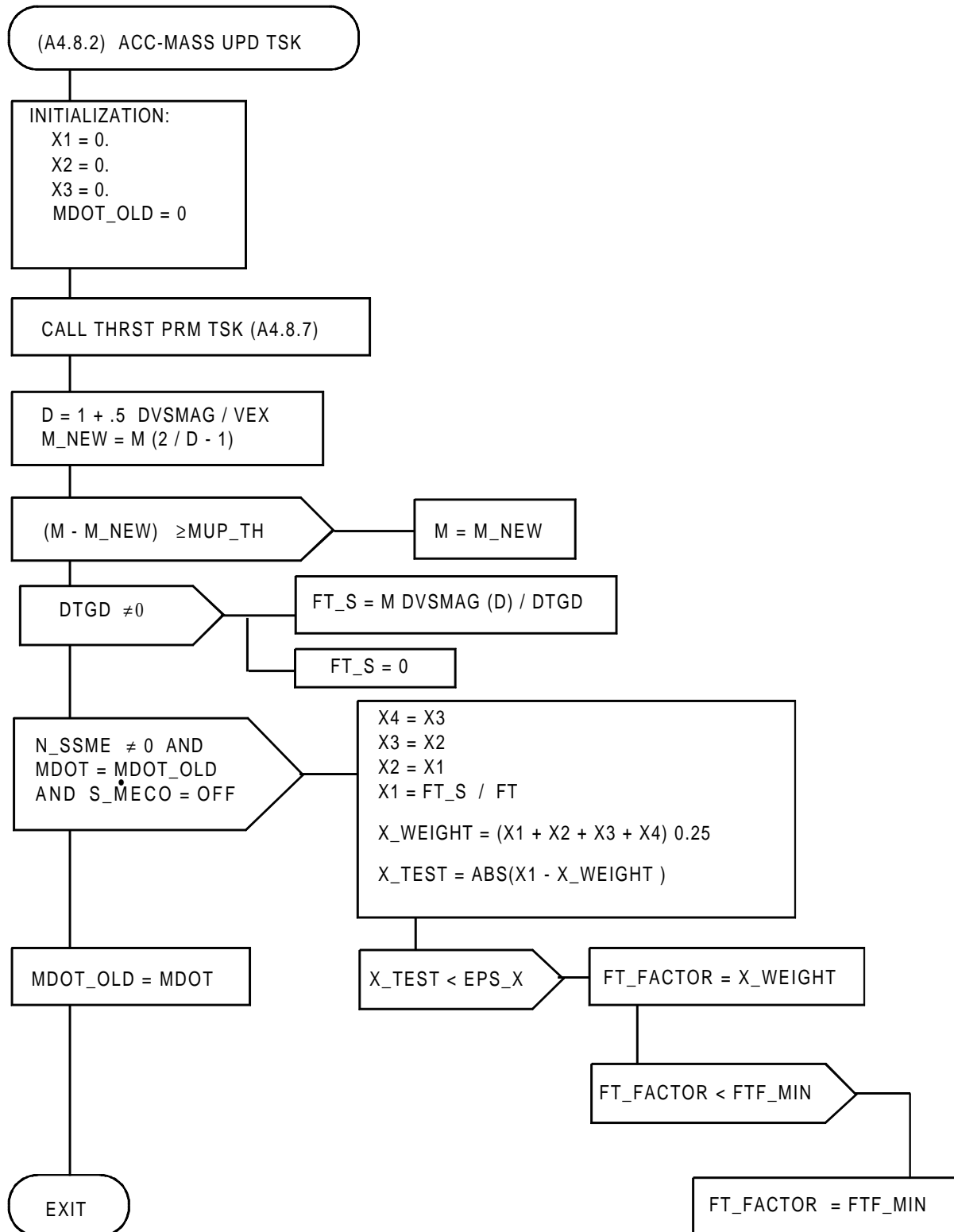


FIGURE A4.8.2. ACC-MASS UPD TSK Flow Diagram

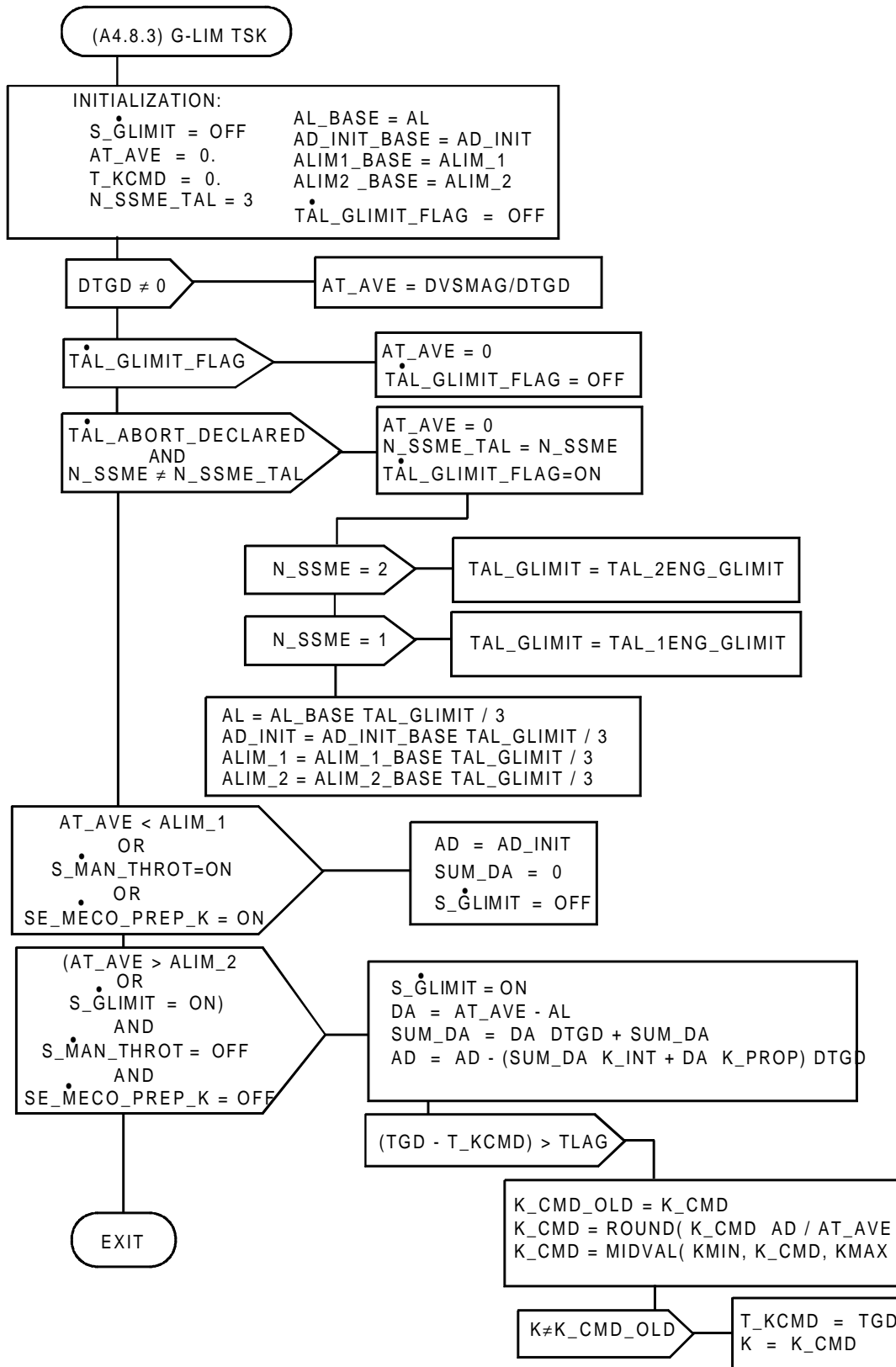


FIGURE A4.8.3. G-LIM TSK Flow Diagram

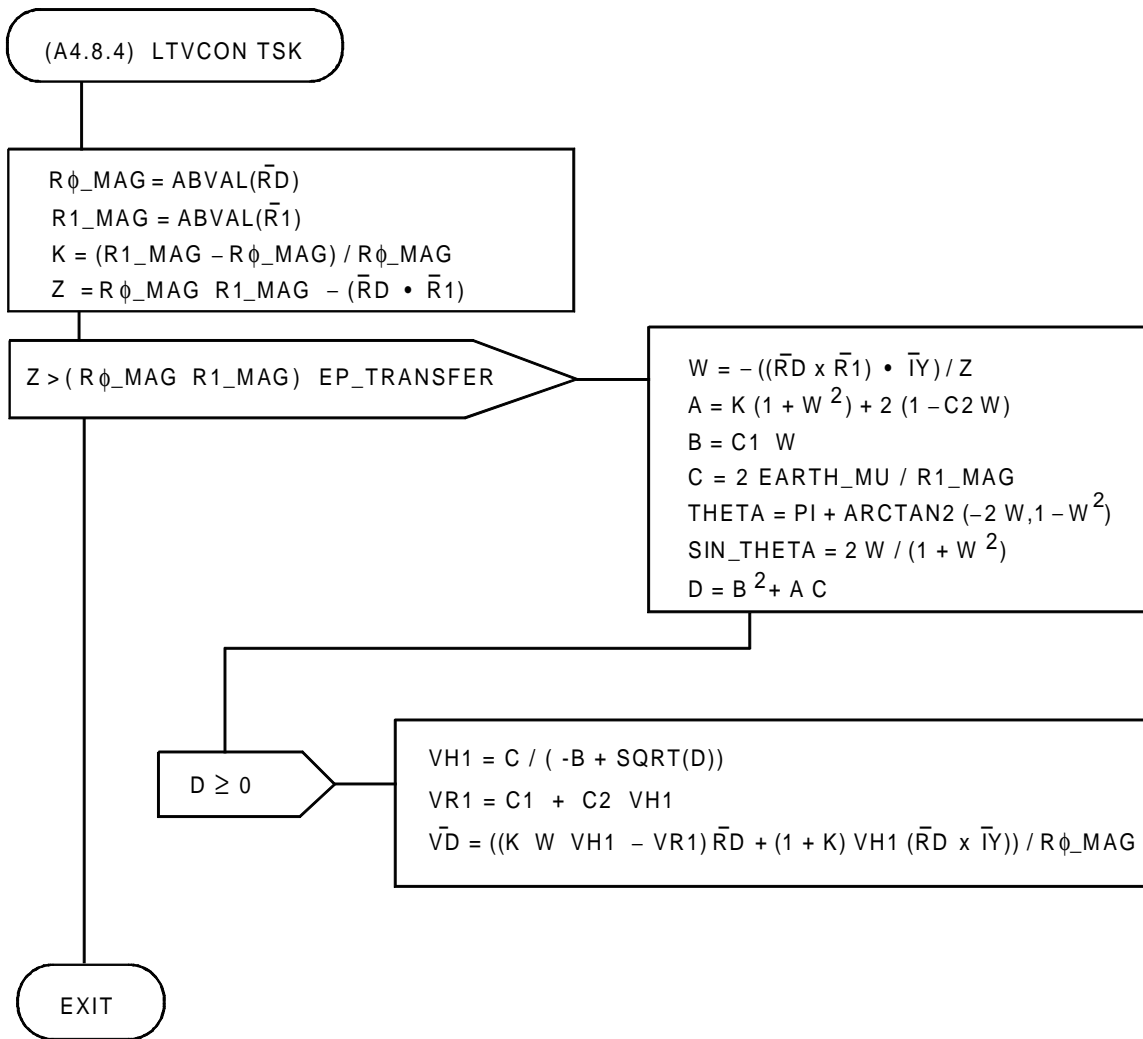


FIGURE A4.8.4. LTVCON TSK Flow Diagram

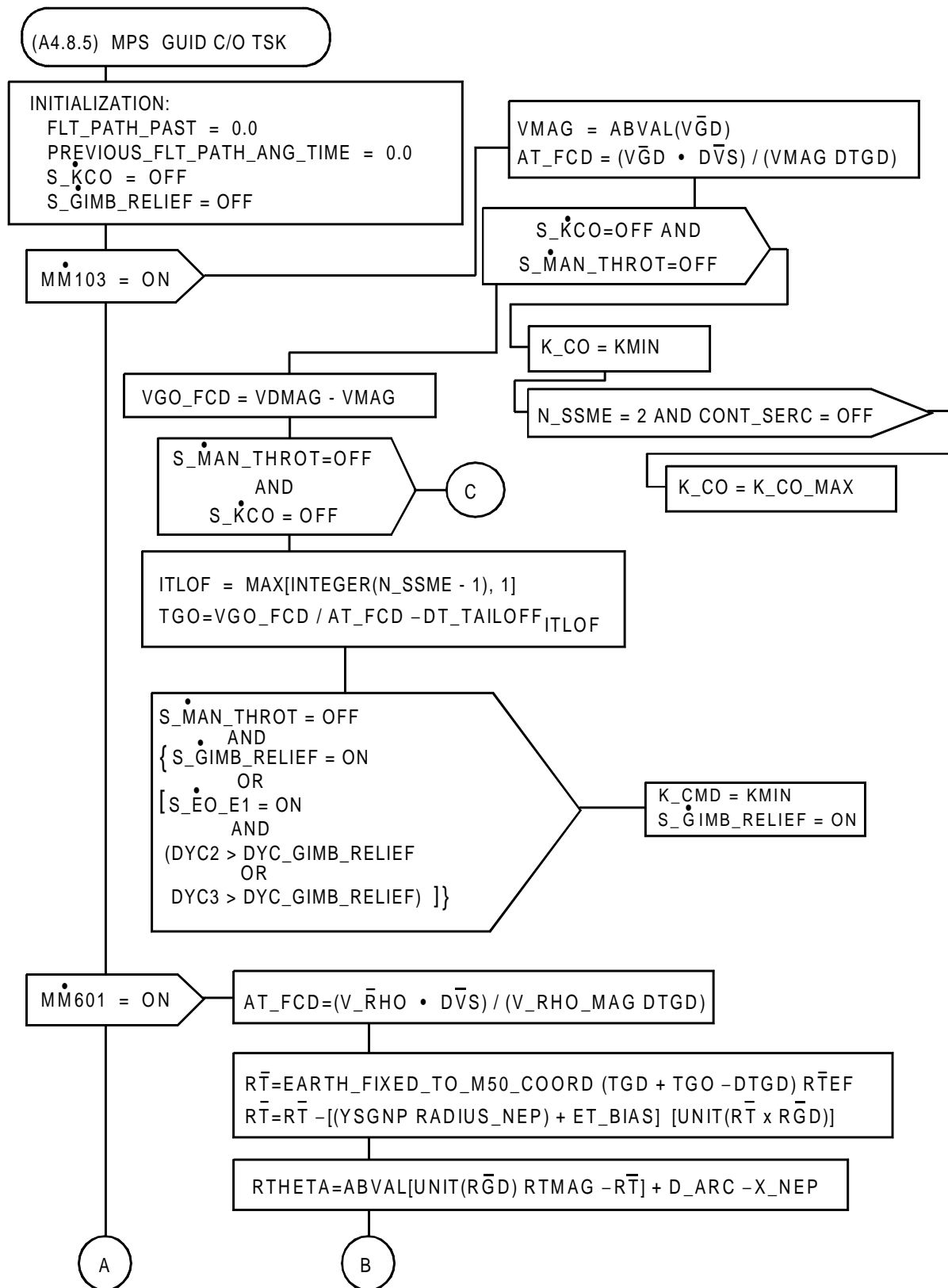


FIGURE A4.8.5.(1) MPS GUID C/O TSK Flow Diagram (Sheet 1 of 3)

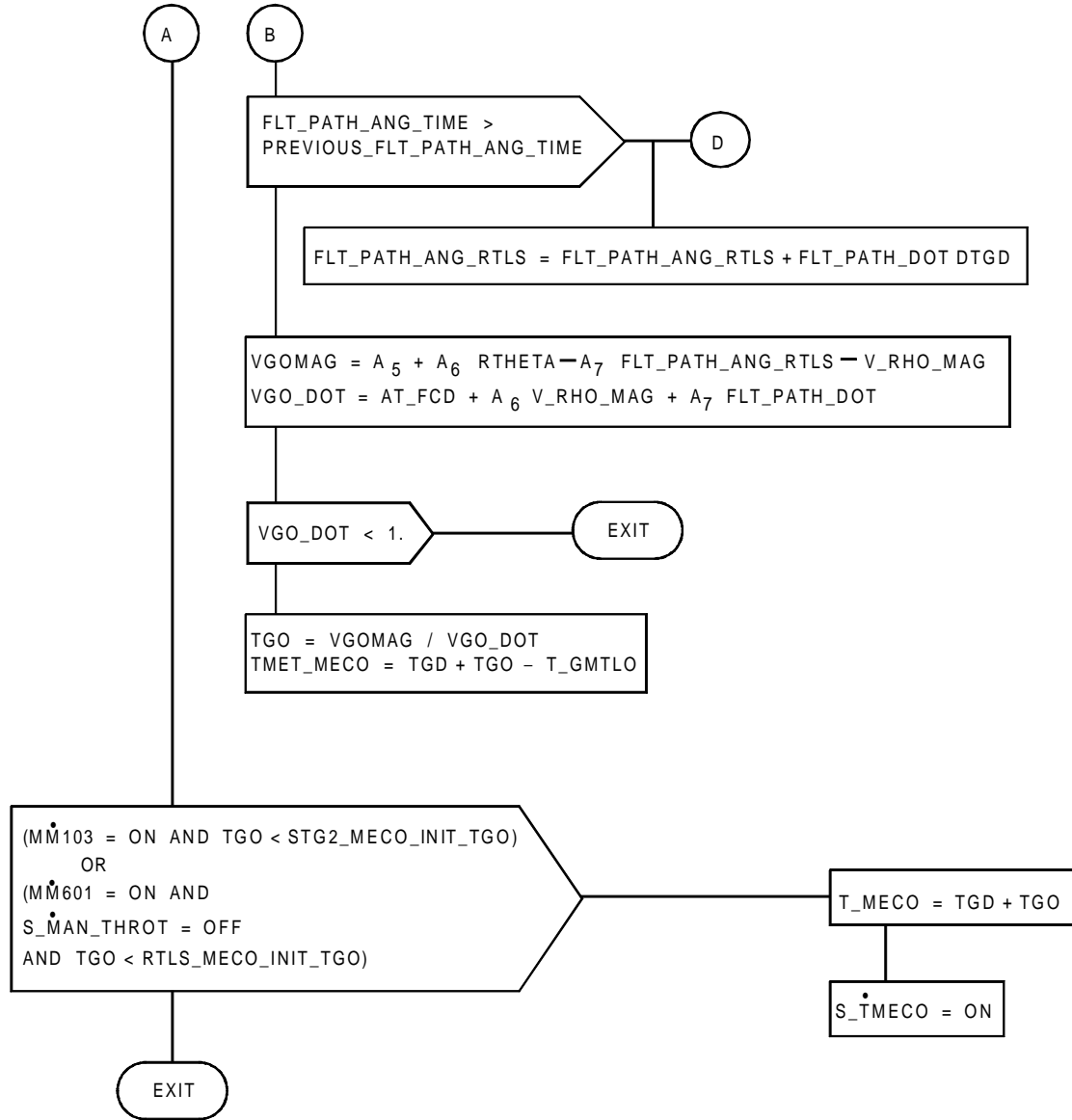


FIGURE A4.8.5.(2) MPS GUID C/O TSK Flow Diagram (Sheet 2 of 3)

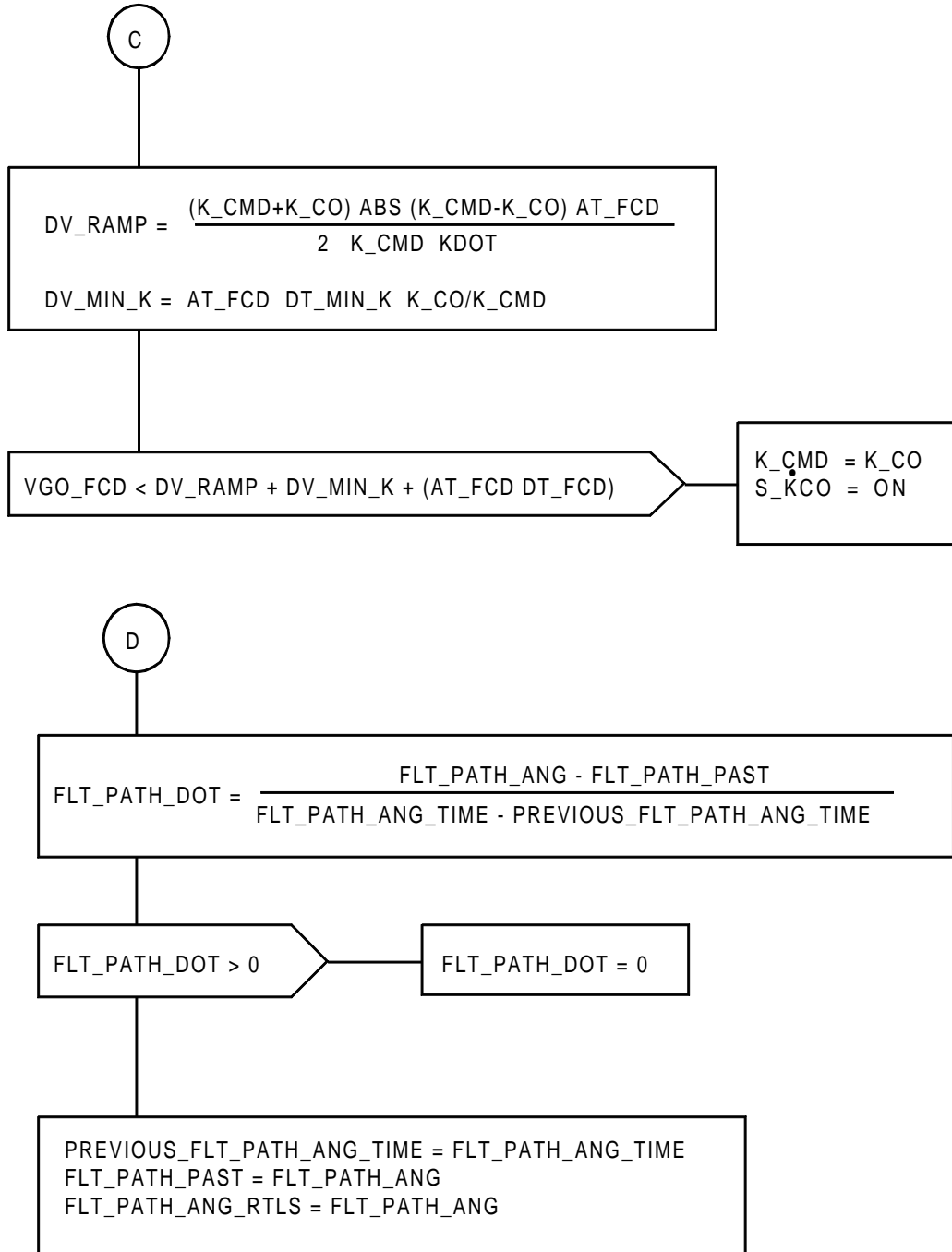


FIGURE A4.8.5.(3) MPS GUID C/O TSK Flow Diagram (Sheet 3 of 3)

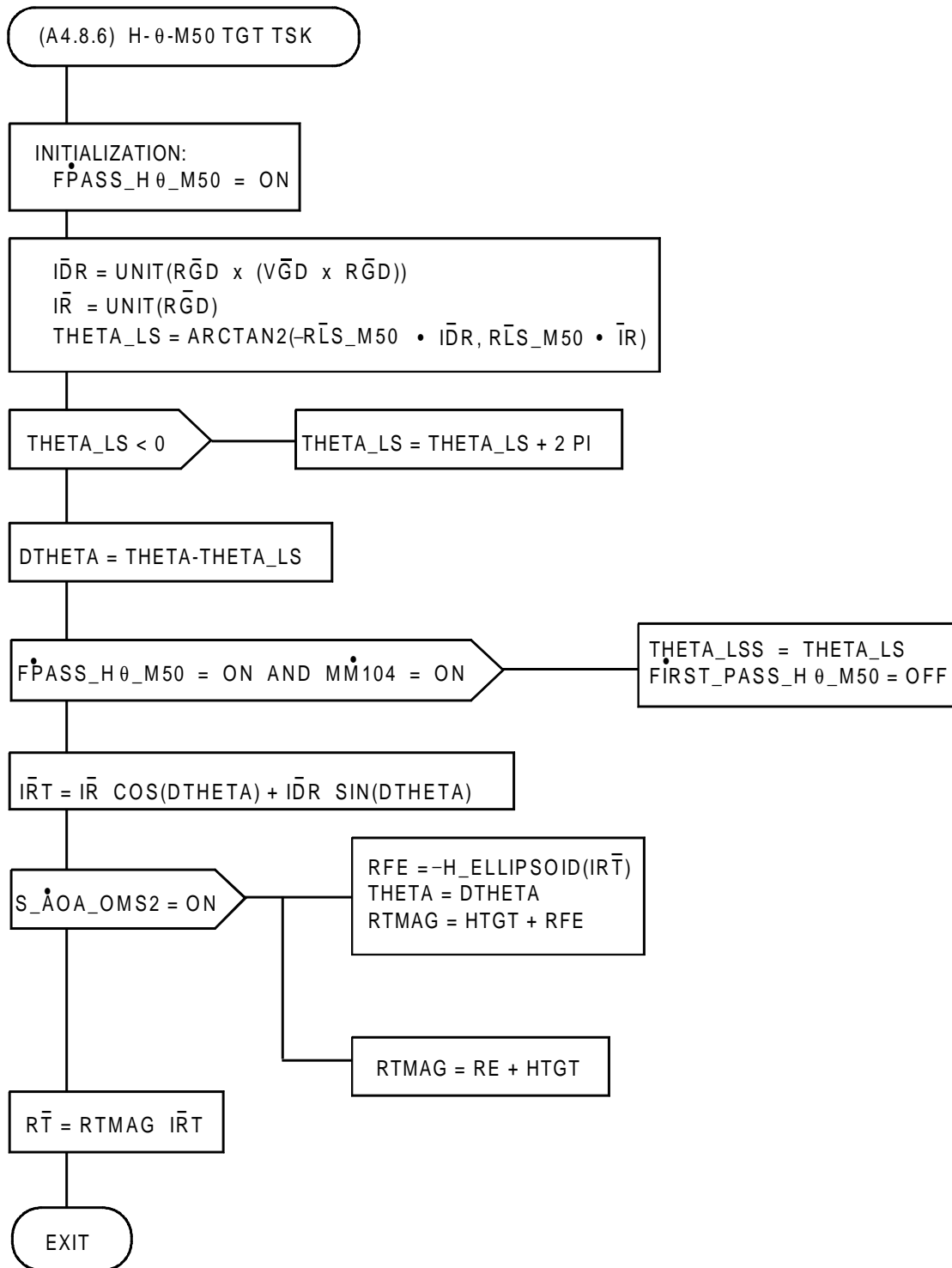


FIGURE A4.8.6. H-θ-M50 TGT TSK Flow Diagram

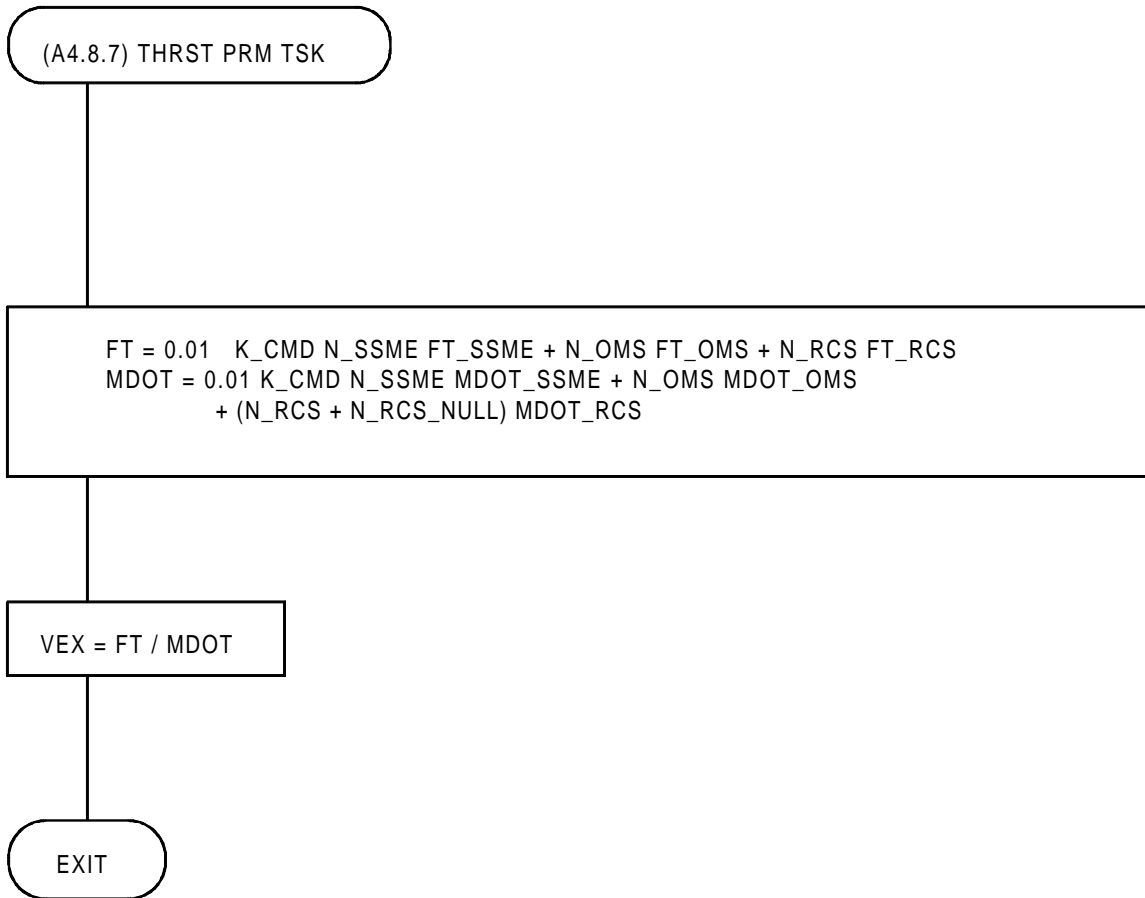


FIGURE A4.8.7. THRST PRM TSK Flow Diagram

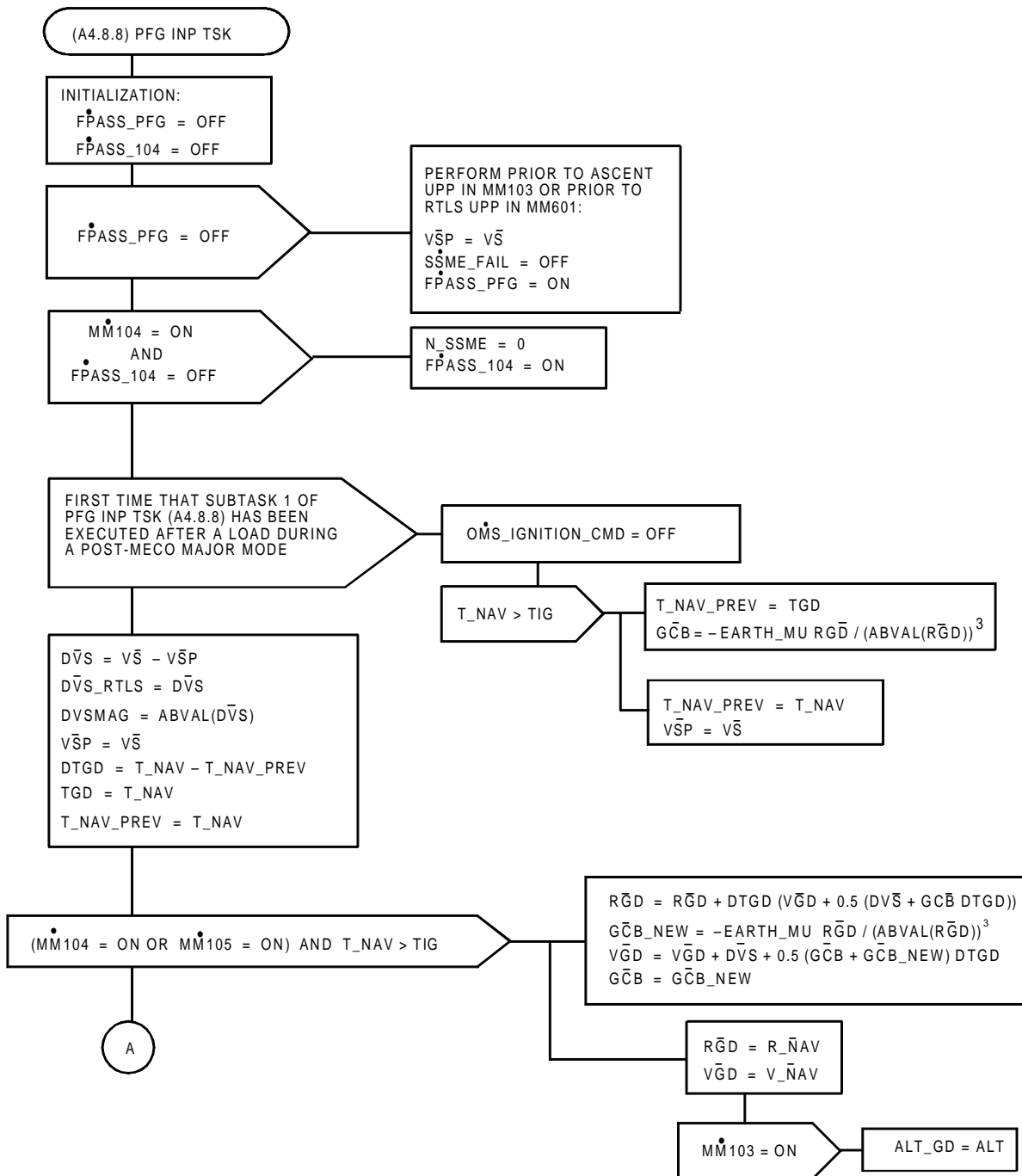


FIGURE A4.8.8.(1) PFG INP TSK Flow Diagram (Sheet 1 of 3)

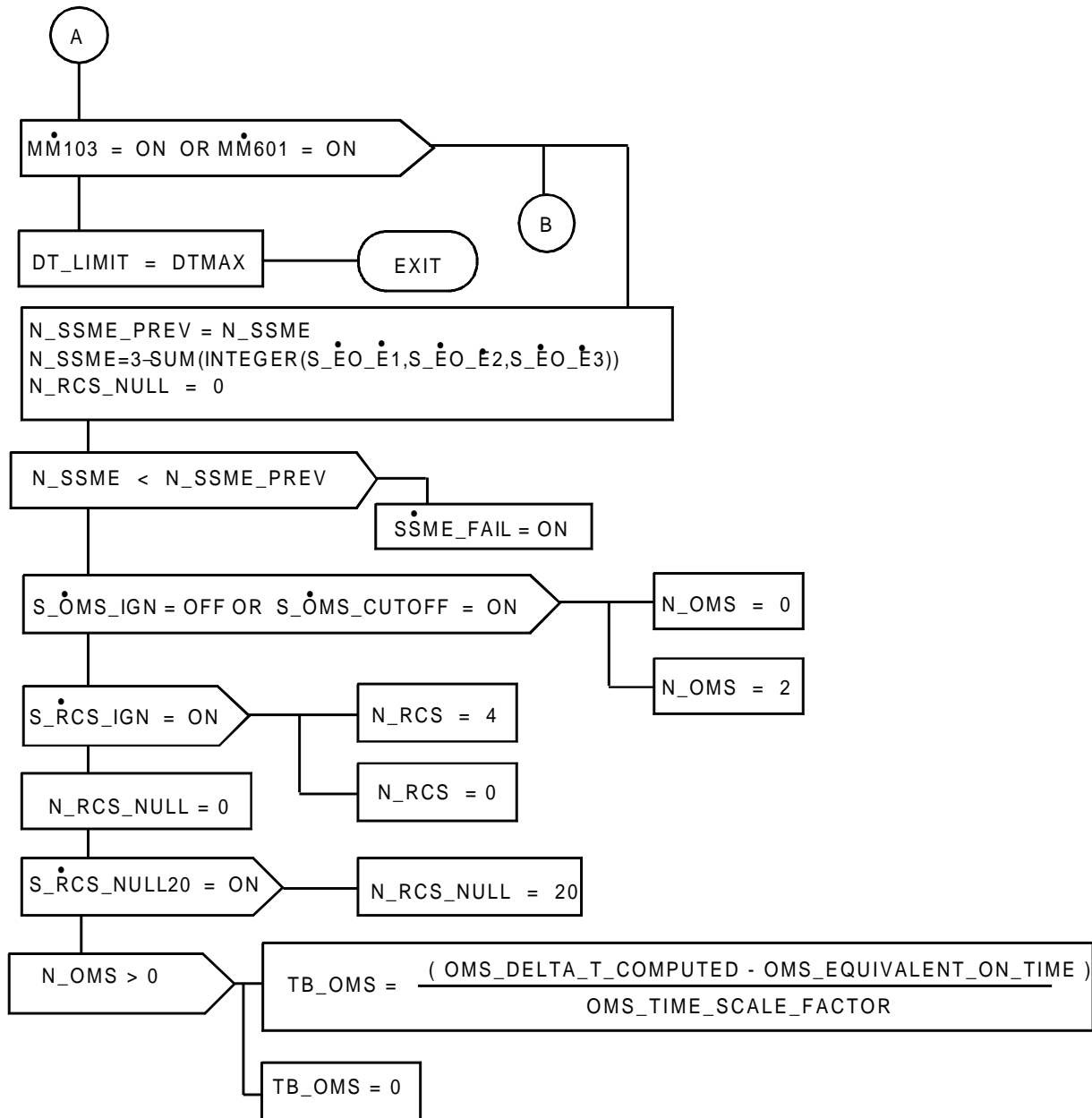


FIGURE A4.8.8.(2) PFG INP TSK Flow Diagram (Sheet 2 of 3)

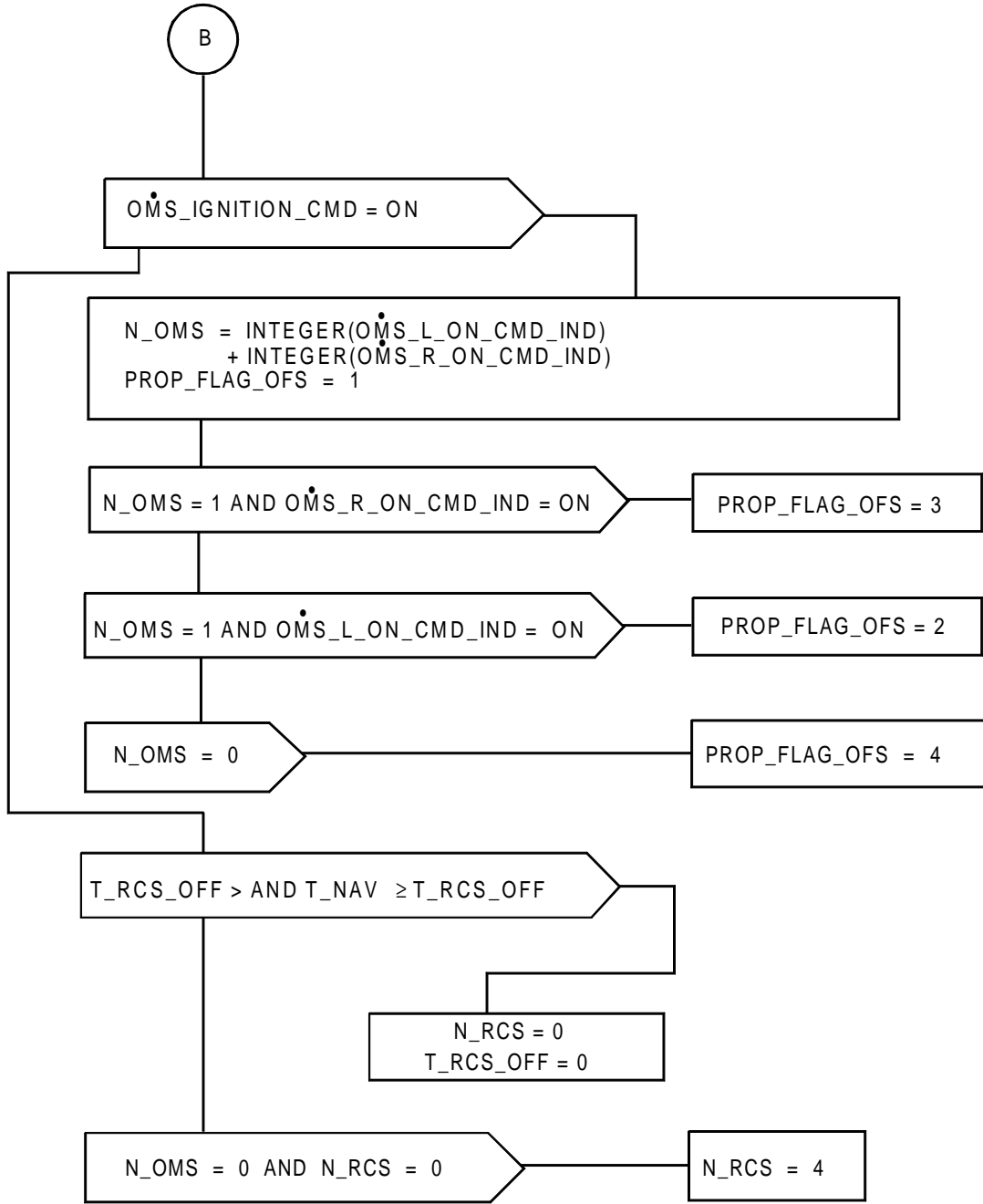


FIGURE A4.8.8.(3) PFG INP TSK Flow Diagram (Sheet 3 of 3)

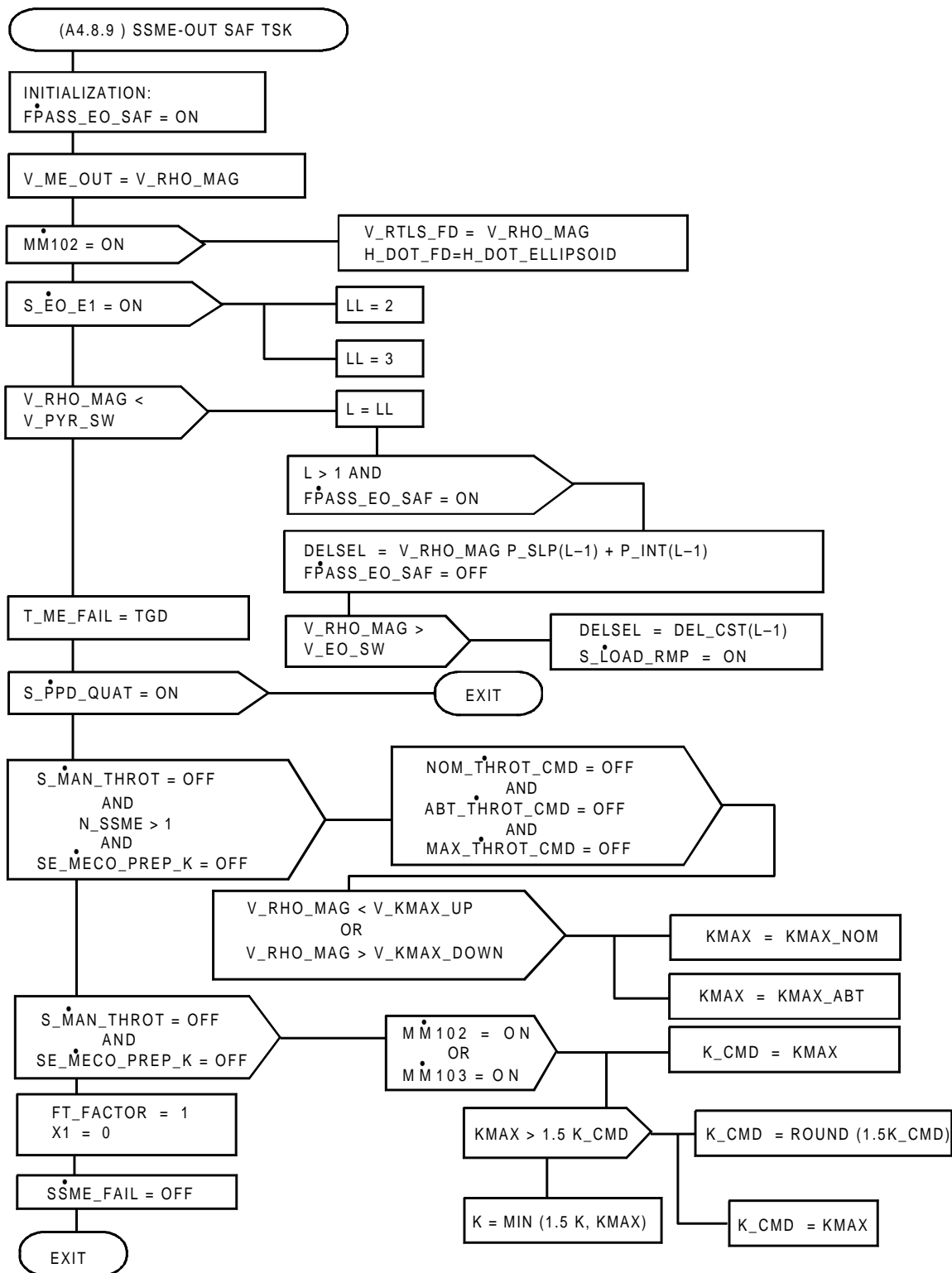


FIGURE A4.8.9. SSME-OUT SAF TSK Flow Diagram

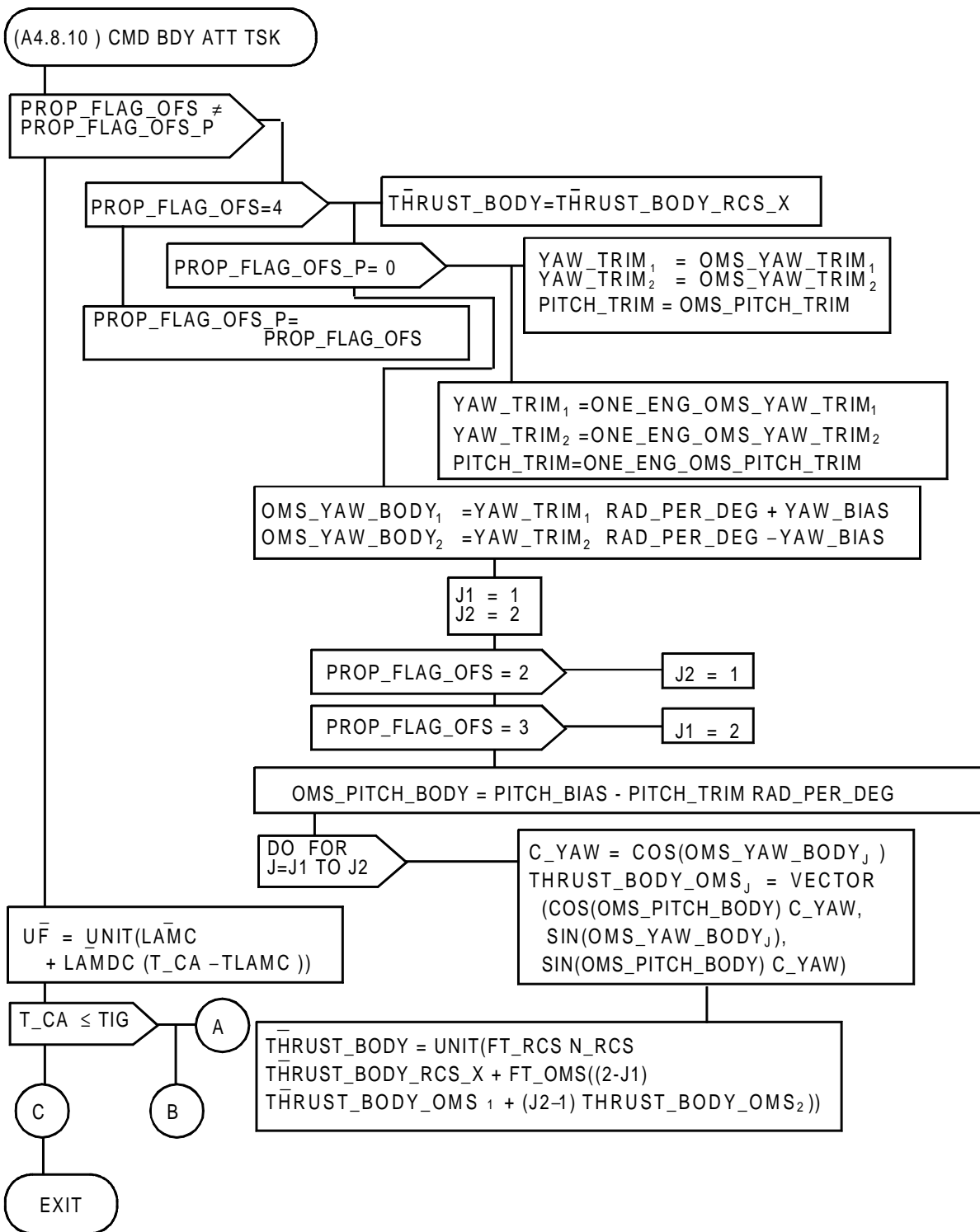


FIGURE A4.8.10.(1) CMD BDY ATT TSK Flow Diagram (Sheet 1 of 4)

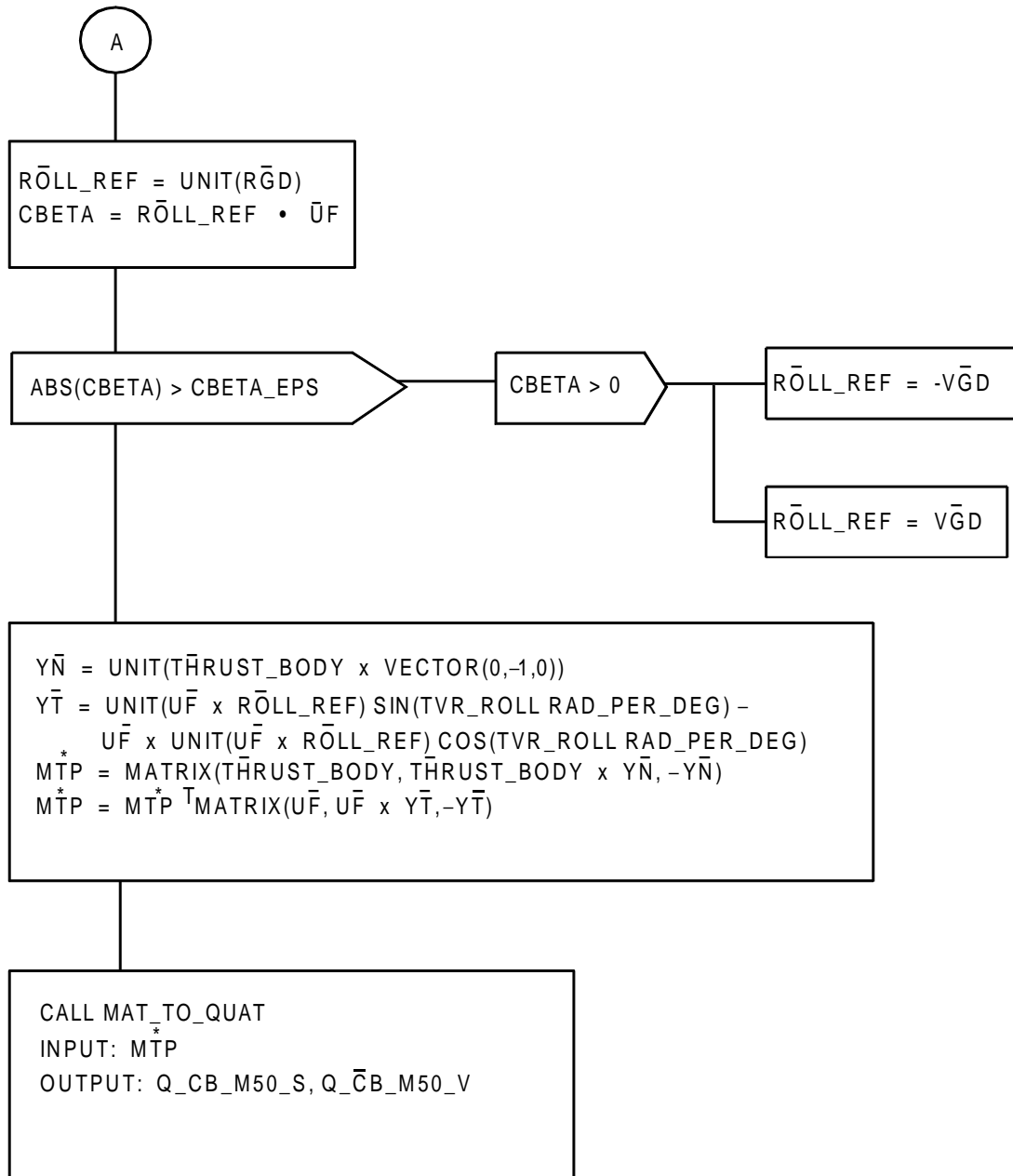


FIGURE A4.8.10.(2) CMD BDY ATT TSK Flow Diagram (Sheet 2 of 4)

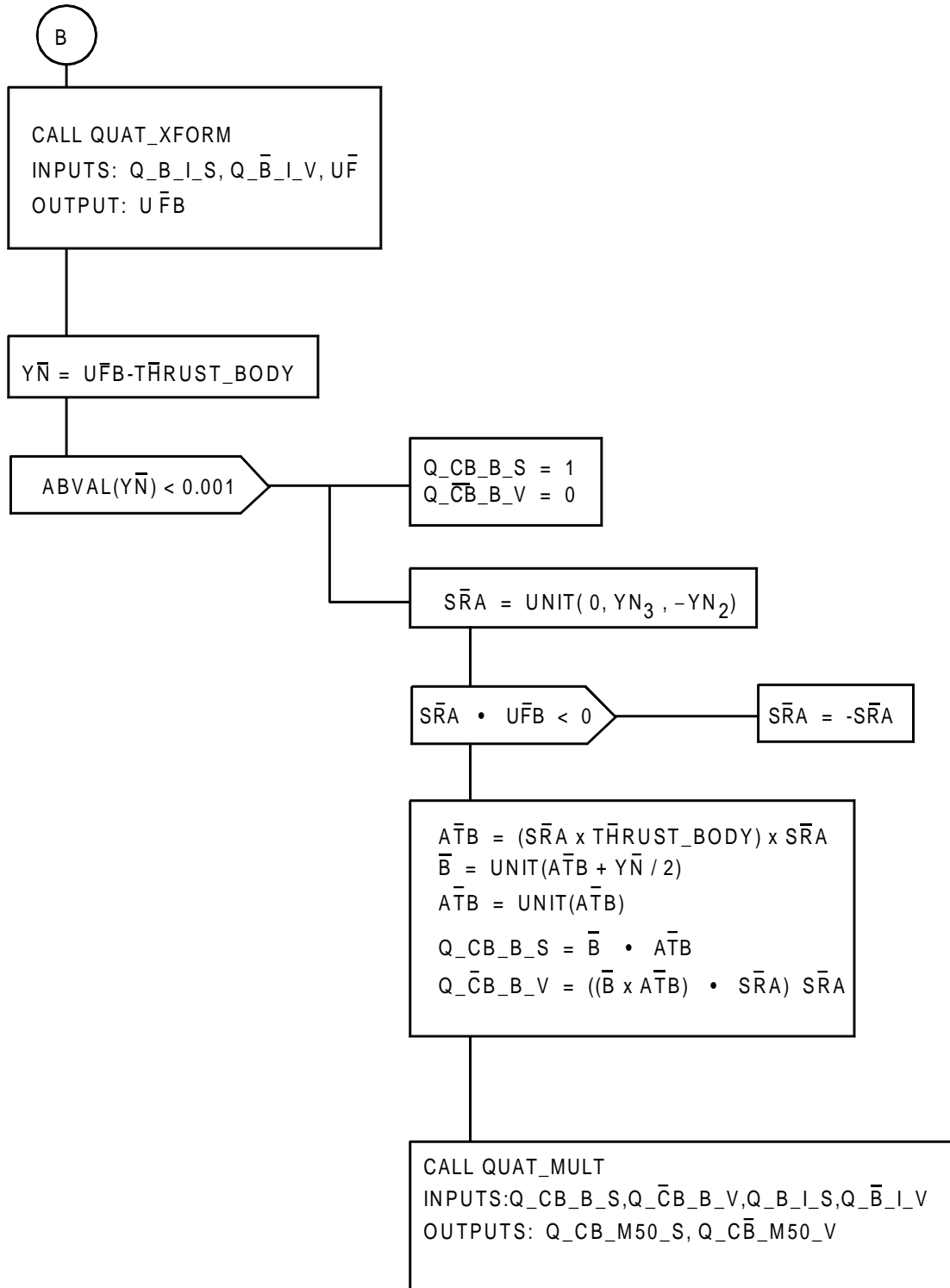


FIGURE A4.8.10.(3) CMD BDY ATT TSK Flow Diagram (Sheet 3 of 4)

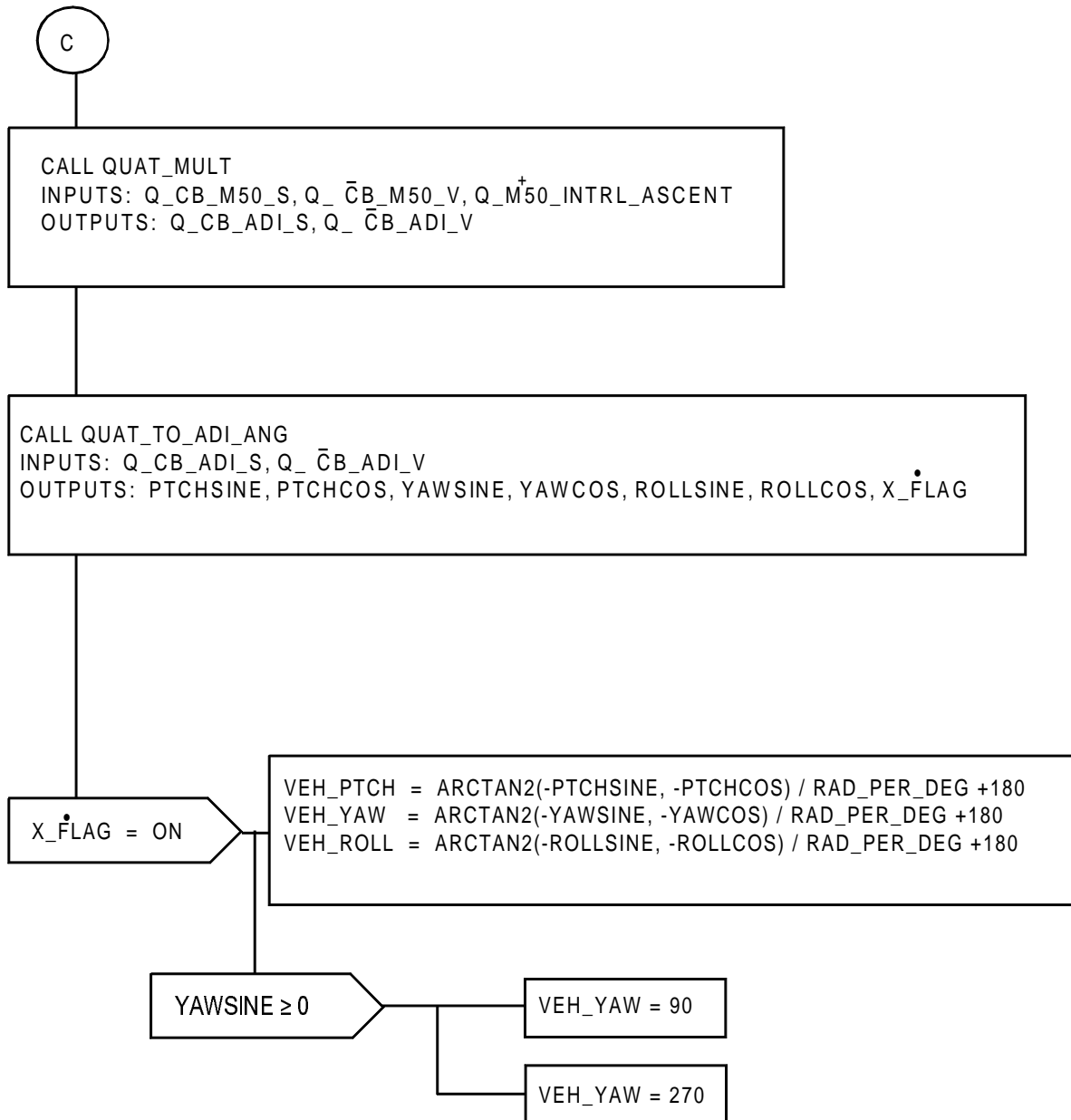


FIGURE A4.8.10.(4) CMD BDY ATT TSK Flow Diagram (Sheet 4 of 4)

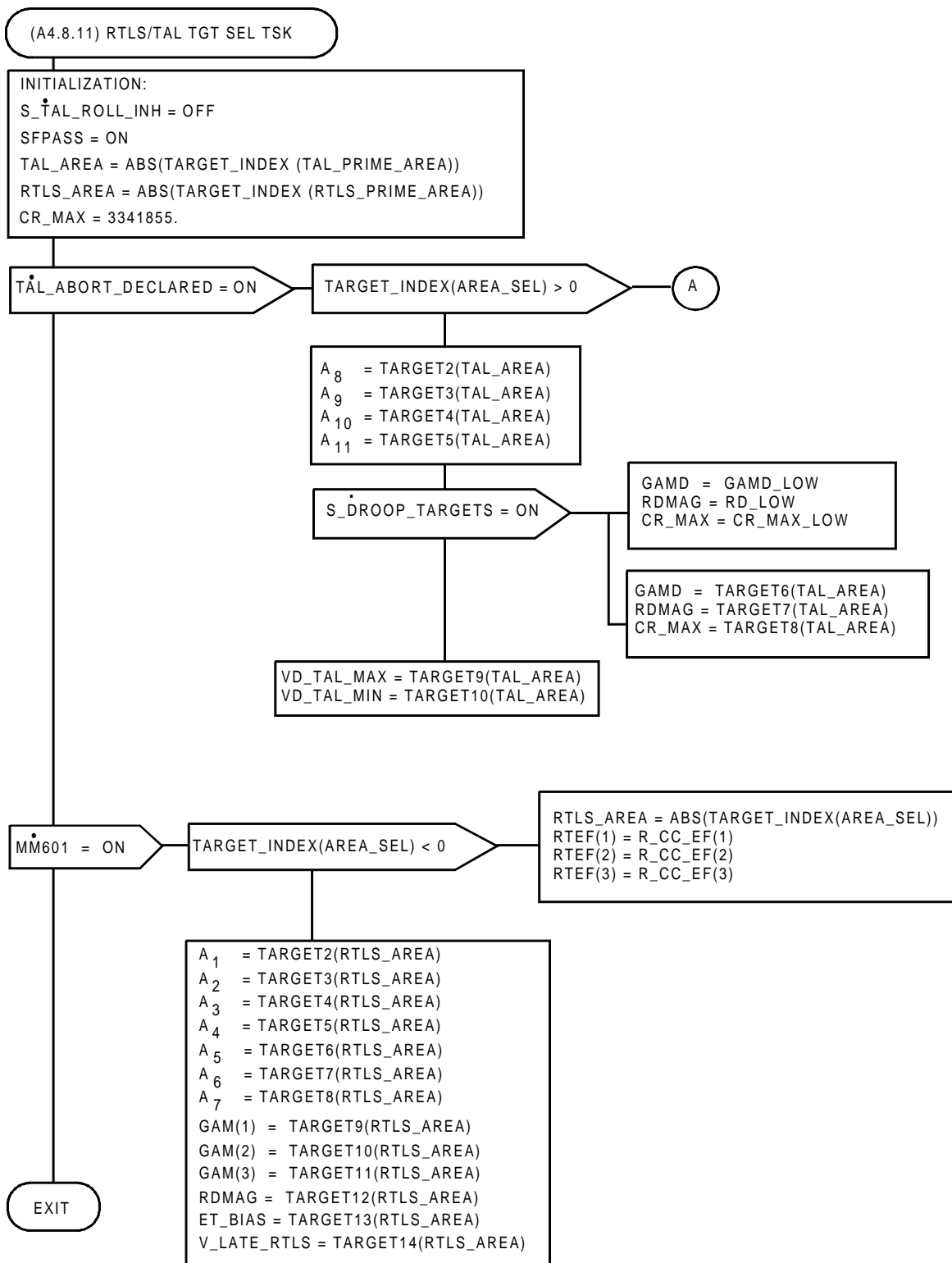


FIGURE A4.8.11.(1) RTLS/TAL TGT SEL TSK Flow Diagram (Sheet 1 of 2)

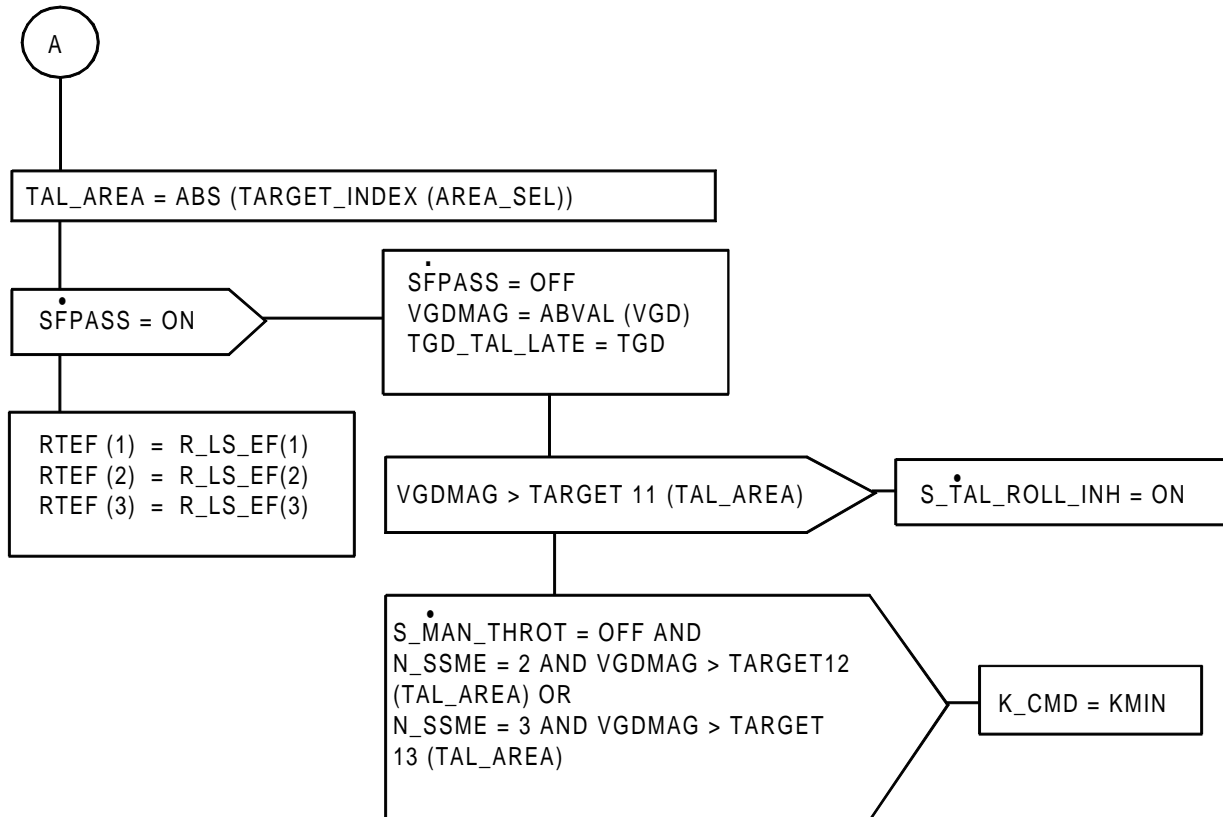


FIGURE A4.8.11.(2) RTLS/TAL TGT SEL TSK Flow Diagram (Sheet 2 of 2)

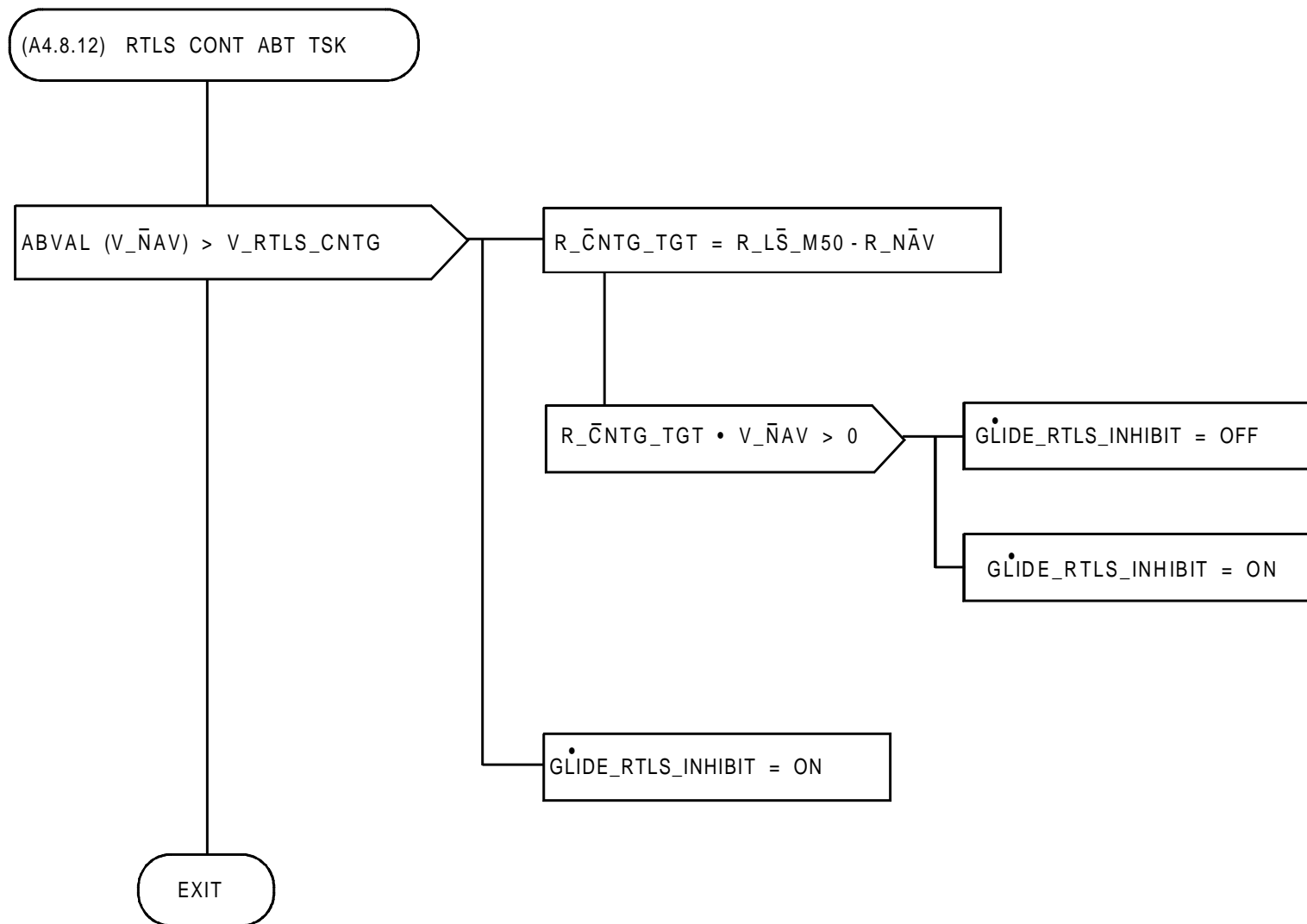


FIGURE A4.8.12. RTLS CONT ABT TSK Flow Diagram

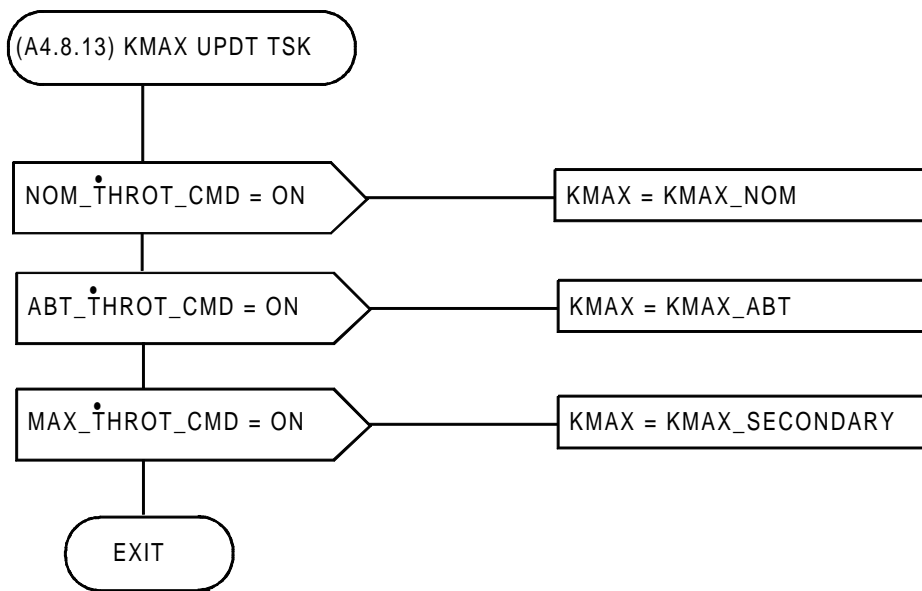


FIGURE A4.8.13. KMAX UPDT TSK Flow Diagram

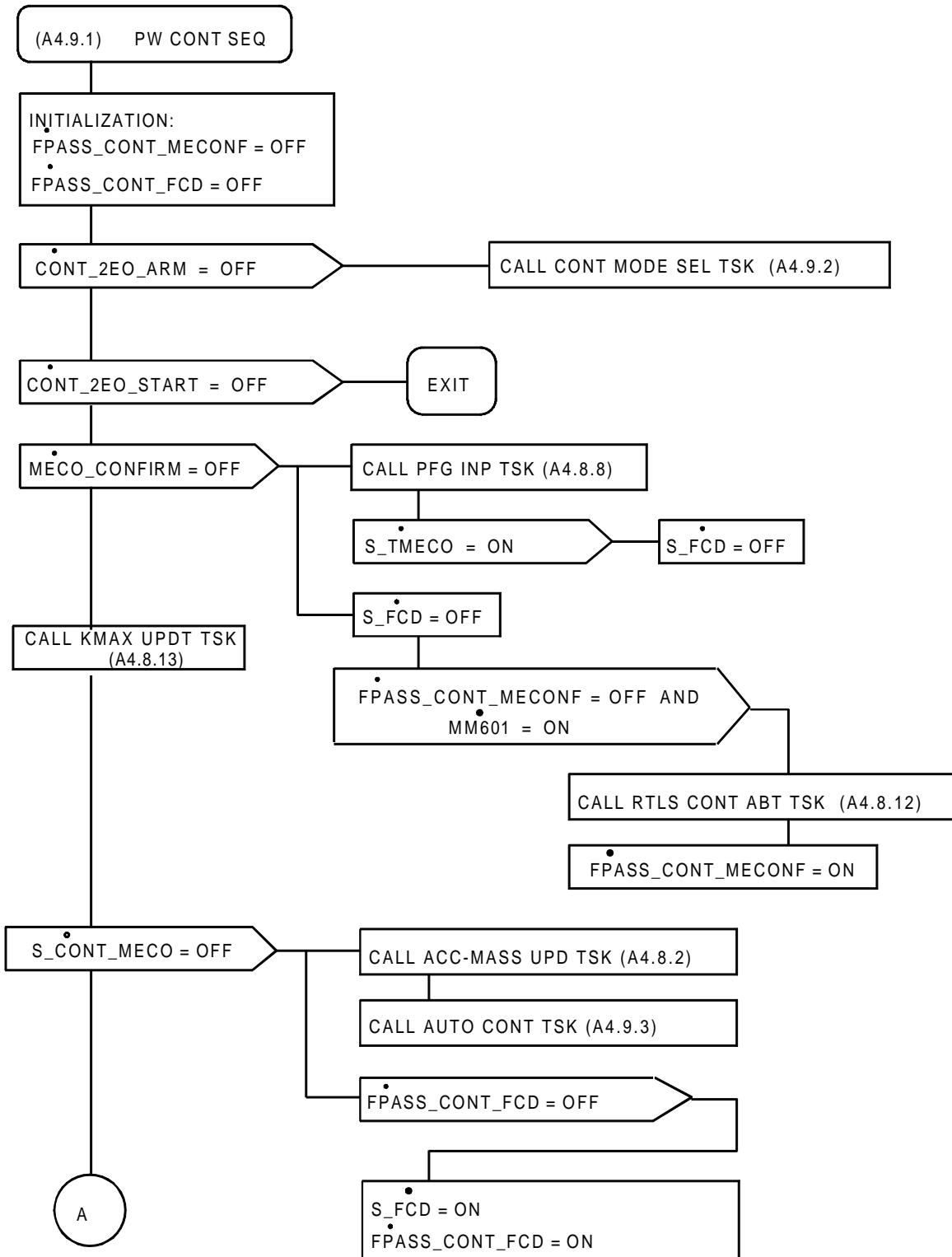


FIGURE A4.9.1.(1) PW CONT SEQ Flow Diagram (Sheet 1 of 2)

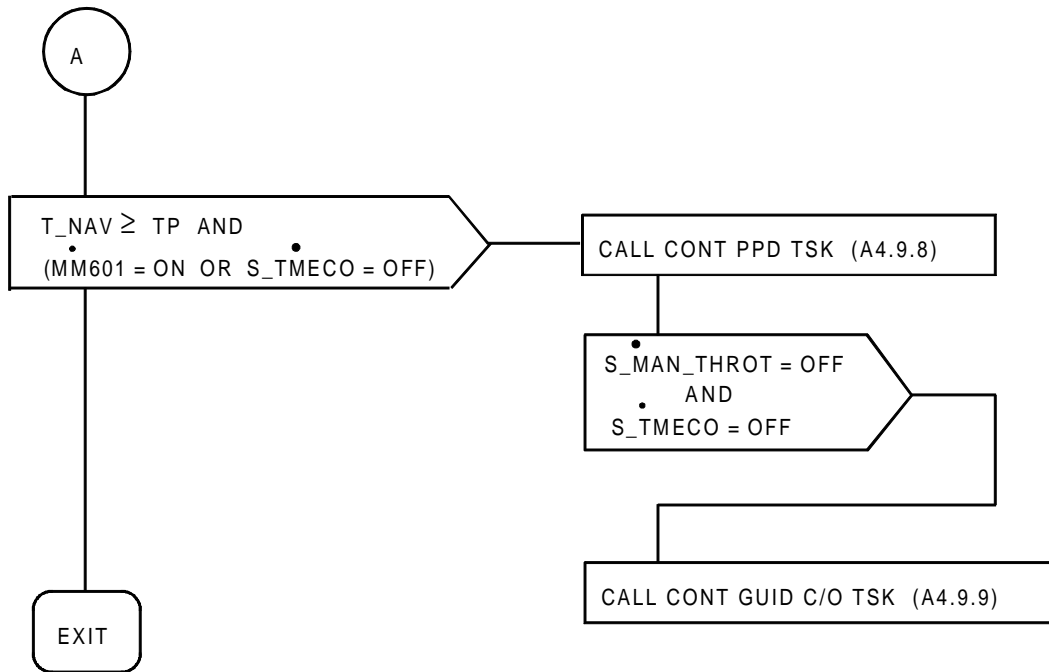


FIGURE A4.9.1.(2) PW CONT SEQ Flow Diagram (Sheet 2 of 2)

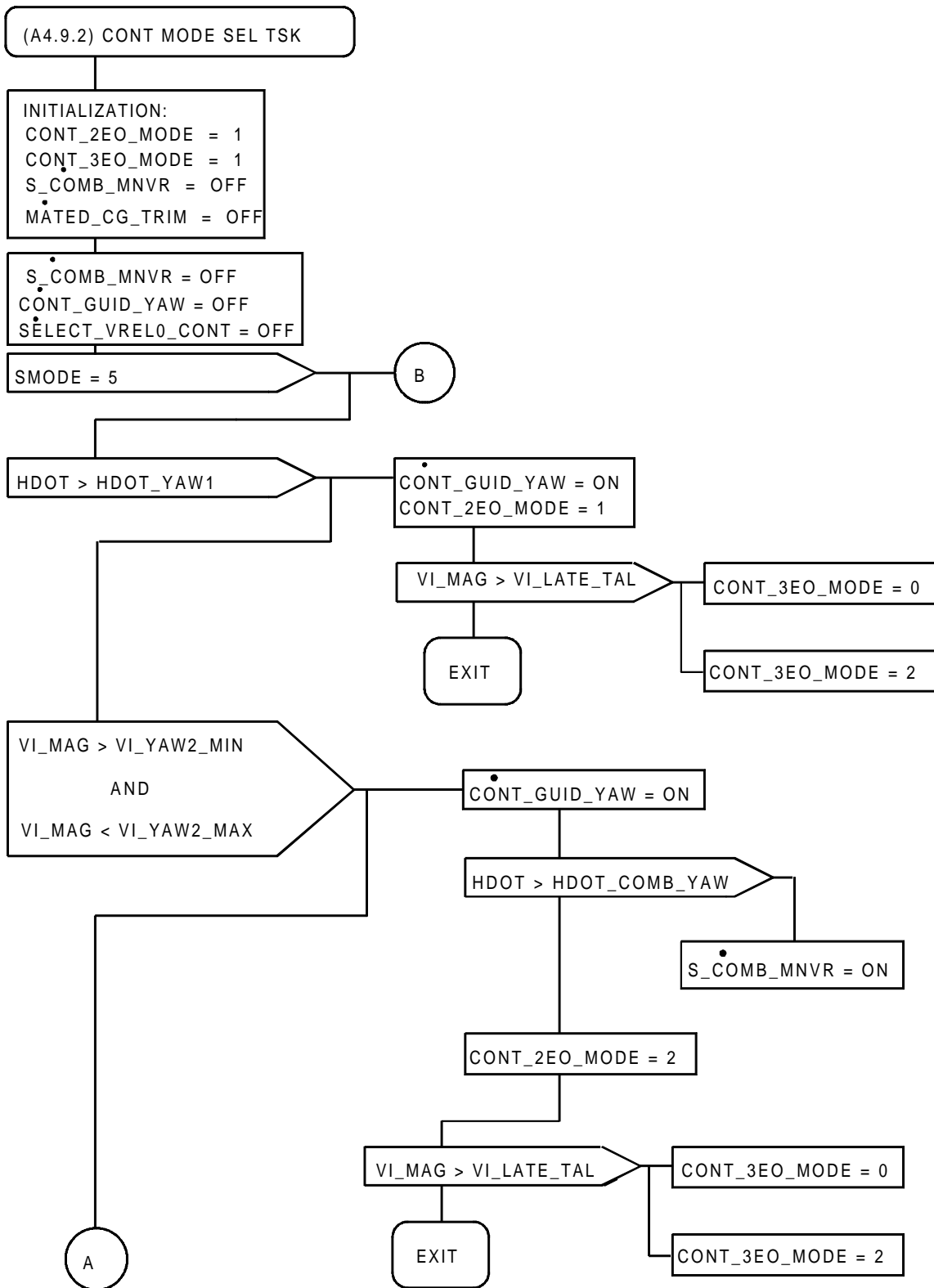


FIGURE A4.9.2.(1) CONT MODE SEL TSK Flow Diagram (Sheet 1 of 5)

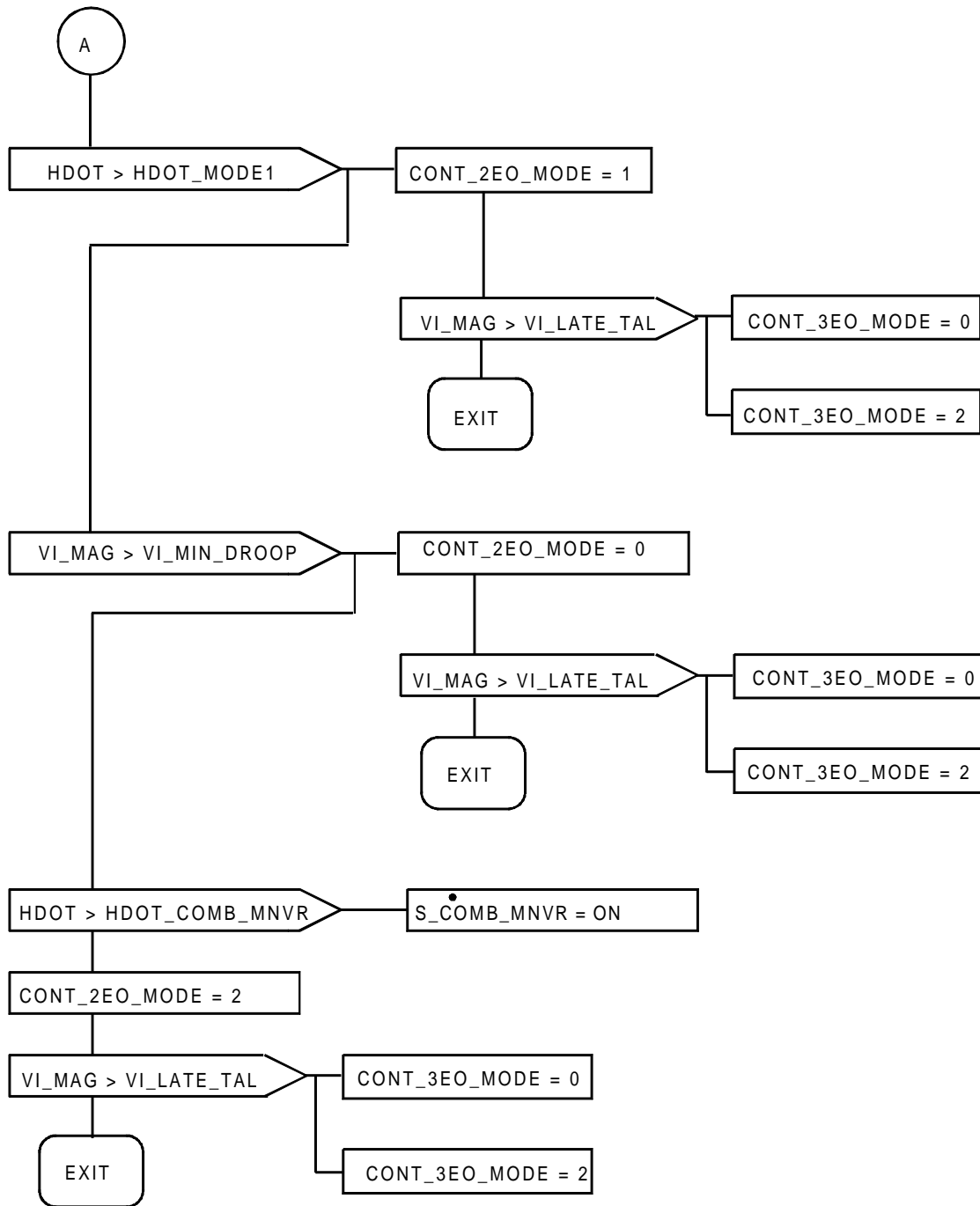


FIGURE A4.9.2.(2) CONT MODE SEL TSK Flow Diagram (Sheet 2 of 5)

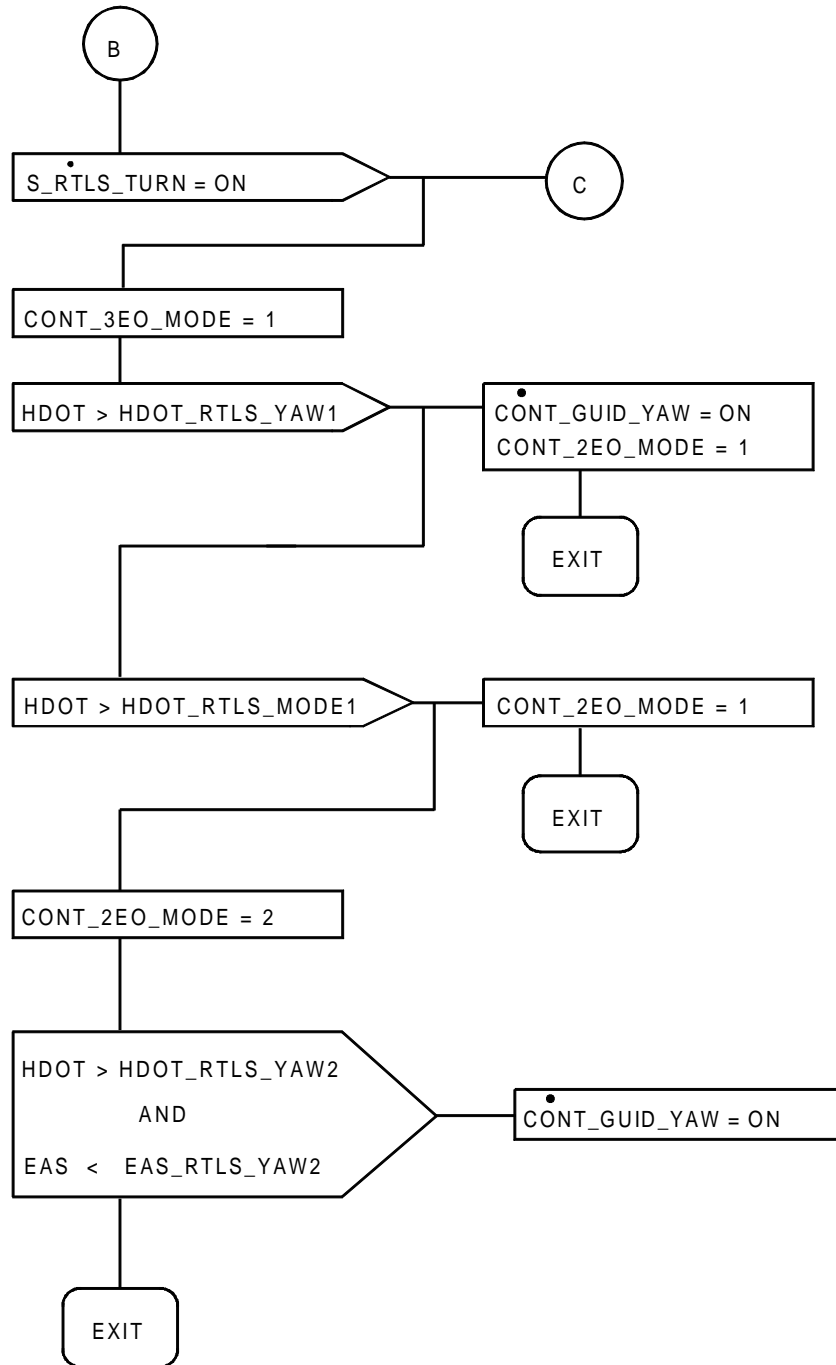


FIGURE A4.9.2.(3) CONT MODE SEL TSK Flow Diagram (Sheet 3 of 5)

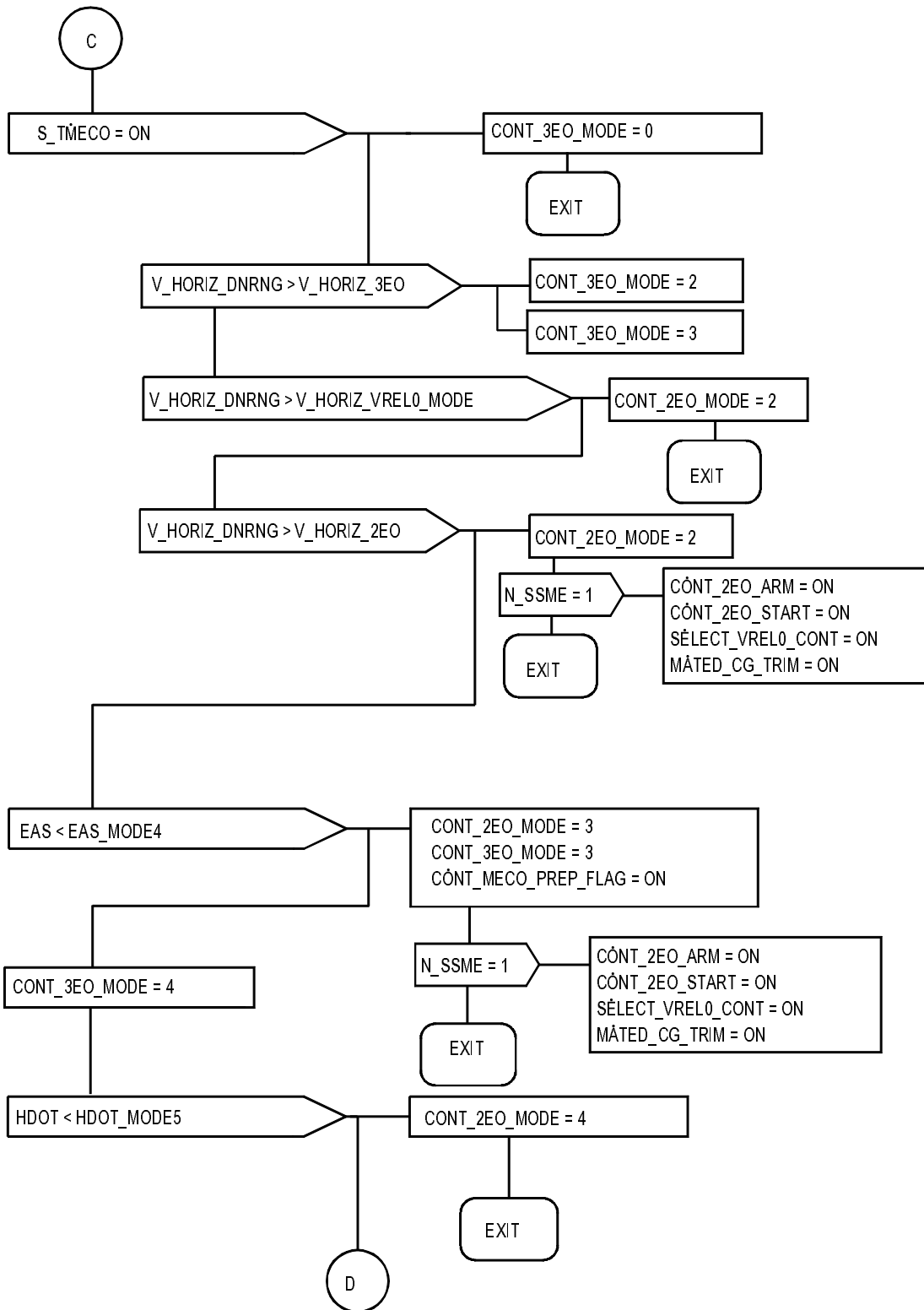


FIGURE A4.9.2.(4) CONT MODE SEL TSK Flow Diagram (Sheet 4 of 5)

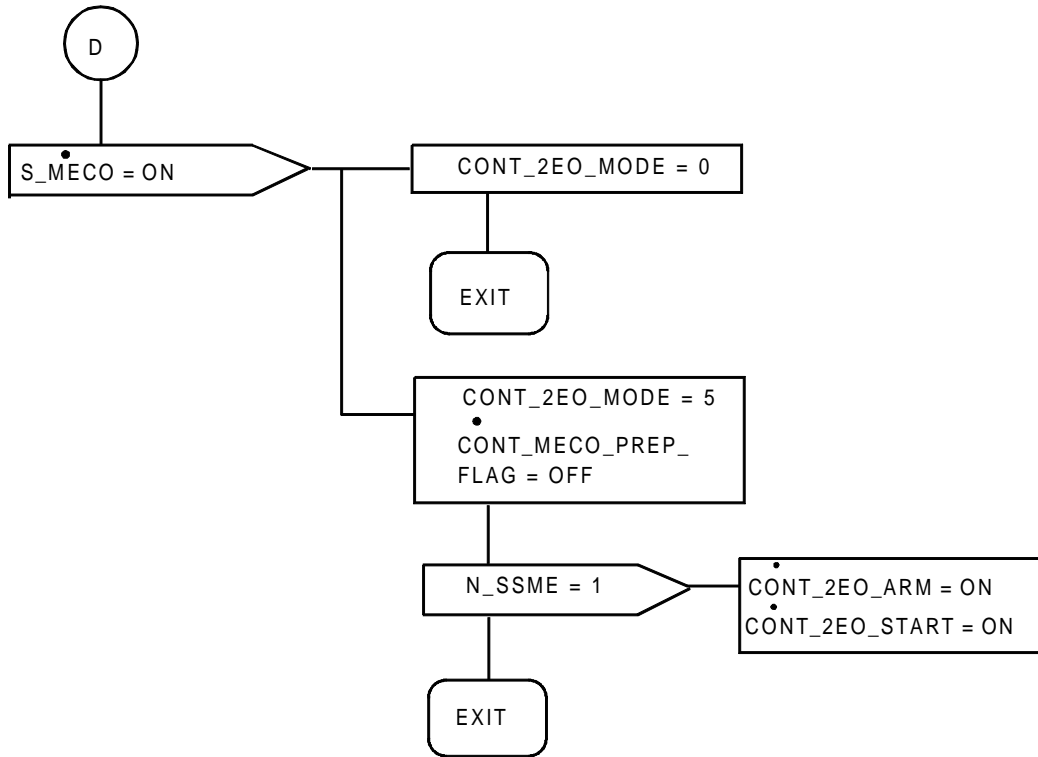


FIGURE A4.9.2.(5) CONT MODE SEL TSK Flow Diagram (Sheet 5 of 5)

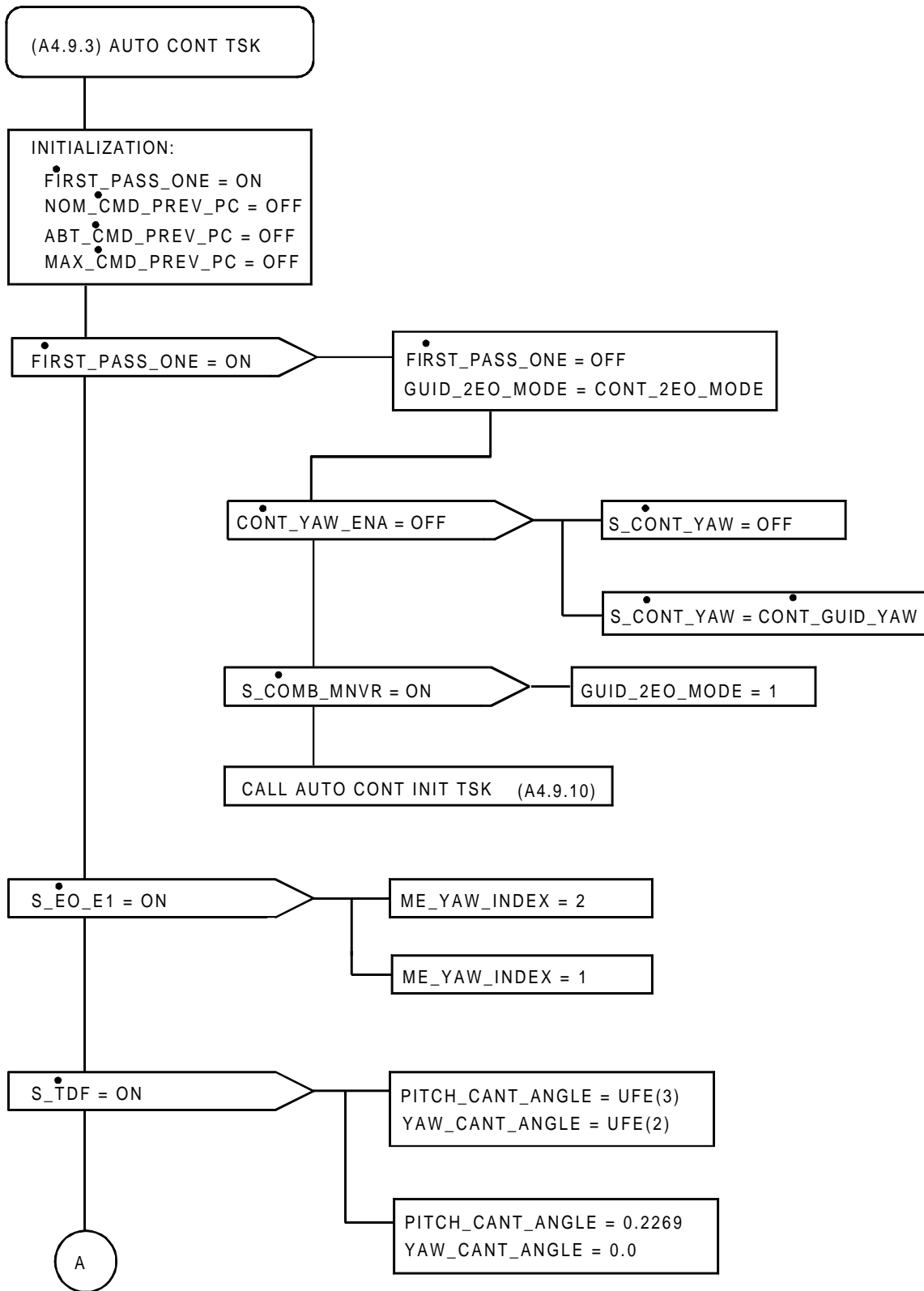


FIGURE A4.9.3.(1) AUTO CONT TSK Flow Diagram (Sheet 1 of 2)

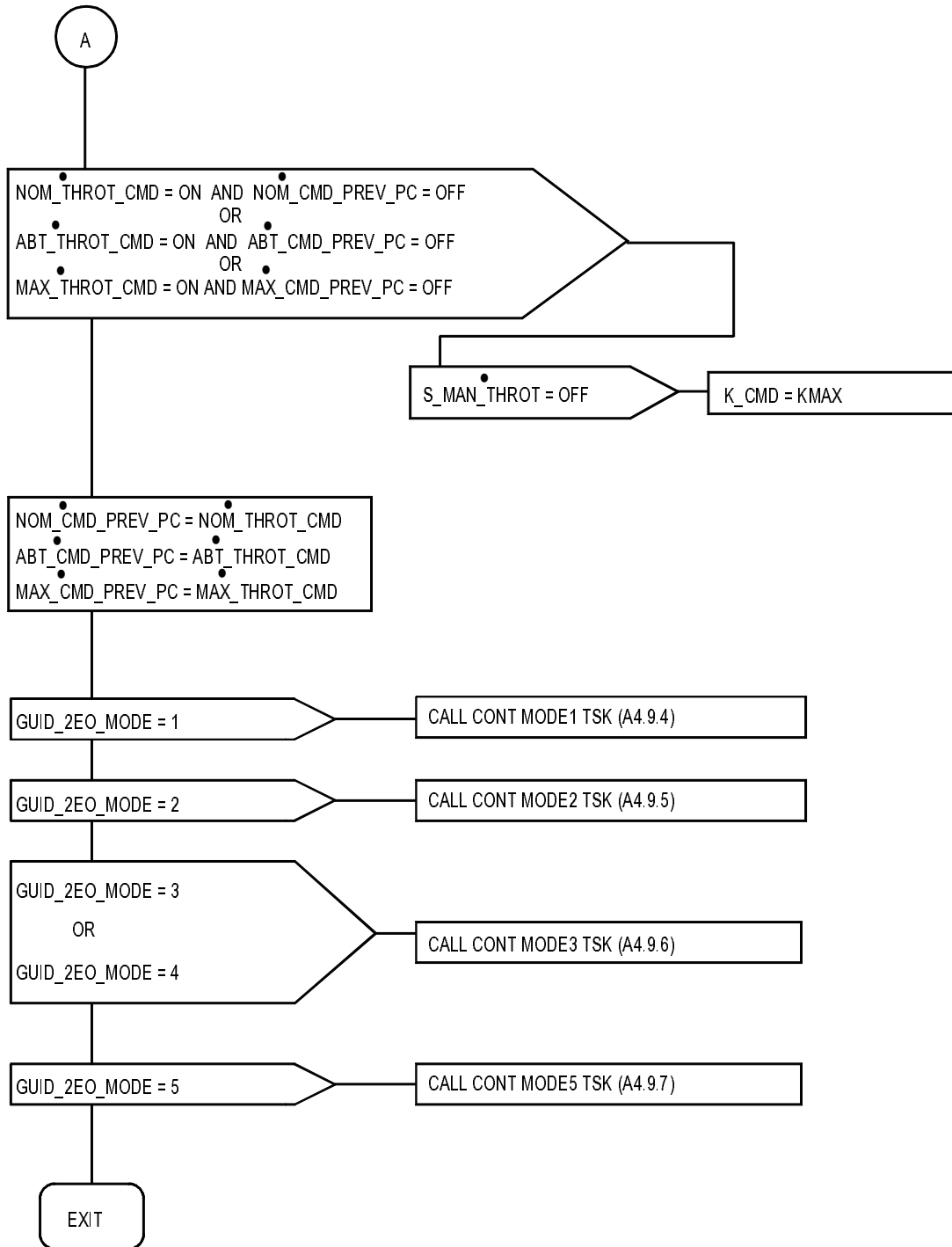


FIGURE A4.9.3.(2) AUTO CONT TSK Flow Diagram (Sheet 2 of 2)

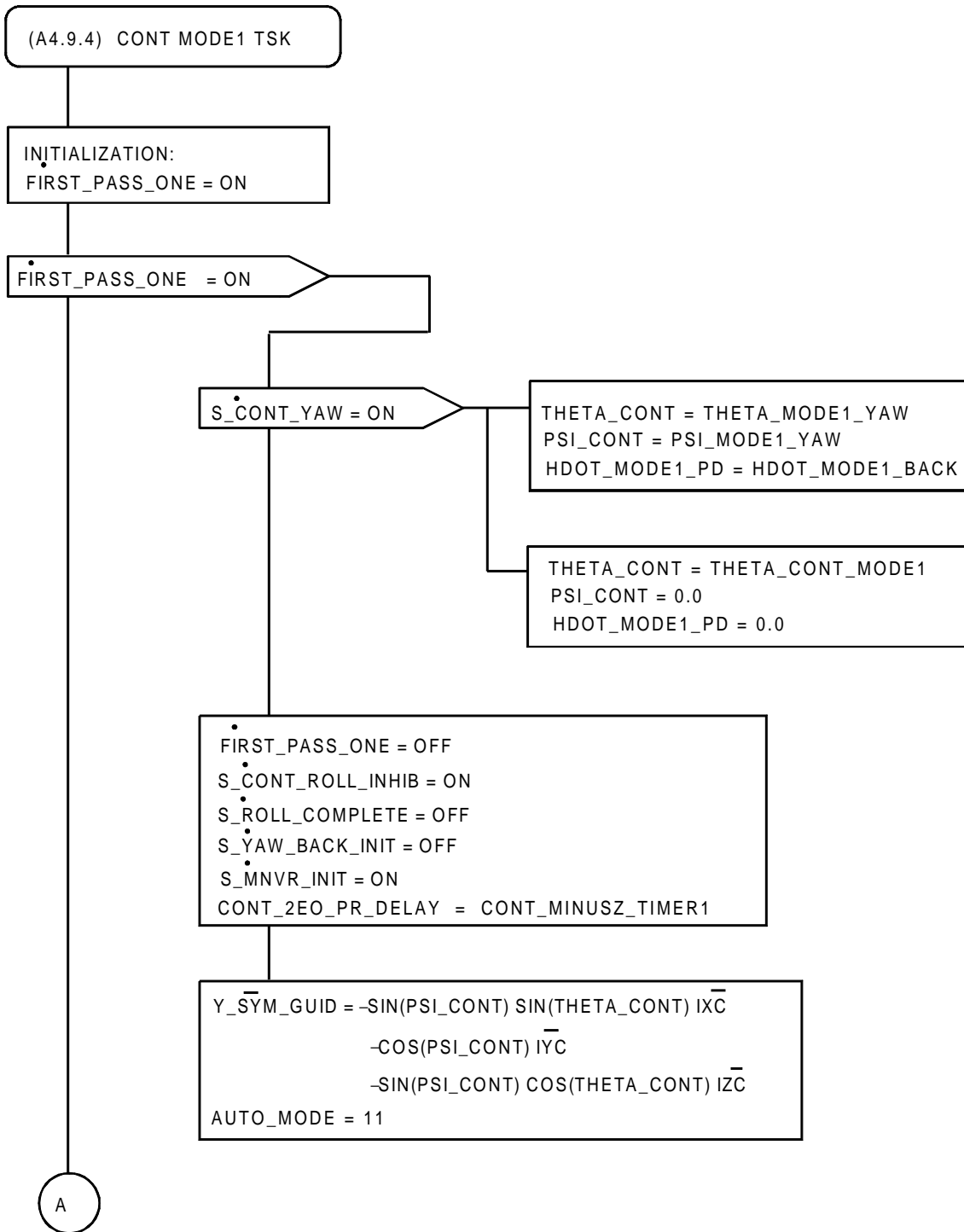


FIGURE A4.9.4.(1) CONT MODE1 TSK Flow Diagram (Sheet 1 of 4)

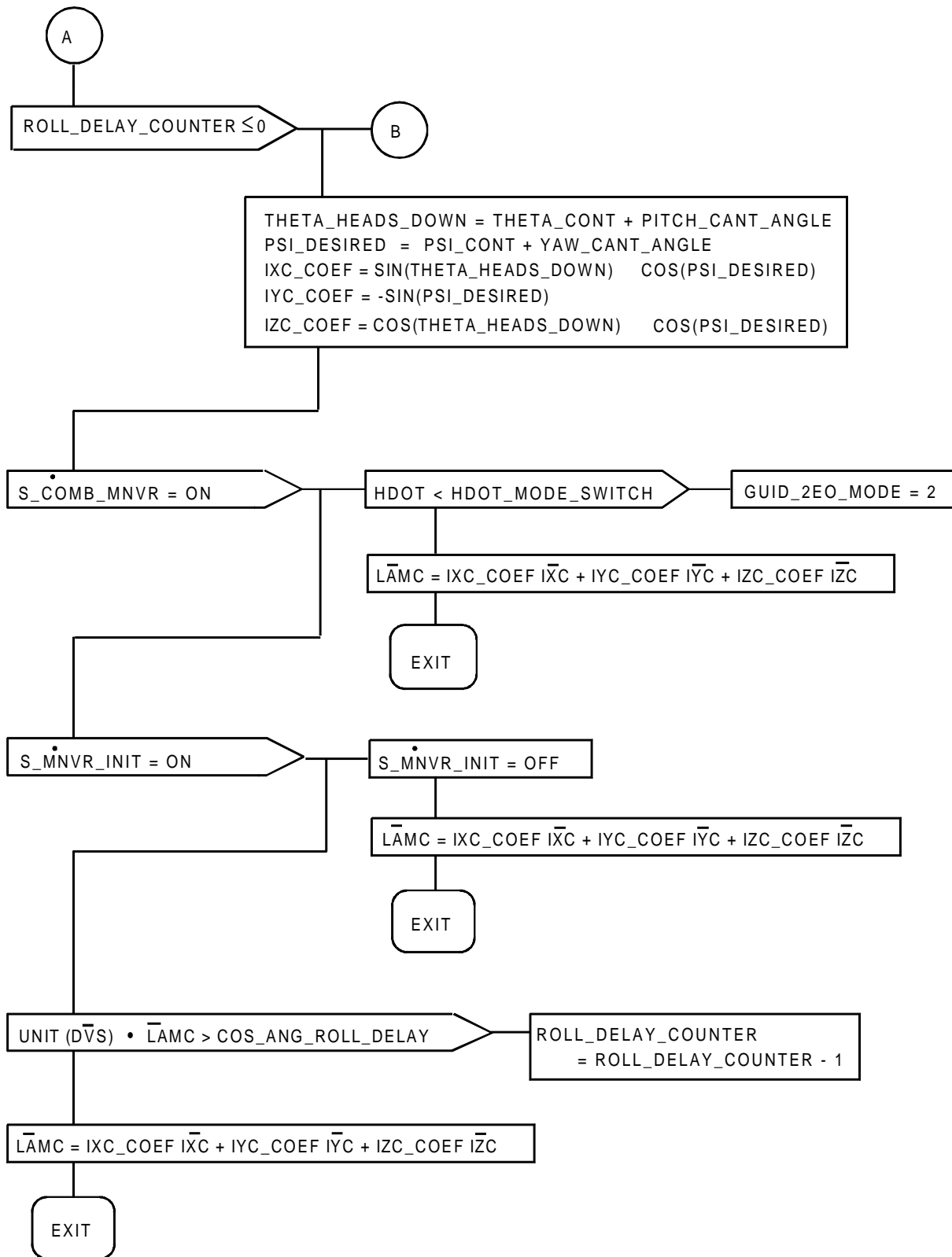


FIGURE A4.9.4.(2) CONT MODE1 TSK Flow Diagram (Sheet 2 of 4)

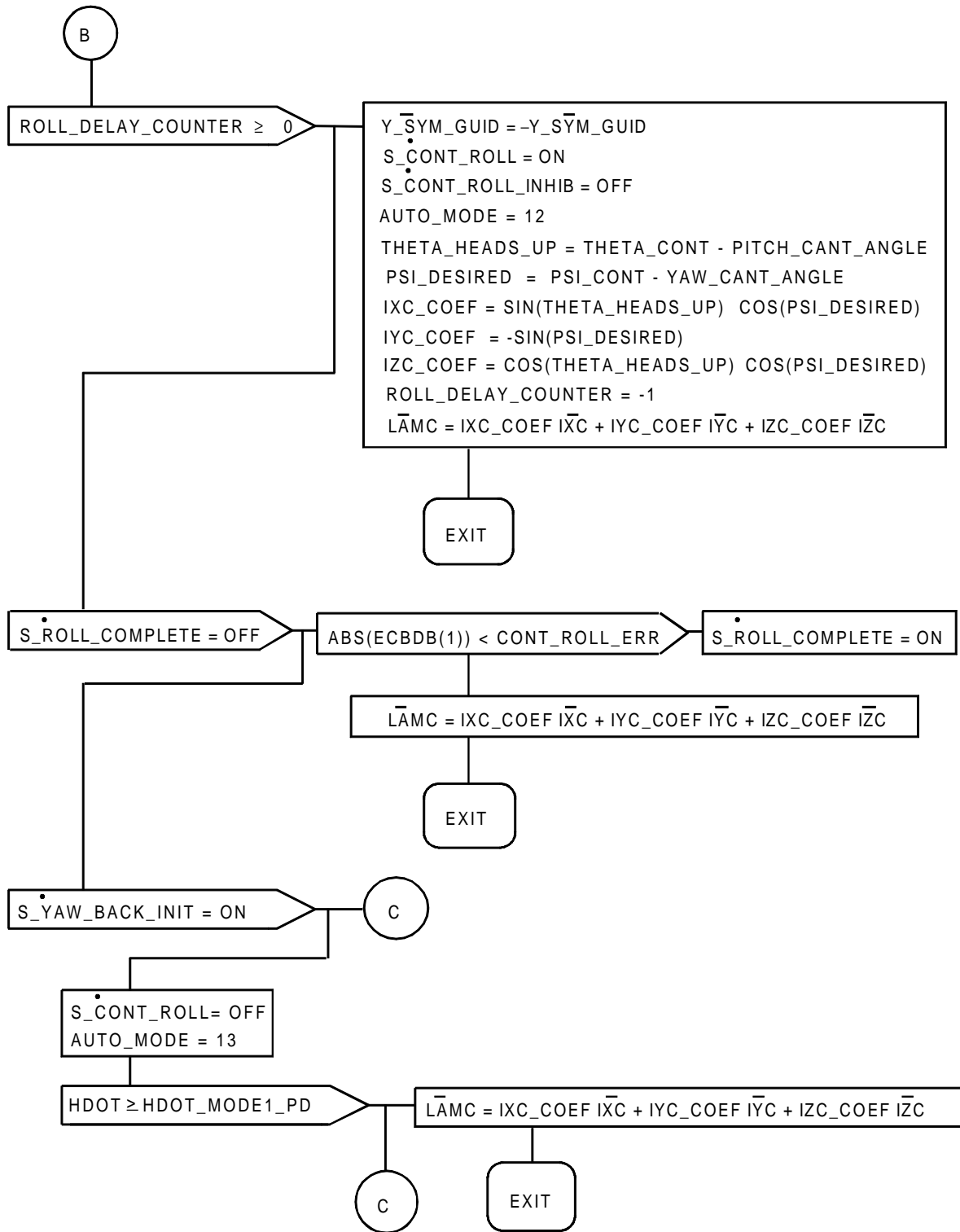


FIGURE A4.9.4.(3) CONT MODE1 TSK Flow Diagram (Sheet 3 of 4)

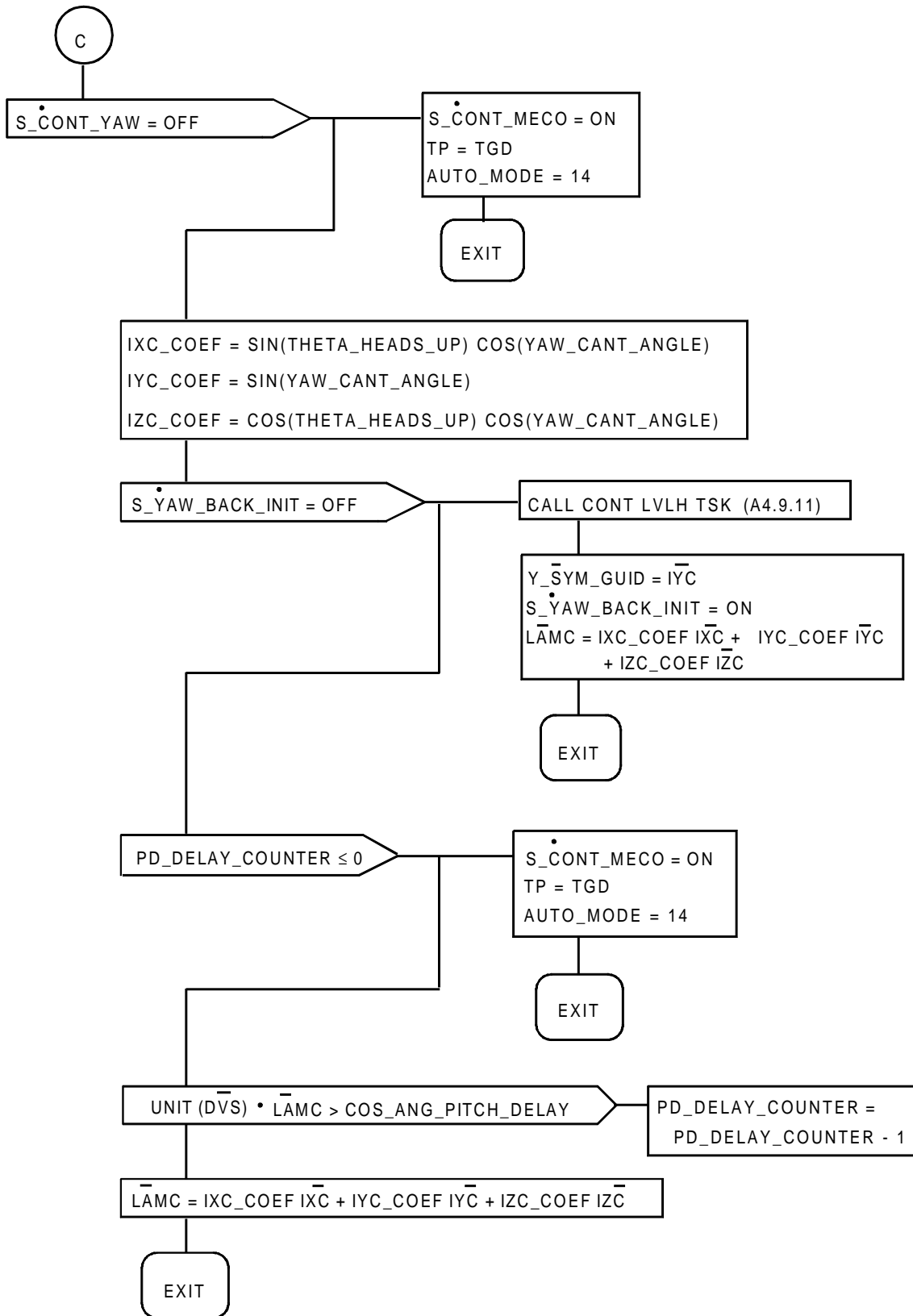


FIGURE A4.9.4.(4) CONT MODE1 TSK Flow Diagram (Sheet 4 of 4)

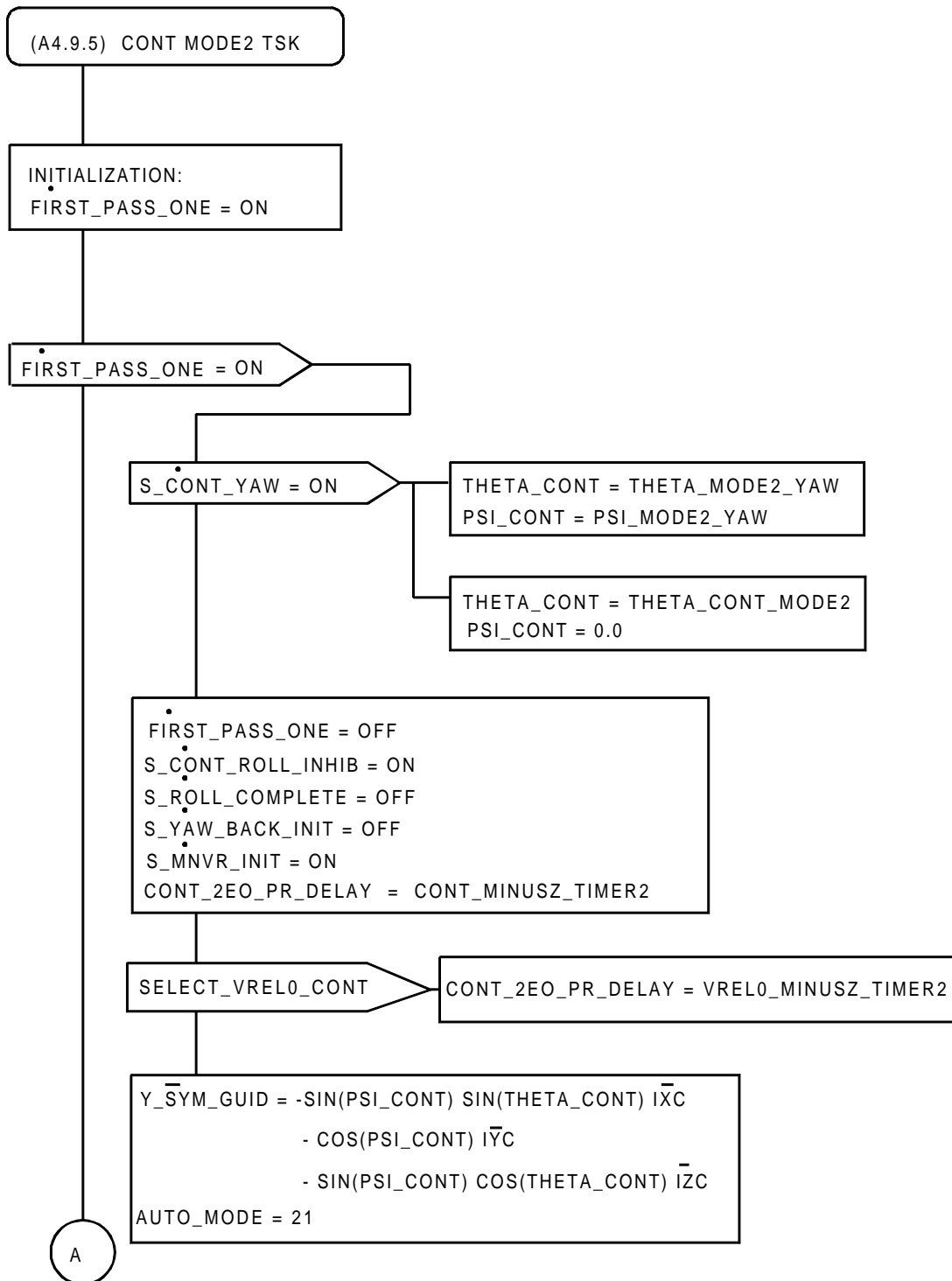


FIGURE A4.9.5.(1) CONT MODE2 TSK Flow Diagram (Sheet 1 of 4)

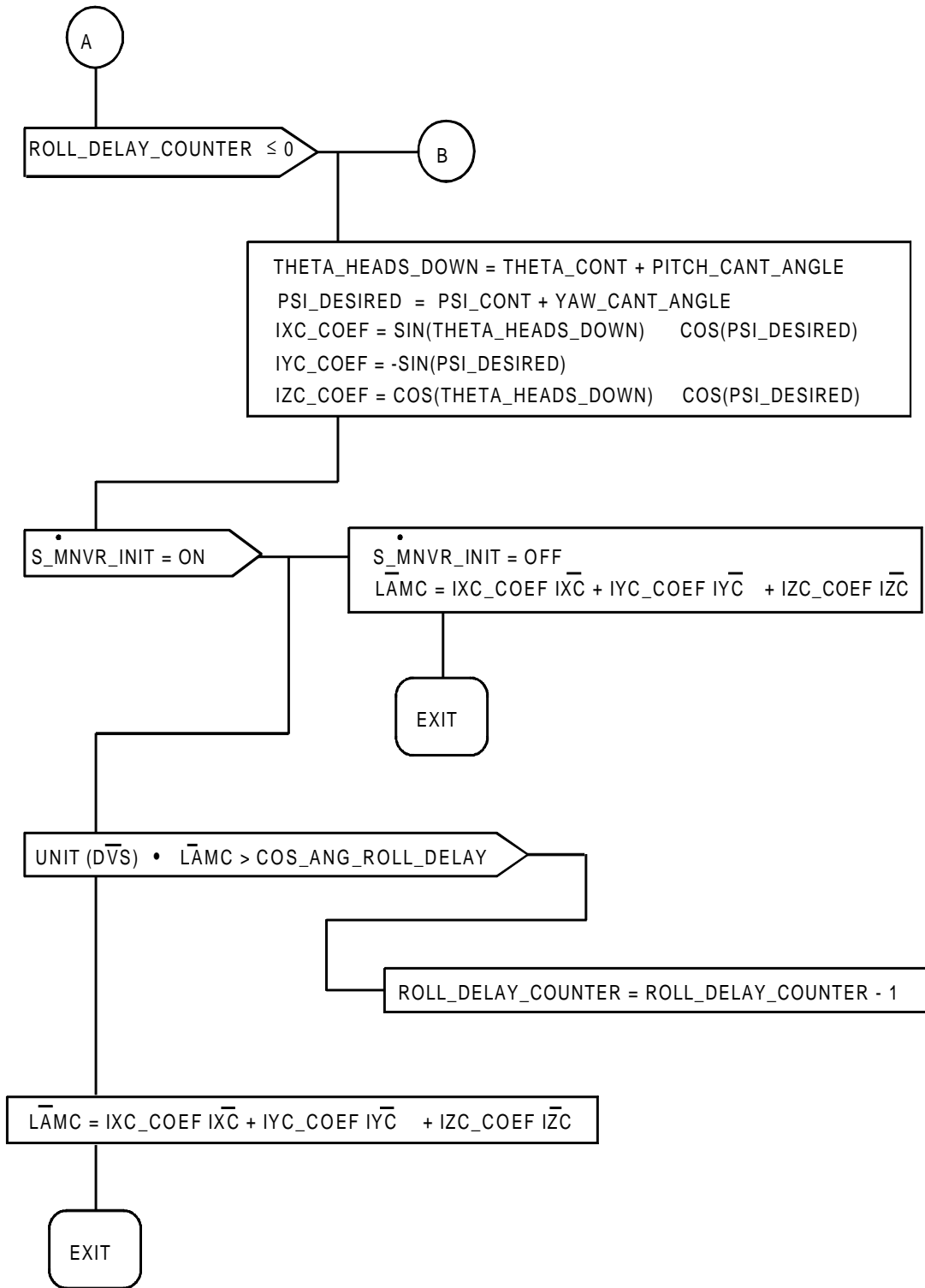


FIGURE A4.9.5.(2) CONT MODE2 TSK Flow Diagram (Sheet 2 of 4)

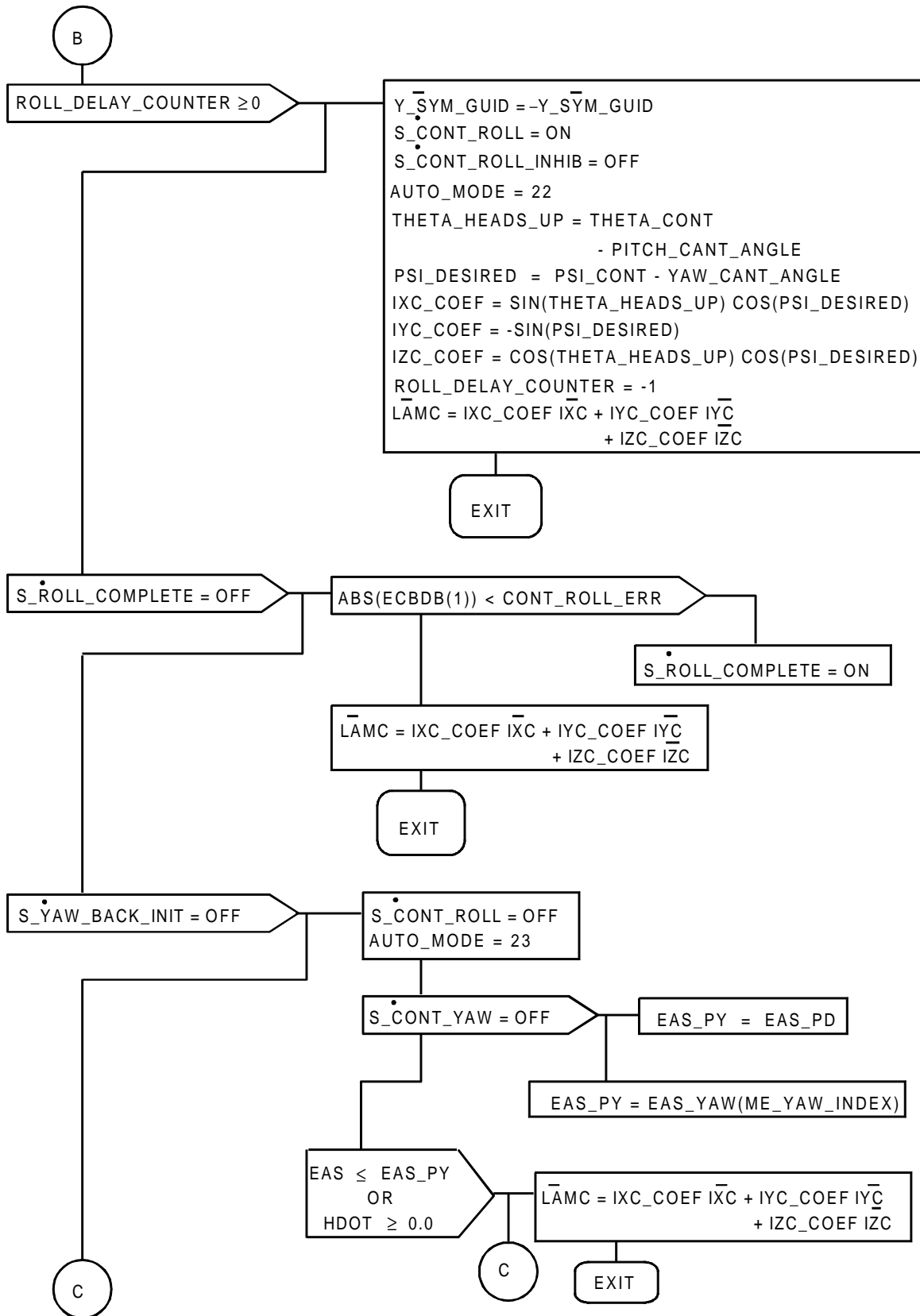


FIGURE A4.9.5.(3) CONT MODE2 TSK Flow Diagram (Sheet 3 of 4)

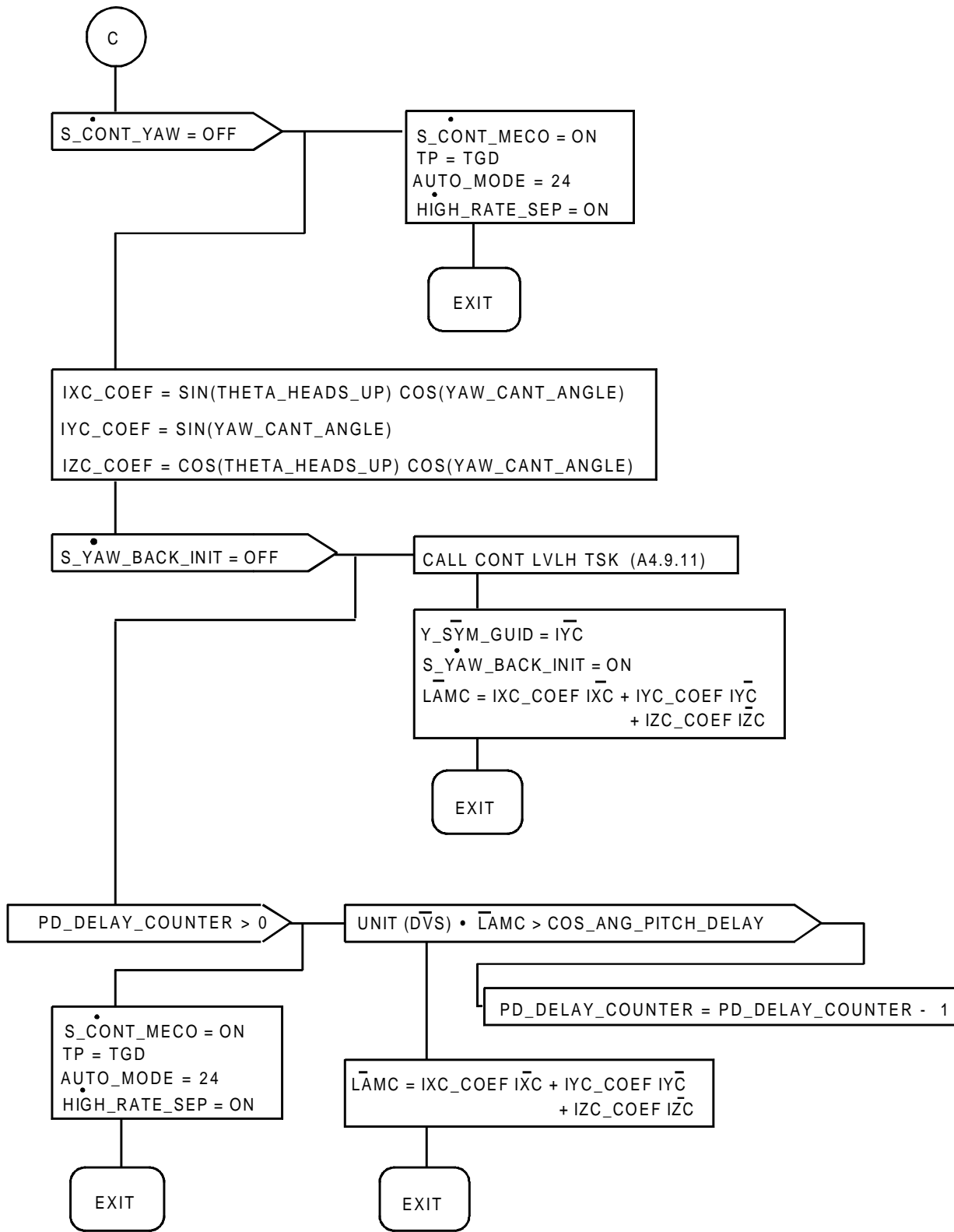


FIGURE A4.9.5.(4) CONT MODE2 TSK Flow Diagram (Sheet 4 of 4)

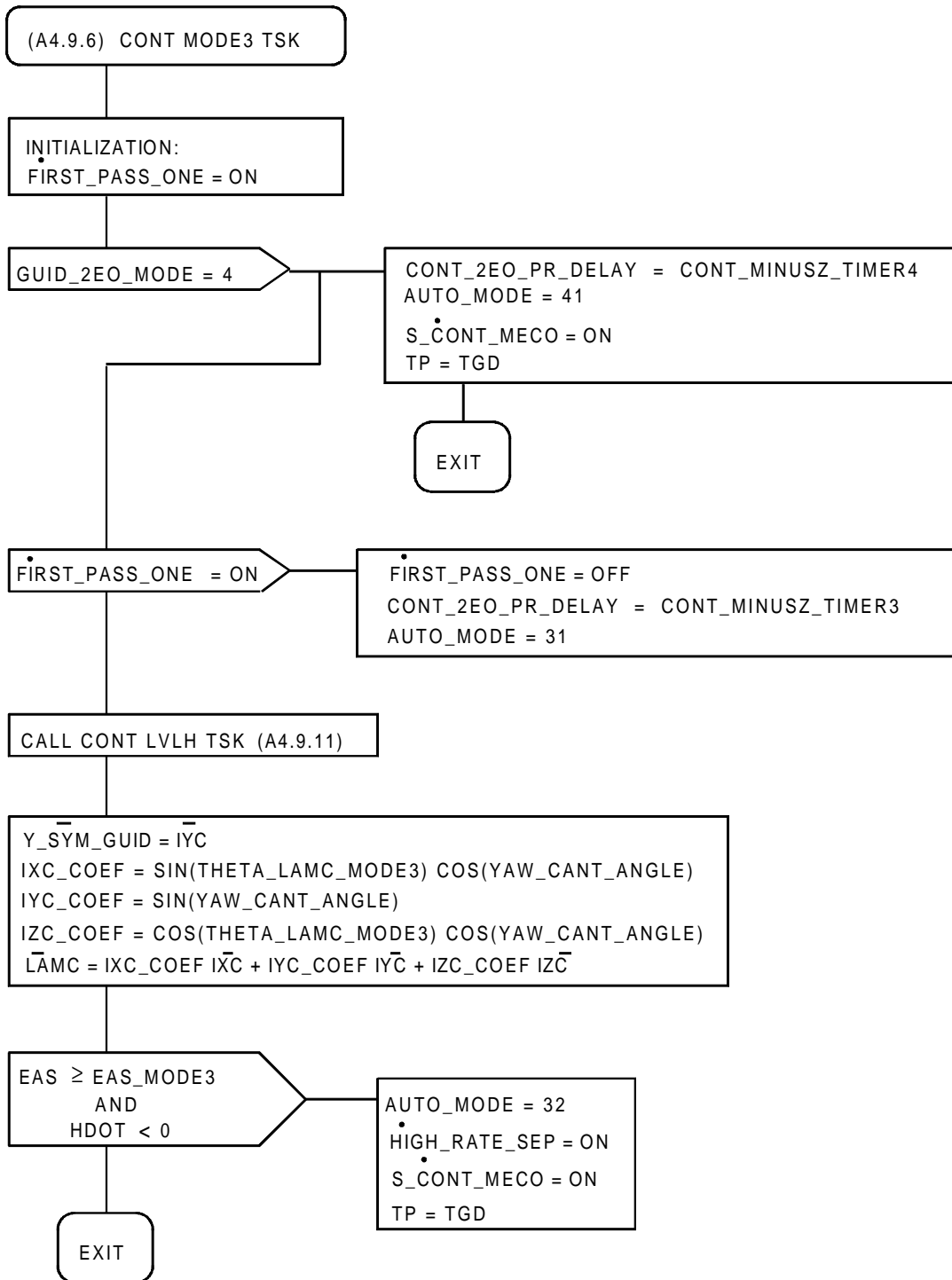


FIGURE A4.9.6. CONT MODE3 TSK Flow Diagram

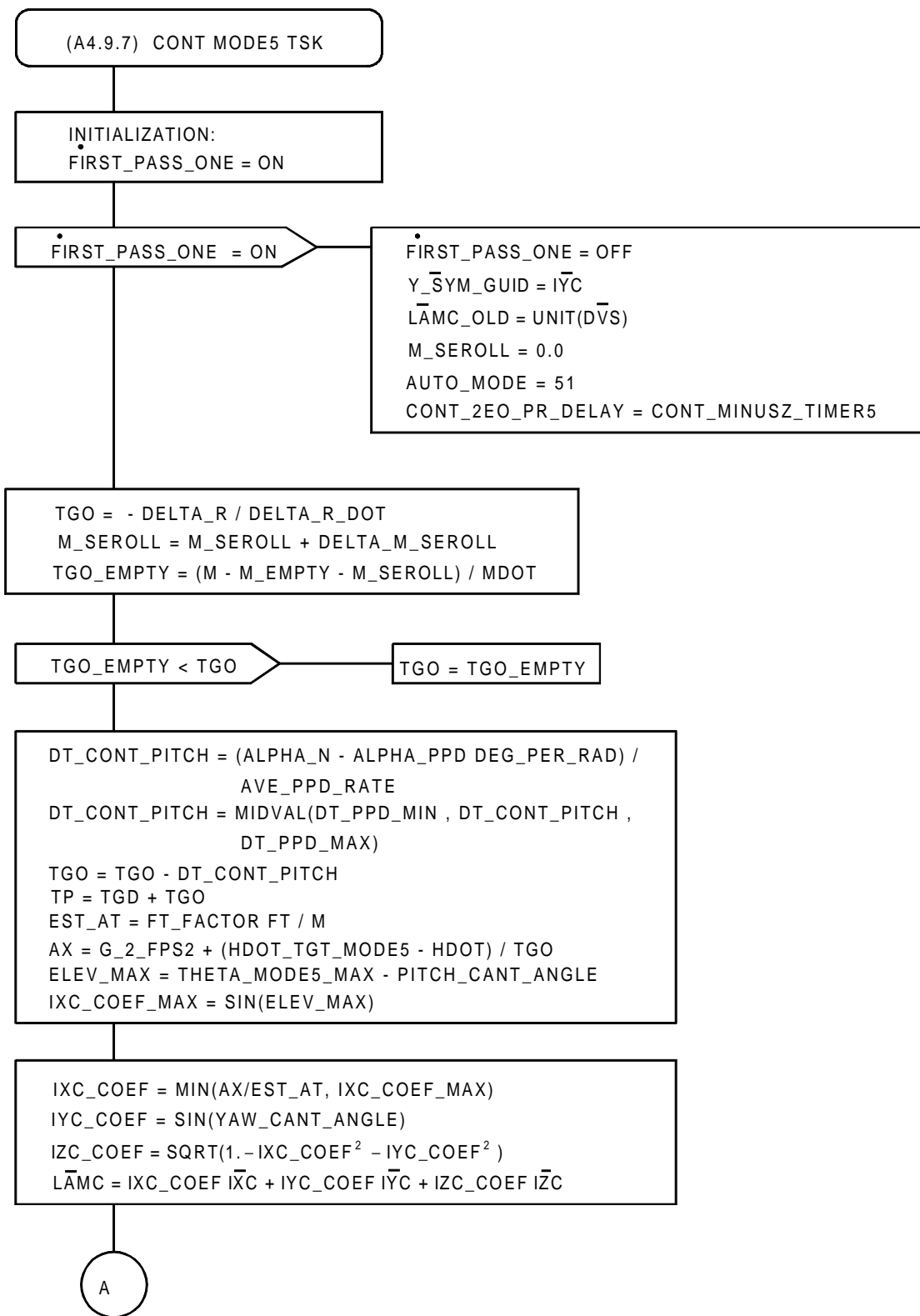


FIGURE A4.9.7.(1) CONT MODE5 TSK Flow Diagram (Sheet 1 of 2)

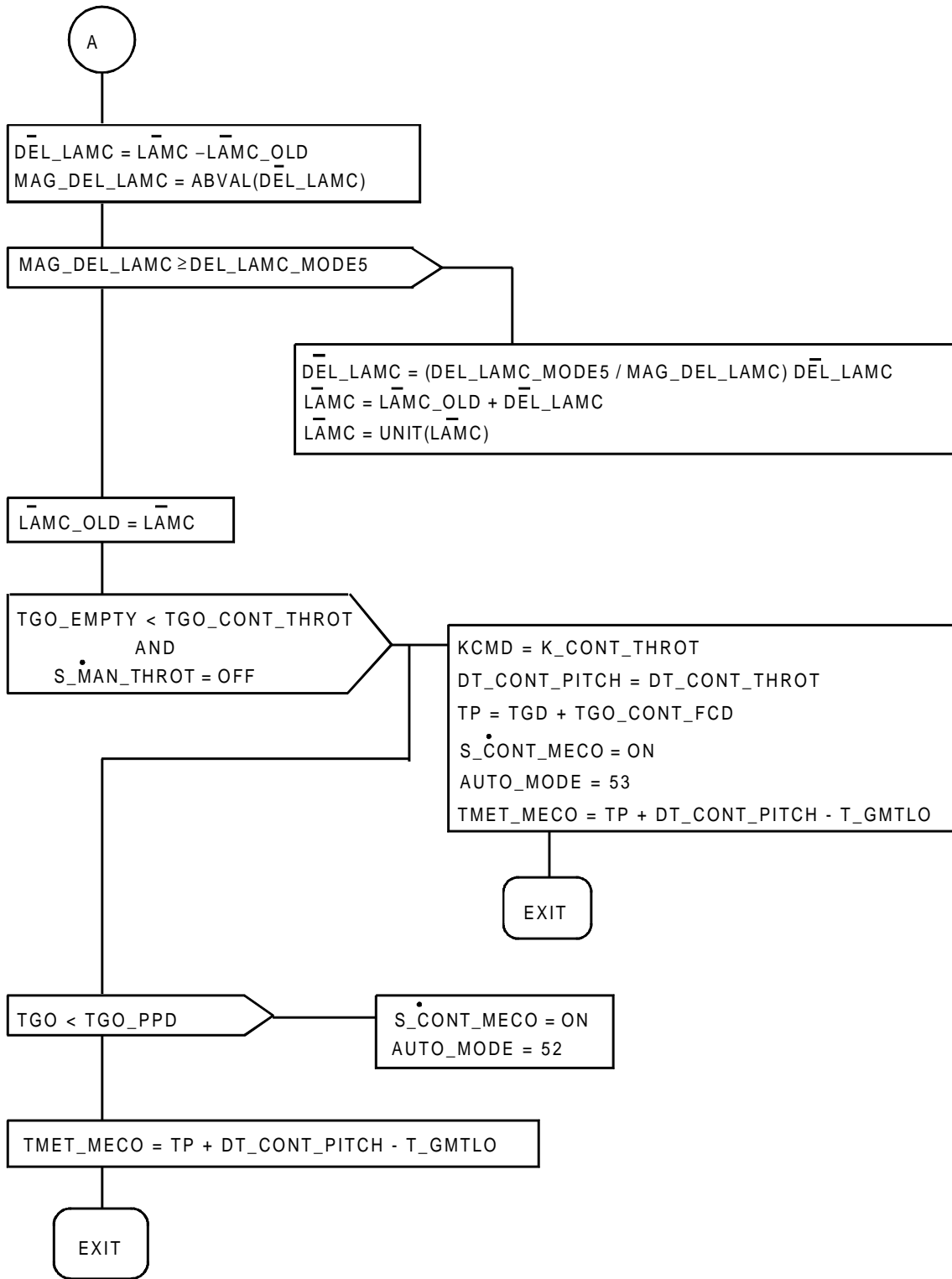


FIGURE A4.9.7.(2) CONT MODE5 TSK Flow Diagram (Sheet 2 of 2)

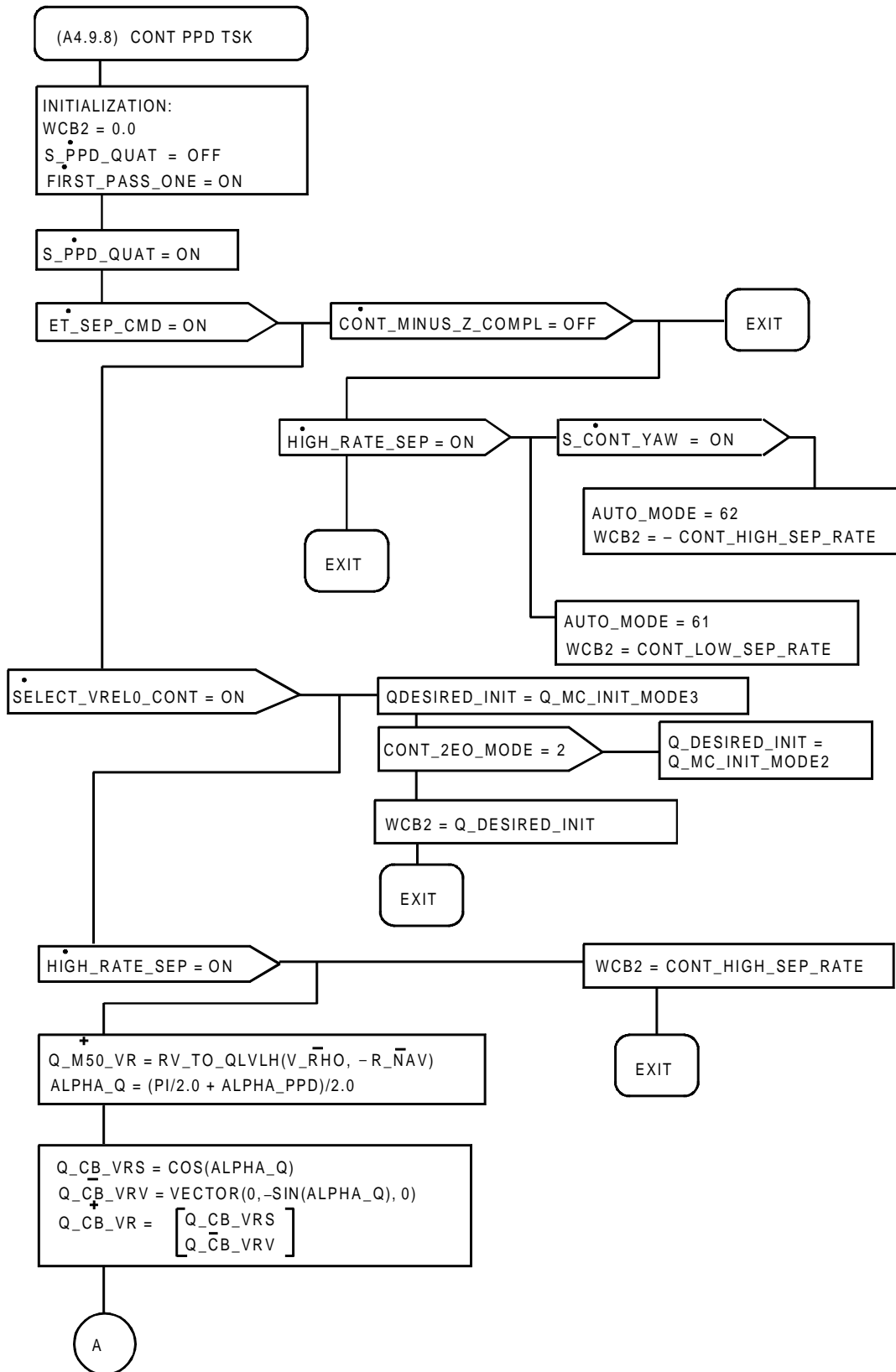


FIGURE A4.9.8.(1) CONT PPD TSK Flow Diagram (Sheet 1 of 2)

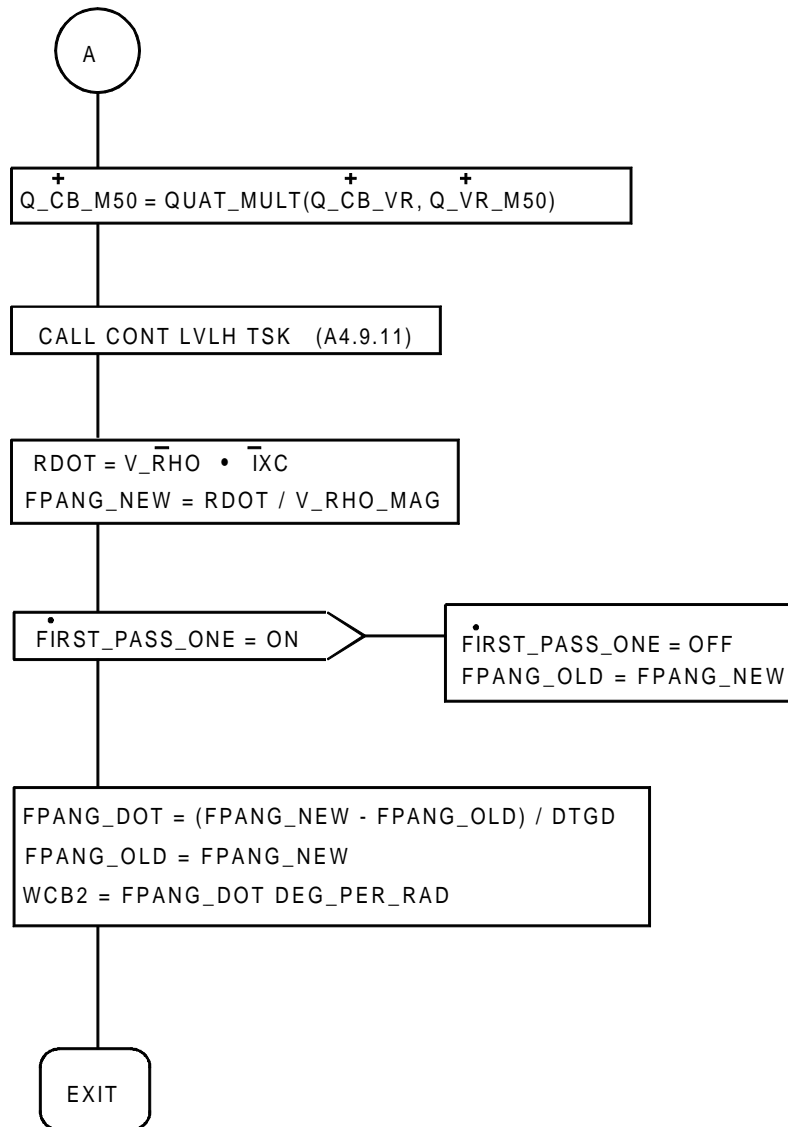


FIGURE A4.9.8.(2) CONT PPD TSK Flow Diagram (Sheet 2 of 2)

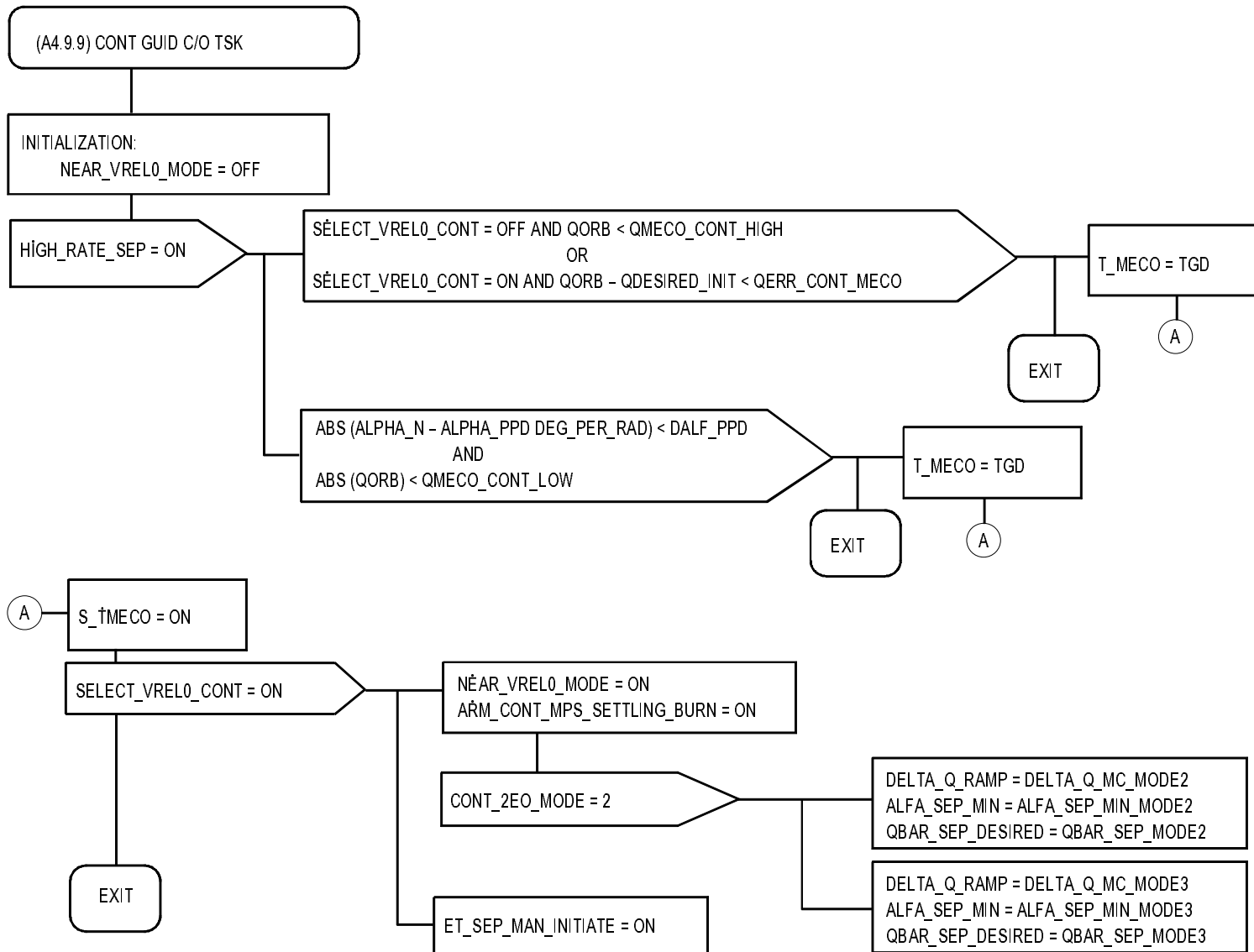


FIGURE A4.9.9. CONT GUID C/O TSK Flow Diagram

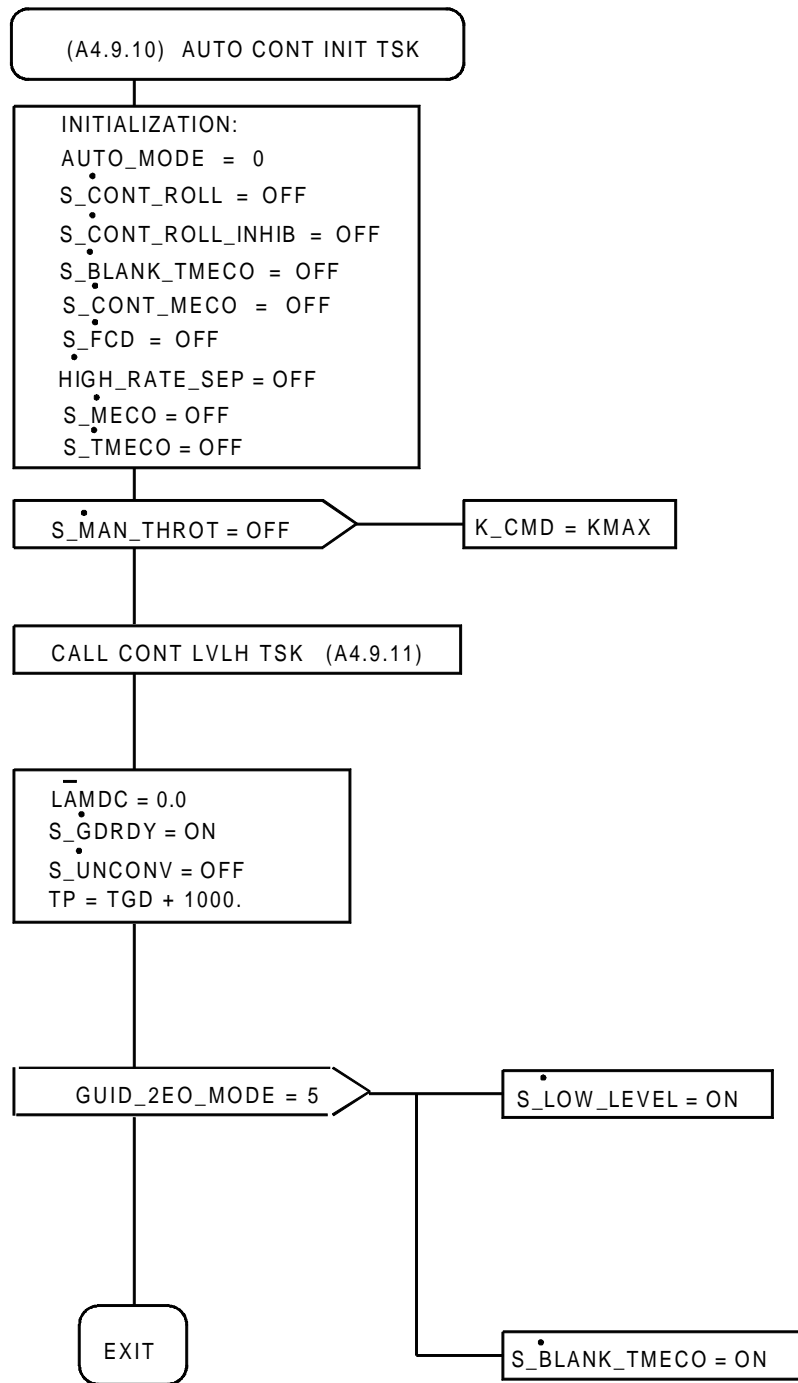


FIGURE A4.9.10. AUTO CONT INIT TSK Flow Diagram

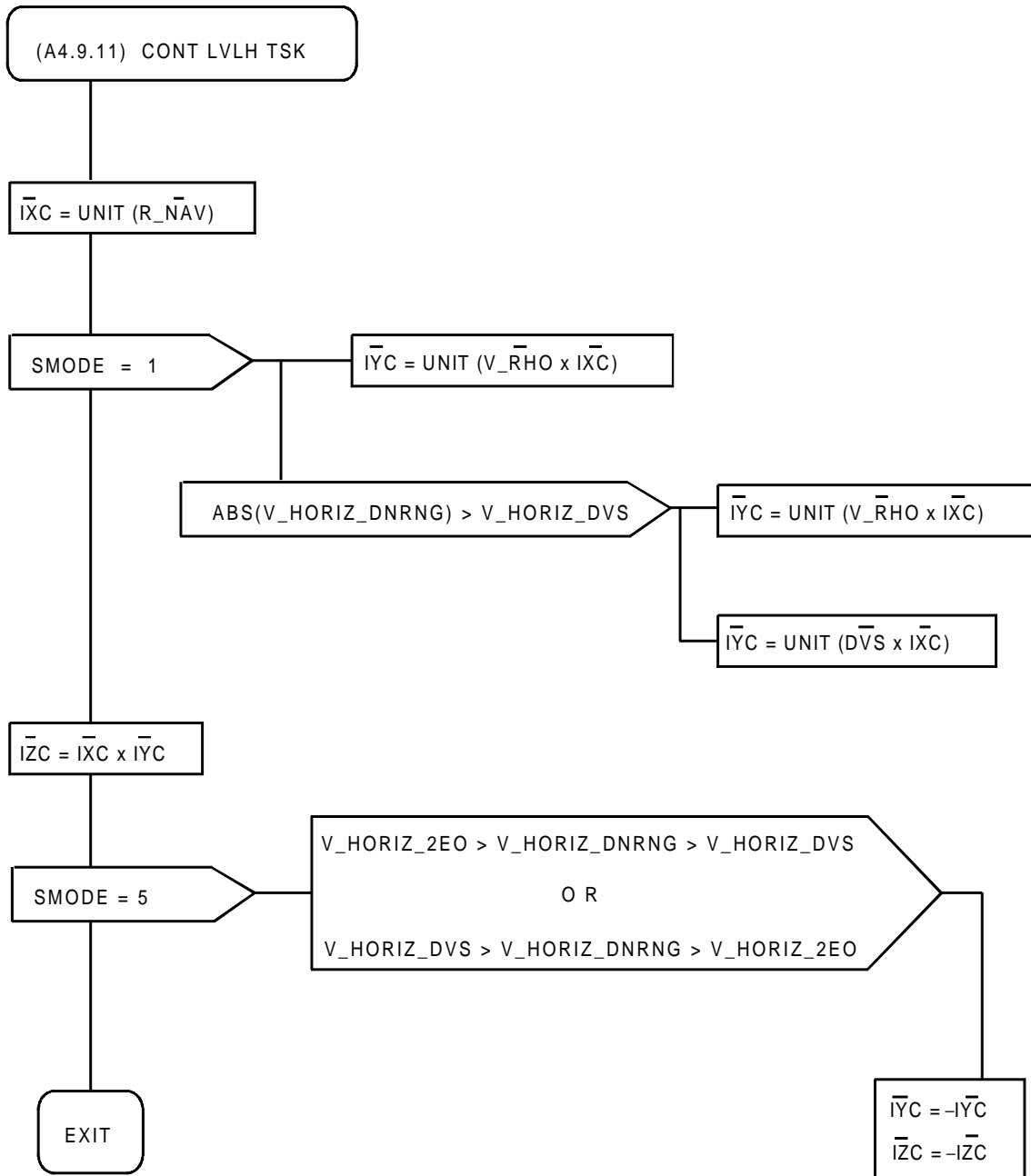


FIGURE A4.9.11. CONT LVLH TSK Flow Diagram

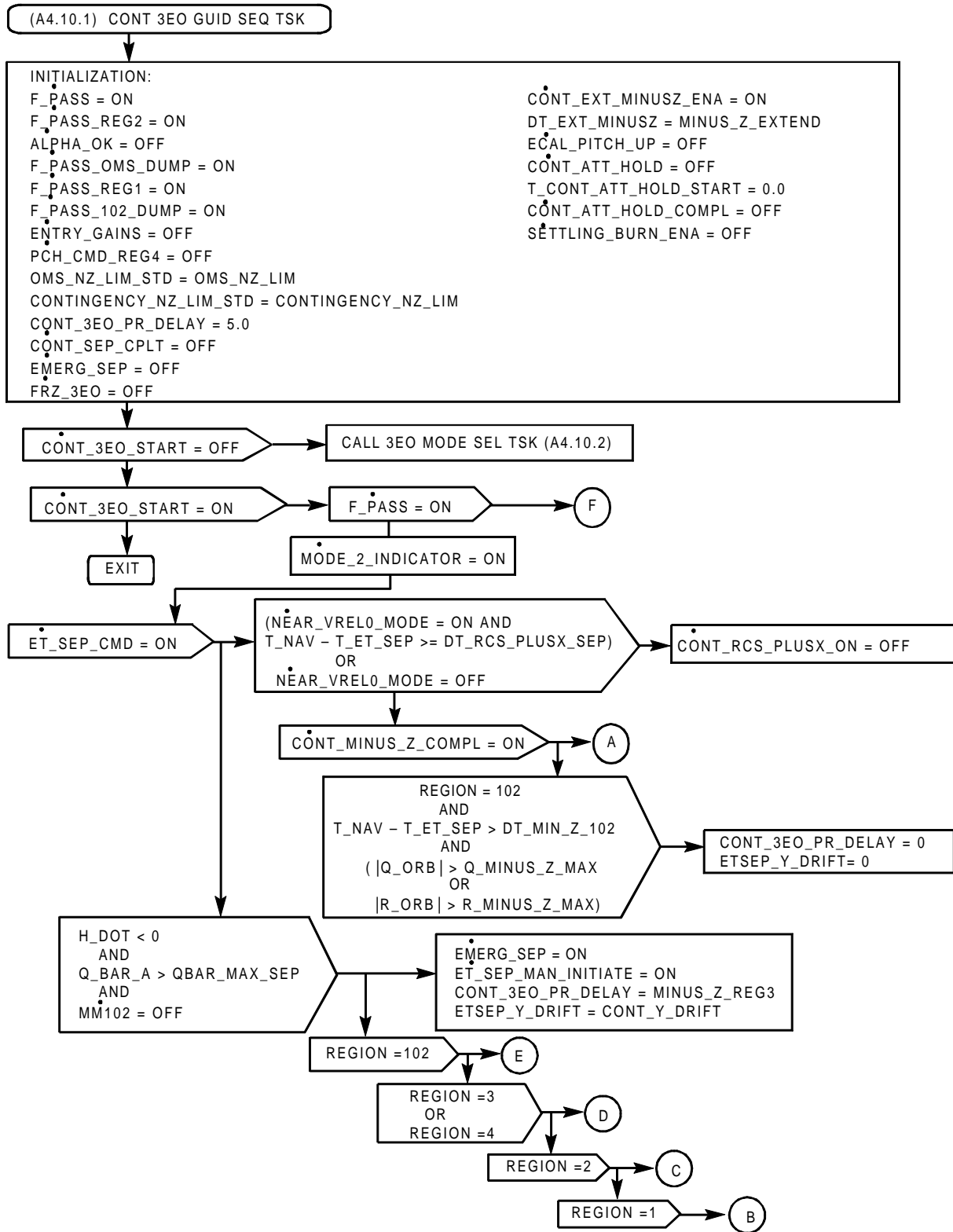


FIGURE A4.10.1(1) CONT 3EO GUID TSK Flow Diagram (Sheet 1 of 6)

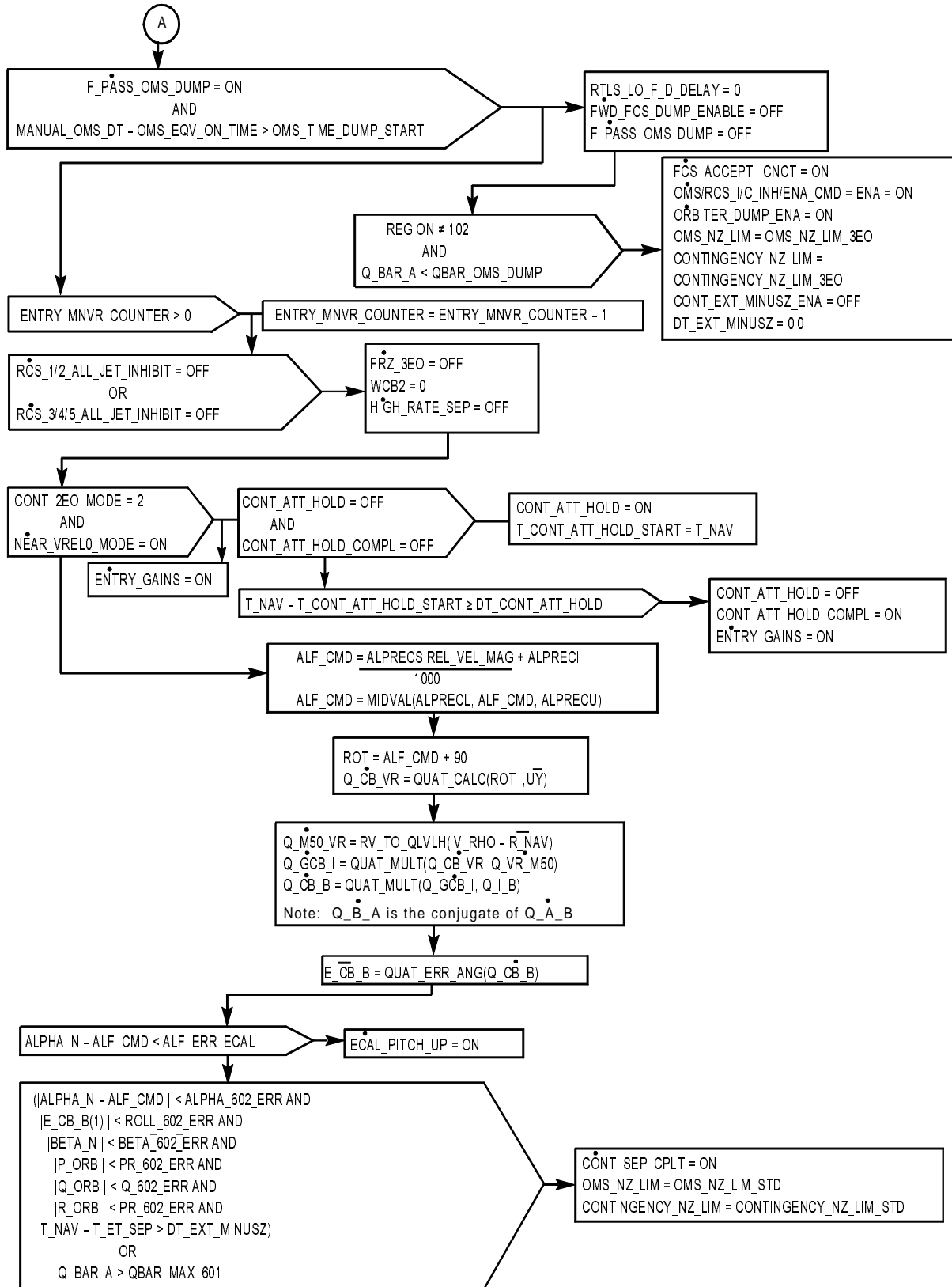


FIGURE A4.10.1.(2) CONT 3EO GUID TSK Flow Diagram (Sheet 2 of 6)

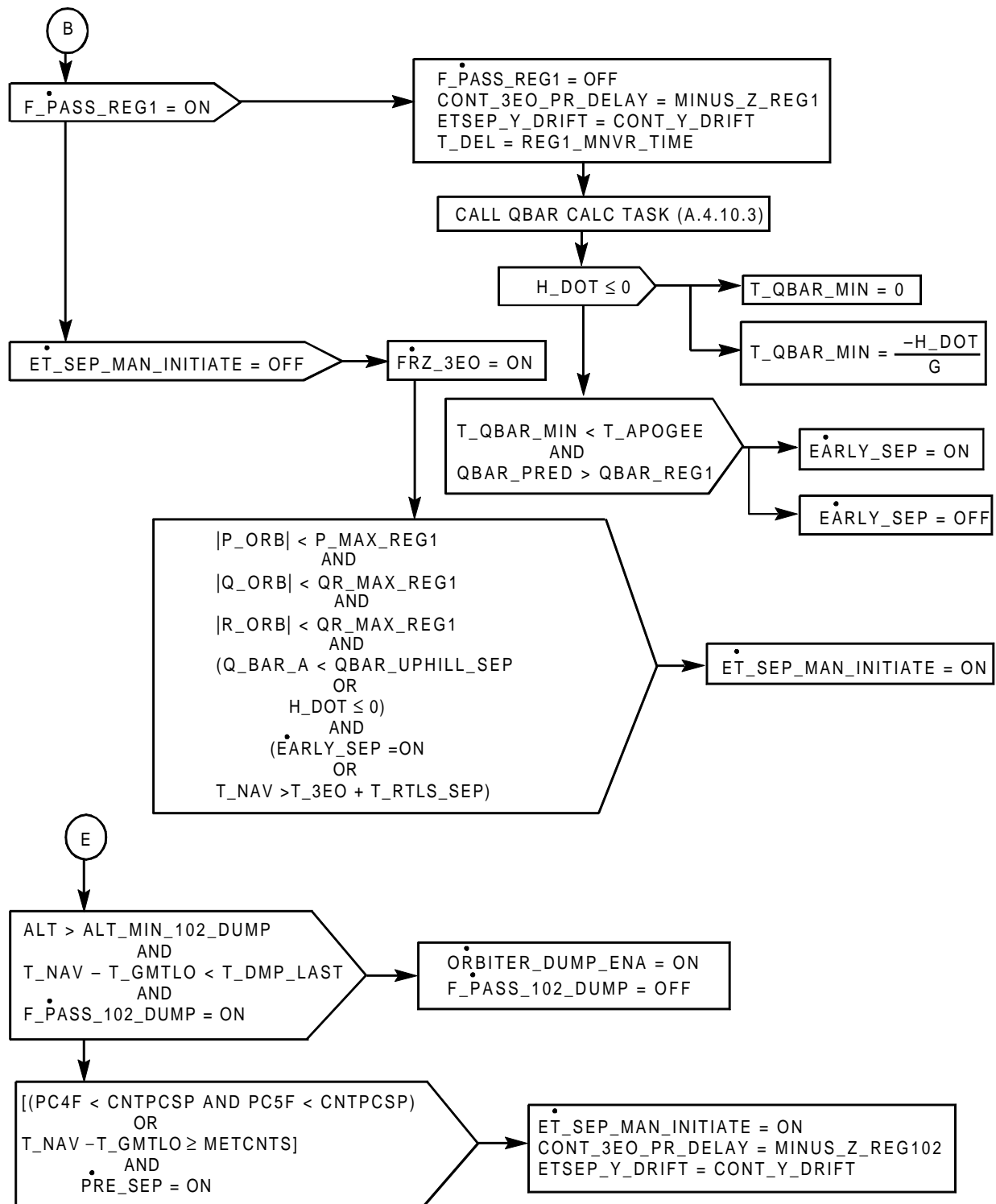


FIGURE A4.10.1.(3) CONT 3EO GUID TSK Flow Diagram (Sheet 3 of 6)

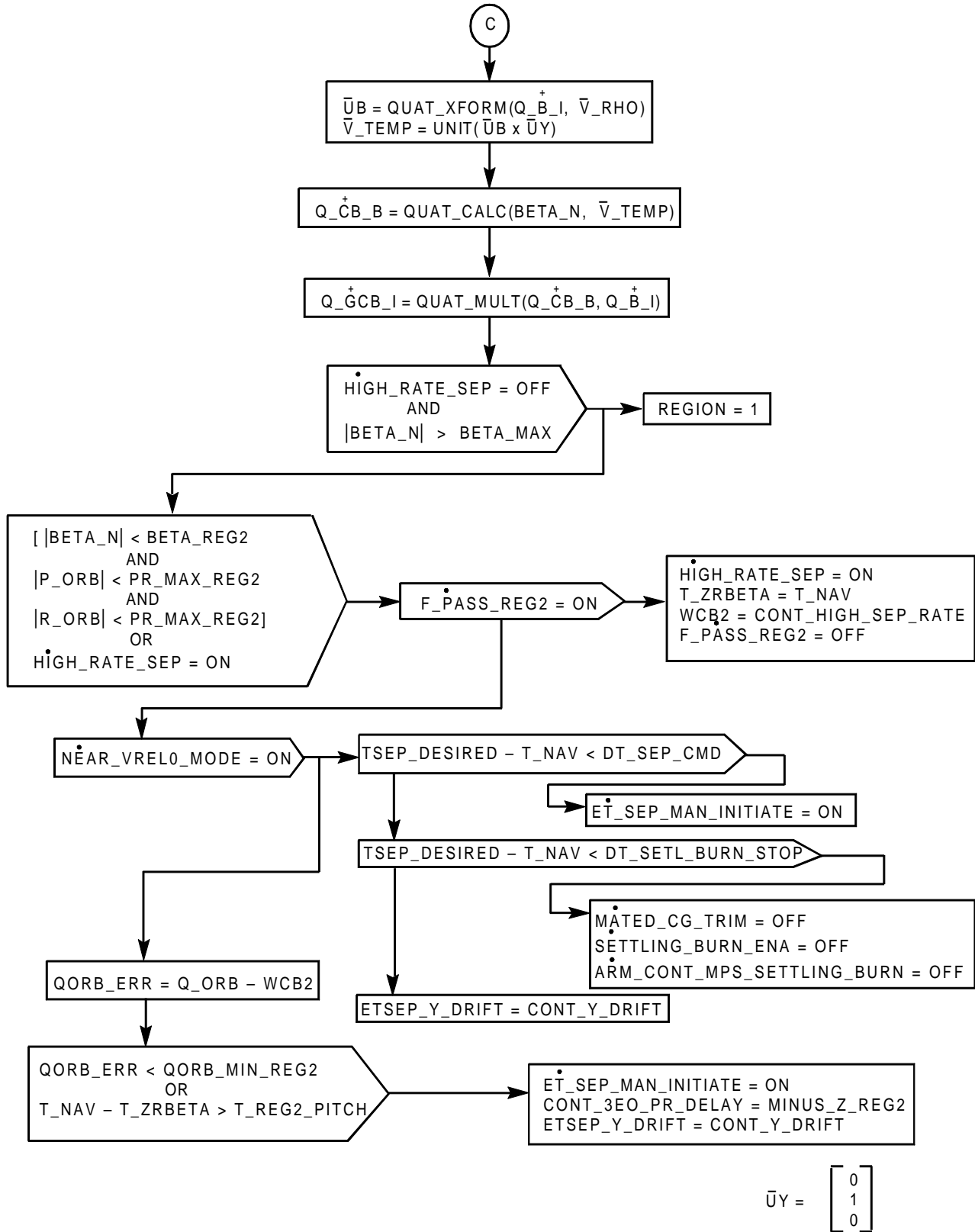


FIGURE A4.10.1.(4) CONT 3EO GUID TSK Flow Diagram (Sheet 4 of 6)

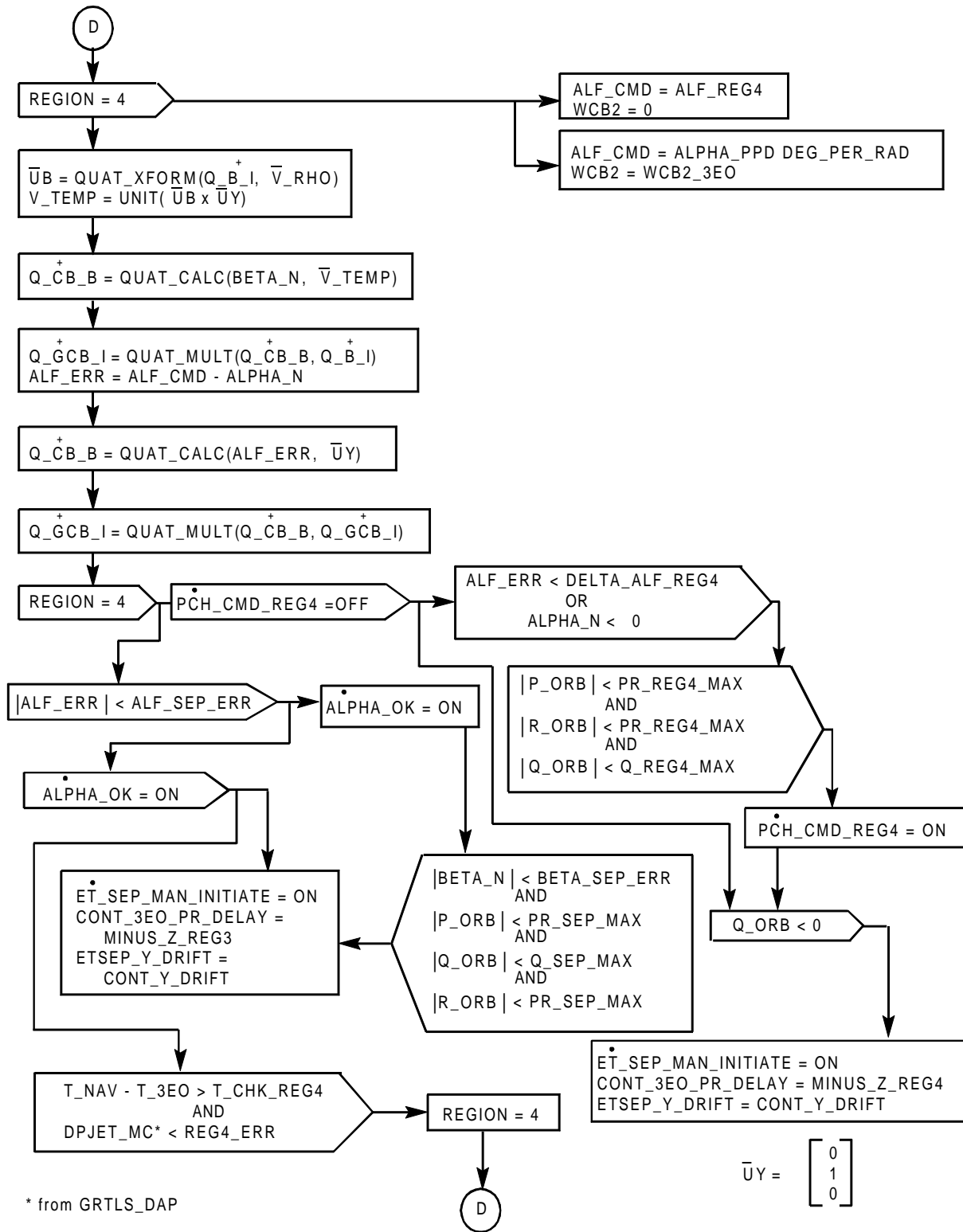


FIGURE A4.10.1.(5) CONT 3EO GUID TSK Flow Diagram (Sheet 5 of 6)

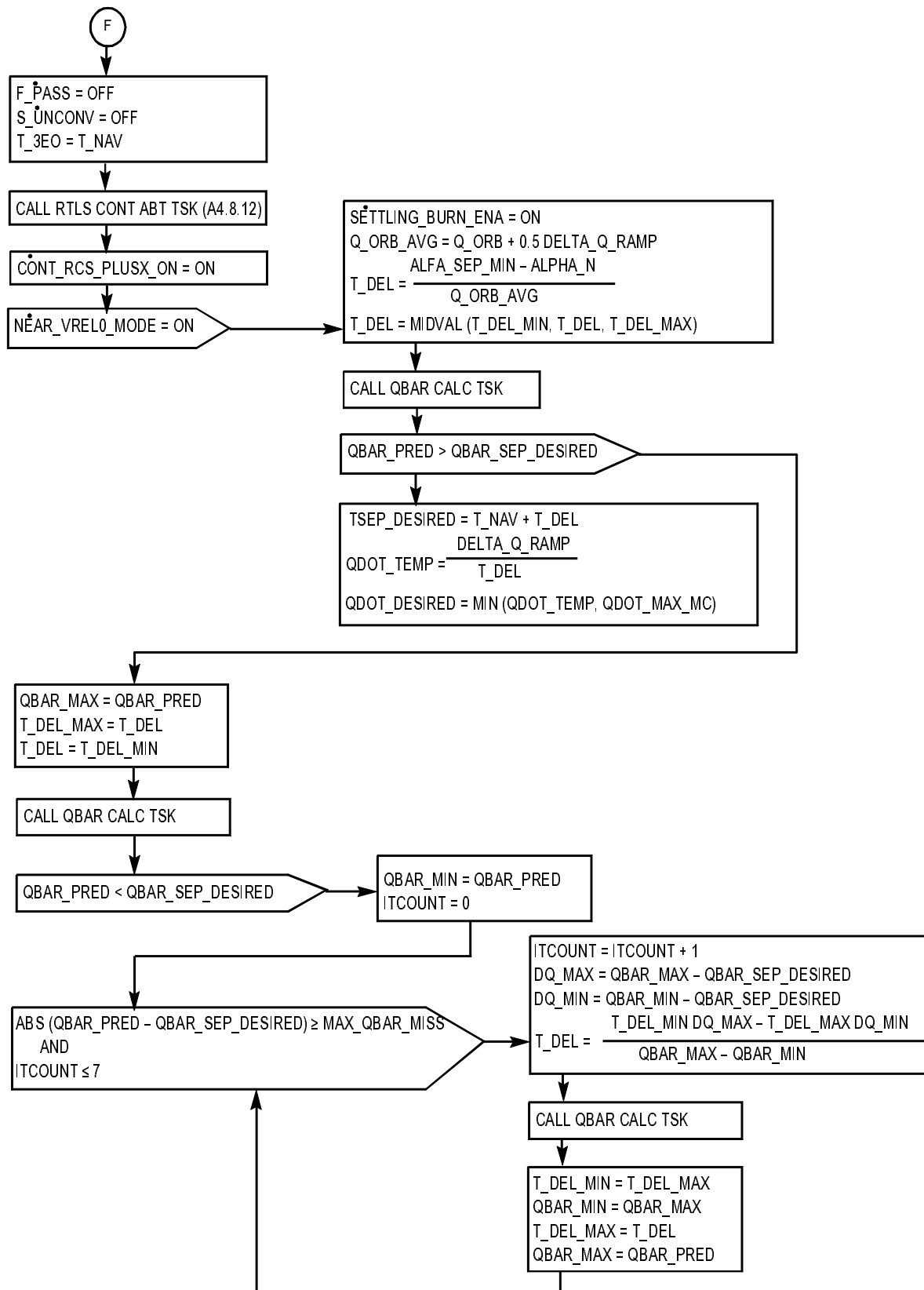


FIGURE A4.10.1.(6) CONT 3EO GUID TSK Flow Diagram (Sheet 6 of 6)

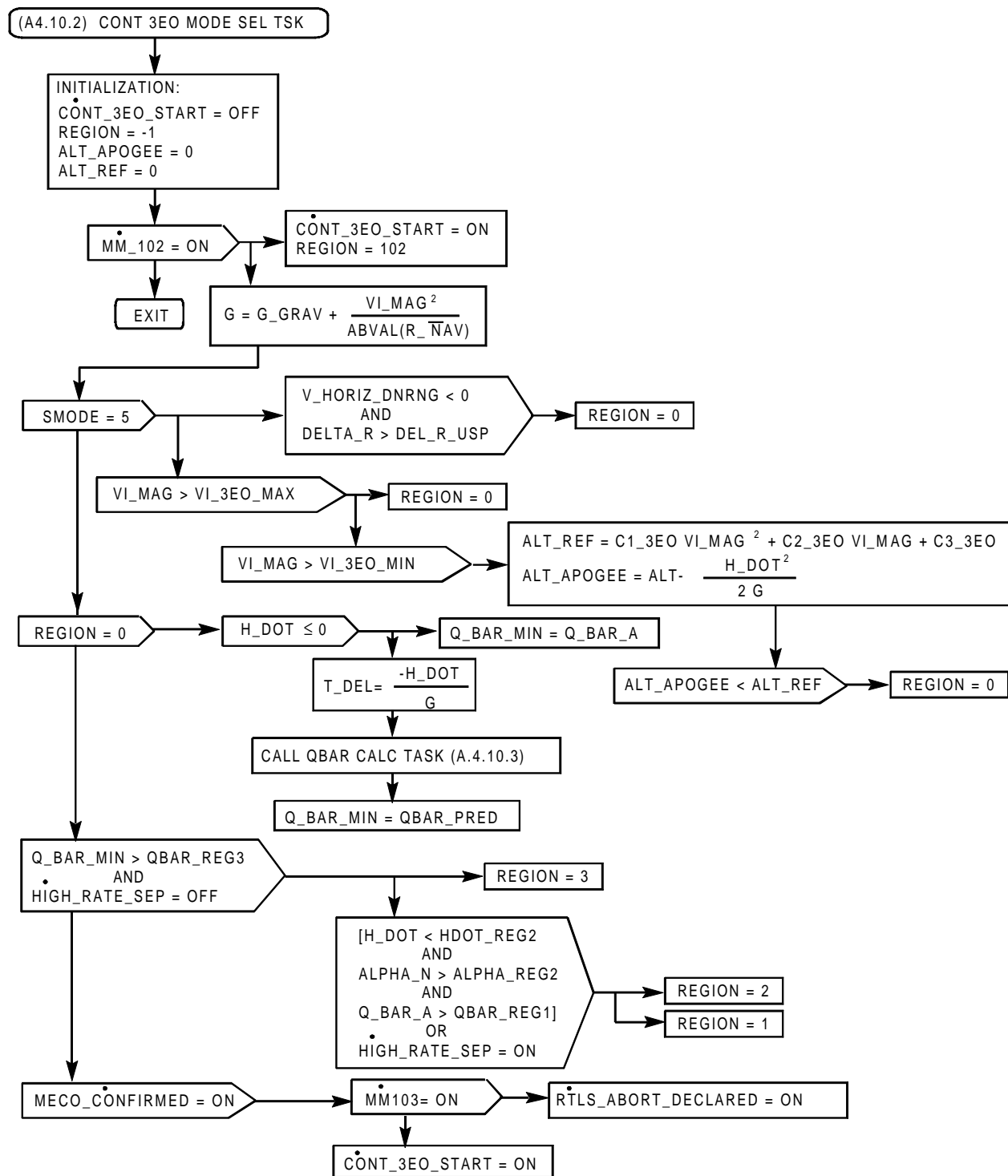


FIGURE A4.10.2.(1) CONT 3EO MODE SEL TSK Flow Diagram (Sheet 1 of 1)

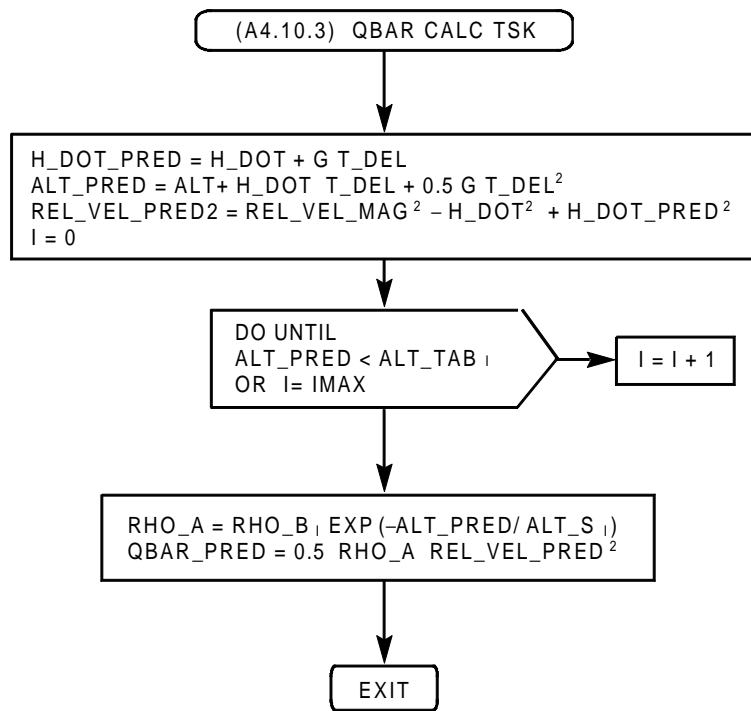


FIGURE A4.10.3.(1) QBAR CALC TSK Flow Diagram (Sheet 1 of 1)

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APPENDIX B TASK INTERNAL VARIABLES

The following table lists the task internal variables used within the various tasks of Section 4. The variable HAL name, definition, required precision, units, and FSSR reference are given.

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
DENOM	Interval between adjacent tabulated values of PPOLY	SP	fps	4.2.3
THETP	Interval between adjacent tabulated values of THET	SP	fps ⁻¹	4.2.3
PSIP	Interval between adjacent tabulated values of PSI	SP	fps ⁻¹	4.2.3
PHIP	Interval between adjacent tabulated values of PHI	SP	fps ⁻¹	4.2.3
DELT	Interval between V_RHO_MAG and greatest value of PPOLY < V_RHO_MAG	SP	fps	4.2.3
THETC	Interpolated value of THET	SP	ND	4.2.3
PSIC	Interpolated value of PSI	SP	ND	4.2.3
PHIC	Interpolated value of PHI	SP	ND	4.2.3
CTHET	Cosine of THETC	SP	ND	4.2.3
STHET	Sine of THETC	SP	ND	4.2.3
CPSI	Cosine of PSIC	SP	ND	4.2.3
SPSI	Sine of PSIC	SP	ND	4.2.3
CPHI	Cosine of PHIC	SP	ND	4.2.3
SPHI	Sine of PHIC	SP	ND	4.2.3
THETC_EO	Engine out pitch command	SP	ND	4.2.3
DPHI	Sum of roll increments for engine out roll bias	SP	ND	4.2.3
THET_LIM_EO	Engine out theta limit	SP	N/A	4.2.3
DDPSI	Late engine out delta PSI	SP	rad	4.2.3
DDPHI	Late engine out delta PHI	SP	rad	4.2.3
DPSIW	Delta PSI wind correction	SP	rad	4.2.3
DDPSI_MAX	Maximum late engine out delta PSI	SP	rad	4.2.3
DDPHI_MAX	Maximum late engine out delta PHI	SP	rad	4.2.3
N_SSME_TAL	Previous N_SSME for TAL	I	N/A	4.8.3
TAL_GLIMIT	TAL glimit	SP	g	4.8.3
RATIO_CHG	Limited yaw ratio	SP	N/S	4.2.3
NORTH	Crosswind due to north wind	SP	ft/s	4.2.3
EAST	Crosswind due to east wind	SP	ft/s	4.2.3
PSID	Interpolated yaw angle	SP	rad	4.2.3
AL_BASE	Base acceleration limit	SP	ft/s ²	4.8.3
AD_INIT_BASE	Base value of AD	SP	ft/s ²	4.8.3

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
ALIM_1_BASE	Base lower limit	SP	ft/s ²	4.8.3
ALIM_2_BASE	Base starting limit	SP	ft/s ²	4.8.3
TAL_GLIMIT_FLAG	TAL glimit flag	D	N/A	4.8.3
F_EARLY_PSI	Early delpsi flag	D	N/A	4.2.3
F_AZ_COMPUTE	Late delpsi flag	D	N/A	4.2.3
NF	Number of cycles that engine out pitch table has faded	I	counts	4.2.3
I	Linear interpolation segment index for first-stage attitude tables	I	N/A	4.2.3
L	Engine out index: L = 1, all ME's operating; ME No. 1 out, L = 2; otherwise L = 3	I	N/A	4.2.3
K_RAMP	Load relief ramping switch	I	N/A	4.2.3
DELPT_BIAS	Engine-out pitch command bias	SP	rad	4.2.3
S_THRT_INIT	Discrete to ensure a one-time computation of TDEL_ADJUST	D	N/A	4.2.3
TDEL_ADJUST_USE	Value of TDEL_ADJUST used for calculations	SP	sec	4.2.3
N_PTCHF_CYCLES	Counter used in transitioning PTCH_FAC	I	ND	4.2.3
S_AGT_EO	Discrete to ensure proper transitioning of PTCH_FAC to zero	D	N/A	4.2.3
FIRST_PASS	Flag indicating initial pass through tailoff constant rate logic	D	N/A	4.2.3
THETC_DOT	Pitch rate increment per frame	SP	ND	4.2.3
THET_TEMP	Temporary value of THETC	SP	ND	4.2.3
EV25E_TIMER	Clock from event 25E to freeze pitch attitude command	SP	sec	4.2.3
ALTG	Guidance estimated altitude	SP	ft	4.2.3
ALTP	Previous value of navigated altitude	SP	ft	4.2.3
SS	Speed of sound	SP	ft/s	4.2.3
IALT	Counter for wind table	I	counts	4.2.3
DALT	Altitude delta between wind points	SP	ft	4.2.3
DWNDE	Slope on east component of wind	SP	sec ⁻¹	4.2.3
DWNDN	Slope on north component of wind	SP	sec ⁻¹	4.2.3
DELTA	Delta altitude from initial wind point to current	SP	ft	4.2.3
EWND	East component of wind	SP	ft/s	4.2.3
NWND	North component of wind	SP	ft/s	4.2.3
J	Boost throttling segment index	I	N/A	4.2.4
AGRAV	Vertical acceleration due to gravity	SP	fps ²	4.3.4
DUMP_OFF_PCT	Percent of droop trajectory without OMS dump	SP	N/A	4.3.4

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
DUMP_ON_PCT	Percent of droop trajectory with OMS dump	SP	N/A	4.3.4
FTS_AVE	Droop trajectory averaged thrust	SP	lbf	4.3.4
FTSSO	Current thrust less the OMS component	SP	lbf	4.3.4
GACC	Velocity corrected effective gravitational acceleration	SP	fps ²	4.3.4
GE	Gravitational acceleration magnitude	SP	fps ²	4.3.4
S_ĎRP_LATCH	S_ĎDROOP latched on discrete	D	N/A	4.3.4
Ī _X _DRP	Vertical unit vector	SP	ND	4.3.4
Ī _Y _DRP	Unit vector normal to thrusting plane	SP	ND	4.3.4
Ī _Z _DRP	Downrange direction unit vector	SP	ND	4.3.4
K_CMD_PREV	Previous value of K_CMD	SP	pct	4.3.4
MDT	Total mass flowrate input to Droop Predictor	SP	slug/ sec	4.3.4
OMS_FT	Thrust due to OMS dump	SP	lbf	4.3.4
PEG_ATT	PEG thrust attitude from local horizontal	SP	rad	4.3.4
PĒG_CMD	PEG commanded thrust direction vector	SP	ND	4.3.4
RATE	Rate of change of unfiltered thrust	SP	lbf/sec	4.3.4
RGRAV	Vertical position gained due to gravity	SP	ft	4.3.4
RINIT	Position vector magnitude	DP	ft	4.3.4
S_ĎATT_CMD	Droop altitude below minimum indicator	SP	N/A	4.3.4
S_ĎRP_EARLY	Early droop take-over indicator	D	N/A	4.3.4
S_ĎFOUND	Predicted droop solution found indicator	D	N/A	4.3.4
S_ĎMIN_ALT	Minimum altitude reached / Droop OFF indicator	D	N/A	4.3.4
S_ĎMIN_RANGE	Performance within droop range indicator	D	N/A	4.3.4
S_ĎMODE_2	Latched contingency mode 2 indicator	D	N/A	4.3.4
S_ĎPEG_OK	PEG solution OK indicator	D	N/A	4.3.4
T1NEW	Actual mode time to droop	SP	sec	4.3.4
T2NEW	Hypothetical mode time to droop	SP	sec	4.3.4
TMMAX	Maximum possible time to droop	SP	sec	4.3.4
TMMIN	Minimum possible time to droop	SP	sec	4.3.4
TNEW	Temporary time to go to droop	SP	sec	4.3.4
TNEXT	Iterative time to droop	SP	sec	4.3.4
TV_HORIZ	Horizontal component of TV_MAX	SP	lbf	4.3.4
TV_MAX	Total thrust input to Droop Predictor	SP	lbf	4.3.4
TV_VERT	Vertical component of TV_MAX	SP	lbf	4.3.4
TVAL	Temporary constant	SP	ND	4.3.4
TVALLN	Log of TVAL	SP	ND	4.3.4

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
VDOT	Rate of change of VOUT	SP	fps ²	4.3.4
VEX_AVE	Droop trajectory averaged exhaust velocity	SP	fps	4.3.4
VEXSO	Overall exhaust velocity without OMS dump	SP	fps	4.3.4
VGDIX	Local vertical component of velocity	SP	fps	4.3.4
VGDIY	Out of plane component of velocity	SP	fps	4.3.4
VGDIZ	Local downrange component of velocity	SP	fps	4.3.4
VGRAV	Vertical velocity gained due to gravity	SP	fps	4.3.4
VOUT	Vertical velocity at minimum droop	SP	fps	4.3.4
XK1	Time independent predictor equation coefficient 1	SP	fps ²	4.3.4
XK2	Time independent predictor equation coefficient 2	SP	fps	4.3.4
XK3	Time independent predictor equation coefficient 3	SP	fps	4.3.4
XK4	Time independent predictor equation coefficient 4	SP	fps	4.3.4
XK5	Droop predictor equation coefficient 5	SP	sec	4.3.4
MAXV	Sine of maximum thrust attitude for droop	SP	ND	4.3.4
MINH	Cosine of maximum thrust attitude for droop	SP	ND	4.3.4
DM_PREMECO	OMS and RCS propellant mass burned pre-MECO	SP	slugs	4.5.4
DV_OMS	Delta V obtainable from OMS propellant remaining	SP	fps	4.5.4
DV_EXCESS	OMS excess delta V capability	SP	fps	4.5.4
MASS_OMS_PREOMS1	OMS propellant available before OMS-1 burn	SP	slugs	4.5.4
MASS_OMS_PREOMS2	OMS propellant available before OMS-2 burn	SP	slugs	4.5.4
DH_OMS1	OMS propellant burned during OMS-1	SP	slugs	4.5.4
KDELTA	Cosine of angle defining flyback thrust constraint	SP	ND	4.6.3
KDPY	Flyback attitude test indicator	I	ND	4.6.3
MF	Predicted vehicle mass at MECO during RTLS fuel dissipation	SP	slugs	4.6.3
U \bar{F} Z	Unit normal to fuel dissipation thrust direction	SP	ND	4.6.3
THETA	RTLS turnaround turn angle	SP	rad	4.6.3
U \bar{F} _PEG	Unit desired initial flyback direction	SP	ND	4.6.3
AT_EST	Estimated thrust acceleration during RTLS	SP	fps ²	4.6.3, 4.6.4
D \dot{E} LAY_COMPLETE	PPD delay complete flag	D	N/A	4.6.5
DELAY_LIMIT	PPD delay time limit	SP	sec	4.6.5
DELAY_TIME	PPD delay time	SP	sec	4.6.5
DELAY_TOTAL	Current total delay time	SP	sec	4.6.5
DT_ME_FAIL	Time between engine failure and powered pitchdown	SP	sec	4.6.5
DT_PPD	Time since initiation of powered pitchdown	SP	sec	4.6.5

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
Q_M50_VR	VR to M50 quaternion	SP	ND	4.6.5, 4.9.8, 4.10.1
ALPHA_Q	Desired half angle of attack during RTLS powered pitchdown	SP	rad	4.6.5, 4.9.8
Q_CB_VR	VR to commanded body quaternion	SP	ND	4.6.5, 4.9.8, 4.10.1
AZ	RTLS azimuth	SP	rad	4.6.6
THETA_C	Thrust vector commanded pitch angle during initial RTLS phase	SP	rad	4.6.6
V_RHO_BR	Vehicle's earth relative velocity in boost reference coordinates	SP	fps	4.6.6, 4.2.3
SRCS	Assumed number of active RCS jets	I	N/A	4.7.7
T_CUR	Current elapsed time in seconds	DP	sec	4.7.8
T_C_DAY	Current time within the current day	SP	sec	4.7.8
T_DAYS	Elapsed time to start of the current day	SP	sec	4.7.8
RJ2, VJ2	Contribution of J ₂ gravity term to burnout state	SP	ft, fps	4.7.8
RMAG	Magnitude of position vector	SP	ft	4.7.9, 4.8.1
R_UNIT	Unit \bar{R}	SP	ND	4.7.9
RDOT	Altitude rate	SP	fps	4.7.9, 4.9.8
AM	Orbit semimajor axis	SP	ft	4.7.9
P	Orbit semilatus rectum	SP	ft	4.7.9
K	Orbit parameter related to J ₂	SP	ft	4.7.9
MM	Sine of geocentric latitude	SP	ND	4.7.9
NN	Polar component of unit horizontal velocity	SP	ND	4.7.9
S_INC	Sine squared of orbit inclination	SP	ND	4.7.9
NU	Inverse of mean orbital rate	SP	sec	4.7.9
M	e sin E	SP	ND	4.7.9
N	e cos E	SP	ND	4.7.9
E	Eccentricity	SP	ND	4.7.9
DELTA	J ₂ correction term	SP	ft	4.7.9
SW	Sign of RDOT		ND	4.7.9
KK	Time to apsis correction factor	SP	ft	4.7.9
DELTB	Sine of 2 x argument of perigee	SP	ft	4.7.9
OMS_YAW_BODYI (I=1,2)	OMS engine yaw angles	SP	rad	4.7.10

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
THRUST $\bar{}$ _BODY_OMSI (I=1,2)	OMS unit thrust vector	SP	ND	4.7.10
OMS_PITCH_BODYI (I=1,2)	OMS engine pitch angles	SP	rad	4.7.10
C_YAW	Cos (OMS_YAW_BODY $\bar{}$ _I)	SP	ND	4.7.10
THRUST_BODY	Resultant unit thrust vector of both OMS engines	SP	ND	4.7.10
U $\bar{}$ F	Unit thrust vector at TIG	SP	ND	4.7.10
R $\bar{}$ OLL_REF	Unit angular momentum vector at TIG	SP	ND	4.7.10
CBETA	R $\bar{}$ OLL_REF . U $\bar{}$ F	SP	ND	4.7.10
Y $\bar{}$ N, Y $\bar{}$ T	Unit vectors used in computing preburn attitude matrix	SP	ND	4.7.10
TFAIL	Earliest engine-out time of GMT for an AOA	DP	sec	4.8.1
TB $\bar{}$ _I (I=1,3)*	Burn time of Ith thrust phase	DP	sec	4.8.1
TGOA $\bar{}$ _I (I=1,3)	Time to end of Ith thrust phase	DP	sec	4.8.1
TAU $\bar{}$ _I (I=1,3)	Hypothetical time until total vehicle mass is consumed, Ith thrust phase	DP	sec	4.8.1
VEXA $\bar{}$ _I (I=1,3)	Average exhaust velocity, Ith thrust phase	SP	fps	4.8.1
LA $\bar{}$ _I (I=1,3), SA $\bar{}$ _I (I=1,3), QA $\bar{}$ _I (I=1,3)	Thrust integrals for Ith thrust phase	DP	fps to ft-sec ²	4.8.1
TPRIME	Previous value at TGD	DP	sec	4.8.1
LREM	Remaining velocity to be gained	DP	fps	4.8.1
TGOP	Previous value of TGO	SP	sec	4.8.1
TGOB	Time to start of Ith thrust phase	SP	sec	4.8.1
L, J, S, Q	Total thrust integrals	DP	fps to ft-sec ²	4.8.1
JOL	Time interval to TLAM	DP	sec	4.8.1
QPRIME	Q-S JOL	DP	ft-sec	4.8.1
R $\bar{}$ GRAV	Position contribution of gravity	SP	ft	4.8.1
R $\bar{}$ GO	Desired position change due to thrust	DP	ft	4.8.1
R $\bar{}$ GOPRIME	Predicted value of R $\bar{}$ GO	SP	ft	4.8.1
RGOX, RGOY, RGOZ	X, Y and Z components of R $\bar{}$ GO in PEG coordinates	DP	ft	4.8.1
R $\bar{}$ GOXY	X-Y plane projection of R $\bar{}$ GO	DP	ft	4.8.1
LAMDY	Y component of L $\bar{}$ AMD	SP	rad/sec	4.8.1

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
TPREV	Previous value of TP	DP	sec	4.8.1
\bar{V}_{GRAV}	Velocity contribution of gravity	SP	fps	4.8.1
\bar{V}_{THRUST}	Velocity change due to thrust	SP	fps	4.8.1
TB_EST	Initial estimate of burn time	SP	sec	4.8.1
\bar{R}_P	Predicted cutoff position vector	DP	ft	4.8.1
\bar{V}_P	Predicted cutoff velocity vector	SP	fps	4.8.1
B	Circular orbit rate squared	SP	sec ⁻²	4.8.1
\bar{W}_E	Earth rotation vector	SP	rad/sec	4.8.1
DTCOAST	Estimated coast time to target	SP	sec	4.8.1
RHOMAG	\bar{V}_{GO} correction factor for Mode 4	SP	ND	4.8.1
RTHETA	Range to target in RTLS	SP	ft	4.8.1, 4.8.5
VDMAG	Desired cutoff velocity magnitude	SP	fps	4.8.1
VRATIO	$LA_1/(6VEXA_1)$	SP	ND	4.8.1
ATRF	Predicted final thrust acceleration	SP	fps	4.8.1
$\bar{\Omega}$	Thrust turning rate vector	SP	sec ⁻¹	4.8.1
THETA_DOT	Orbital rate	SP	sec ⁻¹	4.8.1
\bar{V}_{MISS_G}	\bar{V}_{MISS} in PEG coordinates	SP	fps	4.8.1
M_{I2G}	M50 to PEG coordinates matrix	SP	ND	4.8.1
\dot{S}_{PLANE}	Orbital plane constrained discrete	D	N/A	4.8.1
\dot{S}_{ALT}	Cutoff altitude constrained discrete	D	N/A	4.8.1
\bar{V}_{MISS}	Cutoff velocity error	SP	fps	4.8.1
\bar{D}_{VGO}	\bar{V}_{GO} correction	SP	fps	4.8.1
WMAG	Desired turning rate of thrust	SP	sec ⁻¹	4.8.1
DELK	Desired change in throttle command	SP	pct	4.8.1
KP	Desired throttle setting	SP	pct	4.8.1
EMISS	Maximum value of \bar{V}_{MISS} magnitude for PEG convergence	SP	fps	4.8.1
VGOD	Desired velocity-to-be-gained for RTLS	SP	fps	4.8.1
LAMDMAX	Maximum allowable value of LAMDMAG	SP	sec ⁻¹	4.8.1
LAMDYJOL		SP	rad	4.8.1
\bar{R}_T_AIM	TAL M50 aim point	DP	ft	4.8.1
T_CA	Time of closest approach to the TAL aim point	SP	sec	4.8.1
CRNG_D	Current TAL MECO crossrange	SP	ft	4.8.1
Y_SAVE	Previous value of Y used in RTLS initialization	DP	ND	4.8.1
\bar{I}_Y_DES	Unit normal to the desired orbital plane	DP	ND	4.8.1

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
DSCOUNT, SCOUNT, TCOUNT	Counters used in monitoring the number of successive converged and unconverged PEG cycles	I	N/A	4.8.1
DSCOUNT_PREV	Previous value of DSCOUNT	I	N/A	4.8.1
VGOR	Velocity-to-be-gained in the radial direction for RTLS	SP	fps	4.8.1
IZ	Downrange unit vector at MECO	DP	N/A	4.8.1
L $\bar{\text{A}}\text{M}_\text{G}$	L $\bar{\text{A}}\text{M}$ in PEG coordinates	SP	fps	4.8.1
VGRAVX	Radial component of V RAV	SP	fps	4.8.1
BETA1-BETA3	Variables used in $\bar{\text{V}}\text{GO}$ and K	SP	ND	4.8.1
BETA4	updates for RTLS	SP	pct/fps	4.8.1
BETA5		SP	pct	4.8.1
R $\bar{\text{H}}\text{O}1$	Vector used in $\bar{\text{V}}\text{GO}$ update for RTLS	SP	ND	4.8.1
VGO_ERR	Error in $\bar{\text{V}}\text{GOMAG}$ for RTLS	SP	fps	4.8.1
P $\bar{\text{R}}\text{H}\text{O}$	Vector used in K update for RTLS	SP	pct/fps	4.8.1
D $\bar{\text{V}}\text{GO}_\text{G}$	D $\bar{\text{V}}\text{GO}$ in PEG coordinates	SP	fps	4.8.1
VGOYP	Y component of $\bar{\text{V}}\text{GO}$	SP	fps	4.8.1
V $\bar{\text{G}}\text{OXZ}$	Inplane component of $\bar{\text{V}}\text{GO}$	SP	fps	4.8.1
VGOXZ_SQ	Magnitude squared of V $\bar{\text{G}}\text{OXZ}$	SP	fps ²	4.8.1
VGOMAX_SQ	Square of maximum VGOMAG	SP	fps ²	4.8.1
VGOYMAX_SQ	Square of maximum VGOY	SP	fps ²	4.8.1
VMISSY	Y component of velocity error	SP	fps	4.8.1
VGOY	Desired out of plane velocity component	SP	fps	4.8.1
R $\bar{\text{T}}\text{HRUST}$	Position change due to thrust	DP	ft	4.8.1
R $\bar{\text{B}}\text{IAS}$	Difference between R $\bar{\text{G}}\text{O}$ and R $\bar{\text{T}}\text{HRUST}$	DP	ft	4.8.1
PHI	Thrust turn angle	SP	rad	4.8.1
TI	Value of (t-JOL) at start of thrust phase	DP	sec	4.8.1
TF	Value of (t-JOL) at end of thrust phase	DP	sec	4.8.1
TFMEANSQ	Value of (t-JOL) used to compute mean linear tangent vector for small thrust arcs	DP	sec	4.8.1
SMA_GAIN	Inverse of mean linear tangent vector magnitude for small thrust arcs	DP	ND	4.8.1
IF_MAG_I	Magnitude of linear tangent vector at start of thrust phase	DP	ND	4.8.1
IF_MAG_F	Magnitude of linear tangent vector at end of thrust phase	DP	ND	4.8.1
A	Constant coefficient of the quadratic acceleration profile	DP	fps ²	4.8.1
B	Linear coefficient of the quadratic acceleration profile	DP	fps ²	4.8.1

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
C	Quadratic coefficient of the quadratic acceleration profile	DP	fps ²	4.8.1
y(5), M(3)	Elements along $\bar{L}AM$ and $\bar{L}AMD$ of the position and velocity changes due to thrust	DP	fps ²	4.8.1
EL_LIMIT	LAMDMAG elevation limit	SP	rad/sec	4.8.1
DTA_LIMIT	LAMDMAG turning angle limit	SP	rad/sec	4.8.1
D	Denominator in mass update equation	SP	ND	4.8.2
X2, X3, X4	Prior values of sensed/computed thrust force	SP	ND	4.8.2
X_WEIGHT	Weighted average of X1, ..., X4	SP	ND	4.8.2
X_TEST	X-weight convergence criterion	SP	ND	4.8.2
MDOT_OLD	Previous value of MDOT	SP	slug /sec	4.8.2
M_NEW	Current estimate of the vehicle mass	SP	slugs	4.8.2
AT_AVE	Sensed acceleration magnitude	SP	fps ²	4.8.3
AD	Desired thrust acceleration	SP	fps ²	4.8.3
DA	AT_AVE-AL	SP	fps ²	4.8.3
SUM_DA	Integral of DA	SP	fps	4.8.3
T_KCMD	Time of last throttle change	DP	sec	4.8.3
R ϕ _MAG	Current position vector magnitude	DP	ft	4.8.4
R1_MAG	Target position vector magnitude	DP	ft	4.8.4
K, W	Dimensionless variable used in LTVCON task	DP	ND	4.8.4
A, B, C	Coefficients in equation for VH1	DP	ND -fps ²	4.8.4
D	$B^2 + 4AC$	DP	fps ²	4.8.4
Z	Denominator of W	DP	ft ²	4.8.4
AT_FCD	Sensed acceleration component along \bar{VGD}	SP	fps ²	4.8.5
VMAG	Magnitude of \bar{VGD}	SP	fps	4.8.5
DV_RAMP	Velocity gain during ramp down to KMIN	SP	fps	4.8.5
DV_MIN_K	Velocity gain at KMIN	SP	fps	4.8.5
VGO_FCD	Remaining velocity to be gained	SP	fps	4.8.5
FLT_PATH_DOT	Flight path angle rate, RTLS	SP	rad/sec	4.8.5
FLT_PATH_PAST	Past value of flight path angle	SP	rad	4.8.5
K_CO	MECO throttle setting	I	pct	4.8.5
ITLOF	Index for tailoff time at minimum power level	I	N/A	4.8.5
RT	Position of the RTLS landing site at the estimated time of MECO	DP	ft	4.8.5
PREVIOUS_FLT_PATH_ANG_TIME	Previous value of time of computing of FLT_PATH_ANG	DP	sec	4.8.5

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
FLT_PATH_ANG_RTLS	Predicted current flight path angle	SP	rad	4.8.5
VGOMAG	Magnitude of velocity-to-be-gained	SP	fps	4.8.5
VGODOT	Time rate of change of the velocity-to-be-gained	SP	fps ²	4.8.5
$\bar{I}DR, \bar{I}R$	Downrange and radial unit vectors	DP	ND	4.8.6
$\bar{I}RT$	Unit target position vector, PEG 4	DP	ND	4.8.6
RTMAG	Magnitude of PEG 4 target vector	DP	ft	4.8.6
THETA_LS	Downrange angle from launch site	SP	rad	4.8.6
DTHETA	Remaining downrange angle to target	SP	rad	4.8.6
RFE	Earth radius along $\bar{I}RT$ direction	DP	ft	4.8.6
$\bar{V}SP$	Total sensed velocity	DP	fps	4.8.8
$\bar{G}CB_NEW$	Current gravity acceleration	SP	fps ²	4.8.8
$\bar{G}CB$	Prior value of $\bar{G}C_NEW$	SP	fps ²	4.8.8
MTP^*	M50 to commanded body matrix	SP	ND	4.8.10
TAL_AREA	Index used in selecting TAL abort targets	I	N/A	4.8.11
RTLS_AREA	Index used in selecting RTLS abort targets	I	N/A	4.8.11
R_CNTG_TGT	RTLS launch site heading vector	DP	ft	4.8.12
HDOT_MODE1_PD	Altitude rate for the Mode 1 pitchdown maneuver	SP	fps	4.9.4
IXC_COEF	Thrust vector component in the vertical direction	SP	N/A	4.9.4, 4.9.5, 4.9.6, 4.9.7
IYC_COEF	Out of plane thrust unit vector coefficient	SP	N/A	4.9.4, 4.9.5, 4.9.6, 4.9.7
IZC_COEF	Horizontal thrust unit vector coefficient	SP	N/A	4.9.4, 4.9.5, 4.9.6, 4.9.7
PSI_CONT	Contingency body yaw angle	SP	rad	4.9.4, 4.9.5
PSI_DESIRE	Desired thrust vector angle	SP	rad	4.9.4, 4.9.5
S_MNVR_INIT	Maneuver initiation flag	D	N/A	4.9.4, 4.9.5
$S_ROLL_COMPLETE$	Roll complete flag	D	N/A	4.9.4, 4.9.5
$S_YAW_BACK_INIT$	Yaw back maneuver initiation flag	D	N/A	4.9.4, 4.9.5

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
THETA_CONT	Contingency body pitch angle	SP	rad	4.9.4, 4.9.5
THETA_HEADS_DOWN	Heads down thrust vector pitch attitude	SP	rad	4.9.4, 4.9.5
THETA_HEADS_UP	Heads up thrust vector pitch attitude	SP	rad	4.9.4, 4.9.5
EAS_PY	Final maneuver equivalent airspeed for Mode 2	SP	fps	4.9.4, 4.9.5
EST_AT	Estimated magnitude of the current thrust acceleration	SP	fps ²	4.9.7
AX	Vertical component of the thrust acceleration vector	SP	fps ²	4.9.7
DEL_LAMC	Change in the commanded thrust direction	SP	N/A	4.9.7
DT_CONT_PITCH	Time required for powered pitchdown	SP	sec	4.9.7
ELEV_MAX	Maximum thrust vector elevation	SP	rad	4.9.7
IXC_COEF_MAX	Max value of the thrust vector component in the vertical direction	SP	N/A	4.9.7
LAMC_OLD	Previously commanded thrust vector	SP	N/A	4.9.7
M_SEROLL	Mass loss due to single engine roll control OMS propellant usage	SP	slugs	4.9.7
MAG_DEL_LAMC	Magnitude of change in the commanded thrust direction from the previous cycle	SP	N/A	4.9.7
TGO_EMPTY	Time remaining before MPS propellant depletion	SP	sec	4.9.7
FPANG_DOT	Rate of change of flight path angle	SP	rad/sec	4.9.8
FPANG_NEW	Current relative flight path angle	SP	rad	4.9.8
FPANG_OLD	Relative flight path angle from the previous cycle	SP	rad	4.9.8
ALF_CMD	Commanded angle of attack	SP	deg	4.10.1
ALF_ERR	Angle of attack error	SP	deg	4.10.1
ALT_PRED	Predicted altitude	SP	ft	4.10.3
CONTINGENCY_NZ_LIM_STD	Stored interconnect normal acceleration limit	SP	g	4.10.1
EARLY_SEP	Early ET separation flag	D	N/A	4.10.1
E_CB_B	Angular error vector between body and commanded body frames	SP	deg	4.10.1
H_DOT_PRED	Predicted altitude rate	SP	fps	4.10.3
OMS_NZ_LIM_STD	Stored OMS normal acceleration limit	SP	g	4.10.1
QORB_ERR	Pitch rate error	SP	deg/ sec	4.10.1
Q_CB_B	Quaternion relating body to commanded body ref frames	SP	N/A	4.10.1

Table B-1. Task Internal Variables				
Symbol	Definition	Prec	Units	FSSR Ref
REL_VEL_PRED2	Predicted relative velocity squared	SP	ft ² / sec ²	4.10.3
Q_BAR_MIN	Minimum predicted dynamic pressure	SP	lb/ft ²	4.10.2
ALPHA_OK	Contingency Region 3 alpha target flag	D	N/A	4.10.1
RHO_A	Predicted atmospheric density	SP	slug/ ft ³	4.10.3
ROT	Pitch rotation angle from VR frame to commanded angle of attack	SP	deg	4.10.1
T_QBAR_MIN	Predicted time of minimum dynamic pressure	SP	sec	4.10.1
T_ZRBETA	GMT time of first pass through region 2 contingency 3 E/O maneuver logic	DP	sec	4.10.1
T_3EO	GMT time of initiation of contingency 3 E/O auto maneuver	DP	sec	4.10.1
\bar{U}	Relative velocity vector in body coordinates	SP	fps	4.10.1
\bar{U}_Y	Y-axis unit vector	SP	N/A	4.10.1
\bar{V}_{TEMP}	Temporary vector	SP	N/A	4.10.1
*Number in parentheses indicates number of values.				

APPENDIX C OPS-1 UTILITY ROUTINES

This appendix describes the required inputs and outputs of the utility routines and functions used by powered flight guidance.

1. A/E PREC PRED

Inputs: ($R_{\bar{I}NIT}$, $V_{\bar{I}NIT}$, $T_{\bar{I}NIT}$, $T_{\bar{F}INAL}$, $DT_{\bar{M}AX}$, $GMD_{\bar{P}RED}$, $GMO_{\bar{P}RED}$)

1, 2, and 3. Initial state and time (GMT seconds).

4. Time at which final state is required in GMT (sec).

5. Upper bound for the integration step size (sec).

6. and

7. Degree and order indicators where

	GMD PRED	GMO PRED
Full precision + drag	4	4
Central body + J2	2	0
Central body	0	0

Note: When $D < 4$, drag effects are not included.

Outputs: ($R_{\bar{F}INAL}$, $V_{\bar{F}INAL}$, $G_{\bar{F}INAL}$) 1. Position, 2. velocity, and 3. gravity vectors at $T_{\bar{F}INAL}$.

Ref: Operational Level C Ascent/RTL Navigation FSSR, STS 83-0005.

2. EARTH_FIXED_TO_M50_COORD (T_EPOCH)

Direction cosine matrix which will transform a vector from the earthfixed system to M50 at $T_{\bar{E}POCH}$ (GMT seconds).

Ref: Operational Level C Ascent/RTL Navigation FSSR, STS 83-0005.

3. H_ELLIPSOID (\bar{R})

Output is height above the Fisher ellipsoid of a point described by the position vector, \bar{R} .

Information:

$$H_ELLIPSOID(\bar{R}) = |\bar{R}| - (1-ELLIPT) EARTH_RADIUS_EQUATOR / \sqrt{1 + [(1-ELLIPT)^2 - 1] \left[1 - (\text{UNIT}(\bar{R}) \cdot \bar{EARTH_POLE})^2 \right]}$$

Ref: Operational Level C Ascent/RTLS Navigation FSSR, STS 83-0005.

4. MAT_TO_QUAT

Inputs: (M_CB_I) Direction cosine matrix CB frame with reference to I frame.

Outputs: ($Q_CB_I_S$, $Q_CB_I_V$) scalar and vector parts of the quaternion.

Information: The matrix will transform a vector from Frame I to Frame CB. The output quaternion does this equivalently.

Ref: Operational Level C Ascent Flight Control FSSR, STS 83-0008.

5. QUAT XFORM

Inputs: ($Q_B_A_S$, $Q_B_A_V$, W_A)

1. Scalar part of the quaternion in Frame B with reference to Frame A.

2. Vector part of the quaternion.

3. Vector in Frame A.

Outputs: (W_B)

1. Vector in Frame B.

Information: $\bar{W}^B = Q_A^B \bar{W}^A (Q_A^B)^*$

Ref: Operational Level C Ascent Flight Control FSSR, STS 83-0008.

6. RV_TO_QLVLH

Input: ($\bar{X}\bar{R}$, $\bar{X}\bar{V}$)

1. Vehicle position in M50.
2. Vehicle velocity in M50.

Output: (XO_M50_LVLHS , $\bar{X}\bar{O}_M50_LVLHV$)

1. LVLH-to-M50 quaternion, scalar and vector parts.

Information: $\bar{X}\bar{Z} = \text{UNIT}(-\bar{X}\bar{R})$

$$\bar{X}\bar{Y} = \text{UNIT}(\bar{X}\bar{V} \times \bar{X}\bar{R})$$

$$\bar{X}\bar{X} = \text{UNIT}(\bar{X}\bar{Y} \times \bar{X}\bar{Z})$$

$$\bar{X}\bar{M} = \text{Matrix}(\bar{X}\bar{X}, \bar{X}\bar{Y}, \bar{X}\bar{Z})^T$$

The LVLH_TO_M50 quaternion is formed by operating on the $\bar{X}\bar{M}$ matrix using the function MAT_TO_QUAT.

Ref: Operational Level C Ascent Flight Control FSSR, STS 83-0008.

7. QUAT_MULT

Inputs: ($Q1S$, $Q1\bar{V}$, $Q2S$, $Q2\bar{V}$)

1. Scalar and vector parts of the left quaternion.
2. Scalar and vector parts of the right quaternion.

Outputs: ($Q3S$, $Q3\bar{V}$)

1. Scalar and vector parts of the output quaternion.

Information: $Q_A^C = Q_B^C \quad Q_A^B$

Ref: Operational Level C Ascent Flight Control FSSR, STS 83-0008.

8. QUAT TO ADI ANG

Input: (XQS, \overline{XQV})

Scalar and vector part of the input quaternion.

Output: (XPTCHSINE, XPTCHCOS, XYAWSINE, XYAWCOS, XROLLSINE, XROLLCOS, XFLAG)

Pitch, yaw, and roll sine and cosine values in above order. XFLAG is flag indicating that pitch and roll functions have been updated.

Information: Order of rotation is pitch, yaw, then roll.

Ref: Operational Level C Ascent Flight Control FSSR, STS 83-0008.

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	92740D	30	STS 83-0002 and STS 83-0008V1 Errata Cleanup
	92958A	32	Expand Effectivity of PASS/BFS RTF SCRs to Include OI-32
	92973	32	Reassign Effectivity of SCRs 92542D & 92743D to OI-32
	92992	32	Reassign Effectivity of SCR 92876B to OI-32
1.3 (T)	92103A	26B	FSSR Parameter Table Upgrade
4.2	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92670D	30	Abort Improvements to Improve TAL Performance
4.2-2.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.2-3.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.2.1	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.2.2	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.2.2-1.(T)	92175D	28	Uplink Second Stage I-loads
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.2.2-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
4.2.3	92670D	30	Abort Improvements to Improve TAL Performance
	91015C	26	Pitch Steering During SRB Tailoff
	92010	26	Documentation Addition to Pitch Steering During SRB Tailoff
4.2.3-1.(T)	90958C	26	Onboard Delta PSI Computation
	91015C	26	Pitch Steering During SRB Tailoff
	92670D	30	Abort Improvements to Improve TAL Performance
4.2.3-2.(T)	92670D	30	Abort Improvements to Improve TAL Performance
4.2.4-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.2-4.(F)	90958C	26	Onboard Delta PSI Computation
	91015C	26	Pitch Steering During SRB Tailoff
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
4.2.5-1.(T)	91015C	26	Pitch Steering During SRB Tailoff
	91051K	26B	Streamlined Shuttle GPS Capability
	92067D	27	Three String GPS Capability
	92175D	28	Uplink Second Stage I-loads
	92232B	28	Variable Intact Abort Throttle Limits
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92619A	30	Correction CR for CR 92522D
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement
	93090E	33	Bearing Displays
4.2.5-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92670D	30	Abort Improvements to Improve TAL Performance
	93012D	32	PASS 6X TRAJ Display Enhancement
4.2.5-3.(T)	91015C	26	Pitch Steering During SRB Tailoff
	92227	27	Recategorization of DOLILU II I-Loads in A1N, A1S and A1T
	92243A	27	A1S & A1T I-Load Dependency Change
	92232B	28	Variable Intact Abort Throttle Limits
4.2.5-5.(T)	92670D	30	Abort Improvements to Improve TAL Performance
	92389C	29	Spiral HAC in TAEM Area Navigation
	92332D	30	Add Theta Limits Bracket to MEDS ADI Displays
4.3	93090E	33	Bearing Displays
	92232B	28	Variable Intact Abort Throttle Limits
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.3-2.(F)	92670D	30	Abort Improvements to Improve TAL Performance
	93025B	32	Single Engine Throttle Back for NPSP Protection
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.3-3.(F)	93025B	32	Single Engine Throttle Back for NPSP Protection
	91042A	26	Second Stage Pitch Gimbal Relief
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93025B	32	Single Engine Throttle Back for NPSP Protection
4.3-4.(F)	93079B	32	Correction to Single Engine Throttle Back for NPSP Protection (SCR 93025B)
	93146B	33	Minor Doc Update to FSSRs 1, 2 and 16
	91042A	26	Second Stage Pitch Gimbal Relief
	92232B	28	Variable Intact Abort Throttle Limits
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.3.1	93012D	32	PASS 6X TRAJ Display Enhancement
	93025B	32	Single Engine Throttle Back for NPSP Protection
	91045A	26	106% Throttle in Second Stage
	92175D	28	Uplink Second Stage I-loads
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93079B	32	Correctin to Single Engine Throttle Back for NPSP Protection (SCR 93025B)
	93146B	33	Minor Doc Update to FSSRs 1, 2 and 16
4.3.1-1.(T)	91045A	26	106% Throttle in Second Stage
	92175D	28	Uplink Second Stage I-loads
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93068B	32	PASS 6X TRAJ Display Documentation Clean-up
4.3.1-2.(T)	91045A	26	106% Throttle in Second Stage
	93012D	32	PASS 6X TRAJ Display Enhancement
	93025B	32	Single Engine Throttle Back for NPSP Protection
4.3.2	93025B	32	Single Engine Throttle Back for NPSP Protection
4.3.2-1.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
	93025D	32	Single Engine Throttle Back for NPSP Protection

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.3.2-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.3.3	91042A	26	Second Stage Pitch Gimbal Relief
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-UP
4.3.3-1.(T)	91042A	26	Second Stage Pitch Gimbal Relief
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92670D	30	Abort Improvements to Improve TAL Performance
	91042A	26	Second Stage Pitch Gimbal Relief
4.3.3-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
	92668C	30	Prevent Erroneous Droop Guidance Engagement
4.3.4	92175D	28	Uplink Second Stage I-loads
4.3.4-1.(T)	92668C	30	Prevent Erroneous Droop Guidance Engagement
	93012D	32	PASS 6X TRAJ Display Enhancement
	92668C	30	Prevent Erroneous Droop Guidance Engagement
4.3.4-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
	91042A	26	Second Stage Pitch Gimbal Relief
4.3.5-1.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92067D	27	Three String GPS Capability
	92235B	27	Fix AOA Propellant Wasting Calculation
	90704F	28	DAP Hot-Stick Downmode Alert and Message
	92175D	28	Uplink Second Stage I-loads
	92198A	28	SERC OMS/RCS Interconnect Delay
	92208C	28	GPS Issues for Correction on OI-28
	92232B	28	Variable Intact Abort Throttle Limits
	92237	28	IDD Documentation Cleanup of Uplink Data
	92225A	29	ET SEP Switch Default to Auto on a TAL Abort
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.3.5-2.(T)	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D and 92369B
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104
	92504G	30	Alleviate ET Recontact For RTLS 2EO Yellow and Orange Regions
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92668C	30	Prevent Erroneous Droop Guidance Engagement
	92670D	30	Abort Improvements to Improve TAL Performance
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93064D	32	Errata Issue Clean-Up Part II
	93090E	33	Bearing Displays
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.3.5-3.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
	93090E	33	Bearing Displays
	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-Up
	91042A	26	Second Stage Pitch Gimbal Relief
	91045A	26	106% Throttle in Second Stage
	91086A	26	Cleanup to CR91045A, 106% Throttle in Second Stage
	92232B	28	Variable Intact Abort Throttle Limits
4.3.5-4.(T)	92517C	30	Expand Landing Site Table
	92670D	30	Abort Improvements to Improve TAL Performance
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93090E	33	Bearing Displays
	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
4.3.5-5.(T)	92670D	30	Abort Improvements to Improve TAL Performance
	92329E	29	Onboard Calculation of RNP Matrix

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean
	93090E	33	Bearing Displays
4.4-3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.4-4.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.4.3-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.4.4-1 (T)	91051K	26B	Streamlined Shuttle GPS Capability
	92025B	26B	Onorbit TACAN Deletion
	92067D	27	Three String GPS Capability
	92316B	29	Automating 2 nd MPS Vacuum Inert
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement
	93090E	33	Bearing Displays
4.4.4-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.4.4-3.(T)	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-Up
	93090E	33	Bearing Displays
4.4.4-4.(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
4.4.4-5.(T)	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
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
	93090E	33	Bearing Displays
4.5	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
4.5.1-1.(F)	92235B	27	Fix AOA Propellant Wasting Calculation
4.5.2	92201C	28	Uplink V_MSSN_CNTN I-load
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.5-2.(F)	92522D	30	Overhaul MEDS Composite Flight Instrument Display

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.5.2-1.(T)	92201C	28	Uplink V_MSSN_CNTN I-load
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
4.5.2-2.(T)	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93012D	32	PASS 6X TRAJ Display Enhancement
4.5.3	91014E	26	OMS Assist Performance Enhancement Burn
	91075B	26	CR 91014E Documentation Cleanup CR
4.5.3-1.(T)	91014E	26	OMS Assist Performance Enhancement Burn
4.5.4	92235B	27	Fix AOA Propellant Wasting Calculation
4.5.4-2.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
	90924B	29	Correct OMS Engine Parameters to Match SODB Values
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
4.5.4-3.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
4.5.5	92235B	27	Fix AOA Propellant Wasting Calculation
4.5.5-1.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
4.5.5-2.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
4.5.6-1.(T)	91014E	26	OMS Assist Performance Enhancement Burn
	91075B	26	CR 91014E Documentation Cleanup CR
	91051K	26B	Streamlined Shuttle GPS Capability
	92067D	27	Three String GPS Capability
	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
	92201C	28	Uplink V_MSSN_CNTN I-load
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.5.6-2.(T)	93090E	33	Bearing Displays
	92235B	27	Fix AOA Propellant Wasting Calculation
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93012D	32	PASS 6X TRAJ Display Enhancement
4.5.6-4.(T)	93090E	33	Bearing Displays
	90924B	29	Correct OMS Engine Parameters to Match SODB Values
4.5.6-5.(T)	92067D	27	Three String GPS Capability
	92329E	29	Onboard Calculation of RNP Matrix
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up
4.6	93090E	33	Bearing Displays
	92232B	28	Variable Intact Abort Throttle Limits
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
4.6-4.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	90724D	28	OPS 6 Entry ECAL Automation
	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
	92232B	28	Variable Intact Abort Throttle Limits
4.6.1	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	93012D	32	PASS 6X TRAJ Display Enhancement
	92175D	28	Uplink Second Stage I-loads
4.6.1-1.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92175D	28	Uplink Second Stage I-loads
4.6.1-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.6.2-1.(T)	92232B	28	Variable Intack Abort Throttle Limits
4.6.2-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.6.3	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6.3-1.(T)	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to- Heads-Up
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6.3-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.6.4	93141	33	Delete Downlist Requirement for DT_TURN
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6.4-1.(T)	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6.4-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
4.6.5	93087E	33	RTLS ET Separation Improvements
4.6.5-1.(T)	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93087E	33	RTLS ET Separation Improvements
4.6.5-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
	93087E	33	RTLS ET Separation Improvements
4.6.6	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.6.6-2.(T)	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.6-2.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6-3.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6-4.(F)	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.6.7-1.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92069B	26B	Single-String GPS Documentation Cleanup
	92099B	27	Flight Path Angle RTLS Downlist Units Correction
	90704F	28	DAP Hot-Stick Downmode Alert and Message
	92175D	28	Uplink Second Stage I-loads
	92232B	28	Variable Intact Abort Throttle Limits
	92306A	28	Orbiter Window Protection
	92329E	29	Onboard Calculation of RNP Matrix
	92355B	29	GPC Major Mode to MEDS
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92389C	29	Spiral HAC in TAEM Area Navigation
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.6.7-2.(T)	92504G	30	Alleviate ET Recontact For RTLS 2EO Yellow and Orange Regions
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	92619A	30	Correction CR for CR 92522D
	92670D	30	Abort Improvements to Improve TAL Performance
	92909A	30/32	ET Camera Power Control Commands
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	92950	32	G/C Steer Roll Bias Ramp at PPD or MECO
	93012D	32	PASS 6X TRAJ Display Enhancement
	93064D	32	Errata Issue Clean-Up Part II
	93087E	33	RTLS ET Separation Improvements
	93090E	33	Bearing Displays
	90724D	28	OPS 6 Entry ECAL Automation
	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	4.6.7-3.(T)	93012D	32
93087E		33	RTLS ET Separation Improvements
93090E		33	Bearing Displays
93141		33	Delete Downlist Requirement for DT_TURN
91019A		26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-Up
4.6.7-4(T)	92232B	28	Variable Intact Abort Throttle Limits
	92517C	30	Expand Landing Site Table
	93087E	33	RTLS ET Separation Improvements
	93090E	33	Bearing Displays
	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-Up
4.6.7-5.(T)	90924B	29	Correct OMS Engine Parameters to Match SODB Values
	92069B	26B	Single-String GPS Documentation Cleanup
	92329E	29	Onboard Calculation of RNP Matrix
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
	93090E	33	Bearing Displays
4.7.1	92510E	30	Modification to Maneuver Execute Display
4.7.2	92510E	30	Modification to Maneuver Execute Display
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
4.7.3	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
	93146B	33	Minor Doc Update to FSSRs 1, 2 and 16
	93163	33	Automatic Load Documentation Removal
4.7-1.(F)	92510E	30	Modification to Maneuver Execute Display
4.7-2.(F)	92510E	30	Modification to Maneuver Execute Display
4.7-3.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
	92510E	30	Modification to Maneuver Execute Display
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
4.7-4.(F)	92235B	27	Fix AOA Propellant Wasting Calculation
	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
	92510E	30	Modification to Maneuver Execute Display
4.7.3-1.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
4.7.3-2.(T)	92235B	27	Fix AOA Propellant Wasting Calculation
4.7.4-2.(T)	92876B	32	Remove BURN_ENABLE from Downlist
4.7.7-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
	92510E	30	Modification to Maneuver Execute Display
4.7.8A	92510E	30	Modification to Maneuver Execute Display
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
4.7.8A-1.(T)	92510E	30	Modification to Maneuver Execute Display
	92678C	30	Correction CR for CR 92510E - Requirements Cleanup
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
4.7.8A-2.(T)	92510E	30	Modification to Maneuver Execute Display
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
4.7.10-1.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92025B	26B	Onorbit TACAN Deletion
	92069B	26B	Single-String GPS Documentation Cleanup
	92067D	27	Three String GPS Capability

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.7.10-2(T)	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
	92316B	29	Automating 2 nd MPS Vacuum Inert
	92329E	29	Onboard Calculation of RNP Matrix
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	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	30/32	Preburn Maneuver Time To Go Clean-up
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement
	93090E	33	Bearing Displays
	92235B	27	Fix AOA Propellant Wasting Calculations
	92354	27	Delete Erroneous TLM Destinations
4.7.10-3.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Attitude
	92510E	30	Modification to Maneuver Execute Display
	92859C	30/32	Preburn Maneuver Time To Go Clean-up
	92876B	32	Remove BURN_ENABLE from Downlist
4.7.10-4.(T)	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-Up
	93090E	33	Bearing Displays
4.7.10-5.(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
	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

Table R.1-1. CR Reference Summary				
Paragraph	CR No.	OI	CR Title	
4.8.1	92522D	30	Overhaul MEDS Composite Flight Instrument Display	
	92749B	30	Universal Pointing Processor Degrees to Radians Documentation Clean-up	
	93090E	33	Bearing Displays	
	92670D	30	Abort Improvements to Improve TAL Performance	
	4.8.1-1.(T)	92175D	28	Uplink Second Stage I-loads
	92232B	28	Variable Intact Abort Throttle Limits	
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion	
4.8.1-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown	
	92670D	30	Abort Improvements to Improve TAL Performance	
	93012D	32	PASS 6X TRAJ Display Enhancement	
4.8.3	92670D	30	Abort Improvements to Improve TAL Performance	
	93025B	32	Single Engine Throttle Back for NPSP Protection	
4.8.3-1.(T)	92232B	28	Variable Intact Abort Throttle Limits	
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown	
	92670D	30	Abort Improvements to Improve TAL Performance	
	93012D	32	PASS 6X TRAJ Display Enhancement	
4.8.3-2.(T)	93025B	32	Single Engine Throttle Back for NPSP Protection	
	92670D	30	Abort Improvements to Improve TAL Performance	
	93012D	32	PASS 6X TRAJ Display Enhancement	
4.8.5	91042A	26	Second Stage Pitch Gimbal Relief	
	93025B	32	Single Engine Throttle Back for NPSP Protection	
	93087E	33	RTLS ET Separation Improvements	
4.8.5-1.(T)	91042A	26	Second Stage Pitch Gimbal Relief	
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion	
	92670D	30	Abort Improvements to Improve TAL Performance	
	93012D	32	PASS 6X TRAJ Display Enhancement	
4.8.5-2.(T)	93025B	32	Single Engine Throttle Back for NPSP Protection	
	93012D	32	PASS 6X TRAJ Display Enhancement	
	93025B	32	Single Engine Throttle Back for NPSP Protection	
4.8.9	92232B	28	Variable Intact Abort Throttle Limits	
	93025B	32	Single Engine Throttle Back for NPSP Protection	
4.8.9-1.(T)	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16	
	92232B	28	Variable Intact Abort Throttle Limits	

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.8.9-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93025B	32	Single Engine Throttle Back for NPSP Protection
	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.8.10	92670D	30	Abort Improvements to Improve TAL Performance
	93012D	32	PASS 6X TRAJ Display Enhancement
	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.8.10-1.(T)	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16
	91019A	26	Guidance K-loads to I-Loads for Second Stage Roll-to-Heads-UP
4.8.10-2.(T)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
4.8.11	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.8.11-1.(T)	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92517C	30	Expand Landing Site Table
4.8.11-2.(T)	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93012D	32	PASS 6X TRAJ Display Enhancement
4.8.12-2.(T)	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
4.8.13	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.8.13-1.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.8.13-2.(T)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.9	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9-1.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.9-2.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.9-3.(F)	90724D	28	OPS 6 Entry ECAL Automation
	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
	92232B	28	Variable Intact Abort Throttle Limits
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.1	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
4.9.1-1.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.1-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.2	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.2-1.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.2-2.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.3	92232B	28	Variable Intact Abort Throttle Limits
4.9.3-1.(T)	92232B	28	Variable Intact Abort Throttle Limits
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.3-2.(T)	90724D	28	OPS 6 Entry ECAL Automation
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.5	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.5-1.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.7	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.7-1.(T)	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.7-2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.8	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.8-1.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.9.8–2.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.9	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.9–1.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.9–2.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.10	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.10–1.(T)	92232B	28	Variable Intact Abort Throttle Limits
4.9.10–2.(T)	93012D	32	PASS 6X TRAJ Display Enhancement
4.9.12–1.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92067D	27	Three String GPS Capability
	90704F	28	DAP Hot-Stick Downmode Alert and Message
	92232B	28	Variable Intact Abort Throttle Limits
	92306A	28	Orbiter Window Protection
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92389C	29	Spiral HAC in TAEM Area Navigation
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369E
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	92909A	30/32	ET Camera Power Control Commands
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	93012D	32	PASS 6X TRAJ Display Enhancement
	93023D	32	OI-32 Remote Control Orbiter Capability
	93064D	32	Errata Issue Clean-Up Part II
	93087E	33	RTLS ET Separation Improvements

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.9.12-2.(T)	93090E	33	Bearing Displays
	90724D	28	OPS 6 Entry ECAL Automation
	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
	92198A	28	SERC OMS/RCS Interconnect Delay
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92565A	30	SE RTLS Increased Pitch Authority Using Forward RCS Jets
	93012D	32	PASS 6X TRAJ Display Enhancement
	93068B	32	PASS 6X TRAJ Display Documentation Clean-up
4.9.12-3.(T)	93090E	33	Bearing Displays
	92232B	28	Variable Intact Abort Throttle Limits
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.9.12-4.(T)	93087E	33	RTLS ET Separation Improvements
4.9.12-5.(T)	90924B	29	Correct OMS Engine Parameters to Mach SODB Values
4.10	91051K	26B	Streamlined Shuttle GPS Capability
	92329E	29	Onboard Calculation of RNP Matrix
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
4.10.1	93090E	33	Bearing Displays
	93012D	32	PASS 6X TRAJ Display Enhancement
4.10.1-1.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92672B	30	Correction to CR 92504G
	92175D	28	Uplink Second Stage I-loads
4.10.1-2.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92672B	30	Correction to CR 92504G
4.10.2	93012D	32	PASS 6X TRAJ Display Enhancement
	93012D	32	PASS 6X TRAJ Display Enhancement
4.10.2-2.(T)	92355B	29	GPC Major Mode to MEDS
	93012D	32	PASS 6X TRAJ Display Enhancement
4.10-3.(F)	90724D	28	OPS 6 Entry ECAL Automation

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.10.4-1.(T)	90914C	28	Delay MOV MPS Dump/FRCS Dump at MM602
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	93012D	32	PASS 6X TRAJ Display Enhancement
	91051K	26B	Streamlined Shuttle GPS Capability
	92067D	27	Three String GPS Capability
	92144C	27	Three String GPS Documentation Cleanup
	92235B	27	Fix AOA Propellant Wasting Calculation
	92175D	28	Uplink Second Stage I-loads
	92306A	28	Orbiter Window Protection
	92353D	29	Automated Alpha-Beta Management During Mated Coast & MM104
	92355B	29	GPC Major Mode to MEDS
	92389C	29	Spiral HAC in TAEM Area Navigation
	92404B	29	Preserve MECO Vi, Altitude, & Altitude Rate in MM104
	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Region
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	92619A	30	Correction CR for CR 92522D
	92676B	30	CR 92522D / CR 92619A Correction CR
	92909A	30/32	ET Camera Power Control Commands
	92542D	32	Deletion of LO2 Step Pressurization CMDS
	4.10.4-2.(T)	93012D	32
93023D		32	OI-32 Remote Control Orbiter Capability
93087E		33	RTLS ET Separation Improvements
93090E		33	Bearing Displays
90724D		28	OPS 6 Entry ECAL Automation
90914C		28	Delay MOV MPS Dump/FRCS Dump at MM602
92355B		29	GPC Major Mode to MEDS
92504G		30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
92522D		30	Overhaul MEDS Composite Flight Instrument Display
92672B		30	Correction to CR 92504G
93012D	32	PASS 6X TRAJ Display Enhancement	
93090E	33	Bearing Displays	

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
4.10.4-3.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	93087E	33	RTLS ET Separation Improvements
4.10.4-4.(T)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
4.10.4-5.(T)	91051K	26B	Streamlined Shuttle GPS Capability
	92522D	30	Overhaul MEDS Composite Flight Instrument Display
	93090E	33	Bearing Displays
4.12	90958C	26	Onboard Delta PSI Computation
	92092	27	3-String FCOS GPS I/O Support
	92263A	28	Correct Inconsistent DOULILU and BFS OneShot Contiguous Memory Requirements
	92524C	30	DOC-Only Clarification of DOL/OneShot Order Dependence
4.12-1.(T)	90958C	26	Onboard Delta PSI Computation
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92524C	30	DOC-Only Clarification of DOL/OneShot Order Dependence
4.12-2.(T)	91075B	26	CR 91014E Documentation Cleanup CR
	92092	27	3-String FCOS GPS I/O Support
	92175D	28	Uplink Second Stage I-loads
	92201C	28	Uplink V_MSSN CNTN I-load
	92232B	28	Variable Intact Abort Throttle Limits
	92263A	28	Correct Inconsistent DOLILU and BFS OneShot Contiguous Memory Requirements
	92364D	29	Just-In-Time Flight Design (JITFD) I-Load Uplink Expansion
	92392C	29	Doc-Only Corrections for OI-29 CRs 92329E, 92364D, and 92369B
	92463C	29	Correction of JITFD CRs (CR92364D and CR92392C)
	92524C	30	DOC-Only Clarification of DOL/OneShot Order Dependence
A4.2.1.(F)	92529B	30	GPS Capability Enhancements for OI-30
	93025B	32	Single Engine Throttle Back for NPSP Protection
	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.2.2.(F)	92232B	28	Variable Intact Abort Throttle Limits

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
A4.2.3.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	91015C	26	Pitch Steering During SRB Tailoff
	92010	26	Documentation Addition to Pitch Steering During SRB Tailoff
A4.2.3.(1)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(2)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(3)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(4)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(5)(F)	92670D	30	Abort Improvements to Improve TAL Performance
	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16
A4.2.3.(6)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(7)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(8)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(9)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(10)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(11)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.2.3.(12)(F)	92670D	30	Abort Improvements to Improve TAL Performance
A.4.3.1.(F)	91045A	26	106% Throttle in Second Stage
A4.3.1.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93079B	32	Correction to Single Engine Throttle Back for NPSP Protection (SCR 93025B)
	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16
A4.3.2.(F)	93025B	32	Single Engine Throttle Back for NPSP Protection
A4.3.3.(F)	91042A	26	Second Stage Pitch Gimbal Relief
	92232B	28	Variable Intact Abort Throttle Limits
A4.3.3.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.3.4.(4)(F)	92668C	30	Prevent Erroneous Droop Guidance Engagement
A4.5.2.(F)	92522D	30	Overhaul MEDS Composite Flight Instrument Display
A4.5.4.(F)	92235B	27	Fix AOA Propellant Wasting Calculation
A4.5.5.(F)	92235B	27	Fix AOA Propellant Wasting Calculation
A4.6.1.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.6.3.(F)	92232B	28	Variable Intact Abort Throttle Limits
A4.6.3.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.6.4.(F)	92232B	28	Variable Intact Abort Throttle Limits

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
A4.6.4.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.6.5.(1)(F)	93087E	33	RTLS ET Separation Improvements
A4.6.5.(2)(F)	93087E	33	RTLS ET Separation Improvements
A4.7.2.(F)	92859C	30/32	Preburn Maneuver Time To Go Clean-up
A4.7.3.(F)	92235B	27	Fix AOA Propellant Wasting Calculation
	93163	33	Automatic Load Documentation Removal
A4.7.8A(F)	92859C	30/32	Preburn Maneuver Time To Go Clean-up
A4.8.1.D2.(F)	92670D	30	Abort Improvements to Improve TAL Performance
A4.8.3.(F)	92670D	30	Abort Improvements to Improve TAL Performance
	93025B	32	Single Engine Throttle Back for NPSP Protection
A4.8.5.(F)	91042A	26	Second Stage Pitch Gimbal Relief
A4.8.5.(1)(F)	93025B	32	Single Engine Throttle Back for NPSP Protection
A4.8.9.(F)	92232B	28	Variable Intact Abort Throttle Limits
	93025B	32	Single Engine Throttle Back for NPSP Protection
	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16
A4.8.10.(F)	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude
A4.8.13.(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.9.1.(1)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.9.2.(1).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.9.2.(4).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.9.3.(F)	92232B	28	Variable Intact Abort Throttle Limits
A4.9.3.(2)(F)	92608C	30	Allow Max Throttle Item Entries Post Fine Countdown
A4.9.5.(1).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.9.8.(1).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.9.9.(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.10.1.(1).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.10.1.(2).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92672B	30	Correction to CR 92504G

Table R.1-1. CR Reference Summary			
Paragraph	CR No.	OI	CR Title
A4.10.1.(3).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.10.1.(4).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
	92672B	30	Correction to CR 92504G
A4.10.1.(5).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.10.1.(6).(F)	92504G	30	Alleviate ET Recontact for RTLS 2EO Yellow and Orange Regions
A4.10.2.(1)(F)	93146B	33	Minor Doc Update to FSSRs 1, 2, and 16
B-1.(T)	91015C	26	Pitch Steering During SRB Tailoff
	92670D	30	Abort Improvements to Improve TAL Performance
APPENDIX C	90763E	29	Fix PASS & BFS Maneuver Display Burn Altitude

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.		CR Title
2411B		OMS Engine FDI Simplification-STS-1
2449D		Contingency Abort Requirements-STS-1
2492C		Vehicle Mass Definition-STS-1
2559		PEG Position-STS-1
12019		Standard FSSR Functions-STS-1
12071A		Maneuver Execute-STS-1
12105		Reinstate 6.25 Hz Mass And Mass Fill-STS-1
12132A		Time To Command MECO-STS-1
12134A		TLM Requirements, ASC Guidance-STS-1
12190D		ASC/RTLS Guidance-STS-1
12201		AOA OMS-2 Data-STS-2
12202A		GAMMA Compensation For RTLS-1
12225B		GN&C Level C Uplink Requirements-STS-1 And -2

Table R.2-1. Historical Change Request Summary

CR No.		CR Title
12293		PRTLs Throttle Setting–STS–1
12313C		Addition Of TLM Requirements–STS–1
12316		GN&C Switch RM Proceeding–STS–1
12336		I–Load OFT–1 Baseline–STS–1
12337		I–Load OFT–1 Baseline–STS–1
12338		I–Load OFT–1 Baseline–STS–1
12339		I–Load OFT–1 Baseline–STS–1
12342A		Oms Maneuver, Out Of Plane Velocity–STS–1
12343B		Maximum Integration Step Size–PEG–STS–1 Gravity Prediction
12345		Time–To–Next–APsIS Corrections–STS–2
12358B		Manual Throttling Additions–STS–1
12404A		Proposed FCS 9–STS–1
12425		Remove FPL Restriction–STS–2
12442A		Integrated NAV Interfaces–STS–1
12443		I–Load For Entry FACI–STS–1
12465		Orbital Attitude And Time Task–STS–1
12478		UPDT To Vehicle Mass–STS–1 And –4
12510		PEG Time To Go And Thrust Integral MODS–STS–1
12521A		Variable Iy Targeting–STS–2
12524B		First–Stage Guidance–STS–1
12557A		RTLs Mated Coast And –Z Translation–STS–1
12586		Integrated Interfaces For 6.35, 6.46, And Maneuver DIPS
12588A		Recycle Oms Ignition Capability–STS–1
12600C		Integrated Msid For Uplink D&C, GN&C
12672C		JAN Sequence Mode Team Make Work–STS–1
12681		Initialization Of Mass–STS–2
12689B		Commanded Body Attitude–STS–1
12701		Integrated Manual Guidance/Throttling–STS–1
12719		RTLs Turnaround Prediction Modification–STS–1
12744		VU Thrust Body Geometry–STS–1
12745		Deletion Of OMS/OMS Interconnect S/W–STS–1
12781A		Vehicle Oms Trim–STS–1
12862A		Clarifications To Variable Iy–STS–2
12899A		Ascent FCS FSSR Cleanup
12924A		Cleanup To CR 12588A
12938A		XXXXXX TRAJ IDD
12948		Addition Of Automatic Maneuver–STS–7

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
12993		I-Loads
12994		I-Loads
19031C		Correction Of Interface Discrepancies
19038		I-Loads
19054		I-Loads
19066B		Correct And Define MECO
19072A		Comm Fault Addition
19097A		Addition To M PAD I-Load
19100		FSSR Update
19101A		I-Load Corrections For Ascent FCS
19103A		Abort Cont Sequence
19144		Position Constraint Release
19145A		Manual PRTLs Corrections
19164A		I-Load Value Updates For CYC 2 S/W Build (Ref Only)
19169		M PAD I-Load Cycle 2 Update
19198		Cleanup OMS Recycle
19286A		Desensitizing RTLS THROT To RCS Null Jet Firings
19300		FSSR Update No. 2
19379		Clarification Of Uplink Target Constraints
19385		JSC I/L DISCREP To Rockwell I-Load For Bk 2
19385		JSC I-Load Discrepancy (Ref Only)
19386A		DEL Of Multiple Defined I-Load Parameters
19405A		GUID/UPP Use Of Flight Path Angle
19408B		RTLS GUID/UPP Use Of Flight Path Angle STS-7
19425		Peg Engine Failure Compensation Logic Update
19452B		I-Load Corrections Necessary For 3/19 Release
19455		Measurement Attribute Corrections
19467B		I-Load Corrections To IDB NO. 3
19487		Abort Targeting After Engine Failure
19500		FSSR Update No. 3
19550		DOC Change To Reflect CR 19220A
19552		Cyclic Update Of Vehicle WT And PRPLT On MNVR Display (STS-2)
19553C		Crew Override OV OMS Targets Via Item Entry (STS-2)
19560A		I-Load Updates As A Result Of IBM Testing
19678		OMS Guidance/RM Cleanup
19694A		Delete Entry PREC PRED From OPS-1 And 6 S/W (ASC GUID)
19696		Deletion Of PEG Thrust Phase I-Load

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
19707		FSSR Cleanup To Powered RTLS Guid Seq Replaces CR's 19327 And 19328
19712		Corrections To I-Load Data Tape For FSW/CPDS
19872A		TVR-ROLL I-Load And Formulation Changes-STS-2
19888		I-Load Change To Fix CR 19101A-STS-1
19899		DOC Change To ASC GRID RTLS CNTG ABT TSK-STS-1
19950A		AOA Shallow Target I-Load-STS-1
19958A		ASC Flight Control Documentation Cleanup-STS-1
19970		LEV C GN&C GRID ASC/RTLS (PART A)-STS-2
29005B		Auto ADS/NAVDAD Switch By Altitude-STS-2
29022		Reductions Of LOX Residuals For Engine Out Low Level Shutdowns-STS-2
29071		STS-1 Connections To Oms Evaluation Constrain Logic
29072		Clarify Variable Iy Targeting Requirements-STS-2
29131B		MOD OF CR 19553C To Reduce The Number Of Target Set (STS-2)
29142B		M-Load Update No. 4 For STS-1, Cycle 3
29149B		Add Program Interrupt Handling To Level A CPDS
29162A		I-Load Changes Resulting From "OWNER AUDIT"
29263A		Correction To CR 29022 (STS-2)
29269		Clarify And Complete I/L Requirements Authorized By CR 12521 (STS-2)
29300A		FSSR Update 6
29316		Clarify Reqmts On When the MPS GUID Cutoff Task is Terminated in MM 102 And MM 601 (STS-1)
29396A		I/L Changes For Arming Low Level Sensors (Ref Only)
29407C		MNV EXEC DISP PFS 18/BFS 12-STS-3
29441A		Manual Throttle - RTLS-STS-2
29471B		HFE Overrun Definition
29500		FSSR Update 7
29502		ATT Hold After SRB SEP (Ref Only)
29559A		GUID VEL Vector Precision Corrections
29602A		Make PFG I-Loads Constants
29650A		CR Implement Baseline May 1980 (Report 1037)
29657C		STS-1 Cycle 3.1.1 MPAD I/L
29660A		Cleanup Veh Mass Update
29694B		STS-1 Cycle 3.1.1 MPAD Abort I-Loads
29726		Maneuver DIP GUID I/L Cleanup
29752		Uplink Documentation Cleanup
29777		I/L Crew Override OMS TGTS
29900		Change Value Of DT_MAX

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
29908B		3.1.1 I-Load Changes For RTLS Profile
29938		STS-1 Cycle 3.2.2 AOA To EDW
29974		FSSR Cleanup AOA/ATO Target
29976A		OPS 3 Mass Initialization (Ref Only)
39085		1ST Stage SSME Out Prof I/L'S
39097		Cycle 3.3.2 OMS TGT And RELQUAT (Ref Only)
39099A		Eliminate VEL Extrapolation
39102		N_OMS Initialization In AOA
39106A		Cycle 3.3.2 OMS TGT Abort
39114		Cycle 3.3.2 Mass Changes
39121		STS-1 Cycle 3.3.2 AOA To Edwards I-Load
39132C		Create Secondary Throttle Set
39135A		Delete I-Load NMAX_BRURN
39173		I/L Discrepancy Clean Up (Ref Only)
39184E		STS-2 Cycle 1 MPAD I-Loads (Ref Only)
39192A		Cycle 3.3.3 I-Loads (Ref Only)
39218A		Cycle 3.3.3 MPAD I/L-Abort (Ref Only)
39225A		MPS Low Level Arm
39280A		STS-2 Cycle 1 NOM ASC And E/O
39300B		PRTLS GUID Runway Designate
39311		RTLS Guidance Corrections
39323A		STS-2 Cycle 1 MPAD Abort I/L
39336		STS-2 Cycle 1 MSID Correction (Ref Only)
39348		Update BFS I/L Data Base (Ref Only)
39353B		RTLS Fuel Dissipation MOD
39390A		PRE-MECO OMS Dump-ATO Abort
39400		FSSR Update #10/R18 and #1/R19
39401A		Transatlantic Abort Landing (TAL STS-3)
39467A		DR Closeout-DOC Cleanup
39472A		STS-2 Cycle 1 AOA TO EDW-GUID (superseded by CR 39530F)
39530F		STS-2 Cycle 2 I-Loads (Ref Only)
39569		STS-2 Cycle 2 AOA To NOR (Ref Only)
39595A		CR Implementation Baseline-August, 1981
39601		STS-3 Cycle Ascent 2 And Abort (STS-3, Ref Only)
39604B		STS-3 Cycle 2 AOA To NOR-GUID (STS-3; Ref Only)
39640		FSSR Update #11/R18 and #2/R19
39653A		TAL Guidance Corrections (STS-3)

Table R.2-1. Historical Change Request Summary

CR No.		CR Title
39658E		STS-4 Cycle 1 MPAD I-Loads (STS 4; Ref Only)
39697B		STS-2 CY 3 NOM-Season Update (Ref Only)
39698		STS-2 CY 3 ABT Season Update (Ref Only)
39710A		STS-4 Cycle 1 MPAD I-Loads (STS-4; Ref Only)
39778A		Reinstate RADIUS_NEP I/L (Ref Only)
39790A		CR Implementation Baseline-Nov., 1981
39803C		Launch Delay Window
39904		RADIUS_NEP I-Load To I-COMMON (STS-5; Ref)
39920A		STS-3 Cycle 3-Seasonal Update (Ref Only)
39927		STS-3 Cycle 3 Nominal Ascent (Ref Only)
39935		STS-3 Cycle 3 Ascent Abort (Ref Only)
39939		MPS Low Level Sensor Arm (STS-3; Ref Only)
39950		FSSR Update 12 (R18) (Ref Only)
39966		Make DT_FCD A Constant
39980A		CR Implementation Baseline-Feb., 1982
39988F		STS-5 Cycle 3 DES/ENT I-Loads (STS-5; Ref)
39990E		STS-5 Cycle 3 ASC I-Loads (STS-5; Ref)
59015		STS-4 Cycle 3 Nominal Seasonal Update (Ref Only)
59016D		STS-5 CY 3 Ascent Abort (STS-5; Ref)
59020A		RD_RTLS Change For STS-4 (Ref Only)
59024		STS-4 Cycle 3 Engine Out Seasonal Update (Ref Only)
59025A		STS-4 Cycle 3 AS/ABORT IL Update (Ref Only)
59043E		STS-6 Cycle 2 NAV/ENT I-Loads (STS-6 ONLY; Ref)
59050		FSSR Update 13 (R18) (Ref Only)
59055		Downlist R&D CMB B
59059F		STS-6 CY 2 NOM ASC I-Loads (STS-6 ONLY; Ref)
59064A		STS-4 Cycle 5 NOM ASC Update (Ref Only)
59082A		STS-4 Cycle 5 ENG OUT I-Loads (Ref Only)
59086A		STS-6 CY 2 ASC CAT II/III I-Loads (STS-6 ONLY; Ref)
59095A		1ST Stage Engine Out Guidance (STS-8)
59097		RTLS GUID CMD Throttle Corr (STS-5)
59108B		PEG Prediction Corrections
59111A		Correct STS-5 Cycle 3 I-Loads (STS-5; Ref)
59117C		ASC GUID On-Board Cues
59125A		RD RTLS Change For STS-5 (STS-5 Only; Ref)
59126H		RCS XFEED MCA Optimization
59128		STS-4 Cycle 5 TAL To DAKAR (Ref)

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
59131B		STS-6 Cycle 2 Ascent Abort (STS-6 Only; Ref)
59146		STS-5 Cycle 4 SSME Tailoff (STS-5; Ref)
59150		STS-4 Mass I-Load Update (Ref)
59161A		STS-5 Cycle 4 TAL To DAKAR-GUID (STS-5; Ref)
59220B		CR Implementation Baseline-July, 1982
59228		X_NEP I-Load For OPS 3 (Ref Only)
59253B		Correction To 39803C (IDD Only)
59261		STS-5 CY 5 Ascent/Abort IL (STS-5 Only)
59267C		Adaptive First Stage Guidance
59273C		ABT CONT SEQ-Select Intercnct
59277A		STS-6 I-Load Update For RTLS (STS-6 Only)
59279A		SSME Pitch Parallel 2ND Stage (STS-8)
59322		SSME-Out Safing Task (STS-5)
59362A		Terminate Precise Predictor (IDD Only)
59375A		CR Implementation Baseline, Sept, 1982
59379D		TAL Onboard IY Calculation
59450		FSSR Update No. 7 (Ref Only)
59458A		ASC Flight Design-Summer (STS-8 IL Ref Only)
59522C		I-Load Dependency Change (IL STS-7 Ref Only)
59553B		Guidance Reinitialization
59631		STS-9 CY 1 ASC Abort I-Loads (Ref Only)
59650C		CR Implementantation Baseline - March 1983
59721		Mass Threshold Test In OPS-1
59748		Correct CR 59117-ASC GUID CUE
59750		FSSR Update 2
59751		Update MNVR Data At Disp Rate
59865A		RTLS MBO Calculation
69001		1STG AGT Capability Improvement
69021		STS-8 MPS Throttle SW CMD Chg (I-Loads Only)
69022F		Centaur Abort Dump
69036		Correction To CR 69021 (Ref Only)
69070		FSSR Update
69088		STS 9.3 Option B Ascent I-Loads (Only)
69114		STS 9.3 A To Dump I-Loads (Only)
69237A		STS-13.1 Ascent I-Load Updates
69555A		TAL/RTLS Weather Alternate
69600D		OMS Guidance Improvements (3)

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
69691		STS-51B CYC 1 Ascent/Abort I/L'S
69738A		A2T Category Update
69773D		Doc Cleanup Of CR 29886C
69866		41D(R) Ascent/Abort I/L'S
69877I		TAL/RTLS Weather Alternate Cleanup
69904A		PEG Prediction Correct Updates
69978A		51-D Cycle 1 Ascent/Abort IL'S
69979		51-D I/L For WX ALT To Moron
79019		51-E I/L For WX ALT To Moron
79033		51A 67% Throttle I/L'S
79041		51B I/L For WX ALT To MORON
79042		51B Cycle 2 Ascent/Abort I/L'S
79048A		51F Cycle 1 Ascent/Abort I/L'S
79050		STS-51F I/L For WX ALT To Moron
79091		51G I/L For WX ALT To Moron
79092A		51G Cycle 1 Ascent/Abort I/L'S
79181B		TL Cycle 1 Ascent/Abort I/L'S
79208		STS-TL.1 PRTLS I/L Occurrence
79247		51G Cycle 2 Ascent/Abort I/L'S
79275C		51-I Cycle 1 Ascent/Abort I/L'S
79280A		51-B Cycle 3 Ascent/Abort I/L'S
79281		51-B I/L For WX ALT To MORON
79288		51-B ATO Pump I/L Occurrence
79298E		Lash-Up Requirements 59273C, 69635B
79328		51-D Cycle 3 Ascent/Abort I/L'S
79366		STS-61A Cycle 1 I-Load WX ALT
79385		51-B AGT Throttle I/L Occurrence
79499		FSSR Update
79645A		Centaur/RTLS GUID V_EX COMP
79646D		Auto-Loft, First-Stage Contingency
79705		Ascent HSI Oscillation Corr
79740		FSSR Doc Changes For OI-07
79790		CR Implementation Baseline-Nov 1985
89121C		Errata STS 83-0002A
89140E		Centaur Requirements Deletion
89150H		Abort Control Sequence Scrub
89219B		Auto-Loft, First Stage Contingency Cleanup

Table R.2-1. Historical Change Request Summary

CR No.		CR Title
89245D		Post MECO TAL Declaration
89250B		Bailout Control System
89253D		Late TAL Guidance Enhancements
89301C		Clarification of MM 603 and MM 305 Guidance Initiation Criteria
89332		AUTO-LOFT, Oscillation Correction
89393F	20	Low Thrust-to-Weight Guidance Improvement
89461A		FSSR STS 83-0002B OI-8B Errata/Baseline
89471E		Unique AOA Nav Filter Covariance
89474B		Auto NZ for Contingency Abort
89599C		Clean-up Level-B GN&C Document
89622A		I-Load Changes for STS 83-0003B
89632A		FSSR STS 83-0002B Errata
89655E		First Stage Guidance/Interps Redesign
89676C	20	Adaptive Guidance Enhancements
89677B	20	RTLS Powered Pitcharound Crew Display Parameter
89844B		Correct CR 89655E First Stage Guidance/Interps Redesign
89852A		Replace TGD with T_NAV_PREV in PF4.1
89872A		MPS Cutoff Task Requirements Clarification
89903B		Addition of Fuel Dissipation Reference to MM 601
89942		Restructure of One Shot Data Transfer
89990E	21	Single Engine Auto Contingency Abort
90000E	20	Abort Landing Area Upgrade
90007G	23	MPS Dump Enhancements
90011E	22	Second Stage Engine Out Trim Algorithm
90054A		Entry FCS Errata
90055A		Clean Up to Guidance/INTERPS CR 89655E
90076	20	Correction Page for CR90000E
90114B	21	Abort Sequencing Redesign
90119		OMS Guidance Document Cleanup
90120B		Update Guidance Downmode Requirements
90121B		Chg ASC Precise Predictor Terms-OPS Trans
90122E	22	TAL Droop Control
90221		Change TLAMC from MET to GMT
90243C	22	Second Stage Auto Recognition
90256D	23	Mission Independent First Stage I-Loads
90302B	22	Entry Downlist Additions
90329C	22	Guidance I-Loads to K-Loads

Table R.2-1. Historical Change Request Summary		
CR No.		CR Title
90353G	23	Transition Flight Control I-Load to K-Load Conversion
90366C	22	Single Engine Cntrl Improvements in MM103
90374C	20	Automated FSSR Constants
90476E	25	Wraparound Yaw Jet System w/PTI Effector
90516	22	Correct CR 90122: Call DROOP Control Task Only After Guidance Ready
90528A	22	EARTH_POLE Initialization
90550	22	Correct CR 90122: Inhibit PEG Steering when DROOP Control is Active
90576A	21	Cleanup of CR89990E: Single Engine Auto Contingency Abort
90608D	24	OI-22 Level C Guid Ascent/RTLS FSSR Documentation Clarification
90625A	22	Correct CR 90550: Set IZC Vector in PRTLS Guidance
90646C	24	Replace S_GDRDY With GUIDANCE_INITIATE on TLM
90650	23	Corrections to CR 90256D
90690A	24	Deletion of EQTN MSID Column from K-Load Tables
90699A	24	Clarify Functionalized AOA OMS-2 Target Calculations
90705H	25	3 Engines Out Auto Contingency
90781C	24	Define Parametric Data Nomenclature(s)
90790	24	Add Memory Configuration to the FSSR I-Load Tables
90814C	24	Add Description of Database Generated FSSR Parameter Tables
90827A	22	Initialize 3-Axis RHC SOP Detent and Softstop Parameters
90828A	22	Clarify Ascent Guidance Initiation in MM 103
90866A	23	Clarify PFG Input Initialization Requirements
90960E	25	HAC Initiation Predictor and Position Error Displays
90964	25	Interface Clarification for 3 Engines Out - CR 90705H
90966A	24	Deletion of the Qualifier from the FSSR I-Load Tables
91005B	23	OI-23 GN&C Doc Issues Cleanup
91036B	25	Corrections and Cleanup to CR 90705H: 3 Engines Out Auto Contingency
91066D	25	Standardize the FSSR Correlation Tables
91072D	24	OI-24 GN&C Doc Issues Cleanup
92027B	25	TDMS-2 Required FSSR Changes

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