79- FM-9

JSC-14585
MAR 1 2 1979

Shuttle OFT
Level C
Navigation Requirements

(NASA-TM-79950) SHUTTLE PROGRAM. SHUTTLE OFT LEVEL C: NAVIGATION REQUIREMENTS, ENTRY THROUGH LANDING (NASA) 887 p

N79-75327

Unclas
00/16 18761

Entry through Landing

Mission Planning and Analysis Division

February 1979

APR 1979
RECEIVED
NASA STI FACILITY
ACCESS DEPT.

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

78FM56

79-FM-9

JSC-14585

SHUTTLE PROGRAM

SHUTTLE OFT
LEVEL C

NAVIGATION REQUIREMENTS
ENTRY THROUGH LANDING

By Mathematical Physics Branch, JSC;
and McDonnell Douglas Technical Services Co.

Approved: _____
Emil R. Schiesser, Chief
Mathematical Physics Branch

Approved: _____
Ronald L. Berry, Chief
Mission Planning and Analysis Division

Mission Planning and Analysis Division

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Houston, Texas

February 1979

Document Change Record

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

Issue and date	Change Summary
Basic July 1976	This issue constitutes the navigation FSSR, entry through landing, and is the product of the June 1976 mode team meetings.
A Revision Sept 1976	This issue incorporates modifications resulting from the update No. 1 mode team of August 1976.
B Revision Dec 1976	This issue incorporates modifications resulting from the mode team meeting of September 1976 and constitutes the baseline for the entry through landing phase.
C Revision Oct 1977	This issue updates the baseline to include CR2565A and 12019.
D Revision Sept 1978	This issue updates the baseline to include the following CR's: 2166 2213 2265B 2433C 2463A 2510 12054B 12062A 12063 12087 12148 12174A 12177A 12190D 12191 12225B 12260A 12266A 12269 12285 12307 12308 12312 12316 12324 12325A 12328A 12336 12337 12338 12339 12349A 12353B 12402 12403A 12418B 12423A 12432A 12442A 12443 12456A 12499D 12507 12517 12551 12561A 12606A 12649 12696 12698A 12790 12826A 12873 12974

FOREWORD

This document supersedes all previous publications of the OFT Level C FSSR, Part B, Entry Navigation. It incorporates modifications resulting from approved change requests (CR's) through August 16, 1978. The CR's included are indicated on the preceding page.

CONTENTS

Section		Page
1.0	INTRODUCTION	1-1
1.1	PURPOSE AND SCOPE	1-1
1.2	ORGANIZATION	1-1
2.0	APPLICABLE DOCUMENTS	2-1
3.0	OVERVIEW	3-1
3.1	SOFTWARE LEVEL REQUIREMENTS	3-1
3.2	GN&C SOFTWARE FUNCTIONS	3-1
3.3	NAVIGATION SYSTEM OVERVIEW	3-1
3.3.1	Navigation Functions	3-2
3.3.2	Navigation-Related Functions	3-4
3.3.3	General Requirements	3-5
3.3.4	Requirements and Assumptions Overview	3-6
3.3.4.1	Requirements	3-6
3.3.4.2	Assumptions	3-7
3.4	TRACEABILITY	3-10
3.5	OPS-3 OPERATION SEQUENCE MAJOR MODES	3-10
3.6	IMPLEMENTATION CONSTRAINTS	3-11
3.6.1	Floating Point Overflow	3-11
3.6.2	Floating Point Underflow	3-11
3.6.3	Divide by Zero	3-11
3.6.4	Square Root	3-11
3.6.5	Arc Sine	3-12
3.6.6	Arc Cosine	3-12
3.6.7	Arc Tangent	3-12
3.6.8	Logarithm	3-12
3.6.9	Sine and Cosine	3-12
4.0	DETAIL LEVEL REQUIREMENTS	4-1
4.1	NAVIGATION AND USER PARAMETER SEQUENCER PRINCIPAL FUNCTIONS	4.1-1
4.1.1	Deorbit/Landing Navigation Sequencer	4.1.1-1
4.1.2	Deorbit/Landing User Parameter Processing Sequencer	4.1.2-1

Section		Page
4.2	SUBFUNCTIONS COMMON TO SEVERAL NAVIGATION PRINCIPAL FUNCTIONS	4.2-1
4.2.1	State Propagation	4.2.1-1
4.2.1.1	IMU Data Snap	4.2.1.1-1
4.2.1.2	Acceleration Models	4.2.1.2-1
4.2.1.2.1	Gravity	4.2.1.2.1-1
4.2.1.2.2	Drag	4.2.1.2.2-1
4.2.1.3	Integration of State Equations of Motion	4.2.1.3-1
4.2.2	Covariance Matrix Propagation	4.2.2-1
4.2.3	State Vector Interpolation	4.2.3-1
4.2.4	State and Covariance Measurement Incorporation (Kalman Filter)	4.2.4-1
4.2.5	Vector Selector	4.2.5-1
4.2.6	Delta State Update	4.2.6-1
4.2.7	Measurement Residuals and Partials	4.2.7-1
4.2.7.1	TACAN Range Residuals and Partials	4.2.7.1-1
4.2.7.2	TACAN Bearing Residuals and Partials	4.2.7.2-1
4.2.7.3	Barometric Altimeter Residual and Partials	4.2.7.3-1
4.2.8	Measurement Processing Statistics	4.2.8-1
4.2.8.1	Sensors Status	4.2.8.1-1
4.2.8.2	Measurement Statistics	4.2.8.2-1
4.2.9	Covariance Matrix Initialization	4.2.9-1
4.2.10	User Parameter Propagator Reset	4.2.10-1
4.3	NAVIGATION PROCESSING PRINCIPAL FUNCTIONS	4.3-1
4.3.1	Entry Navigation	4.3.1-1
4.3.1.1	Entry Control	4.3.1.1-1
4.3.1.2	External Sensor Data Snap	4.3.1.2-1
4.3.1.3	Sensor Measurement Selection	4.3.1.3-1
4.3.1.4	Entry Navigation Reconfiguration	4.3.1.4-1
4.3.1.4.1	Measurement reconfiguration	4.3.1.4.1-1
4.3.1.4.2	Delta state update	4.3.1.4.2-1
4.3.1.4.3	Whole vector update	4.3.1.4.3-1
4.3.1.5	State Propagation	4.3.1.5-1
4.3.1.6	Covariance Propagation	4.3.1.6-1
4.3.1.7	State and Covariance Measurement Incorporation	4.3.1.7-1

Section		Page
4.3.1.7.1	Drag altitude	4.3.1.7.1-1
4.3.1.7.2	TACAN range	4.3.1.7.2-1
4.3.1.7.3	TACAN bearing	4.3.1.7.3-1
4.3.1.7.4	Barometric altimeter	4.3.1.7.4-1
4.3.1.8	Measurement Processing Statistics	4.3.1.8-1
4.3.2	Preland Navigation	4.3.2-1
4.3.2.1	Preland Control	4.3.2.1-1
4.3.2.2	External Sensor Data Snap	4.3.2.2-1
4.3.2.3	Sensor Measurement Selection	4.3.2.3-1
4.3.2.4	Preland Navigation Reconfiguration	4.3.2.4-1
4.3.2.4.1	Measurement reconfiguration	4.3.2.4.1-1
4.3.2.4.2	Delta state update	4.3.2.4.2-1
4.3.2.5	State Propagation	4.3.2.5-1
4.3.2.6	Covariance Propagation	4.3.2.6-1
4.3.2.7	State and Covariance Measurement Incorporation	4.3.2.7-1
4.3.2.7.1	TACAN range	4.3.2.7.1-1
4.3.2.7.2	TACAN bearing	4.3.2.7.2-1
4.3.2.7.3	Barometric altimeter	4.3.2.7.3-1
4.3.2.7.4	MSBLS range	4.3.2.7.4-1
4.3.2.7.5	MSBLS azimuth	4.3.2.7.5-1
4.3.2.7.6	MSBLS elevation	4.3.2.7.6-1
4.3.2.8	Measurement Processing Statistics	4.3.2.8-1
4.4	SUBFUNCTIONS COMMON TO SEVERAL NAVIGATION-RELATED PRINCIPAL FUNCTIONS	4.4-1
4.4.1	User Parameter State Propagation	4.4.1-1
4.4.2	Entry/TAEM/Autoland Guidance Parameters	4.4.2-1
4.4.3	Coordinate Transformations	4.4.3-1
4.4.3.1	Transformation From Aries Mean of 1950 to Earth-Fixed	4.4.3.1-1
4.4.3.2	Earth-Fixed to M50	4.4.3.2-1
4.4.3.3	Geodetic to Earth-Fixed	4.4.3.3-1
4.4.3.4	Earth-Fixed to Topodetic	4.4.3.4-1
4.4.3.5	Earth-Fixed to Runway	4.4.3.5-1
4.4.3.6	Earth-Fixed to Scanner	4.4.3.6-1
4.4.3.7	Body to M50	4.4.3.7-1
4.4.3.8	Earth-Fixed to Geodetic	4.4.3.8-1
4.4.3.9	UVW to M50	4.4.3.9-1
4.4.4	TACAN Display Computations	4.4.4-1
4.4.5	Utility Subfunctions	4.4.5-1

Section		Page
4.4.5.1	Altitude Above the Reference Ellipsoid	4.4.5.1-1
4.4.5.2	Velocity Relative to the Windless, Rotating Atmosphere	4.4.5.2-1
4.4.5.3	Partial Derivatives of an Angular Measurement With Respect to the State Vector	4.4.5.3-1
4.4.5.4	Derivative of the Gravitational Acceleration Vector With Respect to the Position Vector	4.4.5.4-1
4.5	GENERAL REQUIREMENT PRINCIPAL FUNCTIONS	4.5-1
4.5.1	Entry Precise Predictor	4.5.1-1
4.5.2	Entry Site Lookup	4.5.2-1
4.5.2.1	Entry Runway/MSBLS Site Lookup	4.5.2.1-1
4.5.2.2	Entry TACAN Site Lookup	4.5.2.2-1
4.5.2.3	Entry Site Lookup Initialization	4.5.2.3-1
4.5.3	Entry Auto TACAN Selection	4.5.3-1
4.6	USER PARAMETER PROCESSING PRINCIPAL FUNCTIONS	4.6-1
4.6.1	Entry User Parameter Processing	4.6.1-1
4.6.1.1	User Parameter State Propagation	4.6.1.1-1
4.6.1.2	Basic Guidance-Related Computations	4.6.1.2-1
4.6.1.3	Guidance and Displays Way Point Computations	4.6.1.3-1
4.6.1.4	TACAN Display Computations	4.6.1.4-1
4.6.1.5	Earth-Fixed Coordinate System Computations	4.6.1.5-1
4.6.2	TAEM User Parameter Processing	4.6.2-1
4.6.2.1	User Parameter State Propagation	4.6.2.1-1
4.6.2.2	Basic Guidance-Related Computations	4.6.2.2-1
4.6.2.3	TACAN Display Computations	4.6.2.3-1
4.6.3	Autoland User Parameter Processing	4.6.3-1
4.6.3.1	User Parameter State Propagation	4.6.3.1-1
4.6.3.2	Basic Guidance-Related Computations	4.6.3.2-1
4.6.3.3	TACAN Display Computations	4.6.3.3-1
4.7	ENTRY AREA NAVIGATION PRINCIPAL FUNCTION	4.7-1
4.8	SPECIALIST FUNCTIONS NAVIGATION SUPPORT FORMULATIONS (RUNWAY REDESIGNATION)	4.8-1
4.9	INITIALIZATION FOR OPS-3 NAVIGATION PARAMETERS	4.9-1
4.9.1	Constants	4.9.1-1
4.9.2	Mission Dependent Parameters	4.9.2-1

Section		Page
4.9.3	Design Dependent Parameters	4.9.3-1
4.9.4	Hard Codeable Parameters	4.9.4-1
4.10	DOWNLIST REQUIREMENTS	4.10-1
4.11	UPLINK REQUIREMENTS	4.11-1
4.11.1	Delta State Vector Update	4.11.1-1
4.11.2	Orbiter State Vector Update	4.11.2-1
4.11.3	Entry Site Lookup Data Uplink	4.11.3-1
4.11.3.1	Deorbit Landing Site Parameters Load	4.11.3.1-1
4.11.3.2	Deorbit TACAN Site Parameters Load	4.11.3.2-1
APPENDIX A -	VARIABLES LIST	A-1
APPENDIX B -	NAVIGATION SEQUENCER PRINCIPAL FUNCTION AND NAVIGATION PRINCIPAL FUNCTIONS FLOW CHARTS	B-1
APPENDIX C -	GENERAL REQUIRMENT PRINCIPAL FUNCTIONS AND COORDINATE TRANSFORMATIONS FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS	C-1
APPENDIX D -	AREA NAVIGATION FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS	D-1
APPENDIX E -	SPECIALIST FUNCTIONS NAVIGATION SUPPORT FORMULATIONS FLOW CHARTS AND VARIABLE NAMES DESCRIPTIONS	E-1
APPENDIX F -	USER PARAMETER FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS	F-1
APPENDIX G -	PRINCIPAL FUNCTION INTERFACE REQUIREMENTS	G-1
APPENDIX H -	OFT-1 CHANGE PAGES	H-1

TABLES

Table		Page
1.3-1	SYMBOLS USED IN INPUT/OUTPUT/CONSTANTS TABLES	1-1
3.4-1	SOFTWARE REQUIREMENT TRACEABILITY	3-10
3.5-1	OPS-3 OPERATION SEQUENCE MAJOR MODES	3-11
4.1.1-1	OPS-3 LEVEL B EVENTS	4.1.1-8
4.1.1-2	DEORBIT/LANDING NAVIGATION SEQUENCER INPUT PARAMETERS	4.1.1-10
4.1.1-3	DEORBIT/LANDING NAVIGATION SEQUENCER OUTPUT PARAMETERS	4.1.1-14
4.1.2-1	EVENT FLAG INPUTS FOR THE DEORBIT/LANDING USER PARAMETER PROCESSING SEQUENCER	4.1.2-3
4.3.1.1-1	ENTRY CONTROL INPUT PARAMETERS	4.3.1.1-4
4.3.1.1-2	ENTRY CONTROL OUTPUT PARAMETERS	4.3.1.1-7
4.3.1.2-1	ENTRY EXTERNAL SENSOR DATA SNAP INPUT PARAMETERS . .	4.3.1.2-3
4.3.1.2-2	ENTRY EXTERNAL SENSOR DATA SNAP OUTPUT PARAMETERS . .	4.3.1.2-5
4.3.1.3-1	ENTRY SENSOR MEASUREMENT SELECTION INPUT PARAMETERS	4.3.1.3-4
4.3.1.3-2	ENTRY SENSOR MEASUREMENT SELECTION OUTPUT PARAMETERS	4.3.1.3-6
4.3.1.3-3	TACAN SELECTION	4.3.1.3-8
4.3.1.3-4	BARO-DRAG SELECTION	4.3.1.3-9
4.3.1.4.1-1	ENTRY MEASUREMENT RECONFIGURATION INPUT PARAMETERS	4.3.1.4.1-3
4.3.1.4.1-2	ENTRY MEASUREMENT RECONFIGURATION OUTPUT PARAMETERS	4.3.1.4.1-4
4.3.1.4.2-1	ENTRY DELTA STATE UPDATE INPUT PARAMETERS	4.3.1.4.2-2
4.3.1.4.2-2	ENTRY DELTA STATE UPDATE OUTPUT PARAMETERS	4.3.1.4.2-4
4.3.1.4.3-1	WHOLE VECTOR UPDATE INPUT PARAMETERS	4.3.1.4.3-4
4.3.1.4.3-2	WHOLE VECTOR UPDATE OUTPUT PARAMETERS	4.3.1.4.3-6

Table		Page
4.3.1.5-1	ENTRY STATE PROPAGATION INPUT PARAMETERS	4.3.1.5-4
4.3.1.5-2	ENTRY STATE PROPAGATION OUTPUT PARAMETERS	4.3.1.5-8
4.3.1.6-1	ENTRY COVARIANCE MATRIX PROPAGATION INPUT PARAMETERS	4.3.1.6-2
4.3.1.6-2	ENTRY COVARIANCE MATRIX PROPAGATION OUTPUT PARAMETERS	4.3.1.6-4
4.3.1.7-1	ENTRY MEASUREMENT INCORPORATION INPUT PARAMETERS	4.3.1.7-3
4.3.1.7-2	ENTRY MEASUREMENT INCORPORATION OUTPUT PARAMETERS	4.3.1.7-6
4.3.1.7.1-1	DRAG MEASUREMENT INPUT PARAMETERS	4.3.1.7.1-4
4.3.1.7.1-2	DRAG MEASUREMENT OUTPUT PARAMETERS	4.3.1.7.1-8
4.3.1.7.2-1	TACAN RANGE MEASUREMENT SUBFUNCTION INPUT PARAMETERS	4.3.1.7.2-3
4.3.1.7.2-2	TACAN RANGE MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS	4.3.1.7.2-8
4.3.1.7.3-1	TACAN BEARING MEASUREMENT SUBFUNCTION INPUT PARAMETERS	4.3.1.7.3-3
4.3.1.7.3-2	TACAN BEARING MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS	4.3.1.7.3-8
4.3.1.7.4-1	BAROMETRIC ALTIMETER INPUT PARAMETERS	4.3.1.7.4-3
4.3.1.7.4-2	BAROMETRIC ALTIMETER OUTPUT PARAMETERS	4.3.1.7.4-7
4.3.1.8-1	ENTRY MEASUREMENT PROCESSING STATISTICS INPUT PARAMETERS	4.3.1.8-2
4.3.1.8-2	ENTRY MEASUREMENT PROCESSING STATISTICS OUTPUT PARAMETERS	4.3.1.8-6
4.3.2.1-1	PRELAND CONTROL INPUT PARAMETERS	4.3.2.1-3
4.3.2.1-2	PRELAND CONTROL OUTPUT PARAMETERS	4.3.2.1-5
4.3.2.2-1	PRELAND EXTERNAL SENSOR DATA SNAP INPUT PARAMETERS	4.3.2.2-3

Table		Page
4.3.2.2-2	PRELAND EXTERNAL SENSOR DATA SNAP OUTPUT PARAMETERS	4.3.2.2-6
4.3.2.3-1	MSBLS VERSUS TACAN	4.3.2.3-3
4.3.2.3-2	BAROMETRIC ALTIMETER	4.3.2.3-3
4.3.2.3-3	PRELAND SENSOR MEASUREMENT SELECTION INPUT PARAMETERS	4.3.2.3-5
4.3.2.3-4	PRELAND SENSOR MEASUREMENT SELECTION OUTPUT PARAMETERS	4.3.2.3-7
4.3.2.4.1-1	PRELAND MEASUREMENT RECONFIGURATION INPUT PARAMETERS	4.3.2.4.1-3
4.3.2.4.1-2	PRELAND MEASUREMENT RECONFIGURATION OUTPUT PARAMETERS	4.3.2.4.1-4
4.3.2.4.2-1	DELTA STATE UPDATE INPUT PARAMETERS	4.3.2.4.2-2
4.3.2.4.2-2	DELTA STATE UPDATE OUTPUT PARAMETERS	4.3.2.4.2-4
4.3.2.5-1	PRELAND STATE PROPAGATION INPUT PARAMETERS	4.3.2.5-3
4.3.2.5-2	PRELAND STATE PROPAGATION OUTPUT PARAMETERS	4.3.2.5-5
4.3.2.6-1	PRELAND COVARIANCE MATRIX PROPAGATION INPUT PARAMETERS	4.3.2.6-2
4.3.2.6-2	PRELAND COVARIANCE MATRIX PROPAGATION OUTPUT PARAMETERS	4.3.2.6-4
4.3.2.7-1	PRELAND STATE AND COVARIANCE MEASUREMENT INCORPORATION INPUTS	4.3.2.7-3
4.3.2.7-2	PRELAND STATE AND COVARIANCE MEASUREMENT INCORPORATION OUTPUTS	4.3.2.7-5
4.3.2.7.1-1	TACAN RANGE MEASUREMENT SUBFUNCTION INPUT PARAMETERS	4.3.2.7.1-3
4.3.2.7.1-2	TACAN RANGE MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS	4.3.2.7.1-7
4.3.2.7.2-1	TACAN BEARING MEASUREMENT SUBFUNCTION INPUT PARAMETERS	4.3.2.7.2-3
4.3.2.7.2-2	TACAN BEARING MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS	4.3.2.7.2-7

Table | Page

4.3.2.7.3-1 BAROMETRIC ALTIMETER INPUT PARAMETERS 4.3.2.7.3-2

4.3.2.7.3-2 BAROMETRIC ALTIMETER OUTPUT PARAMETERS 4.3.2.7.3-5

4.3.2.7.4-1 MSBLS RANGE MEASUREMENT INPUT PARAMETERS 4.3.2.7.4-3

4.3.2.7.4-2 MSBLS RANGE MEASUREMENT OUTPUT PARAMETERS 4.3.2.7.4-5

4.3.2.7.5-1 MSBLS AZIMUTH MEASUREMENT INPUT PARAMETERS 4.3.2.7.5-3

4.3.2.7.5-2 MSBLS AZIMUTH MEASUREMENT OUTPUT PARAMETERS 4.3.2.7.5-5

4.3.2.7.6-1 MSBLS ELEVATION MEASUREMENT INPUT PARAMETERS 4.3.2.7.6-4

4.3.2.7.6-2 MSBLS ELEVATION MEASUREMENT OUTPUT VARIABLES 4.3.2.7.6-7

4.3.2.8-1 PRELAND MEASUREMENT PROCESSING STATISTICS INPUT PARAMETERS 4.3.2.8-2

4.3.2.8-2 PRELAND MEASUREMENT PROCESSING STATISTICS OUTPUT PARAMETERS 4.3.2.8-7

4.4.3-1 COORDINATE TRANSFORMATIONS INPUT PARAMETERS 4.4.3-2

4.4.3-2 COORDINATE TRANSFORMATIONS OUTPUT PARAMETERS 4.4.3-5

4.4.5-1 UTILITY SUBFUNCTIONS INPUT PARAMETERS 4.4.5-2

4.4.5-2 UTILITY SUBFUNCTIONS OUTPUT PARAMETERS 4.4.5-3

4.5.1-1 ENTRY PRECISE PREDICTOR INPUT PARAMETERS 4.5.1-5

4.5.1-2 ENTRY PRECISE PREDICTOR OUTPUT PARAMETERS 4.5.1-6

4.5.2.1-1 ENTRY RUNWAY/MSBLS SITE LOOKUP INPUT PARAMETERS 4.5.2.1-4

4.5.2.1-2 ENTRY RUNWAY/MSBLS SITE LOOKUP OUTPUT PARAMETERS 4.5.2.1-10

4.5.2.2-1 ENTRY TACAN SITE LOOKUP INPUT PARAMETERS 4.5.2.2-3

4.5.2.2-2 ENTRY TACAN SITE LOOKUP OUTPUT PARAMETERS 4.5.2.2-5

4.5.2.3-1 ENTRY SITE LOOKUP INITIALIZATION INPUT PARAMETERS 4.5.2.3-3

4.5.2.3-2 ENTRY SITE LOOKUP INITIALIZATION OUTPUT PARAMETERS 4.5.2.3-5

Table		Page
4.5.3-1	OUTPUT VALUE DETERMINATION FOR AUTO_CHANNEL_ID IN MIDDLE REGION	4.5.3-4
4.5.3-2	ENTRY AUTO TACAN SELECTION INPUT PARAMETERS	4.5.3-5
4.5.3-3	ENTRY AUTO TACAN SELECTION OUTPUT PARAMETERS	4.5.3-6
4.6.1	TAEM USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM	4.6.1-2
4.6.1.1-1	ENTRY USER PARAMETER STATE PROPAGATION INPUT PARAMETERS	4.6.1.1-2
4.6.1.1-2	ENTRY USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS	4.6.1.1-3
4.6.1.2-1	INPUT PARAMETERS FOR ENTRY BASIC GUIDANCE-RELATED COMPUTATIONS	4.6.1.2-2
4.6.1.2-2	OUTPUTS FROM ENTRY BASIC GUIDANCE-RELATED COMPUTATIONS	4.6.1.2-4
4.6.1.3-1	INPUT FOR ENTRY GUIDANCE AND DISPLAYS WAY POINT COMPUTATIONS	4.6.1.3-5
4.6.1.3-2	OUTPUT FOR ENTRY GUIDANCE AND DISPLAYS WAY POINT COMPUTATIONS	4.6.1.3-7
4.6.1.4-1	TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS	4.6.1.4-2
4.6.1.4-2	TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS	4.6.1.4-4
4.6.1.5-1	INPUT PARAMETERS FOR EARTH-FIXED COORDINATE SYSTEM COMPUTATIONS	4.6.1.5-2
4.6.1.5-2	OUTPUT PARAMETERS FOR EARTH-FIXED COORDINATE SYSTEM COMPUTATIONS	4.6.1.5-3
4.6.2	TAEM USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM	4.6.2-2
4.6.2.1-1	TAEM USER PARAMETER STATE PROPAGATION INPUT PARAMETERS	4.6.2.1-2
4.6.2.1-2	TAEM USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS	4.6.2.1-3
4.6.2.2-1	INPUT PARAMETERS FOR BASIC TAEM GUIDANCE-RELATED COMPUTATIONS	4.6.2.2-2

Table		Page
4.6.2.2-2	OUTPUT PARAMETERS FROM BASIC TAEM GUIDANCE-RELATED COMPUTATIONS	4.6.2.2-5
4.6.2.3-1	TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS	4.6.2.3-2
4.6.2.3-2	TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS	4.6.2.3-4
4.6.3	AUTOLAND USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM	4.6.3-2
4.6.3.1-1	AUTOLAND USER PARAMETER STATE PROPAGATION INPUT PARAMETERS	4.6.3.1-2
4.6.3.1-2	AUTOLAND USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS	4.6.3.1-4
4.6.3.2-1	INPUT PARAMETERS FOR BASIC AUTOLAND GUIDANCE-RELATED COMPUTATIONS	4.6.3.2-2
4.6.3.2-2	OUTPUTS FROM BASIC AUTOLAND GUIDANCE-RELATED COMPUTATIONS	4.6.3.2-6
4.6.3.3-1	TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS	4.6.3.3-2
4.6.3.3-2	TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS	4.6.3.3-4
4.7-1	HSI DISPLAY PARAMETER/MODE SWITCH MATRIX	4.7-24
4.7-2	CORRESPONDENCE OF ENTRY AREA NAVIGATION MISSION DEPENDENT PARAMETERS AND TAEM & A/L GUIDANCE (4.9 & 4.10) PARAMETERS	4.7-25
4.7-3	AREA NAVIGATION INPUT PARAMETERS	4.7-27
4.7-4	AREA NAVIGATION OUTPUT PARAMETERS	4.7-35
4.8-1	RUNWAY REDESIGNATE INPUT PARAMETERS	4.8-3
4.8-2	RUNWAY REDESIGNATE OUTPUT PARAMETERS	4.8-4
4.9.1-1	CONSTANTS	4.9.1-2
4.9.2-1	MISSION DEPENDENT PARAMETERS	4.9.2-2
4.9.3-1	DESIGN DEPENDENT PARAMETERS	4.9.3-2
4.9.4-1	HARD CODEABLE PARAMETERS	4.9.4-2

FIGURES

Figure		Page
4.7-1	Left-hand forward flight station	4.7-38
4.7-2	HSI display	4.7-39
4.7-3	Flightpath geometry plane	4.7-40
4.7-4	Flightpath geometry - vertical	4.7-41

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of the Entry Navigation Level C document is to present the detail level requirements for those navigation functions which are operative during the entry through landing portion of the orbital flight test (OFT). The navigation functions are those specified in the GN&C Level B OFT functional level requirements document, SS-P-0002-510I.

1.2 ORGANIZATION

The applicable documents are listed in Section 2. An overview of the navigation program is described in Section 3 and Section 4 presents the detail level requirements of the document. Each subsection of Section 4 which describes a principal function is structured as follows:

- Text
- Input parameter table
- Output parameter table

Table 1.3-1 lists the symbols used in the tables.

TABLE 1.3-1.- SYMBOLS USED IN INPUT/OUTPUT/ CONSTANTS TABLES

Symbol	Description
CHAR	Character string
D	Discrete
DIP	Display interface processor
DP	Double precision
F	Scalar, floating point
I	Integer
M	Matrix
S	Single precision
V	Vector

The tables which present the parameters for principal function interfaces are given in Appendix G.

2.0 APPLICABLE DOCUMENTS

Document no.	Originator	Title	Issue Date
JSC Internal Note No. 75-FM-80	NASA	Shuttle Program Postentry SDR Navigation Input to Level C OFT Navigation Functional Subsystem Software Requirements	December 4, 1975
SS-P-0002-510I		OFT Functional Level Requirements, GN&C	April 28, 1978
SS-P-0002-520		OFT Detail Level Requirements, GN&C	
SS-P-0002-530		OFT Functional Level Requirements, Systems Management	
SS-P-0002-540		OFT Detail Level Requirements, Systems Management	
SS-P-0002-550		OFT Functional Level Requirements, Vehicle Utility-02	
SS-P-0002-560		OFT Detail Level Requirements, Vehicle Utility-02	
SS-P-0002-570		OFT Functional Level Requirements, Payloads	
SS-P-0002-580		OFT Detail Level Requirements, Payloads	

3.0 OVERVIEW

3.1 SOFTWARE LEVEL REQUIREMENTS

For the orbital flight tests (OFT), the software requirements are specified at three levels: system Level (A), functional Level (B), and detail Level (C). In addition, the Level B and C requirements are presented in separate documents for the four major functions: guidance, navigation, and control (GN&C); system management (SM): vehicle utility (VU) and payloads (PL). This document is part of the GN&C Level C requirements.

3.2 GN&C SOFTWARE FUNCTIONS

The software for the GN&C major function is composed of the following functions:

- Guidance (GUID)
- Navigation (NAV)
- Flight Control (FC)
- Redundancy management/moding, sequencing, and control (RM/MSC)
- Subsystem operation programs (SOP)
- Displays and controls (D&C)
- Other

This document specifies the software detail level requirements for the navigation function during the entry operational sequence (OPS-3) phase of the flight.

3.3 NAVIGATION SYSTEM OVERVIEW

The basic function of the navigation system is to provide an estimate of the Orbiter state, based on either inertial measurement unit (IMU) only or IMU-NAVAID data.

3.3.1 Navigation Functions

In general, the navigation software requirements can be divided into two parts: part (a) navigation and part (b) user parameter processing. Part (a) is divided into the following six functions:

(1) Navigation Control. Performs the initialization of navigation function parameters and sets up the sequencing of functions to accomplish navigation requirements.

(2) Measurement Scheduler. Selects the appropriate sensor measurements in accordance with selection criteria.

(3) Data Handler. Prepares data for sensor measurement processing.

(4) Navigation Reconfiguration. Initializes state vector and covariance matrix for sensor measurement processing or manual updates and prepares site location data for changing sensor sites.

(5) Navigation State and Covariance Propagation. Propagates state vector with IMU data and covariance matrix by means of the state transition matrix for subsequent sensor measurement processing.

(6) Navigation State and Covariance Update. Determines and performs (by means of a Kalman filter scheme) state and covariance updates based on the measurements from barometric altimeter, TACAN, MSBLS and pseudo-altitude measurements derived from IMU data.

Part (b) is divided into the following two functions:

(1) User Parameter State Propagation. Propagates the state at a faster rate than Nav for user parameter calculations. The user parameter state is updated with the most recent Nav updated state.

(2) User Parameter Calculations. Computes state-related parameters for other GN&C functions.

In this document, the details of Part (a) are presented under three principal functions:

(1) Deorbit/Landing Navigation Sequencer (Section 4.1.1).

(2) Entry Navigation (Section 4.3.1) and

(3) Preland Navigation (Section 4.3.2).

In a similar manner, the details of Part (b) are presented under four principal functions:

(1) Deorbit/Landing User Parameter Processing Sequencer (Section 4.1.2).

(2) Entry User Parameter Processing (Section 4.6.1).

(3) TAEM User Parameter Processing (Section 4.6.2) and

(4) Autoland User Parameter Processing (4.6.3)

In addition, the flow charts for each function are presented in Appendix B for Part (a) and in Appendix F for Part (b). These flow charts are not to be construed as requirements, but rather as examples of how the requirements stated in the text may be implemented.

3.3.2 Navigation-Related Functions

The navigation-related function, area navigation, supports the horizontal situation indicator (a dedicated display device) by computing directions and distances to defined way points as well as nominal course and glidepath deviations.

3.3.3 General Requirements

This section discusses software requirements in the categories of service, single-use, or multiple-use that are not uniquely related to the navigation function.

The general requirements include, but are not limited to, the following:

Coordinate transformations (this publication contains transformations required for navigation)

Entry precise predictor

Entry site lookup

Entry auto TACAN selection

3.3.4 Requirements and Assumptions Overview

The following two sections present an overview of the requirements and assumptions of the OFT entry through landing GN&C navigation-related software.

The navigation software requirements and assumptions as presented make statements about the performance of non-navigation functions. Completion of the software requirements will require adequate definition of the timing and data time-tagging mechanization and the Input/Output Processor (IOP) mechanization. Changes in the navigation software requirements may be necessary, depending on actual implementation of the non-navigation functions.

3.3.4.1 Requirements

The following statements are grouped under six general categories and represent the navigation requirements which must not be violated. To illustrate the requirements, references are made to the flow charts in Appendix B. Requirements concerning:

a. Definition of State Vector

(1) The six elements of the navigated state vector consist of the position and the velocity of the Shuttle navigation base point in M50 coordinates.

b. Kalman Filter Equations

(1) Filter statistics are in double precision so that the quadratic form of the Kalman filter can be used.

c. Input Data

(1) Statements that snap data upon entry into navigation shall be such that a timewise consistent set of data is obtained before the set of data is used. The time tag is assumed to be in mean solar seconds from the beginning of the year in which the mission is launched.

(2) The redundancy management selection filter must provide navigation with the total accumulated sensed velocity in M50 coordinates.

(3) Selected sensed velocity data are used without reference to the IMU DATA GOOD flags.

(4) Data from all sensors will be collected at the beginning of each filter cycle, so that they are timewise as close to each other as possible. The sensor data snap functions should not be interrupted by other programs until they are completed.

d. Output Data

(1) During the time when a state vector is being read by non-navigation application software, that state vector or portions thereof will not be updated by the navigation software. The reset equations in the user parameter propagator shall be so protected.

e. Sensor Data Processing

(1) Both automatic and manual capability will be available for selecting navigation sensors for navigation processing.

(2) Sensor read boxes refer to picking up of sensor data from appropriate locations. The sensor data and the time tag (GMT elapsed time in seconds) must be consistent.

(3) The navigation sensor read functions should not be interrupted by other programs until they are completed.

(4) There will be a manual override of the filter residual edit for TACAN and barometric altimeter sensors and drag altitude measurement processing.

f. Update of State Vector and Covariance Matrix

(1) The processing of a measurement to update the state vector and the covariance matrix must be completed before the processing of the next measurement is started (NAV_FILTER).

(2) Processing of all measurements available at a given filter cycle will be completed before starting the next filter cycle.

3.3.4.2 Assumptions

The following statements are grouped under four general categories and represent assumptions used for the navigation formulations; they are reflected in the flow charts given in Appendix B. Assumptions concerning:

a. State Vector

(1) All states will be integrated in entry navigation without regard to failures.

(2) A whole vector (M50 coordinates) update to the onboard state may be command uplinked from the ground during OPS-3.

(3) A delta state vector (runway coordinates) correction update from ground calculated data may be performed either directly via ground command uplink or manually via keyboard entry by the crew during OPS-3.

b. Major Modes and Navigation Phases

(1) Only during MM301 (predeorbit coast) is there a provision for transition to OPS-2 from OPS-3. One state vector is provided for this transition.

(2) During the entry navigation phase there is a provision for transition from MM 303 (preentry monitor) to MM 301 (predeorbit coast).

(3) Three state vectors are maintained in OPS-3 by navigation until the preland phase; thereafter, one state vector is maintained.

(4) The navigation sequencer never returns to entry NAV (three states) once the preland NAV (one state) has been selected.

(5) Automatic criterion for the switch from entry NAV to preland NAV is that MSBLS is indicated to be available at the landing site and MSBLS range and azimuth data are indicated as valid.

c. Sensor Data Processing

General

(1) No manual capability to override sensor data-good flags exists within the navigation software. Such override, if any, will be through the redundancy management or selection filter functions. Data will be presented to the filter for processing only if the data-good flag is set to ON.

(2) Data presented to the filter will be incorporated into the state vector and covariance matrix only if the residual edit test is passed or if the sensor force switch is set.

IMU

(1) Once an IMU fails, its state vector is lost for the duration of the entry. There is no direct capability to transfer state vectors from slots associated with nonfailed IMU's to slots associated with "healed" IMU's. Such a capability exists indirectly by the crew's performance of a zero-delta manual update.

(2) The change in IMU-sensed velocity is used to calculate the sensed acceleration due to aerodynamic forces. This acceleration is then employed to compute a pseudo-altitude measurement (drag altitide).

BARO

(1) The BARO probe is assumed to be at the navigation base.

(2) Barometric data processing may be performed with TACAN data processing.

(3) Drag altitude measurement processing is not performed with barometric data processing.

TACAN

(1) The capability exists to process only TACAN range or only TACAN bearing.

(2) The RM will supply a separate data good for TACAN range and bearing; RM will also set the appropriate data-good to bad if either range or bearing is not locked up.

(3) Drag altitude measurement processing may be performed with TACAN data processing.

(4) There is no on-board antenna location correction for TACAN range and bearing measurements.

MSBLS

(1) The RM sets a data-good for each of the MSBLS measurements.

(2) All MSBLS onboard antennas are assumed to be collocated.

(3) There is no on-board antenna location correction for MSBLS range and azimuth measurements.

d. Site Lookup Data

(1) Runway and TACAN site location data will be loaded prior to launch for a possible AOA entry. Software must exist in OPS-2 to redefine the parameters for a nominal entry.

3.4 TRACEABILITY

Table 3.4-1 shows the traceability of the software segments in the FSSR Level C with respect to the CPDS Level B, April 28, 1978, issue.

TABLE 3.4-1.- SOFTWARE REQUIREMENT TRACEABILITY

CPDS Level B section no.	Software segment	FSSR Level C section no.
4.123	Deorbit/Landing Navigation Sequencer	4.1.1
4.214	Deorbit/Landing User Parameter Processing Sequencer	4.1.2
4.127	Entry Navigation	4.3.1
4.144	Preland Navigation	4.3.2
4.124	Entry Site Lookup	4.5.2
4.223	Entry Precise Predictor	4.5.3
4.239	Entry Auto TACAN Select	4.5.4
4.23	Entry User Parameter Processing	4.6.1
4.24	TAEM User Parameter Processing	4.6.2
4.25	Autoland User Parameter Processing	4.6.3
4.220	Entry Area Navigation Processing	4.7

3.5 OPS-3 OPERATION SEQUENCE MAJOR MODES

Table 3.5-1 identifies the major modes for the OPS-3 operation sequence as referenced in Section 4, Detail Level Requirements, and Appendices B and F. Detailed descriptions may be found in the Level B CPDS, April 28, 1978, issue.

TABLE 3.5-1.- OPS-3 OPERATION SEQUENCE MAJOR MODES

Major mode no.	Major mode name
301	Predeorbit coast
302	Deorbit execute
303	Preentry monitor
304	Entry
305	TAEM/landing

3.6 IMPLEMENTATION CONSTRAINTS

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

Check or error interrupts shall be prevented by software safeguards, or standard fixup and error returns shall be provided which are appropriate in the navigation function as described below.

3.6.1 Floating Point Overflow

The task in process should be terminated and the previous stored value of the variable retained.

3.6.2 Floating Point Underflow

This may be treated in the same manner as floating point overflow, or the variable may be set to zero and processing continued.

3.6.3 Divide by Zero

This should be treated in the same manner as floating point overflow.

3.6.4 Square Root

The square root of a negative number should be treated in the same manner as floating point overflow.

3.6.5 Arc Sine

If the argument is greater than +1, a value of $\pi/2$ should be returned. If the argument is less than -1, a value of $-\pi/2$ should be returned. In either case, processing shall not be terminated.

3.6.6 Arc Cosine

If the argument is greater than +1, a value of zero should be returned. If the argument is less than -1, a value of π should be returned. In either case, processing shall not be terminated.

3.6.7 Arc Tangent

If both arguments are zero, a value of zero should be returned.

3.6.8 Logarithm

If the argument of the logarithm function is negative or zero, the task in process should be terminated, and the previous value of the result retained.

3.6.9 Sine and Cosine

The returned value of sine and cosine functions should be limited to ± 1, and the functions shall be capable of accepting any valid floating point numbers as arguments.

4.0 DETAIL LEVEL REQUIREMENTS

The various subsections of this section specify the detail level requirements for the Shuttle navigation system flight software package.

When viewed in the larger context of the total Shuttle flight software, the navigation software package documented herein is, itself, a modular system whose function is to supply various parameters required by other major modular systems such as guidance, displays, flight control, and others. The requirements placed upon the navigation system by these various users often play a large role in determining the design structure and cyclic rate structure of the navigation system. The required interfaces between the navigation system and the other major software systems that use navigation system data are presented in Appendix G.

4.1 NAVIGATION AND USER PARAMETER SEQUENCER PRINCIPAL FUNCTIONS

The sequencer principal functions shall initialize and sequence the proper navigation and user parameter principal functions to meet navigation and user requirements.

4.1.1 Deorbit/Landing Navigation Sequencer

The deorbit/landing navigation sequencer principal function will initialize and sequence the navigation principal functions from the predeorbit coast major mode through the autoland major mode. Detailed requirements for each navigation principal function are identified in the specific principal function descriptions.

Cues for performing the proper navigation initialization and sequencing during OPS-3 may be available in the form of event flags as defined in the Level B GN&C CPDS. The particular events pertaining to the deorbit/landing navigation sequencer are shown in Table 4.1.1-1, together with associated navigation actions. For the purpose of discussion in this section, the action of canceling a function shall mean that the function is permitted to complete an in-progress execution and that subsequent initialization computations are not performed before the canceled function has completed final execution. Variables interfacing with this principal function are identified in Appendix G.

A. Detailed requirements. For OFT deorbit through landing (OPS-3), navigation requirements can be divided into four navigation phases: deorbit preparation, deorbit execute, entry, and preland. (For definitions of variables, see input and output Table 4.1.1-2 and 4.1.1-3.)

(1) Deorbit preparation navigation phase - The deorbit preparation navigation phase will begin upon entry to the predeorbit coast major mode (301). This will use the entry navigation principal function. If major mode 301 is entered through initiation of the entry operational sequence, the deorbit/landing navigation sequencer will provide the capability to initialize the three state vectors, covariance matrix, and other required navigation parameters on the basis of one-state data obtained from protected computer locations unaffected by the computer program reconfiguration from the ascent or on-orbit to entry operational sequence.

Prior to the initialization of the three-state vectors, a capability will be provided to obtain past values for the total accumulated velocity sensed by the IMU's ($\underline{V}$_LAST_FILT_ONE, $\underline{V}$_LAST_FILT_TWO, $\underline{V}$_LAST_FILT_THREE), previous value of selected total accumulated sensed IMU velocity ($\underline{V}$_LAST_FILT), and the associated time tag (T_LAST_FILT). Then the state vector from the previously exercised operational sequence will be propagated to the current time by using the entry precise predictor principal function (Section 4.5.1). The input variables required by this function will be equated as follows prior to its execution:

GMD_PRED = 4

GMO_PRED = 4

DT_MAX = DEL_TIME_STEP

$\underline{R}$_INIT = $\underline{R}$_FILT_INIT

$\underline{V}$ _INIT = $\underline{V}$ _FILT_INIT

T_INIT = T_FILT_INIT

T_FINAL = T_LAST_FILT

The state vector $\underline{R}$ _FILT_ONE, $\underline{V}$ _FILT_ONE and the gravity vector, $\underline{G}$ _RESET, shall be equated to the propagation state vector and the total acceleration vector, respectively.

$\underline{R}$ _FILT_ONE = $\underline{R}$ _FINAL

$\underline{V}$ _FILT_ONE = $\underline{V}$ _FINAL

$\underline{G}$ _RESET = $\underline{G}$ _FINAL

The remaining two state vectors are to be initialized and the three state operation is to be indicated by

$\underline{R}$ _FILT_TWO = $\underline{R}$ _FILT_ONE

$\underline{R}$ _FILT_THREE = $\underline{R}$ _FILT_ONE

$\underline{V}$ _FILT_TWO = $\underline{V}$ _FILT_ONE

$\underline{V}$ _FILT_THREE = $\underline{V}$ _FILT_ONE

NAV_THREE_STATE = ON

The position vector associated with the current covariance matrix is to be initialized as

$\underline{R}$ _COV_LAST = $\underline{R}$ _FILT_ONE

The user parameter state propagation subfunction (Section 4.4.1) will be initialized as

$\underline{R}$ _RESET = $\underline{R}$ _FILT_ONE, $\underline{V}$ _RESET = $\underline{V}$ _FILT_ONE

$\underline{V}$ _IMU_RESET = $\underline{V}$ _LAST_FILT, T_RESET = T_LAST_FILT

FILT_UPDATE = ON

If the predeorbit coast major mode is entered from the on-orbit operational sequence, the 6 by 6 covariance matrix is to be initialized by exercising the subfunction covariance matrix initialization (Section 4.2.9) with variables required therein defined by

$\underline{S}$IG = $\underline{S}$IG_DIAG_UVW_INIT

$\underline{C}$OR = $\underline{C}$ORR_COEFF_INIT

$\underline{R}$ = $\underline{R}$ _FILT_ONE

$\underline{V}$ = $\underline{V}$ _FILT_ONE

where SIG_DIAG_UVW_INIT and CORR_COEFF_INIT are parameters computed by OPS-2 software (ORB/RND NAV SEQ) prior to the OPS reconfiguration.

If the predeorbit coast major mode is entered from OPS-1 (Events 59 or A20), the covariance matrix will be initialized as described above but SIG_DIAG_UVW_INIT and CORR_COEFF_INIT are defined by premission-loaded constants.

Execution of the user parameter state propagation is to be enabled by setting

OPS_3_INITIALIZE_COMPLETE = ON

Finally, a flag is set to indicate OPS-3 initialization complete.

OPS_3_RECONFIGURE = ON

If Major Mode 301 is entered from Major Mode 302 or 303, the deorbit/landing navigation sequencer shall provide the capability to cancel the current entry navigation principal function.

After completion of any in-progress execution, the capability will be provided for sequencing the entry navigation principal function at the designed repetition rate.

The capability also will exist to return to the on-orbit operational sequence (OPS-2) from the deorbit preparation navigation phase. In the event of a return to OPS-2, entry navigation will be canceled and required OPS-2 single-state initialization will be obtained prior to data being transferred into or contained in computer locations that will be unaffected by this operational sequence transition:

$\underline{R}$ _FILT_INIT = $\underline{R}$ _FILT

$\underline{V}$ _FILT_INIT = $\underline{V}$ _FILT

The time associated with the current Shuttle state vector and covariance matrix will be defined as:

T_FILT_INIT = T_LAST_FILT

In addition to saving the required single state parameters, the covariance matrix of Orbiter position and velocity shall also be saved by conversion into UVW standard deviations and correlation coefficients, by calling the COV_INIT_UVW_INVERSE subfunction

CALL: COV_INIT_UVW_INVERSE

INLIST: E,R _FILT_INIT, V _FILT_INIT

OUTLIST: SIG_DIAG_UVW_INIT, CORR_COEFF_INIT

The detailed requirements of the above subfunction are specified below:

a. The input parameters are re-named for local usage

INLIST: E_TEMP, R, V

b. Compute a transformation matrix from UVW to M50

$$M = UVW\_TO\_M50\ (\underline{R}, \underline{V})$$

c. Transform the input covariance matrix from M50 to UVW coordinates

$$E\_TEMP_{1\ to\ 3,\ 1\ to\ 3} = M^T\ E\_TEMP_{1\ to\ 3,\ 1\ to\ 3}\ M$$

$$E\_TEMP_{4\ to\ 6,\ 4\ to\ 6} = M^T\ E\_TEMP_{4\ to\ 6,\ 4\ to\ 6}\ M$$

$$E\_TEMP_{1\ to\ 3,\ 4\ to\ 6} = M^T\ E\_TEMP_{1\ to\ 3,\ 4\ to\ 6}\ M$$

d. Compute standard deviations

$$SIG_I = \sqrt{E\_TEMP_{I,\ I}} \quad \text{for } I = 1, 6 \qquad \text{F4}$$

e. Compute selected correlation coefficients

$$COR_1 = E\_TEMP_{1,\ 2}/(SIG_1\ SIG_2) \qquad \text{F3}$$

$$COR_2 = E\_TEMP_{1,\ 4}/(SIG_1\ SIG_4) \qquad \text{F3}$$

$$COR_3 = E\_TEMP_{1,\ 5}/(SIG_1\ SIG_5) \qquad \text{F3}$$

$$COR_4 = E\_TEMP_{2,\ 4}/(SIG_2\ SIG_4) \qquad \text{F3}$$

$$COR_5 = E\_TEMP_{2,\ 5}/(SIG_2\ SIG_5) \qquad \text{F3}$$

$$COR_6 = E\_TEMP_{3,\ 6}/(SIG_3\ SIG_6) \qquad \text{F3}$$

$$COR_7 = E\_TEMP_{4,\ 5}/(SIG_4\ SIG_5) \qquad \text{F3}$$

F3-This equation shall be protected against division by zero (Reference 3.6.3).
F4-This equation shall be protected against square roots of a negative number (Reference 3.6.4)

f. The output parameters are defined

OUTLIST: SIG, COR

where SIG is a 6 by 1 vector, and COR a 7 by 1 vector, defined as follows:

SIG_1, U position standard deviation

SIG_2, V position standard deviation

SIG_3, W position standard deviation

SIG_4, $\dot{U}$ velocity standard deviation

SIG_5, $\dot{V}$ velocity standard deviation

SIG_6, $\dot{W}$ velocity standard deviation

COR_1, U-V correlation coefficient

COR_2, U-$\dot{U}$ correlation coefficient

COR_3, U-$\dot{V}$ correlation coefficient

COR_4, V-$\dot{U}$ correlation coefficient

COR_5, V-$\dot{V}$ correlation coefficient

COR_6, W-$\dot{W}$ correlation coefficient

COR_7, $\dot{U}$-$\dot{V}$ correlation coefficient

The following protected variables will then be saved for initialization of the on-orbit navigation principal function:

OPS-2 Variable Definition	OPS-3 Variable Name
Current Shuttle position and velocity vectors used in filter update computations	R_FILT_INIT V_FILT_INIT
Time of current Shuttle state vectors and covariance matrix	T_FILT_INIT
Correlation coefficient to initialize the covariance matrix	CORR_COEFF_INIT
Square root of diagonal elements for covariance matrix initialization	SIG_DIAG_UVW_INIT

(2) Deorbit execute navigation phase - The deorbit execute navigation phase will begin whenever the deorbit execute major mode (302) is active and the event flag indicating the deorbit burn is to begin in TBD seconds is on. This phase uses the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function and to initialize the deorbit burn flag to ON to prevent measurement processing. The capability will also be provided for sequencing the entry navigation principal function at the designated repetition rate.

(3) Major Mass Change Event - E 14A (OMS cutoff) - At the end of the OMS burn, the drag constant parameter shall be recomputed using the current mass.

DRAG_CONST = 0.5 REF_AREA/VEH_MASS

This parameter is used in the entry navigation state propagation subfunction (drag acceleration task, see section 4.2.1.2.2.) and drag measurement processing (section 4.3.1.7.1).

(4) Entry navigation phase - The entry navigation phase will begin at initiation of the pre-entry monitor major mode (303). This phase will use the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function.

The deorbit burn flag will be set to OFF to enable measurement processing.

After completion of initialization, the capability will be provided for sequencing the entry navigation principal function at the designated repetition rate.

(5) Preland navigation phase - The preland navigation phase will begin whenever MSBLS is available at the landing site, Major mode 304 or Major mode 305 is active, and the selected MSBLS range and azimuth data are valid.

This phase will use the preland navigation principal function.

Upon satisfaction of the transition criterion, repetition of the current entry navigation principal function will be cancelled. The flag indicating three-state-operation will be turned OFF.

NAV_THREE_STATE = OFF

Finally, a flag is to be set to indicate preland transition complete.

PRELAND_TRANSITION = ON

The capability also will be provided for sequencing the preland navigation principal function at a premission determined repetition rate.

B. Interface Requirements. The deorbit/landing navigation sequencer principal function will be sequenced at least once at the beginning of Major Modes 301 and 303. This principal function will be sequenced at a 0.52-hertz rate upon entrance to Major Mode 302 until the requirements associated with the deorbit burn event flag are completed and upon entrance to Major Mode 304 and for Major Mode 305 until the requirements associated with valid MSBLS data are completed.

C. Processing Requirements. Before the OPS-2 initialization subfunction can be accomplished, entry navigation must be executed at least once.

D. Constraints. Calculation of DRAG_CONST after OMS cutoff shall not interrupt operations of the entry navigation principal function. OPS_3_RECONFIGURE and PRELAND_TRANSITION shall be initialized to 'OFF'.

E. Supplemental Information. A suggested implementation of these requirements is illustrated in Appendix B, DEORBIT/LANDING_NAV_SEQUENCER.

TABLE 4.1.1-1.- OPS-3 LEVEL B EVENTS

Event No.*	Event Name	Nav Criteria	Nav Action
85	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition initialization. Initiate entry navigation (deorbit preparation phase).
59	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	Same as above.
A20	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	Same as above.
E1	OPS transition to OPS-2 from OPS-3	OPS transition to OPS-2 from OPS-3	Reduce three-state to one-state and save off OPS-2 initialization data.
E11A	Initiate power flight navigation	Deorbit maneuver begins in TBD seconds	Cancel entry navigation (deorbit preparation phase). Initiate entry navigation (deorbit execute phase.)
E10	Mode transition to 301 from 302	Mode transition to 301 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (deorbit preparation phase).
E14A	Major Mass Change event (OMS cut off)	Major Mass Change event (OMS cut off)	Compute drag constant with the current mass of the Shuttle.
E15	Mode transition to 303 from 302	Mode transition to 303 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (entry phase).

TABLE 4.1.1-1.- Concluded

Event No.*	Event Name	Nav Criteria	Nav Action
E16B	Mode transition to 301 from 303	Mode transition to 301 from 303	Cancel entry navigation (entry phase). Initiate entry navigation (deorbit preparation phase).
E20	Three-state to one-state switch	MSBLS range and azimuth valid.	Cancel entry navigation (entry phase). Initiate pre-land navigation.

*Current Level B event numbers.

TABLE 4.1.1-2.- DEORBIT/LANDING NAVIGATION SEQUENCER INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Major mode number (set by MSC for use by navigation)	MM_CODE	*	I	S			Seq rate
Flag inidicating (ON) that OPS-3 initialization is complete.	OPS_3_ RECONFIGURE	***	D		OFF/ON		Seq rate
Flag indicating (ON) that the deorbit burn begins in TBD seconds	INITIATE_PWR_ FLIGHT_NAV_ EVENT	*	D		OFF/ON		Seq rate
Sequencing time interval for entry navigation during coasting flight prior to deorbit burn	DT_DEORB_PREP _NAV	**	F	S		sec	Seq rate
Sequencing time interval for entry navigation during deorbit burn	DT_DEORB_PF_ NAV	**	F	S		sec	Seq rate
Sequencing time interval for entry navigation after completion of deorbit burn	DT_ENTRY_NAV	**	F	S		sec	Seq rate
Flag indicating (ON) a transition from OPS-3 to OPS-2	EVENT E1	*	I				Seq rate

*See Deorbit/landing principal function IN_LIST (Appendix G)
**See Section 4.9
***See Section 4.1.1.D. (constraints)

TABLE 4.1.1-2.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that transition to preland navigation principal function is complete	PRELAND_ TRANSITION	***	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_DATA _GOOD	*	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	*	D		OFF/ON		Seq rate
Flag indicating the availability of MSBLS data at the selected at the selected runway	MLS_AVAIL	*	D		OFF/ON		Seq rate
Sequencing time interval for MSBLS navigation sensor processing function	DT_LAND	**	F	S		sec	Seq rate
Previous value of selected accumulated IMU velocity	V _LAST_FILT	*	V	S		ft/sec	Seq rate
Shuttle position vector for OPS-3 initialization	R _FILT_INIT	*	V	DP		ft	Once
Shuttle velocity vector for OPS-3 initialization	V _FILT_INIT	*	V	S		ft/sec	Once
Time tag of R _FILT_INIT and V _FILT_INIT	T_FILT_INIT	*	F	DP		sec	Once
Past value for total acumulated velocity sensed by IMU 1	V _LAST_FILT_ ONE	*		S		ft/sec	Once

*See D/L navigation principal function in list (Appendix G)
**See Section 4.9
***See Section 4.1.1D. (constraints)

TABLE 4.1.1-2.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Past value for total accumulated velocity sensed by IMU 2	V_LAST_FILT_TWO	*	F	S		ft/sec	Once
Past value for total accumulated velocity sensed by IMU 3	V_LAST_FILT_THREE	*	F	S		ft/sec	Once
Time tag associated with the past values for total accumulated velocity sensed by the IMU's	T_LAST_FILT	*	F	DP		sec	Once
Position vector propagated to current time	R_FINAL	*	V	DP		ft	Once
Velocity vector propagated to current time	V_FINAL	*	V	S		ft/sec	Once
Current gravity vector	G_FINAL	*	V	S		ft/sec^2	Once
Current middle selected position vector	R_FILT	*	V	DP		ft	Once
Current middle selected velocity vector	V_FILT	*	V	S		ft/sec	Once
Time step to propagate the state vector from the previous operation sequence	DEL_TIME_STEP	**	F	S		sec	Once
Square roots of the diagonal elements or the covariance matrix from OPS-2/premission load.	SIG_DIAG_UVW_INIT	*	V	DP		vary	Once

*See D/L nav principal function in list (Appendix G)

TABLE 4.1.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Correlation coefficients from OPS-2/premission load	CORR_COEFF_INIT	*	V	DP		-	Once

*See D/L nav principal function in list (Appendix G)
**See Section 4.9

TABLE 4.1.1-3.- DEORBIT/LANDING NAVIGATION SEQUENCER OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration	R_FILT_ONE	*	V	DP		ft	Once
Shuttle initial position vector	R_INIT	*	V	DP		ft	Once
Current Shuttle position vector for three-state configuration	R_FILT_TWO	*	V	DP		ft	Once
Current Shuttle position vector for three-state configuration	R_FILT_THREE	*	V	DP		ft	Once
Shuttle velocity vector, state one	V_FILT_ONE	*	V	S		ft/sec	Once
Shuttle velocity vector-initial value	V_INIT	*	V	S		ft/sec	Once
Shuttle velocity vector, state two	V_FILT_TWO	*	V	S		ft/sec	Once
Shuttle velocity vector, state three	V_FILT_THREE	*	V	S		ft/sec	Once
Previously read accumulated IMU one velocity	V_LAST_LAST_ONE	*	V	S		ft/sec	Once
Previously read accumulated IMU two velocity	V_LAST_FILT_TWO	*	V	S		ft/sec	Once
Previously read accumulated IMU velocity	V_LAST_FILT_THREE	*	V	S		ft/sec	Once
Updated vehicle position vector associated with current covariance matrix	R_COV_LAST	*	V	DP		ft	Once

*Refer to Deorbit/Landing Seq. principal function out list (Appendix G)

TABLE 4.1.1-3.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Time of the filter state vectors	T_LAST_FILT	*	F	DP		sec	Once
Time of initial state vectors	T_INIT	*	F	DP		sec	Once
Time of last state vectors	T_FINAL	*	F	DP		sec	Once
Integer indicating order of modeled accelerations	GMO_PRED	*	I	S		--	As needed
Integer indicating degree of modeled accelerations	GMD_PRED	*	I	S		--	As needed
Flag indicating whether the mode of operation is single state or three state	NAV_THREE_STATE	*	D		OFF/ON	--	Once
Vehicle position vector after all navigation updates reserved for reset of guidance integrator position vector R_AVG_G	R_RESET	*	V	DP		ft	Once
Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector V_AVG_G	V_RESET	*	V	S		ft/sec	Once
Copy of V_CURRENT_FILT reserved as velocity count at start of extrapolation interval when guidance integrator is reset	V_IMU_RESET	*	V	DP		ft/sec	Once

*See D/L nav principal function outlist (Appendix G)

TABLE 4.1.1-3.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Time associated with reserved reset state	T_RESET	*	F	DP		sec	Once
Switch indicating (ON) that current measurement processing is complete	FILT_UPDATE	*	D		OFF/ON	--	Once
Flag to enable scheduling of the user parameter state propagation principal function	OPS_3_ INITIALIZE_ COMPLETE	*	D		OFF/ON	--	Once
Filter covariance matrix	E	*	M	DP		vary	Once
Previous value of selected accumulated IMU velocity	V _LAST_FILT	*	V	S		ft/sec	Seq rate
Vehicle gravity acceleration vector reserved for reset of guidance integrator acceleration vector	G _RESET	*	V	S		ft/sec	Once
Square roots of the diagonal elements of the covariance matrix for OPS-2 initialization	SIG_DIAG_UVW_ INIT	*	V	DP		ft, and ft/sec	Once
Correlation coefficients of covariance matrix for OPS-2 initialization	CORR_COEFF_ INIT	*	V	DP		-	Once
Shuttle position vector for OPS-2 initialization	R _FILT_INIT	*	V	DP		ft	Once

*See D/L nav principal function out list (Appendix G)

TABLE 4.1.1-3.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector for OPS-2 initialization	V_FILT_INIT	*	V	S		ft/sec	Once
Flag indicating (ON) that major mode is deorbit maneuver execute	DEORBIT_BURN	*	D		OFF/ON		As needed

*See D/L nav principal function out list (Appendix G)

4.1.2 Deorbit/Landing User Parameter Processing Sequencer (4.214)

This principal function shall provide a capability for initialization and control of those principal functions and subfunctions associated with the computations of user parameters during the deorbit through landing operational sequence. These consist of the entry, TAEM, and autoland user parameter processing principal functions. This sequencer also will provide initialization and control of the HSI processing principal function.

Events to be used as cues by the sequencer for performing the required initialization and sequencing are defined in the Level B GN&C CPDS. The particular events and a summary of the associated user parameter actions pertaining to the deorbit/landing user parameter sequencer are given in Table 4.1.2-1.

A. Detailed Requirements. The deorbit/landing user parameter processing sequencer shall be initiated upon the occurrence of any of the following events:

(1) OPS transition to OPS-3 from OPS-2.

(2) OPS transition to OPS-3 from OPS-1.

This sequencer shall be terminated upon transition from OPS-3 to OPS-2 or upon transition to OPS-9. The initiation and termination of this principal function are controlled by MSC.

The following paragraphs specify the detailed requirements summarized in Table 4.1.2-1. These requirements specify, for each of the event cues to be utilized by the sequencer, the actions that the sequencer is to initiate.

OPS 3 INITIALIZE COMPLETE - OPS transition to OPS-3. Based upon this cue, cyclic execution of the user parameter state propagation function (section 4.6.1.1) shall commence at a repetition rate of 0.52 Hertz, and Earth-fixed coordinate system computations (Section 4.6.1.5) shall be initiated at a repetition rate of 0.52 Hertz.

EVENT E3 - Major mode transition from 301 to 302. Based upon this cue, the Earth-fixed coordinate system computations shall be cancelled.

EVENT E11 - Guidance initiate. Based upon this cue, the current scheduling of user parameter state propagation is to be cancelled. Cyclic processing of the user parameter state propagation is to be rescheduled at a repetition rate of 1.04 Hertz.

EVENT E16B - Major mode transition from 303 (preentry monitor) to 301 (predeorbit coast). Based upon this cue, the user parameter state propagation function shall be rescheduled at a repetition rate of 0.52 Hertz, and Earth-fixed coordinate system computations shall be initiated at a repetition rate of 0.52 Hertz.

EVENT E16 - Major mode transition from 303 to 304 (entry). Based upon this cue, the user parameter state propagation function shall be rescheduled at a repetition rate of 6.25 Hertz, the basic guidance-related computations for entry, H_HDOT_ACCVERT and GUIDECOMP (Section 4.6.1.2), shall commence cyclic execution at a repetition rate of 1.04 Hertz, cyclic execution of the guidance and displays way point computations (Section 4.6.1.3) and TACAN display computations (Section 4.6.1.4) for entry shall commence at a repetition rate of 0.52 Hertz, and cyclic execution of the HSI processing function (Section 4.7) will commence at a repetition rate of 1.04 Hertz.

EVENT E21 - Mode transition from 304 to 305 (TAEM). Based upon this cue, the guidance and displays way point computations for entry shall be cancelled.

TG END - TAEM guidance termination. Based upon this cue, the subfunction H_HDOT_ACCVERT will be cancelled and cyclic execution of the subfunction GUIDECOMP shall be rescheduled at a repetition rate of 6.25 Hertz.

B. Interface Requirements. Input and output parameters for the sequencer are given in two tables corresponding to the principal function input list and the principal function output list (see Appendix G).

C. Processing Requirements. None.

D. Constraints. Cyclic execution of the user parameter propagator shall not be initiated until initialization of necessary state parameters has been accomplished within the D/L navigation sequencer.

E. Supplemental Information. A suggested implementation for these requirements is illustrated in Appendix F, DEORB_LAND_UPP_SEQ.

The purpose of cancelling and rescheduling the user parameter state propagator upon the guidance initiate signal is to get the execution of this module in "sync" with the execution of the deorbit guidance function which is to be initiated upon this signal. This cancelling and rescheduling process is to occur "y" seconds prior to OMS ignition such that a subsequent user state update will occur (as nearly as possible) at the time of OMS ignition.

TABLE 4.1.2-1.- EVENT FLAG INPUTS FOR THE DEORBIT/LANDING

USER PARAMETER PROCESSING SEQUENCER

Event flag	Event flag description	Action taken by sequencer in response to event flag
OPS_3_INITIALIZE_COMPLETE	Signal to enable cyclic execution of UPSP	Initiate performance of the (off-orbit) user parameter state propagation function at a repetition rate of 0.52 Hz. Initiate performance of the Earth-fixed coordinate system computations at a repetition rate of 0.52 Hz.
EVENT_E3	Mode trans. from 301 to 302	Cancel Earth-fixed coordinate system computation.
EVENT_E11	Guidance initiate	Cancel and reschedule cyclic processing of the user parameter propagation function at a rate of 1.04 Hz.
EVENT_E16B	Mode transition from 303 to 301 (301 = predeorbit coast)	Reduce repetition rate of the user parameter state propagation function to 0.52 Hz.
EVENT_E16	Mode transition from 303 to 304 (304 = entry)	Increase repetition rate of the user parameter state propagation function to 6.25 Hz.
		Initiate performance of basic guidance-related computations for entry at a repetition rate of 1.04 Hz.
		Initiate performance of guidance and displays way point computations for entry at a repetition rate of 0.52 Hz.
		Initiate performance of the HSI processing function at a repetition rate of 1.04 Hz.
		Initiate performance of Tacan display computations at a repetition rate of 0.52 Hz.

TABLE 4.1.2-1.- Concluded

Event flag	Event flag description	Action taken by sequencer in response to event flag
EVENT_E21	Mode transition from 304 to 305 (305 = TAEM)	Cancel the guidance and displays way point computations for entry.
TG_END	TAEM guidance termination	Cancel the basic guidance-related computations submodule, H_HDOT_ACCVERT. Increase repetition rate of the basic guidance-related computations submodule, GUIDECOMP to a repetition rate of 6.25 Hz.

4.2 SUBFUNCTIONS COMMON TO SEVERAL NAVIGATION PRINCIPAL FUNCTIONS

This section documents detailed requirements for subfunctions identified as being common to two or more navigation principal functions or their major subfunctions. The detailed requirements specified here will be referenced from the sections to which they are common and, when referenced, may be regarded as inserts to paragraph A, Detailed Requirements, in these sections.

4.2.1 State Propagation

This subfunction will perform a number of tasks related to propagation of the Shuttle state vector. The task of reading (snapping) the IMU's is performed when the total accumulated sensed velocity is required to account for non-gravitational accelerations during integration of the equations of motion. Modeled drag acceleration is computed in those circumstances in which IMU accumulated sensed velocity is not used. The equations of motion are integrated with the use of a super-g algorithm designed primarily for powered-flight phases (i.e., those phases in which appreciable nongravitational accelerations are experienced); but also used for coasting-flight phases.

4.2.1.1 IMU Data Snap

The IMU data snap task will provide the capability to obtain the IMU-sensed accumulated velocities, expressed in M50 coordinates, along with their associated GMT time tag. These data will be stored for use in the state propagation subfunction. In the one-state mode (preland) data from one good IMU are required as indicated in the following example:

SNAP IMU (V_CURRENT_FILT, T_CURRENT_FILT)

These data are obtained from the IMU RM.

In the three-state mode (entry), data from three IMU's individually as well as the selected data are required as indicated in the following example:

SNAP IMU (V_CURRENT_FILT_ONE, V_CURRENT_FILT_TWO,

V_CURRENT_FILT_THREE, V_CURRENT_FILT, T_CURRENT_FILT)

These data are obtained from the IMU RM, V_CURRENT_FILT being the selected IMU data.

The SNAP statements above imply the assignment of current values to the variable names shown in parentheses.

4.2.1.2 Acceleration Models

The tasks that perform integration of the Shuttle equations of motion require models to compute either gravitational and/or nongravitational (drag) accelerations. If IMU accelerometer-sensed velocity data are used in the integration process, then only gravitational accelerations need be modeled. If accelerometer data are not used, then the drag acceleration needs to be modeled in addition to the gravitational acceleration.

During entry and preland navigation phases, the acceleration function shall be called by its users with values of GMD, GMO, $\underline{R}$, $\underline{V}$, and T. The input flags GMD and GMO control the degree and order of the gravitational potential model to be used. $\underline{R}$ and $\underline{V}$ are the position and velocity vectors of the vehicle in the M50 coordinate system and T is the time tag associated with both of these vectors.

First, the central force term of the Earth's gravitational acceleration shall be computed. This is to be accomplished by calling a special routine (CENTRAL), which is available for execution by functions other than the navigation function.

CALL: CENTRAL

IN LIST: R

OUT LIST: $\underline{A}$CCEL, R_INV

The calculations performed within the routine CENTRAL are the following:

$$R\_INV = 1./|\underline{R}|$$

$$\underline{A}CCEL = -EARTH\_MU|R\_INV^3|\underline{R}$$

The parameter R_INV must be output because it will be used later in computing the other (non-central force) terms of the gravitational acceleration, if so requested by the user function.

Next, the input flag GMD will be tested to see if only the central force term is requested or if additional acceleration calculations are desired.

If the central force alone is required (GMD = 0) then no other calculations need to be performed. If, however, perturbing accelerations are wanted (GMD>0), the following gravity and drag perturbing acceleration vectors shall be initialized:

$$\underline{G} = 0.$$

$$\underline{D} = 0.$$

Next, the transformation matrix from Earth-fixed to M50 coordinates shall be obtained in order to find the Earth-fixed position vector and the corresponding unit vector:

FIFTY = EARTH_FIXED_TO_M50_COORD(T)

$\underline{R}$ _EF = FIFTY^T $\underline{R}$

$\underline{U}$R = R_INV $\underline{R}$ _EF

The gravitational perturbation to $\underline{A}$CCEL (section 4.2.1.2.1) shall be calculated, and stored in the vector $\underline{G}$. If GMD = 4, then the acceleration vector due to drag (Section 4.2.1.2.2) shall be obtained and stored in the vector $\underline{D}$. The total acceleration shall then be calculated:

$\underline{A}$CCEL = $\underline{A}$CCEL + $\underline{G}$ + $\underline{D}$

A suggested implementation of this task is shown in the detailed flow chart, $\underline{A}$CCEL, in Appendix B.

4.2.1.2.1 Gravity. The Earth's gravitational attraction will be modeled by using S. Pines' uniform formulation of the spherical harmonics development.

The following variables are to be set up to serve as starting values for the recursion relations used in the Pines formulation:

AUXILIARY = 0.

RO_ZERO = EARTH_RADIUS_GRAV R_INV

RO_N = RO_ZERO EARTH_MU R_INV^2

$A_{1,2} = 3.\ UR_3$

$A_{2,2} = 3.$

L = 1

$ZETA\_REAL_1 = 1.$

$ZETA\_IMAG_1 = 0.$

A is a two-column array used for temporary storage of the Legendre polynomials and the derived Legendre functions (which are latitude-dependent terms), RO_N is the distance-related term, and AUXILIARY is an intermediate scalar variable.

The recursive calculations then will proceed, using as many components of the one-column arrays ZETA_REAL and ZETA_IMAG as required to account for the effects of the tesseral harmonics.

Do for I = 1 to GMO:

$ZETA\_REAL_{I+1} = UR_1\ ZETA\_REAL_I - UR_2\ ZETA\_IMAG_I$

$ZETA\_IMAG_{I+1} = UR_1\ ZETA\_IMAG_I + UR_2\ ZETA\_REAL_I$

The derived Legendre functions then will be obtained by means of recursion formulas, multiplied by the appropriate combinations of tesseral harmonics (the Legendre polynomials will be multiplied by the zonal harmonics coefficients), and stored as auxiliary variables - F1, F2, F3, and F4.

Do for N = 2 to GMD the following steps (1 through 5):

(1) $A_{N+1,1} = 0.$

$A_{N=1,2} = (2.\ N + 1.)\ A_{N,2}$

$A_{N,1} = A_{N,2}$

$A_{N,2} = UR_3\ A_{N+1,2}$

K = 2

(2) Do for J = 2 to N:

$A_{N-J+1,1} = A_{N-J+1,2}$

$A_{N-J+1,2} = (UR_3\ A_{N-J+2,2} - A_{N-J+2,1})/K$

$K = K + 1$

(3) $F1 = 0.$

$F2 = 0.$

$F3 = -A_{1,1}\ ZONAL_N$

$F4 = -A_{1,2}\ ZONAL_N$

(These account for the zonal harmonics contributions.)

(4) If the maximum order of tesserals wanted has not been attained (i.e., if $N \leq GMO$), do for N1 = 1 to N:

$F1 = F1 + N1\ A_{N1,1}\ (C_L\ ZETA\_REAL_{N1} + S_L\ ZETA\_IMAG_{N1})$

$F2 = F2 + N1\ A_{N1,1}\ (S_L\ ZETA\_REAL_{N1} - C_L\ ZETA\_IMAG_{N1})$

$DNM = C_L\ ZETA\_REAL_{N1+1} + S_L\ ZETA\_IMAG_{N1+1}$

$F3 = F3 + DNM\ A_{N1+1,1}$

$F4 = F4 + DNM\ A_{N1+1,2}$

$L = L + 1$

(These take into account the contributions of the tesseral and sectorial harmonics.)

(5) $RO\_N = RO\_N\ RO\_ZERO$

$G_1 = G_1 + RO\_N\ F1$

$G_2 = G_2 + RO\_N\ F2$

$G_3 = G_3 + RO\_N\ F3$

$AUXILIARY = AUXILIARY + RO\_N\ F4$

(These equations multiply the sum of the zonal and tesseral effects by the appropriate distance-related factors, store the results as the components of the acceleration vector $\underline{G}$, and prepare for final computation by obtaining the intermediate scalar variable AUXILIARY, which accounts for an additional effect proportional to the unit radius vector $\underline{UR}$.)

Once these calculations have been completed (N = GMD) and stored, the Earth-fixed force vector will be obtained and rotated to the M50 coordinate system.

$\underline{G}$ = $\underline{G}$ - AUXILIARY $\underline{UR}$

$\underline{G}$ = FIFTY $\underline{G}$

This is the perturbing gravitational acceleration vector needed for the equations of motion of the Shuttle. The values of GMD and of GMO may be set by the user independently. However, it is necessary that GMO $\leq$ GMD. A maximum value of 4 for GMD will be used, which will make the array $\underline{Z}$ONAL have 4 components, the arrays $\underline{C}$ and $\underline{S}$ have 9 components each, $\underline{Z}$ETA_REAL and $\underline{Z}$ETA_IMAG have 5 each, and A has a maximum dimension of 5 by 2.

The terms shown in the Earth's gravity calculations as C_L and S_L are usually represented by $C_{n,m}$ and $S_{n,m}$, respectively, but were renumbered for single subscript utilization; the terms called $ZONAL_N$ correspond to J_N.

A suggested implementation of this task is shown in the detailed flow chart, ACCEL_EARTH_GRAV CODE, in Appendix B.

The S. Pines formulation of the gravitational potential may be found, in condensed form, in the paper "Uniform Representation of the Gravitational Potential and its Derivatives," AIAA Journal, Vol. 11, No. 11, November 1973. In expanded form, and with an earlier draft of the computer program herein presented, it may be found in JSC Internal Note No. 75-FM-29, of May 27, 1975, "Use of a Nonsingular Potential."

4.2.1.2.2 Drag. The computation of drag accelerations will vary according to the values of an input indicator, designated here as GMD.

The value $\underline{D}$ of this acceleration will be set to zero when the acceleration function is called.

If GMD $\neq$ 4, the value of $\underline{D}$ shall not be changed.

If GMD = 4, $\underline{D}$ shall be computed as

$$\underline{D} = - CD\ RHO\ DRAG\_CONST\ |\underline{V}\_R|\underline{V}\_R$$

where the CD is the vehicle's drag coefficient; $\underline{V}\_R = \underline{V}\_REL\ (\underline{V}, \underline{R})$, where $\underline{V}$ and $\underline{R}$ are, respectively, the velocity and position vectors in M50 coordinates; $\underline{V}\_REL$ is the function that computes the relative velocity of the vehicle with respect to the atmosphere (assuming no wind), described in Section 4.4.5.2; RHO is the density of the Earth's atmosphere; and DRAG_CONST is one-half the cross-sectional area of the vehicle divided by the vehicle's mass, a premission-stored constant, updated in value by the deorbit/landing nav sequencer principal function (section 4.1.1).

The calculations will be performed in the following order: First, the altitude (needed for the computation of the atmospheric density, RHO) will be obtained from the expression

$$ALT = H\_ELLIPSOID(\underline{R})$$

H_ELLIPSOID is the function that computes altitude above the reference ellipsoid, described in Section 4.4.5.1.

The density then will be found, from different equations; the equation used will depend on the altitude range. For ALT $\leq$ ALT_ZONE_CHANGE,

$$RHO = SEA\_LEVEL\_DENSITY\ EXP\ \left(DENSE_1 + DENSE_2\ ALT + DENSE_3/ALT\right) \qquad F1$$

For ALT > ALT_ZONE_CHANGE,

$$RHO = SEA\_LEVEL\_DENSITY\ EXP\ \left(DENSE_4 + DENSE_5\ ALT + DENSE_6/ALT\right) \qquad F1$$

Once the atmospheric density has been obtained, the velocity $\underline{V}\_R$, relative to the atmosphere but expressed in M50 coordinates, will be found.

F1-This equation shall be protected against floating point overflow (Reference 3.6.1).

After the vector $\underline{V}$ _R has been calculated, the drag coefficient will be obtained from the square of the sine of the angle of attack (SA) and the absolute value of the sine of the sideslip angle (SB)

$$SA = [SIN(ALPHA)]^2 \qquad F9$$

$$SB = [SIN(BETA)] \qquad F9$$

where the angle of attack (ALPHA) and the angle of sideslip (BETA) are available from the attitude applications calculation subfunction. The sine of double the sideslip angle is also needed -

$$S2B = 2.\ SB\ SQRT(1. - SB^2) \qquad F4$$

and the drag coefficient is given by

$$CD = \left(CDF + CDN\ SA^{EXP\_SHAPE\_FACTOR}\right)(1. - SB) + CDS\ SB + CDA\ S2B\ SA$$

where CDF, CDN, CDA, CDS and EXP_SHAPE_FACTOR are constants described in Section 4.9.

Finally, the drag acceleration shall be obtained from the expression presented earlier

$$\underline{D} = -\ CD\ RHO\ DRAG\_CONST\ |\underline{V}\_R|\ \underline{V}\_R$$

A suggested implementation of this task is shown in the detailed flow charts, ACCEL, DENSITY and ACCEL_DRAG CODE in Appendix B.

Section 4.9 contains the values of all constants, mission dependent parameters, design dependent parameters, and hard-codeable parameters used by navigation. Of all the parameters contained in Section 4.9, the following are used in the computation of accelerations: ALT_ZONE_CHANGE, C, CDA, CDF, CDN, CDS, DENSE, EARTH_MU, EARTH_RADIUS_GRAV, EXP_SHAPE_FACTOR, S, SEA_LEVEL_DENSITY, and ZONAL.

F9-This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9).

F4-This equation shall be protected against square roots of a negative number (reference 3.6.4.).

4.2.1.3 Integration of State Equations of Motion

The algorithm for integration of the Shuttle equations of motion can use either accumulated IMU-sensed velocity to represent the nongravitational accelerations, or model drag to compute this acceleration. Section 4.2.1.2 presents detailed requirements for the ACCEL function, which computes the Shuttle acceleration vector (gravitational only or with modeled drag). The super-g computational scheme will be performed as follows:

(1) Test the flag (USE_IMU_DATA) which determines whether or not IMU data is to be used.

If USE_IMU_DATA = ON, then the IMU sensed velocity will be used: set

$$\underline{DV} = \underline{V}\_CURRENT - \underline{V}\_LAST.$$

otherwise set

$$\underline{DV} = 0.$$

(2) Save the value of the current IMU-accumulated sensed velocity for the next cycle:

$$\underline{V}\_LAST = \underline{V}\_CURRENT$$

(3) Evaluate the acceleration vector with the use of the previous values of position, velocity, time, and the indicators GM_DEG and GM_ORD as arguments of the ACCEL function:

$$\underline{G}\_ONE = ACCEL(GM\_DEG, GM\_ORD, \underline{R}, \underline{V}, T\_LAST\_FILT)$$

(4) Advance the position vector with use of the previous position, velocity, and acceleration vector and the time interval DT_FILT:

$$\underline{R} = \underline{R} + DT\_FILT\ (\underline{V} + .5\ (\underline{DV} + DT\_FILT\ \underline{G}\_ONE))$$

(5) Reevaluate the acceleration vector with use of the new value of the position vector, the old value of velocity, and the final time:

$$\underline{G}\_TWO = ACCEL(GM\_DEG, GM\_ORD, \underline{R}, \underline{V}, T\_CURRENT\_FILT)$$

(6) Advance the velocity vector with use of an average acceleration vector and IMU-sensed velocity change:

$$\underline{V} = \underline{V} + \underline{DV} + 0.5\ DT\_FILT\ (\underline{G}\_ONE + \underline{G}\_TWO)$$

(7) Adjust the position vector with use of the new acceleration vector:

F4-This equation shall be protected against square roots of a negative number (Reference 3.6.4.).

$$\underline{R} = \underline{R} + \frac{1.}{6.} (\underline{G}\_TWO - \underline{G}\_ONE)\ DT\_FILT^2$$

A suggested implementation of this task is shown in the detailed flow chart, SUPER_G_NAV, in Appendix B.

4.2.2 Covariance Matrix Propagation

The covariance matrix propagation subfunction will propagate the covariance matrix forward in time by using the state transition matrix. Additive process noise will be incorporated to account for unmodeled state and dynamic errors.

The components of the state transition matrix, PHI of dimension 6 by 6, are mathematically defined as the partials of the current state with respect to the previous state (old). An approximate formulation which makes use of a gravity gradient matrix (3 by 3) is to be used in construction of this matrix.

$PHI_{1 \text{ to } 6,\ 1 \text{ to } 6}$ is equal to the following submatrices.

$$PHI_{1 \text{ to } 3,\ 1 \text{ to } 3} = ID\_MATRIX\_3X3 + (DT\_FILT^2/2)\ GRAV\_GRAD\_OLD$$

$$PHI_{1 \text{ to } 3,\ 4 \text{ to } 6} = (DT\_FILT)\ ID\_MATRIX\_3X3$$

$$PHI_{4 \text{ to } 6,\ 1 \text{ to } 3} = (DT\_FILT/2)\ (GRAV\_GRAD\_OLD + GRAV\_GRAD\_NEW)$$

$$PHI_{4 \text{ to } 6,\ 4 \text{ to } 6} = ID\_MATRIX\_3X3 + (DT\_FILT^2/2)\ (GRAV\_GRAD\_NEW)$$

where

$$GRAV\_GRAD\_OLD = GRAVITY\_GRADIENT(\underline{R}\_COV\_LAST)$$

$$GRAV\_GRAD\_NEW = GRAVITY\_GRADIENT(\underline{R}\_FILT)$$

and $\underline{R}$ _FILT is obtained by the vector selection of $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, and R_FILT_THREE if the NAV_THREE_STATE flag is ON, and it is equal to the single-state filter position vector if the NAV_THREE_STATE FLAG is OFF.

The quantity ID_MATRIX_3X3 is the 3-by-3 identity matrix, and the gravity gradient matrix function is defined in Section 4.4.5.4.

The covariance matrix, E, will be propagated using the following equation.

$$E = PHI\ E\ PHI^T + STATE\_NOISE$$

where the state noise covariance matrix, STATE_NOISE, is used to account for unmodeled state errors and uncertainty in the propagation of the state. It will be formulated as shown in Figure 4.2.2-1.

During the nonpowered flight, i.e., when IMU data is not being used in state propagation (the flag USE_IMU_DATA is OFF), variables required in the state noise formulation will be defined as follows:

$$VAR\_ACC\_QUANT = VAR\_ACC\_QUANT\_COAST$$

$$VAR\_UNMOD\_ACC\_DT = VAR\_UNMOD\_ACC\_DT\_COAST$$

$$
\text{STATE\_NOISE} = \left[\begin{array}{ccc|ccc}
\text{NOISE\_R} & 0 & 0 & \text{NOISE\_RV} & 0 & 0 \\
0 & \text{NOISE\_R} & 0 & 0 & \text{NOISE\_RV} & 0 \\
0 & 0 & \text{NOISE\_R} & 0 & 0 & \text{NOISE\_RV} \\
\hline
\text{NOISE\_RV} & 0 & 0 & \text{NOISE} & 0 & 0 \\
0 & \text{NOISE\_RV} & 0 & 0 & \text{NOISE} & 0 \\
0 & 0 & \text{NOISE\_RV} & 0 & 0 & \text{NOISE}
\end{array}\right]
$$

where

NOISE = VAR_ACC_QUANT + (VAR_UNMOD_ACC_DT) DT_FILT

NOISE_R = NOISE (DT_FILT^2) 0.25

NOISE_RV = NOISE (DT_FILT) 0.5

Figure 4.2.2-1. State Noise Formulation

And during the powered flight when IMU data is being used in state propagation (i.e., the flag USE_IMU_DATA is ON), variables required in the state noise formulation will be defined as follows:

VAR_ACC_QUANT = VAR_ACC_QUANT_IMU

VAR_UNMOD_ACC_DT = VAR_UNMOD_ACC_DT_IMU

Finally, since the covariance matrix, E, must be symmetric, state noise terms need only be added to the upper triangular portion of the matrix triple product PHI E PHI^T and symmetry shall be maintained by

$$E_{J,I} = E_{I,J} \quad \text{for} \quad \begin{array}{l} I = 1,6 \\ J = 1,6 \end{array}$$

A suggested implementation of this task is shown in the detailed flow chart, COVEXTRAP_PF, in Appendix B.

4.2.3 State Vector Interpolation

The state vector interpolation subfunction will provide the capability to propagate the Shuttle's position vector over a small time increment. Propagation will be accomplished by using a simple, low-order integrator. This subfunction will be used to update the position vector from its current time to the time of a sensor measurement (either TACAN, MSBLS, or barometric altimeter), as required by the navigation filter to correctly compute an estimated measurement and residual. The error due to the use of the low-order integrator in calculating the position vector is not cumulative. Position propagation by this algorithm is done only if the difference between the sensor measurement time and the current time exceeds a predetermined value (EPS_TAG). This value is a function of sensor accuracy and is premission-loaded (see Section 4.9).

The following steps will be followed (in the order specified) to accomplish this subfunction.

(1) Data will be input according to the in list

IN LIST: T_SENSORS, $\underline{R}$, $\underline{V}$, $\underline{DV}$, G

where T_SENSORS is the measurement time tag, $\underline{R}$ and $\underline{V}$ are the orbiter's position and velocity vectors in M50 coordinates, $\underline{DV}$ is the IMU-sensed velocity change over the current navigation cycle, and $\underline{G}$ is the gravitional acceleration vector in M50 coordinates (if using IMU data) or the modeled total acceleration vector in M50 coordinates (if not using IMU data).

(2) The interpolation time interval will be computed as follows:

DT_INTERP = T_SENSORS-T_LAST_FILT

where T_LAST_FILT is the time associated with the recently propagated orbiter state vector.

(3) If the absolute value of DT_INTERP is less than or equal to a prestored epsilon (EPS_TAG), then the output vector R_RESID is to be equated to the input position vector

$\underline{R}$ _RESID = $\underline{R}$

and thus, no interpolation is performed.

(4) If the absolute value of DT_INTERP is greater than EPS_TAG, interpolation of the position vector will be accomplished according to the following equation:

$\underline{R}$ _RESID = $\underline{R}$ + DT_INTERP ($\underline{V}$ + .5 DT_INTERP ($\underline{DV}$/DT_FILT + $\underline{G}$)) F3

F3-This equation shall be protected against division by zero (reference 3.6.3).

A suggested implementation of this task is shown in the detailed flow chart, SV_INTERP, of Appendix B.

4.2.4 State and Covariance Measurement Incorporation (Kalman Filter)

This subfunction will use a Kalman filter to incorporate the measurement data to update the covariance matrix and the state vectors. To perform these tasks, the Kalman filter uses the covariance matrix, measurement partials, measurement residuals, and the a-priori measurement variance. Nonlinear compensation will be included if required.

If the measurement data have been judged valid and the proper measurement subfunction has been executed, the following update equations will be computed. (Note: The measurement subfunction generates the partial vector, the residuals, and the a-priori variance.)

First, the scalar quantity BT_E_B will be calculated from the covariance matrix E and vector measurement partials $\underline{B}$:

$$\underline{EB\_COPY} = E\ \underline{B}$$

$$BT\_E\_B = \underline{B} \cdot \underline{EB\_COPY}$$

where the second equation requires a dot product. The three diagonal elements of the covariance matrix pertaining to the Shuttle position uncertainty will then be summed: $E_{1,1} + E_{2,2} + E_{3,3}$. If the sum is greater than the constant MS_POS_UND_WGT, the a-priori variance will be compensated for nonlinear effects by

$$VAR = VAR + K\_UND\_WGT\ BT\_E\_B$$

This compensation underweights the measurement to prevent the state error covariance matrix from shrinking more rapidly than the actual errors. The quantity MS_DELQ, which represents the expected variance in the measurement, will then be computed by

$$MS\_DELQ = BT\_E\_B + VAR$$

A residual edit will be performed. A flag corresponding to the appropriate measurement subfunction will be set to inform the crew if the edit fails, that is, if the square of the residual is greater than the quantity RESID_TEST, where RESID_TEST = K_RES_EDIT MS_DELQ and K_RES_EDIT is a measurement-dependent multiplier established by the measurement subfunction. It should be noted that nonlinear compensation, when performed, also adjusts this edit; the larger the compensation, the larger will be the residual that passes the edit. The residual edit will be overridden or inhibited, however, if the manual edit override for the particular sensor being processed is active.

If there is no edit, the subfunction will compute the Kalman filter gain,

$$\underline{OMEGA} = \underline{EB\_COPY}/MS\_DELQ \qquad F3$$

F3-This equation shall be protected against division by zero (reference 3.6.3).

and update the covariance matrix,

$$E = E - \underline{O}MEGA\ (\underline{E}B\_COPY^T)$$

If three state vectors are being maintained, this subfunction will update them with use of the following equations.

$$\underline{R}\_FILT\_ONE = \underline{R}\_FILT\_ONE + \underline{O}MEGA_{1\ to\ 3}\ DELQ\_ONE$$

$$\underline{V}\_FILT\_ONE = \underline{V}\_FILT\_ONE + \underline{O}MEGA_{4\ to\ 6}\ DELQ\_ONE$$

$$\underline{R}\_FILT\_TWO = \underline{R}\_FILT\_TWO + \underline{O}MEGA_{1\ to\ 3}\ DELQ\_TWO$$

$$\underline{V}\_FILT\_TWO = \underline{V}\_FILT\_TWO + \underline{O}MEGA_{4\ to\ 6}\ DELQ\_TWO$$

$$\underline{R}\_FILT\_THREE = \underline{R}\_FILT\_THREE + \underline{O}MEGA_{1\ to\ 3}\ DELQ\_THREE$$

$$\underline{V}\_FILT\_THREE = \underline{V}\_FILT\_THREE + OMEGA_{4\ to\ 6}\ DELQ\_THREE$$

where DELQ_ONE, DELQ_TWO, and DELQ_THREE correspond to the appropriate measurement residuals.

If one state vector is being maintained, this subfunction will update it with use of the following equations.

$$\underline{R}\_FILT = \underline{R}\_FILT + \underline{O}MEGA_{1\ to\ 3}\ DELQ$$

$$\underline{V}\_FILT = \underline{V}\_FILT + \underline{O}MEGA_{4\ to\ 6}\ DELQ$$

where DELQ corresponds to the appropriate measurement residual. The edit flag corresponding to the appropriate measurement subfunction will be set to indicate that the measurement data have been processed rather than edited.

This subfunction will also be used to compute the residual test quantity for manually selected sensor types whenever the filter is not incorporating data. This quantity, together with residuals calculated by the measurement subfunctions, will be required for display purposes. A flag corresponding to the appropriate measurement type will be set by the navigation sensor selection task to prevent Kalman filter gain computations and state and covariance matrix updates under this condition. The filter edit flag will be set, in this case, to indicate to Measurement Processing Statistics (Section 4.2.8) that the data have been computed for display purposes only.

It is required that the residual, the residual test quantity (RESID_TEST), and the residual edit flag corresponding to each measurement subfunction be available for display purposes.

A suggested implementation of this task is shown in the detailed flow chart, NAV_FILTER, in Appendix B.

4.2.5 Vector Selector

This subfunction will provide the capability to produce a single vector from three vectors, each of which possesses a status indicating that vector as "good" or "bad." For example, the vector selector subfunction will be used to select a single valid position and velocity vector for users (guidance and display) and for Kalman gain calculation.

If all IMU's are good, a middle selected vector will be generated, composed of component-by-component middle selected values. If one IMU is determined to be bad by the redundancy management logic, the selected vector will be generated by averaging the two good vectors on a component-by-component basis. If only one IMU is performing satisfactorily, then the associated vector will be selected.

A suggested implementation of this task is shown in the detailed flow chart, VECTOR_SELECTION, in Appendix B.

4.2.6 Delta State Update

A capability will be provided for updating the position and velocity of the Shuttle in flight by using information conveyed via ground-originated command uplink or by voice from the ground to the crew for entry via the HSD. This capability will be provided by a task that corrects the Shuttle's position and velocity vectors by using state updates referenced to the current selected runway coordinate system.

The performance of a delta state update will require two difference vectors (DR_RW and DV_RW) to be supplied. These vectors must be set to the desired values before the delta state update task is invoked. The appropriate navigation control subfunction (Entry or Preland) will invoke the delta state update task only when a flag (DO_DELTA_UPDATE) has been set to ON (the control subfunctions are described in Sections 4.3.1.1 (Entry) and 4.3.2.1 (Preland)).

DR_RW is the difference between the ground estimated position of the Shuttle and the onboard navigation system's estimate of the Shuttle's position (runway coordinates). DV_RW is the difference between the ground estimated velocity of the Shuttle and the onboard navigation system's estimate of the Shuttle's velocity (runway coordinates).

The sense of these differences is: ground estimated minus onboard estimated. The onboard estimated vectors are downlinked to the ground at regular intervals (see Section 4.10 for downlist rates) and used by the ground to calculate these differences, which are then used to correct the onboard vectors.

The update will be performed as follows:

(1) In three-state navigation (NAV_THREE_STATE = ON), a single Shuttle velocity vector will be obtained through the use of the vector selection subfunction (a single Shuttle position vector will be available, having been selected by the covariance propagation subfunction prior to the execution of the delta state update subfunction). Otherwise, the current one-state Shuttle position and velocity vectors will be used.

(2) Using the Earth-fixed to M50 transformation matrix and the runway to Earth-fixed transformation matrix for the current selected runway (see Sections 4.4.3.2 and 4.4.3.5 for these transformations) the delta state update task will convert the difference vectors from the runway system to M50 coordinates. A new filter state will then be formed by adding the M50 difference vectors to the filter state with the same time tag as that used for the Earth-fixed to M50 transformation matrix. For the velocity part of the state vector, it will be necessary to take into account the rotation of the Earth.

(3) In the next step, the covariance matrix E shall be set to zero, and reinitialized with the appropriate diagonal and off-diagonal elements obtained from premission loaded values. The parameters required to compute these elements will be premission loaded in the UVW coordinate system and rotated to M50 coordinates at the time of their incorporation into the covariance matrix. Detailed requirements for this covariance matrix

reinitialization are described in Section 4.2.9. A flag (FILT_UPDATE) will automatically be set to ON at the end of the navigation filter cycle following the formation of the new filter state, and will cause the user parameter state propagation subfunction (Section 4.4.1) to reinitialize itself to the updated filter state in the same manner as if sensor data were used by the filter to update the state.

The equations required to generate the new vectors $\underline{R}$ _FILT and $\underline{V}$ _FILT and to perform the required reinitialization of the navigation subsystem are detailed in the following description:

M_TEMP = EARTH_FIXED_TO_M50_COORD (T_LAST_FILT) M_EFTORW^T

$\underline{D}$R = M_TEMP $\underline{D}$R_RW

$\underline{R}$ _FILT = $\underline{R}$ _FILT + $\underline{D}$R

$\underline{V}$ _FILT = $\underline{V}$ _FILT + M_TEMP $\underline{D}$V_RW + EARTH_RATE ($\underline{E}$ARTH_POLE x $\underline{D}$R)

In one-state navigation, the updated $\underline{R}$ _FILT and $\underline{V}$ _FILT become the current orbiter state vector. For three-state navigation, the state vectors are initialized as follows:

$\underline{R}$ _FILT_ONE = $\underline{R}$ _FILT

$\underline{R}$ _FILT_TWO = $\underline{R}$ _FILT

$\underline{R}$ _FILT_THREE = $\underline{R}$ _FILT

$\underline{V}$ _FILT_ONE = $\underline{V}$ _FILT

$\underline{V}$ _FILT_TWO = $\underline{V}$ _FILT

$\underline{V}$ _FILT_THREE = $\underline{V}$ _FILT

After computation of the updated state vector, the difference vectors shall be set to zero and the DO_DELTA_UPDATE flag set to the OFF position to inhibit repeated state updates. The necessary equations are

$\underline{D}$R_RW = 0.

$\underline{D}$V_RW = 0.

DO_DELTA_UPDATE = OFF.

A suggested implementation of this task is shown in the detailed flow chart OPS_3_DELTA_STATE_UPDATE, in Appendix B.

4.2.7 Measurement Residuals and Partials

This section documents detailed requirements for measurement subfunctions that have been identified as being common to more than one navigation principal function. The measurement subfunctions will provide the measurement residual, the measurement partials, and a-priori measurement variance per measurement type.

4.2.7.1 TACAN Range Residual and Partials

This subfunction computes the estimated range from the Shuttle to the TACAN station, the range residual, and the range measurement partials, and selects the proper variance to model the instrument error.

(1) TACAN Range Residual - The subfunction will compute the estimated Shuttle relative range by using the equation.

$$Q = |\underline{R}\_RESID - \underline{R}\_SCANNER| + BIAS\_TAC\_R$$

where

$$M\_EFTOM50 = EARTH\_FIXED\_TO\_M50\_COORD(T\_TACAN)$$

$$\underline{R}\_SCANNER = M\_EFTOM50 \ \underline{R}\_TACAN\_EF$$

The state vector used, $\underline{R}$ _RESID, may have been interpolated to the sensor measurement time (T_TACAN) if this time was different from the filter state vector time by a premission constant (Section 4.2.3). The deterministic bias correction term, BIAS_TAC_R, and the TACAN station Earth-fixed position vector, $\underline{R}$ _TACAN_EF, are obtained from the measurement reconfiguration subfunctions.

The residual shall then be calculated by

$$DQ = Q\_TAC\_R^{*} - Q$$

(2) TACAN Range Partials - The partial derivatives of the range measurement with respect to the state are to be computed as follows:

$$B_{1 \text{ to } 3} = \underline{UNIT}(\underline{R}\_RESID - \underline{R}\_SCANNER)$$

$$B_{4 \text{ to } 6} = 0.$$

where the function UNIT is to compute the unit vector, and the state vector used, $\underline{R}$ _RESID, is middle selected from the three interpolated position vectors used in the computations of the residuals if in the three-state configuration or the interpolated state vector if in the one-state configuration.

The variance of the TACAN range measurement error is selected from premission determined constants as a function of the relative range from the station to the vehicle, RNG,

$$RNG = |\underline{R}\_FILT - \underline{R}\_SCANNER|$$

where $\underline{R}$ _FILT is the middle selected state vector if in the three-state configuration or the filter state vector if in the one-state configuration.

If the range, RNG, is greater than a premission constant, RNG_VAR_RNG_STEP, then

VAR = VAR_TAC_R_HIGH

otherwise

VAR = VAR_TAC_R_LOW.

where VAR_TAC_R_HIGH and VAR_TAC_R_LOW are design dependent parameters (Section 4.9.3).

4.2.7.2 TACAN Bearing Residual and Partials

This subfunction computes the estimated bearing measurement with respect to the TACAN station, the measurement residual, and the bearing measurement partials, and selects the proper variance to model the instrument error.

(1) TACAN bearing residual - This subfunction shall compute the TACAN station location in M50 coordinates, $\underline{R}$ _SCANNER, and the transformation matrix from M50 to topodetic coordinates by using the following equations:

M_EFTOM50 = EARTH_FIXED_TO_M50_COORD(T_TACAN)

$\underline{R}$ _SCANNER = M_EFTOM50 $\underline{R}$ _TACAN_EF

M_M50TOTD = M_EFFTOTD_TACAN M_EFTOM50^T

where M_EFTOTD_TACAN and $\underline{R}$ _TACAN_EF are obtained from the measurement reconfiguration subfunctions. The estimated azimuth measurement shall then be computed as

Q = ARCTAN2(REL_R_2, REL_R_1) + BIAS_TAC_BRG

- ANGLE_CORR_TNTOMAG + PI

where ANGLE_CORR_TNTOMAG is the correction from true north to magnetic north, BIAS_TAC_BRG is the deterministic bias correction term, and $\underline{R}$EL_R, the relative position of the Shuttle in topodetic coordinates, is calculated by

$\underline{R}$EL_R = M_M50TOTD ($\underline{R}$ _RESID - $\underline{R}$ _SCANNER)

The state vector used, $\underline{R}$ _RESID, may have been interpolated to the sensor measurement time if this time was different from the filter state vector time by a premission constant (Section 4.2.3).

The residual is then calculated as

DQ= Q_TAC_BRG - Q

This residual should be checked to ensure that its magnitude is less than π; if not, the smaller of the two possible central angles is required:

If DQ > 0, DQ = DQ - 2 PI

If DQ < 0, DQ = DQ + 2 PI

(2) TACAN bearing partials - The bearing partials shall be computed by invoking the utility subfunction ANGLE_PARTIALS (described in Section 4.4.5.3) using

as inputs the vector $\underline{R}$ _SCANNER and the third row of the transformation matrix from M50 to topodetic cordinates:

CALL: ANGLE_PARTIALS

IN LIST: $\underline{R}$_SCANNER, M_M50TOTD$_{3,1 \text{ to } 3}$

The state vector used in ANGLE_PARTIALS, $\underline{R}$ _RESID, is middle selected from the three interpolated position vectors used in the computations of the residuals if in the three-state configuration or the interpolated state vector if in the one-state configuration.

The variance of the TACAN bearing measurement error is selected from premission determined constants as a function of the relative range from the station to the vehicle, RNG,

$$\text{RNG} = \text{ABVA}\left(\underline{R}\text{ _FILT} - \underline{R}\text{ _SCANNER}\right)$$

where $\underline{R}$ _FILT is the middle selected state vector if in the three-state configuration or the filter state vector if in the one-state configuration.

If the range, RNG, is greater than a premission constant, RNG_VAR_BEARING_STEP

then

VAR = VAR_TAC_BRG_HIGH

otherwise

VAR = VAR_TAC_BRG_LOW.

where VAR_TAC_BRG_HIGH and VAR_TAC_BRG_LOW are design dependent parameters (Section 4.9.3).

A suggested implementation of these tasks is shown in the detailed flow charts TACAN_NAV, TACAN_RANGE_COMP and TACAN_BRG_COMP, in Appendix B.

4.2.7.3 Barametric Altimeter Residual and Partials

This subfunction computes the estimated altitude measurement, the altitude residual, the altitude measurement partials, and the variance that models the instrument error.

(1) Barometric Altimeter Residuals - The estimated barometric altimeter measurement shall be calculated by the equation

Q = H_ELLIPSOID (R_RESID) + BIAS_BARO - DELH_MLS_ELLIPSOID_RW.

The state vector used in this equation, R_RESID, may have been interpolated to the sensor measurement time, if required, as described in Section 4.2.3. Requirements for H_ELLIPSOID, which is the function used to calculate the height above the reference ellipsoid, are contained in section 4.4.5.1.

The residual will then be calculated by

DELQ = Q_BARO - Q.

If the navigation is in the one-state configuration, this will be done only once. If in the three-state configuration, it will be done three times, and the resulting values, locally called Q_ONE, Q_TWO, Q_THREE, DELQ_ONE, DELQ_TWO, and DELQ_THREE, will be presented to the vector selection subfunction (Section 4.2.5) from which a single value for each selected quantity will emerge, with the names Q and DELQ.

(2) Barometric Altimeter Partials - The partial derivative of the barometric measurement with respect to the state vector is computed as follows:

$B_{1 \text{ to } 3}$ = UNIT(R_FILT)

$B_{4 \text{ to } 6}$ = 0.

where the function UNIT computes the unit vector.

R_FILT is the mid-selected position vector if in the three-state configuration, and the filter position vector if in the one-state configuration.

The variance of the barometric measurement error will be calculated as

$$VAR = VAR\_H1 + VAR\_H2\ (Q-ALT\_RW)^2$$

where ALT_RW is the altitude of the runway threshold above the reference ellipsoid.

A suggested implementation of this task is shown in the flow charts BARO_NAV and BARO_COMP, in Appendix B.

4.2.8 Measurement Processing Statistics

During navigation phases that utilize external measurements, the measurement processing statistics subfunction will compute for display certain parameters that are indicative of the condition of the navigation filter and the external sensor measurements that it utilizes. The measurement processing statistics subfunction will be performed as a subfunction of each navigation processing principal function that utilizes an external sensor measurement. It will be performed after the corresponding state and covariance measurement incorporation subfunction has been performed. Filter edit indicators, which will have been initialized to a default value during the corresponding sensor measurement selection subfunction, will be redefined during the performance of the state and covariance measurement incorporation subfunction. This will indicate to the measurement processing statistics subfunction, for each measurement type being utilized, which of the following four cases has occurred:

(1) edit indicator = OFF - the filter was not configured for the measurement type, or the data were bad and the filter did not attempt to process data of that type,

(2) edit indicator = ON - the filter did attempt to process the measurement type but automatically edited the data,

(3) edit indicator = PROCESSED - the filter did process the measurement type, or

(4) edit indicator = STAT - the filter was used solely for producing the residual and ratio parameters for display.

Moreover, the state and covariance measurement incorporation subfunction will provide the measurement processing statistics subfunction with the value of each measurement residual and the square of the denominator of the display residual edit ratio, which is described in the following paragraphs. The data supplied to the measurement processing statistics subfunction can be used for two different purposes:

(1) to calculate the status of the processing of the external sensor data and

(2) to compute statistics for the sensor measurement type selected by the sensor measurement type selected by the sensor measurement selection subfunction.

These two sets of calculations are described as follows:

4.2.8.1 Sensors Status

An indication of the status of external data processing by navigation is provided to the crew by the navigation event lamp. This event lamp indicates whether particular external sensor data are being incorporated when the Shuttle is within specific altitude regions. The sensor types are as follows:

TACAN azimuth

TACAN range

Drag derived altitude

BARO altitude

MSBLS azimuth

MSBLS range

MSBLS elevation

Radar altimeter altitude

The setting of the navigation event lamp indicator (EVENT_LAMP_FIVE) involves user parameter processing principal functions as well as the measurement processing statistics subfunctions. Measurement processing subfunctions shall set the discrete, NAV_EL_FLAG, based upon processing of the first seven sensor types above. User parameter processing principal functions shall set EVENT_LAMP_FIVE based upon the discrete set by measurement processing and, when appropriate, the status of radar altimeter data as described in Section 4.6.

Within the entry navigation measurement processing statistics subfunction, the setting of NAV_EL_FLAG shall be based upon processing of TACAN range, TACAN azimuth, barometric altitude and drag derived altitude as follows. If the vehicle is above a predetermined altitude; if ALT > ALT_EL_1 then NAV_EL_FLAG shall retain its initial value of OFF and computation of sensor statistics shall commence. If ALT $\leq$ ALT_EL_1, the value of NAV_EL_FLAG shall be established as follows.

The temporary discrete, EV_LT, shall be initialized to ON. Then if MLS_AVAIL = OFF or if ALT_WHEELS > ALT_EL_2, the following test shall be performed. (MLS_AVAIL indicates whether or not MSBLS transmitters are associated with the landing runway.) If either $SENSOR\_EDIT_1$ = "PROCESSED" or IN_CONE_FLAG = ON and if $SENSOR\_EDIT_2$ = "PROCESSED," then RAW_RA_PROC is to be tested. If RAW_RA_PROC = ON, then set EV_LT to OFF. Otherwise, if $SENSOR\_EDIT_3$ = "PROCESSED", or if $SENSOR\_EDIT_4$ = "PROCESSED", or if H_INHIB = ON, set EV_LT to OFF.

Within the preland navigation measurement processing statistics subfunction, the setting of the NAV_EL_FLAG shall be based upon the processing of MSBLS range, MSBLS azimuth, and MSBLS elevation as follows. A discrete, EV_LT, shall be set to ON and if $SENSOR\_EDIT_5$ = "PROCESSED" and if $SENSOR\_EDIT_6$ = "PROCESSED", then the flag which indicates whether radar altimeter data are being utilized within

the Autoland UPP principal function shall be tested. If RAW_RA_PROC = ON, then set EV_LT to OFF. Otherwise, if $SENSOR\_EDIT_7$ = "PROCESSED", then set EV_LT to OFF.

Finally, after establishing the value of EV_LT, its value is tested. If EV_LT = OFF, then initialize the sequential counter N_SEQ to one and set NAV_EL_FLAG to OFF. Otherwise, N_SEQ shall be incremented by one and then if N_SEQ > N_SEQ _MAX, set NAV_EL_FLAG to ON.

The indexed variables have the following definitions:

$SENSOR\_EDIT_1$ is the edit indicator for the TACAN bearing measurement.

$SENSOR\_EDIT_2$ is the edit indicator for the TACAN range measurement.

$SENSOR\_EDIT_3$ is the edit indicator for the barometric altitude measurement.

$SENSOR\_EDIT_4$ is the edit indicator for the drag altitude measurement.

$SENSOR\_EDIT_5$ is the edit indicator for the MSBLS azimuth measurement.

$SENSOR\_EDIT_6$ is the edit indicator for the MSBLS range measurement.

$SENSOR\_EDIT_7$ is the edit indicator for the MSBLS elevation measurement.

4.2.8.2 Measurement Statistics

For each TACAN, drag altitude, barometric altimeter, and MSBLS measurement type, three parameters are to be computed to show how well the navigation filter is processing external measurements of that particular type. The three parameters to be computed for each measurement are as follows:

(1) The display measurement residual is to be the actual measurement residual computed by the navigation filter for the particular type, provided the navigation filter has done the computation (i.e., provided that the filter was configured to attempt processing of that particular measurement type during the filter cycle just completed). If the filter was not configured for the measurement type, so that no residual was computed, then the display measurement residual for the particular measurement type shall be displayed as a BLANK in accordance with display requirements.

(2) The display residual edit ratio is, for a particular measurement type, the absolute value of the actual measurement residual divided by the maximum magnitude that the residual for this measurement type may attain before automatic data editing in the filter occurs. Again, if the filter was not configured for the particular measurement, this display parameter shall be presented as BLANK.

(3) The display edit history indicator, if displayed as the symbol "↓" on the cathode-ray tube, shall indicate that, for more than K_MAX times out of the last 4 times that the filter attempted to process the particular measurement type, automatic data editing occurred. Otherwise, this indicator shall be displayed as a BLANK. K_MAX is a padloaded integer such that $1 \leq$ K_MAX ≤ 4.

The actual calculation of the three parameters above shall be accomplished as follows. To compute the display edit history indicators, it is necessary to retain edit information about the last 4 cycles for each measurement type. This will be accomplished by the use of an MX4 matrix EDIT_ARRAY, where M represents the maximum number of measurement types to be managed by this subfunction during the various navigation phases. In the equations below, the following definitions are used.

$DISP\_DELQ_I$ = parameter (1) above for the I-th measurement type.

$DISP\_SIG_I$ = parameter (2) above for the I-th measurement type.

$DISP\_EDIT_I$ = parameter (3) above for the I-th measurement type.

$SENSOR\_EDIT_I$ = the filter edit indicator for the I-th measurement type.

$SENSOR\_DELQ_I$ = the filter measurement residual for the I-th measurement type.

$SENSOR\_RESID\_TEST_I$ = the square of the denominator of the display residual edit ratio for the I-th measurement type.

The correspondence between the subscript, I, and measurement type shall be as follows:

I = 1 - TACAN azimuth

I = 2 - TACAN range

I = 3 - barometric altitude

I = 4 - drag altitude

I = 5 - MSBLS azimuth

I = 6 - MSBLS range

I = 7 - MSBLS elevation

For each value of the integer I in the interval (1, M), the following procedure will be performed.

The indicator $SENSOR\_EDIT_I$ shall be tested; and if found to have the value "OFF," both $DISP\_DELQ_I$ and $DISP\_SIG_I$ shall be given the value "BLANK" and the calculations shall cease at this point. If the value tested is not "OFF," then $DISP\_DELQ_I$ shall be given the value $SENSOR\_DELQ_I$ and $DISP\_SIG_I$ shall be calculated according to

$$DISP\_SIG_I = \frac{ABVAL(SENSOR\_DELQ_I)}{(SENSOR\_RESID\_TEST_I)^{1/2}} \qquad \text{F3, F4}$$

provided that $SENSOR\_RESID\_TEST_I$ is positive.

The $SENSOR\_EDIT_I$ indicator shall again be tested; and if found to have the value "STAT", $DISP\_EDIT_I$ shall be given the value "BLANK" and the calculations shall cease at this point. If the value tested is not "STAT", the column index, J_I, shall be incremented by 1 and reset to 1 if its value then should be 5. Next, the parameter SUM_I shall be determined as $SUM_I = SUM_I - EDIT\_ARRAY_{I,COLUMN}$, where $COLUMN = J_I$, and $SENSOR\_EDIT_I$ shall again be tested. If its value is "ON", then $EDIT\_ARRAY_{I,COLUMN}$ shall be given the value one and SUM_I shall be incremented by one. If its value is not "ON", then $EDIT\_ARRAY_{1,COLUMN}$ shall be set to zero. Finally, SUM shall be tested; and if its value exceeds the value K_MAX, $DISP\_EDIT_I$ shall be given the value "↓"; otherwise, $DISP\_EDIT_I$ = BLANK.

The range residual, $DISP\_DELQ_2$, will be tested and if not equal to BLANK, its dimension will be transformed from units of feet to units of nautical miles.

F3-This equation shall be protected against division by zero (reference 3.6.3)
F4-This equation shall be protected against square roots of a negative number (reference 3.6.4)

Thus

if $\quad$ $DISP\_DELQ_2 \neq BLANK$

then $\quad$ $DISP\_DELQ_2 = DISP\_DELQ_2 \; NAUTMI\_PER\_FT$

A suggested implementation of these tasks is shown in the detailed flow charts, MEAS_PROCESSING_STATISTICS_ENTRY CODE and MEAS_PROCESSING_STATISTICS_PRELAND CODE, in Appendix B.

4.2.9 Covariance Matrix Initialization

In circumstances in which the position and velocity elements of the onboard filter covariance matrix are to be initialized to UVW values (i.e., as a result of ground updates and entrance into operational Sequence 3 from either OPS-1 or OPS-2), the following steps must be performed (in the order indicated):

(1) Data will be input to this subfunction as described by the in list below:

IN LIST: SIG, COR, R, V

where SIG is a six-element vector of standard deviations in the UVW coordinate system

SIG_1, U-position

SIG_2, V-position

SIG_3, W-position

SIG_4, U-velocity ($\dot{U}$)

SIG_5, V-velocity ($\dot{V}$)

SIG_6, W-velocity ($\dot{W}$)

and where COR is a seven-element vector of correlation coefficients, also in the UVW coordinate system

COR_1, correlation between U-V

COR_2, correlation between U-$\dot{U}$

COR_3, correlation between U-$\dot{V}$

COR_4, correlation between V-$\dot{U}$

COR_5, correlation between V-$\dot{V}$

COR_6, correlation between W-$\dot{W}$

COR_7, correlation between $\dot{U}$-$\dot{V}$

and where R and V are the current orbiter position and velocity vectors, respectively, in M50 coordinates.

(2) The 6 by 6 covariance matrix temporary array will be zeroed

E_TEMP = 0.

(3) The diagonal elements of E_TEMP will be computed

$$E\_TEMP_{I,I} = SIG_I \; SIG_I, \text{ for } I = 1,6$$

(4) Next, position and velocity submatrix elements, as well as the upper right position-velocity covariance elements, will be computed

$$E\_TEMP_{1,2} = COR_1 \; SIG_1 \; SIG_2$$

$$E\_TEMP_{1,4} = COR_2 \; SIG_1 \; SIG_4$$

$$E\_TEMP_{1,5} = COR_3 \; SIG_1 \; SIG_5$$

$$E\_TEMP_{2,4} = COR_4 \; SIG_2 \; SIG_4$$

$$E\_TEMP_{2,5} = COR_5 \; SIG_2 \; SIG_5$$

$$E\_TEMP_{3,6} = COR_6 \; SIG_3 \; SIG_6$$

$$E\_TEMP_{4,5} = COR_7 \; SIG_4 \; SIG_5$$

$$E\_TEMP_{2,1} = E\_TEMP_{1,2}$$

$$E\_TEMP_{5,4} = E\_TEMP_{4,5}$$

(5) And, finally, a transformation matrix from UVW to M50 coordinate systems is acquired at current time, and used to rotate the E-matrix into the M50 system. The lower left position-velocity covariance is also defined

$$M = UVW\_TO\_M50(\underline{R},\underline{V})$$

$$E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3} = M \; E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3} \; M^T$$

$$E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6} = M \; E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6} \; M^T$$

$$E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6} = M \; E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6} \; M^T$$

$$E\_TEMP_{4 \text{ TO } 6,\ 1 \text{ TO } 3} = (E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6})^T$$

(6) The 6 by 6 covariance matrix E_TEMP will be output from this subfunction.

A suggested implementation of this task is shown in the detailed flow chart, COVINIT, in Appendix B.

4.2.10 User Parameter Propagator Reset

The user parameter propagator reset subfunction will store the vehicle position, velocity, the associated time tag, the velocity count, and the gravity acceleration vector after all navigation updates for use by the user parameter state propagator.

$\underline{R}$ _RESET = $\underline{R}$ _FILT

$\underline{V}$ _RESET = $\underline{V}$ _FILT

T_RESET = T_FILT

$\underline{V}$ _IMU_RESET = $\underline{V}$ _LAST_FILT

$\underline{G}$ _RESET = $\underline{G}$ _OLD

Also, the current value of the filter state vector will be saved for subsequent covariance matrix propagation.

$\underline{R}$ _COV_LAST = $\underline{R}$ _FILT

Finally, the filter update flag will be set to ON to indicate to users that the current navigation filter update is complete.

FILT_UPDATE = ON

A suggested implementation of this task is shown in the detailed flow chart, UPP_STATE_RESET, in Appendix B.

4.3 NAVIGATION PROCESSING PRINCIPAL FUNCTIONS

The two principal navigation processing functions are entry and preland navigation. Each of these functions will be initialized and cyclically executed under the control of the deorbit/landing navigation sequencer principal function (Section 4.1.1). Detailed requirements for each of the principal navigation processing functions are discussed in the following sections.

4.3.1 Entry Navigation

The entry navigation principal function is to provide an up-to-date estimate of the Shuttle's position, velocity, and other parameters for software users, such as guidance and displays. This principal function will be scheduled by the deorbit/landing navigation sequencer. Variables interfacing with this function are identified in Appendix G.

Entry navigation will use data from as many as three IMU's to maintain current estimates of three state vectors. However, navigation state propagation will not use accelerometer data unless the sensed velocity magnitude is above a premission-determined level. The measured accelerations due to drag will also be used, together with an atmosphere model, to generate pseudo altitude measurements.

A Kalman filtering technique will be used when updating the three inertial state vectors with TACAN, BARO altimeter or pseudo DRAG altitude measurements. If a whole vector or time tag update is indicated, the state vectors will be updated and covariance matrix reinitialized as described in Section 4.3.1.4.3. Otherwise, the three state vectors will be propagated and then will be reduced to single quantities, as described in Section 4.2.5, to obtain a vector to compute the state transition matrix. The state error covariance matrix will then be propagated. If a delta state update is indicated, the state vectors will be updated and covariance matrix reinitialized as described in Section 4.2.6. The measurement partials and the Kalman filter gain will be computed. The filter will then compute the three measurement residuals and select one; and after a reasonability test and data editing, the Kalman gain and the measurement residuals will be used to update the initial three propagated state vectors. The three position and velocity state vectors will then be reduced to single vectors as described in Section 4.2.5 for computing user parameters and display parameters.

4.3.1.1 Entry Control

The entry navigation principal function will provide the capability to control state and covariance matrix propagation and filter updates; three state vectors will be maintained.

A. Detailed Requirements. Entry control will perform the following tasks in the order indicated. (For definitions of variables, see input and output Tables 4.3.1.1-1 and 4.3.1.1-2.)

(1) An attitude parameters data snap will be performed as described in Section 4.3.1.2. The data snapped will be converted from degrees into radians for internal use.

ALPHA = ALPHAIN RAD_PER_DEG

BETA = BETAIN RAD_PER_DEG

(2) The accumulated sensed velocities from three IMU's the selected sensed velocity and the corresponding time tag will be obtained as described in Section 4.3.1.5.

(3) An external sensor data snap will be performed as described in Section 4.3.1.2.

(4) The op-code associated with uplinked data shall be tested to determine if a whole vector (M50 coordinates) has been provided via the ground communication link. If data has been uplinked, the onboard state vector shall be replaced as described in section 4.3.1.4.3 and the op-code set to a value of zero to prevent repeated use of the same information. Items 5, 6, 7, and 8 below shall be bypassed if a whole vector update has been performed.

(5) If there is no whole vector update to be accomplished, a flag, DO_DELTA_T_UPDATE, (indicating that a downrange position correction shall be accomplished by a state vector time tag adjustment) shall be tested. If DO_DELTA_T_UPDATE has been set to 'ON' by a keyboard entry, then the input data needed by a whole vector update processing will be defined, the flag turned to 'OFF' position to prevent repeated execution and the navigation state updated as described in section 4.3.1.4.3. The necessary equations are:

$\underline{R}$ _GND = $\underline{R}$ _FILT

$\underline{V}$ _GND = $\underline{V}$ _FILT

T_GND = T_LAST_FILT + DELTA_T

DO_DELTA_T_UPDATE = OFF

CALL: WHOLE_VECTOR_UPDATE

where DELTA_T is defined through a keyboard entry. The sense of the update mode is that a positive value of DELTA_T is used to correct the onboard navigated state when the navigated state is in error by being too far downtrack compared to the solution obtained from groundtracking data. A negative value of DELTA_T is used when the onboard state lags behind the downtrack position as determined from groundtracking data. Items 6, 7, and 8 shall be bypassed if a DELTA_T update is performed.

(6) The three state vectors will be propagated as described in section 4.3.1.5.

(7) The covariance matrix propagation subfunction will propagate the covariance matrix as described in section 4.3.1.6.

(8) After propagation of the navigation state vectors and covariance matrix, a flag, DO_DELTA_UPDATE, shall be tested to determine if a delta state update has been requested by either keyboard entries or via command uplink. If such an update has been requested, the navigation state shall be updated as described in section 4.3.1.4.2.

(9) The entry sensor measurement selection subfunction will determine which measurements (drag altitude, TACAN range and bearing, BARO altitude) are to be presented to the filter for processing as described in section 4.3.1.3.

(10) The navigation reconfiguration subfunction will set up the proper state vectors and covariance matrix or TACAN site location data for use by the state and covariance matrix update task as described in section 4.3.1.4.

(11) The state and covariance measurement incorporation subfunction will update the state vectors and covariance matrix as described in section 4.3.1.7. A counter, (DRAG_MARK_NUM, TACAN_MARK_NUM, or BARO_MARK_NUM), will be incremented for each measurement processed to indicate the mark number for post-mission analysis purposes.

(12) The following parameters necessary for the user parameter propagation principal function will be reduced to single parameters as discussed in section 4.2.5: the filter's position and velocity vector and the gravity vector.

(13) The position and velocity, the associated time tag, the selected gravity vector, and the selected IMU velocity counts will then be stored for use by the user parameter state propagator as described in section 4.2.10.

(14) Finally, the entry measurement processing statistics subfunction (Section 4.3.1.8) shall be performed.

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.1.1-1 and 4.3.1.1-2.

C. Processing Requirements. Entry control will be executed at a premission-determined rate when the entry navigation principal function is scheduled.

D. Constraints. The attitude data SNAP statement implies the assignment of current values, to the variable names ALPHAIN and BETAIN which are assumed to be in units of degrees from the ATT PROC principal function. The flag DO_DELTA_T_UPDATE may not be set to the 'ON' position (by software external to navigation) until after the desired value of DELTA_T has been established.

E. Supplemental Information. A suggested implementation of entry control is illustrated by NAV_ENTRY in Appendix B.

TABLE 4.3.1.1-1.- ENTRY CONTROL INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	1,2,3,*	V	DP	--	ft	Filter rate
Current Shuttle position vector for three-state configuration, state two	R_FILT_TWO	1,2,3,*	V	DP	--	ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R_FILT_THREE	1,2,3,*	V	DP	--	ft	Filter rate
Shuttle velocity vector, state one	V_FILT_ONE	1,2,3,*	V	S	--	ft/sec	Filter rate
Shuttle velocity vector, state two	V_FILT_TWO	1,2,3,*	V	S	--	ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	1,2,3,*	V	S	--	ft/sec	Filter rate
Time of the filter state vectors	T_LAST_FILT	Entry state propagation, *	F	DP	--	sec	Filter rate
Previous value of selected accumulated IMU velocity	V_LAST_FILT	Entry state propagation, *	V	S	--	ft/sec	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU 1	G_ONE_OLD	Entry state propagation,	V	S	--	ft/sec^2	Filter rate

1. Entry state propagation
2. Delta state update
3. Entry nav state and covariance measurement incorporation

*Refer to entry navigation principal function input list (Appendix G).

TABLE 4.3.1.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Gravity acceleration vector at end of integration interval associated with IMU 2	G_TWO_OLD	Entry state propagation	V	S	--	ft/sec^2	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU 3	G_THREE_OLD	Entry state propagation	V	S	--	ft/sec^2	Filter rate
Flag indicating (ON) that drag altitude data are to be processed	DO_DRAG_NAV	Entry measurement selection	D	-	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data are to be processed	DO_TACAN_NAV	Entry measurement selection	D	-	OFF/ON	--	Filter rate
Flag indicating (ON) that BARO data are to be processed	DO_BARO_NAV	Entry measurement selection	D	-	OFF/ON	--	Filter rate
Angle of attack	ALPHAIN	*	F	S		deg	Filter rate
Angle of sideslip	BETAIN	*	F	S		deg	Filter rate
Flag indicating (ON) that a delta state vector update shall be performed	DO_DELTA_UPDATE	*, delta state update	D	-	OFF/ON	--	Filter rate

*Refer to the entry navigation principal function input list (Appendix G).

TABLE 4.3.1.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Bit string indicating which command uplink has occurred	OP_CODE	*, whole vector update task	B(7)	-	-	-	Filter rate
Conversion factor from degrees to radians	RAD_PER_DEG	**	F	S	-	rad/deg	Filter rate
Flag indicating (ON) that a time tag update is to be performed	DO_DELTA_T_UPDATE	*	D	--	OFF/ON	--	Filter rate
Amount by which the state vector time-tag is to be incremented	DELTA_T	*	S	S	--	sec	Filter rate

*Refer to the entry navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.1-2.- ENTRY CONTROL OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Vehicle position vector after all navigation updates reserved for reset of guidance integrator position vector	R_RESET	*	V	DP		ft	Filter rate
Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector	V_RESET	*	V	S		ft/sec	Filter rate
Time associated with reserved reset state	T_RESET	*	F	DP		sec	Filter rate
Copy of V_LAST_FILT accumulated velocity counts reserved for reset of guidance integrator	V_IMU_RESET	*	V	S		ft/sec	Filter rate
Switch indicating (ON) that current measurement processing is complete	FILT_UPDATE	*	D	-	OFF/ON	--	Filter rate
Updated vehicle position vector associated with current covariance matrix	R_COV_LAST	Entry covariance propagation	V	DP		ft	Filter rate
Angle of attack	ALPHA	State prop	F	S	-	rad	Filter rate
Angle of sideslip	BETA	State prop	F	S	-	rad	Filter rate
Counter indicating the particular drag measurement processed by the filter	DRAG_MARK_NUM	*	I	S		--	Filter rate

*Refer to the entry navigation principal function output list (Appendix G).

TABLE 4.3.1.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Counter indicating the particular TACAN measurement processed by the filter	TACAN_MARK_NUM	*	I	S			Filter rate
Gravitational acceleration vector reserved for reset of guidance integrator gravity vector	G _RESET	*	V	S		ft/sec^2	Filter rate
Flag indicating (ON) that BARO data are to be processed	DO_BARO_NAV	*	D	-	OFF/ON	--	Filter rate
Flag indicating (ON) that DRAG data are to be processed	DO_DRAG_NAV	*	D	-	OFF/ON		Filter rate
Flag indicating (ON) that TACAN data are to be processed	DO_TACAN_NAV	*	D	-	OFF/ON		Filter rate
Counter indicating the particular BARO altitude measurement processed by the filter	BARO_MARK_NUM	*	I	S		--	Filter rate
Flag indicating (ON) that a time-tag update is to be performed.	DO_DELTA_T_ UPDATE	*	D	-	OFF/ON	--	Filter rate
Amount by which the state vector time-tage is to be incremented	DELTA_T	*	S	S		sec	Filter rate

*Refer to the entry navigation principal function output list (Appendix G).

4.3.1.2 External Sensor Data Snap

The purpose of this subfunction during the entry navigation phase is to collect and store sensor data (TACAN and BARO altimeter) for subsequent use in the state and covariance measurement incorporation subfunction. This subfunction is required to ensure that the data sets used in navigation processing are properly saved for use in the state and covariance measurement incorporation subfunction, whereas the actual data may continue to be refreshed by hardware sensor reading, sensor SOP processing, and selection filter unification. In addition, attitude parameters will be collected and stored for subsequent use in the calculation of drag acceleration.

A. Detailed Requirements. During the entry phase, the magnetic bearing of the TACAN station from the Shuttle and the slant range distance from the TACAN ground beacon, together with the data-good flags, will be collected and stored. The associated time tag will be collected, adjusted by a premission-loaded time bias, and stored. The current TACAN line replacement unit (LRU) number also will be collected and stored. The following equations define the parameters necessary to accomplish the above requirements:

```
SNAP TACAN (Q_TAC_BRG, Q_TAC_R, TAC_RNG_DATA_GOOD,

            TAC_BRG_DATA_GOOD, T_TACAN, SEL_LRU_ID)

T_TACAN = T_TACAN - TIME_BIAS_TACAN
```

Barometric altimeter data is also collected and stored. This includes the Shuttle's barometric altitude, a flag indicating if the Shuttle is in the MACH jump region, its data good flag and the associated time tag, adjusted by a premission loaded time bias. The following equations define the parameters necessary to accomplish the above requirements:

```
SNAP BARO ALTIMETER (Q_BARO, MACH_JUMP, BARO_DATA_GOOD, T_BARO)

T_BARO = T_BARO - TIME_BIAS_BARO
```

In addition, the angle of attack, sideslip angle, and the M50-to-body quaternion will be collected and stored. The following equation defines the parameters necessary to accomplished this requirement:

```
SNAP ATTITIUDE (ALPHAIN, BETAIN, Q_M50_BODY)
```

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.1.2-1 and 4.3.1.2-2, respectively. The output time tag is assumed to have been associated with the sensor's measurement (the time FCOS commands the read, adjusted by applying a time bias correction).

C. Processing Requirements. It is required that the TACAN sensor data (measurements, ID's, validity flags, and time tags) be made available for the collection and storage processes. The collection rates (not necessarily sensor interrogations) are indicated by the entry navigation sequencers. However, these rates assume that the available data are fresh. This implies

that SOP's processing and selection filtering must be at a rate equal to or greater than the collection rate. This is also true for BARO altimeter data.

D. Constraints. The data collections should occur after a complete current set is available and just prior to use in navigation in order to supply current data.

E. Supplementary Information. A suggested implementation of the entry external sensor data snap subfunction, in the detailed flow chart NAV_ENTRY, can be found in Appendix B. The snap statement above implies the assignment of current values to the variable names shown in parentheses.

TABLE 4.3.1.2-1.- ENTRY EXTERNAL SENSOR DATA SNAP INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
TACAN bearing sensor measurement	Q_TAC_BRG	*	F	DP		rad	Filter rate
TACAN range sensor measurement	Q_TAC_R	*	F	DP		ft	Filter rate
BARO altimeter sensor measurement	Q_BARO	*	F	DP		ft	Filter rate
Time at which TACAN was read	T_TACAN	*	F	DP		sec	Filter rate
Pad loaded bias used to correct TACAN time tag	TIME_BIAS_ TACAN	**	F	DP		sec	Filter rate
Integer indicating which TACAN LRU (1,2, or 3) is selected by RM for use by NAV filter for TACAN data processing	SEL_LRU_ID	*	I	S	1,2,3	--	Filter rate
Current range data-good flag reserved for measurement processing	TAC_RNG_DATA_ GOOD	*	D		OFF/ON	--	Filter rate
Current bearing data-good flag reserved for measurement processing	TAC_BRG_DATA_	*	D		OFF/ON	--	Filter rate
Angle of attack	ALPHAIN	*	F	DP		rad	Filter rate
Sideslip angle	BETAIN	*	F	DP		rad	Filter rate
M50-to-body coordinates quaternion	Q_M50_BODY	*	V(4)	DP			Filter rate
Flag indicating (ON) that the Shuttle is in the MACH jump region	MACH_JUMP	*	D		OFF ON	--	Filter rate

*Entry navigation principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current BARO altimeter data good flag reserved for measurement processing	BARO_DATA_GOOD	*	D		OFF/ON	--	Filter rate
Time at which BARO altimeter was read	T_BARO	*	F	DP		sec	Filter rate
Pad loaded bias used to correct BARO altimeter time tag	TIME_BIAS_BARO	**	F	DP		sec	Filter rate

*Entry navigation principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.2-2.- ENTRY EXTERNAL SENSOR DATA SNAP OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN bearing sensor measurement	Q_TAC_BRG	Entry navigation TACAN brg meas incorp, *	F	DP		rad	Filter rate
TACAN range sensor measurement	Q_TAC_R	Entry navigation TACAN range meas incorp, *	F	DP		ft	Filter rate
BARO altimeter sensor measurement	Q_BARO	Entry navigation BARO meas incorp, *	F	DP		ft	Filter rate
Time at which TACAN was read	T_TACAN	Entry navigation TACAN range meas incorp, Entry navigation TACAN brg meas incorp, *	F	DP		sec	Filter rate
Integer indicating which TACAN LRU (1,2, or 3) is selected by RM for use by navigation filter for TACAN data processing	SEL_LRU_ID	Entry navigation measurement reconfiguration, *	I	S	1,2,3	--	Filter rate

*Refer to entry navigation principal function outlist (Appendix G).

TABLE 4.3.1.2-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current bearing data-good flag reserved for measurement processing	TAC_BRG_DATA_GOOD	Entry navigation TACAN bearing measurement incorp, *	D	--	OFF/ON	--	Filter rate
Current range data-good flag reserved for measurement processing	TAC_RNG_DATA_GOOD	Entry navigation TACAN range measurement incorp, *	D	--	OFF/ON	--	Filter rate
Angle of attack	ALPHAIN	Entry control	F	S		deg	Filter rate
Sideslip angle	BETAIN	Entry control	F	S		deg	Filter rate
M50-to-body coordinates quaternion	Q_M50_BODY	Entry navigation drag measurement incorp	V(4)	DP		--	Filter rate
Time at which BARO altimeter was read	T_BARO	Entry navigation BARO meas incorp, *	F	DP		sec	Filter rate
Flag indicating (ON) that the Shuttle is in the MACH jump region	MACH_JUMP	Entry measurement selection	D	--	OFF/ON	--	Filter rate

*Refer to entry navigation principal function outlist (Appendix G).

TABLE 4.3.1.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current BARO altimeter data good flag reserved for measurement processing	BARO_DATA_GOOD	Entry navigation BARO measurement incorp, *	D	--	OFF/ON	--	Filter rate

*Refer to entry navigation principal function outlist (Appendix G).

4.3.1.3 Sensor Measurement Selection

A capability, designated as the entry sensor measurement selection subfunction, is required to determine whether sensor measurement data will be presented to the state and covariance measurement incorporation subfunction (Section 4.3.1.7) when the entry navigation principal function is active. Selection of sensor measurement data will also mean that knowledge of this data selection will be provided to the measurement reconfiguration subfunction (Section 4.3.1.4.1) to cause proper initialization of TACAN site data.

A. Detailed Requirements. The requirements for this subfunction are given as a set of necessary sensor selection capabilities. Only TACAN, BARO, and DRAG altitude measurement data will be considered for selection while the entry navigation principal function is active. The following capabilities will be provided.

(1) There will be both manual (crew) and automatic control of sensor measurement selection.

(2) The crew will be able to force or inhibit each measurement data type, or allow automatic selection.

(3) Manual control (force or inhibit) overrides automatic selection. If a crewman forces valid TACAN data then these data will be presented to the state and covariance measurement incorporation subfunction. If a crewman inhibits valid TACAN or barometric altimeter data then these data will be processed for statistical display purposes only. The force or inhibit of sensor measurement data stays in effect across major mode transitions and is removed by reverting to automatic selection.

(4) The forcing of a sensor measurement data type will override the residual edit of that data type if it is selected for processing.

(5) If barometric altimeter data are indicated valid and are forced, then BARO data will be selected for processing provided the Shuttle is not in the MACH jump region (discontinuity region). If barometric altimeter data are indicated as valid and the automatic selection mode is employed, then BARO data will be selected for processing provided the Shuttle is not in the MACH jump region and the magnitude of the Orbiter relative velocity does not exceed a landing site dependent maximum. Otherwise, the H_INHIB flag is set to ON, to be used by the entry measurement processing statistics subfunction event lamp processing. If barometric altimeter data are not indicated as valid then BARO data will not be selected for processing.

(6) If barometric altimeter data are not indicated as valid, then DRAG data will be selected for processing provided DRAG data are forced; or, if the automatic selection mode for DRAG data is employed, the orbiter is above a premission-determined altitude, and the magnitude of sensed acceleration is larger than a premission-determined minimum value. If DRAG processing is in the automatic selection mode and the orbiter is

above a premission-determined altitude and the magnitude of sensed acceleration is less than a premission-determined minimum value, then the H_INHIB flag will be set to ON, to be used by the entry measurement processing statistics subfunction event lamp processing. If DRAG processing is in the automatic selection mode and if the orbiter is below a premission-determined altitude and if the magnitude of the orbiter's relative velocity is greater than a landing site dependant maximum, then H_INHIB is set to ON, to be used by the entry measurement processing statistics event lamp processing.

(7) If TACAN data selection is automatic, then TACAN data will be selected provided either TACAN range or bearing data are indicated valid.

(8) No sensor measurement data type shall be selected while the deorbit burn is in progress.

Also, this subfunction will initialize the measurement edit indicators to zero for subsequent use by the state and covariance measurement incorporation subfunction.

The result of selection of sensor measurements for processing of data or for computation of measurement statistics will be provided as indicated in Tables 4.3.1.3-3 and 4.3.1.3-4. The terminology "process" means that the state and covariance measurement incorporation subfunction may incorporate the measurement data into the state estimation. The terminology "display" means that the state and covariance measurement incorporation subfunction may perform the processing of data for display of measurement statistics, but is prohibited from incorporating the data into the state estimation.

B. Interface Requirements. The input and output parameters for this subfunction are indicated in Tables 4.3.1.3-1 and 4.3.1.3-2.

C. Processing Requirements. This subfunction will be performed after sensor data have been saved and the covariance matrix propagated, and before the measurement reconfiguration subfunction (Section 4.3.1.4.1) is executed.

D. Constraints. Drag processing will not be performed during the deorbit burn even if the crewman forces drag.

E. Supplemental Information. The foregoing requirements indicate the existence of a three-position software switch for each sensor measurement data type; that is, AUTO/INHIBIT/FORCE. Display requirements indicate the existence of a return three-position software switch for each sensor to activate the HSD processor according to the actual condition.

The minimum acceleration magnitude constraint upon processing of drag data is employed to prevent incorporation of "noise" from the accelerometers. The altitude constraint is employed because of modeling errors in atmospheric density and the vehicle's drag coefficient.

A candidate implementation of this subfunction is shown in ENTRY_SENSOR_SELECT code (Appendix B). This code is executed by NAV_ENTRY, the candidate implementation of the entry control subfunction.

TABLE 4.3.1.3-1.- ENTRY SENSOR MEASUREMENT SELECTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Drag auto/inhibit/force switch	DRAG_AIF	*	CHAR	S		--	Filter rate
Vehicle cg drag acceleration	ACC_DRAG	*	F	DP		ft/sec^2	Filter rate
Minimum acceleration magnitude required for processing drag data in auto	ACC_DRAG_MIN	**	F	DP		ft/sec^2	Filter rate
Current Orbiter altitude above reference ellipsoid	ALT	*	F	S		ft	Filter rate
Altitude below which the drag data are not processed in auto	H_DRAG_LOW	**	F	DP		ft	Filter rate
Flag indicating (ON) that major mode is deorbit maneuver execute	DEORBIT_BURN	*	D	--	OFF/ON	--	As needed
TACAN AUTO/INHIBIT/FORCE switch	TACAN_AIF	*	CHAR	S		--	Filter rate
Copy of current range data-good discrete reserved for measurement processing	TAC_RNG_DATA_GOOD	Entry external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of current bearing data-good discrete reserved for measurement processing	TAC_BRG_DATA_GOOD	Entry external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of current BARO data-good discrete reserved for measurement processing	BARO_DATA_GOOD	Entry external sensor data snap	D	--	OFF/ON	--	Filter rate

*Entry navigation principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
BARO AUTO/INHIBIT/FORCE switch	BARO_AIF	*	CHAR	--		--	Filter rate
Flag indicating (ON) that the Shuttle is in the MACH jump region	MACH_JUMP	*	D	--	OFF/ON	--	Filter rate
Maximum relative velocity magnitude for BARO processing	RV_MAX	*	F	S		ft/sec	As needed
Current Shuttle M50 velocity vector, state one	V_FILT_ONE	1,2,3	V	S		ft/sec	As needed
Current Shuttle M50 velocity vector, state two	V_FILT_TWO	1,2,3	V	S		ft/sec	As needed
Current Shuttle M50 velocity vector, state three	V_FILT_THREE	1,2,3	V	S		ft,sec	As needed
Current Shuttle M50 position vector	R_FILT	Entry co-variance prop	V	DP		ft	As needed

1. Entry control
2. Nav state propagation
3. Delta state update

*Entry navigation principal function input list (Appendix G).

TABLE 4.3.1.3-2.- ENTRY SENSOR MEASUREMENT SELECTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag indicating (ON) that drag altitude data are to be processed	DO_DRAG_NAV	Entry control, *	D	--	OFF/ON	--	Filter rate
Flag used (ON) to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	TACAN range data processing, TACAN azimuth data processing	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data are to be processed for statistical display only	TACAN_STAT	TACAN range data processing, TACAN azimuth data processing	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data are to be processed	DO_TACAN_NAV	Entry control, *	D	--	OFF/ON	--	Filter rate
General edit indicator for I-th measurement type, I = 1,7	SENSOR_EDIT(I)	Entry state and covariance measurement incorporation, Entry measurement processing statistics	CHAR	S		--	Filter rate
Flag indicating which TACAN AIF command is in effect	TAC_AIF_RECD	*	CHAR	S		--	Filter rate

*Refer to the entry navigation principal function output list (Appendix G).

TABLE 4.3.1.3-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag indicating which DRAG_AIF command is in effect	DRAG_AIF_RECD	*	CHAR	S		--	Filter rate
Flag used (ON) to override drag residual edit test	DRAG_EDIT_ OVERRIDE	Drag data processing	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that drag data are to be processed for statistical display only	DRAG_STAT	Drag data processing	D	-	OFF/ON	--	Filter rate
Flag indicating (ON) that BARO data are to be processed	DO_BARO_NAV	Entry control, *	D	--	OFF/ON	--	Filter rate
Flag used (ON) to override the BARO residual edit test	BARO_EDIT_ OVERRIDE	Entry NAV BARO measurement incorp	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that BARO data are to be processed for statistical display purposes only	BARO_STAT	Entry NAV BARO measurement incorp	D	--	OFF/ON	--	Filter rate
Flag indicating which BARO AIF command is in effect	BARO_AIF_RECD	*	CHAR				Filter rate
Flag indicating (ON) that altitude data has been deselected based on an automatic selection constraint	H_INHIB	Entry meas processing statistics	D	--	OFF/ON	--	Filter rate

*Refer to the entry navigation principal function output list (Appendix G).

TABLE 4.3.1.3-3.- TACAN SELECTION

	RANGE AND BEARING DATA BAD	RANGE OR BEARING DATA GOOD
FORCE	No Selection	Process
INHIBIT	No Selection	Display
AUTO	No Selection	Process

TABLE 4.3.1.3-4.- BARO-DRAG SELECTION

BARO SELECTION LOGIC

	DATA BAD	DATA GOOD					
		MACH CONSTRAINTS MET			SOME MACH CONSTRAINTS FAILED		
		AUTO	INHIBIT	FORCE	AUTO	INHIBIT	FORCE
EMPLOY DRAG SELEC-TION LOGIC		PROCESS BARO	DISPLAY BARO	PROCESS BARO	NO SELECTION	DISPLAY BARO	PROCESS* BARO NO # SELECTION

DRAG SELECTION LOGIC[1]

AUTO		INHIBIT	FORCE
ALTITUDE OR ACCEL. CONSTRAINTS FAILED	ALTITUDE AND ACCEL. CONSTRAINTS MET		
NO SELECTION	PROCESS DRAG	DISPLAY DRAG	PROCESS DRAG

*If above baro mach maximum but not in baro discontinuity region.
#If in baro discontinuity region.

[1]Employed only if Baro data is labeled bad.

4.3.1.4 Entry Navigation Reconfiguration

A capability will be provided for initialization or reinitialization of certain navigation variables when events occur that require configuration of the navigation software. These events include the initialization of TACAN station information when the TACAN ID changes, and ground updates to the onboard navigated state vector and associated covariance matrix reinitializations.

4.3.1.4.1 Measurement reconfiguration. A capability will be provided for initialization of the TACAN station information when TACAN processing begins or when the TACAN station ID has changed.

A. Detailed Requirements. The entry sensor measurement selection subfunction will provide a capability for determining when TACAN measurements are to be processed. The measurement reconfiguration subfunction will be executed when TACAN measurements are first available or when the TACAN station ID has changed. This subfunction shall obtain the following information from the site lookup principal function (Section 4.5.2) only if the selected TACAN channel is indicated valid.

TACAN station information:

$$TAC\_CHAN\_VALID = TACAN\_CHAN\_VALID\_SL_{SEL\_LRU\_ID}$$

$$R\_TACAN\_EF = R\_TACAN\_EF\_SL_{SEL\_LRU\_ID}$$

$$M\_EFTOTD\_TACAN = M\_EFTOTD\_TACAN\_SL_{SEL\_LRU\_ID}$$

$$ANGLE\_CORR\_TNTOMAG = ANGLE\_CORR\_TNTOMAG\_SL_{SEL\_LRU\_ID}$$

$$BIAS\_TAC\_R = BIAS\_TAC\_R\_SL_{SEL\_LRU\_ID}$$

$$BIAS\_TAC\_BRG = BIAS\_TAC\_BRG\_SL_{SEL\_LRU\_ID}$$

$$TACAN\_ID\_LAST = TACAN\_ID_{SEL\_LRU\_ID}$$

B. Interface Requirements. The input and output variables for this subfunction are described in Table 4.3.1.4.1-1 and 4.3.1.4.1-2.

C. Processing Requirements. The measurement reconfiguration subfunction shall be performed prior to processing of TACAN measurements and after the execution of the entry sensor selection subfunction.

D. Constraints. It is required that the TACAN redundancy management and the entry navigation principal function execute in the following sequence:

(1) TACAN RM

(2) Entry navigation

The site lookup principal function TACAN-related output parameters may not be changed during the time interval starting with the initiation of TACAN RM selection filtering and ending with the completion of the entry navigation execution.

E. Supplementary Information. Although the detailed requirements show data being copied from the site lookup principal function into specific navigation variables; there is no reason why the site lookup data could not be used directly by the filter if the above constraint is realized. A suggested implementation of the measurement reconfiguration subfunction is illustrated by the flow chart NAV_SENSOR_INIT in Appendix B.

TABLE 4.3.1.4.1-1.- ENTRY MEASUREMENT RECONFIGURATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Comp rate
TACAN station range bias (each LRU) output from site lookup, I = 1, 3	$BIAS\_TAC\_R\_SL_I$	*	F	S		ft	As needed
TACAN station bearing bias (each LRU) output from site lookup, I = 1, 3	$BIAS\_TAC\_BRG\_SL_I$	*	F	S		rad	As needed
Integer indicating which TACAN LRU (1, 2, or 3) is selected by RM for use by nav filter for TACAN data processing	SEL_LRU_ID	Entry sensor data snap	I	S		--	As needed
Switch (each LRU) indicating (ON) a valid TACAN channel has been selected (site lookup output), I = 1, 3	$TACAN\_CHAN\_VALID\_SL_I$	*	D	--	OFF/ON	--	As needed
Earth-fixed position vector of TACAN station (each LRU) output from site lookup, I = 1, 3	$\underline{R}\_TACAN\_EF\_SL_I$	*	V	DP		ft	As needed
Transformation matrix from earth-fixed to topodetic coordinates at TACAN site (each LRU) output from site lookup, I = 1, 3	$M\_EFTOTD\_TACAN\_SL_I$	*	M	S		--	As needed
Variation of magnetic north from true north at TACAN site (each LRU) output from site lookup, I = 1, 3	$ANGLE\_CORR\_TNTOMAG\_SL_I$	*	F	S		rad	As needed
Current TACAN channel/mode identifier (each LRU) output from site lookup, I = 1, 3	$TACAN\_ID_I$	*	I	S		--	As needed

*Reference entry navigation principal function input list (Appendix G).

TABLE 4.3.1.4.1-2.- ENTRY MEASUREMENT RECONFIGURATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Copy of R_TACAN_EF_SL for TACAN station used by nav filter	R _TACAN_EF	Entry nav state and covariance measurement incorpora- tion, TACAN range measurement, TACAN bearing measurement	V	DP		ft	As needed
Copy of M_EFTOTD_TACAN_SL from site lookup	M_EFTOTD_ TACAN	Entry nav state and covariance measurement incorpora- tion, TACAN range measurement, TACAN bearing measurement	M	S		--	As needed
Copy of ANGLE_CORR_TNTOMAG_SL for navigation processing	ANGLE_CORR_ TNTOMAG	Entry nav state and covariance measurement incorpora- tion	F	S		rad	As needed

TABLE 4.3.1.4.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Copy of TACAN_CHAN_VALID_SL for TACAN station used by nav filter	TAC_CHAN_ VALID	Entry nav state and covariance measurement incorpora- tion, entry TACAN range measurement	D	--	OFF/ON	--	As needed
Copy of BIAS_TAC_R_SL for TACAN station used by nav filter	BIAS_TAC_R	Entry nav state and covariance measurement incorpora- tion, entry TACAN range measurement	F	S		ft	As needed
Copy of BIAS_TAC_BRG_SL for TACAN station used by nav filter	BIAS_TAC_BRG	Entry nav state and covariance measurement incorpora- tion, entry TACAN bearing measurement	F	S		rad	As needed

4.3.1.4.2 Delta state update. During operation of the entry navigation principal function, a capability for a delta state update of the Orbiter's onboard navigated state shall be provided.

A. Detailed Requirements. Detailed requirements for the performance of the delta state update task are described in Section 4.2.6.

B. Interface Requirements. Input and output requirements for the delta state update task are shown in Tables 4.3.1.4.2-1 and 4.3.1.4.1-2.

C. Processing Requirments. The delta state update task will be initiated from inputs supplied by either the HSD specialist function processing software or by the ground uplink processing software. The delta state update subfunction (during operation of the entry navigation principal function) will be initiated after state propagation, and covariance propagation subfunctions have been completed, at a rate as specified by the navigation sequencer principal function. This task will be performed prior to the measurement selection subfunction if a whole vector update is not indicated (OP_CODE ≠ 0001001), a time-tag update is not indicated (DO_DELTA_T_UPDATE = OFF), and if the DO_DELTA_UPDATE flag is detected to be in the ON position. This flag is checked by the NAV entry control subfunction in every cycle of the NAV entry principal function.

D. Constraints. None

E. Supplementary Information. Procedures will be established to inhibit redesignation of the runway and the incorporation of measurement data into the onboard state vector during the time interval between

(1) the time of the difference vectors computation and

(2) the time of their application to the onboard state vector. Correction terms, rather than the total vector, are sent up by the ground because the correction terms are less sensitive to errors between the time of their computation and the time that they are actually applied to correct the onboard state vector.

A suggested implementation in the form of a detailed flow chart (OPS_3_DELTA_UPDATE) may be found in Appendix B.

TABLE 4.3.1.4.2-1.- ENTRY DELTA STATE UPDATE INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	As needed
Time of the filter state vectors	T_LAST_FILT	Entry navigation state propagation	F	DP		sec	As needed
Ground computed position deviations to update on-board state vector	DR_RW	*	V	S		ft	As needed
Ground computed velocity deviations to update onboard state vector	DV_RW	*	V	S		ft/sec	As needed
Earth fixed to prime RW transformation matrix	M_EFTORW	*	M	S		--	As needed
Earth rotation rate	EARTH_RATE	**	F	DP		rad/sec	As needed
Unit vector in direction of Earth's axis of rotation	EARTH_POLE	**	V	S		--	As needed
Vehicle position and velocity standard deviations used when delta state update is invoked	SIG_DIAG_UPDATE	**	V	DP		ft and ft/sec	As needed
Selected Shuttle position vector	R _FILT	Entry navigation covariance propagation	V	DP		ft	As needed
Covariance correlation coefficients	CORR_COEFF_UPDATE	**	V	DP		ft	As needed

*Refer to the entry navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.4.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector, state one	V_FILT_ONE	Entry navigation state propagation	V	S		ft/sec	As needed
Shuttle velocity vector, state two	V_FILT_TWO	Entry navigation state propagation	V	S		ft/sec	As needed
Shuttle velocity vector, state three	V_FILT_THREE	Entry navigation state propagation	V	S		ft/sec	As needed

TABLE 4.3.1.4.2-2.- ENTRY DELTA STATE UPDATE OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	DP		ft	As needed
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	DP		ft	As needed
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	DP		ft	As needed

1. Entry control

TABLE 4.3.1.4.2-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Shuttle velocity vector, state one	V_FILT_ONE	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	S		ft/sec	As needed
Shuttle velocity vector, state two	V_FILT_TWO	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	S		ft/sec	As needed
Shuttle velocity vector, state three	V_FILT_THREE	Entry navigation state propagation, entry state and covariance measurement incorporation, 1	V	S		ft/sec	As needed
Filter covariance matrix	E	Entry covariance propagation	S	DP		vary	As needed

1. Entry control

TABLE 4.3.1.4.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Position deviations to update onboard state vector (zeroed out for display)	DR_RW	*	V	S		ft	As needed
Velocity deviations to update onboard state vector (zeroed out for display)	DV_RW	*	V	S		ft/sec	As needed
Flag indicating (OFF) that a delta 3 state update is not to be performed	DO_DELTA_UPDATE	*	D	--	OFF/ON	-	As needed

*Refer to the entry navigation principal function output list (Appendix G).

4.3.1.4.3 Whole vector update. During operation of the entry navigation principal function, a capability for a whole vector update of the Orbiter's onboard navigated state shall be provided.

A. Detailed Requirements. A capability shall be provided for updating the position and velocity of the Orbiter in flight by ground-originated command uplink. This capability shall be provided by a whole vector update that replaces the Orbiter's position and velocity vectors with values uplinked in Mean of 1950 (M50) coordinates, with associated time tag.

The performance of a whole vector update will require the vectors R_GND and V_GND and the associated time tag T_GND to be supplied. These variables must be set to the desired values before the whole vector update task is invoked. The entry navigation control subfunction invokes the whole vector update task when the command uplink identification code, OP_CODE, has been set to a value of 0001001.

R_GND is the uplinked ground estimated position of the Orbiter in M50 coordinates.

V_GND is the uplinked ground estimated velocity of the Orbiter in M50 coordinates.
T_GND is the uplinked time tag of the ground estimated state vector.

The update shall be performed as follows:

Using the entry precise predictor principal function (see Section 4.5.1) with GMD_PRED and GMO_PRED both equal to 4 and DT_MAX equal to a premission determined value, the uplinked vectors shall be propagated from the time T_GND to the time T_CURRENT_FILT. The resulting vectors will then replace the onboard estimated position and velocity vectors. The final modeled acceleration vector calculated by the entry precise predictor principal function will also replace that calculated within the navigation state propagation task for use by the user parameter state propagation task.

The equations required to generate the new vectors R_FILT_ONE, R_FILT_TWO, R_FILT_THREE, V_FILT_ONE, V_FILT_TWO, V_FILT_THREE, G_ONE_OLD, G_TWO_OLD, and G_THREE_OLD and to perform the required reinitialization of the navigation subsystem, are detailed in the following description.

(1) Predict the uplinked state vector to current time

GMD_PRED = 4

GMO_PRED = 4

DT_MAX = DEL_TIME_STEP

R_INIT = R_GND

V_INIT = V_GND

T_INIT = T_GND

T_FINAL = T_CURRENT_FILT

CALL: ENTRY_PRECISE_PREDICTOR

(2) Replace the filter states with the predictor outputs:

R_FILT_ONE = R_FINAL

R_FILT_TWO = R_FINAL

R_FILT_THREE = R_FINAL

V_FILT_ONE = V_FINAL

V_FILT_TWO = V_FINAL

V_FILT_THREE = V_FINAL

G_ONE_OLD = G_FINAL

G_TWO_OLD = G_FINAL

G_THREE_OLD = G_FINAL

V_LAST_FILT = V_CURRENT_FILT

T_LAST_FILT = T_CURRENT_FILT

(See Section 4.5.1 for detailed requirements of the entry precise predictor principal function.)

(3) In the next step, the covariance matrix E shall be set to zero, and reinitialized with the appropriate diagonal (SIG_DIAG_UPDATE_M50) and off-diagonal (CORR_COEFF_UPDATE_M50) elements obtained from premission loaded values. The parameters required to compute these elements will be premission loaded in the UVW coordinate system and rotated to M50 coordinates at the time of their incorporation into the covariance matrix. Detailed requirements for this covariance matrix reinitialization are described in Section 4.2.9.

B. Interface Requirements. Input and output requirements for the whole vector update task are shown in Tables 4.3.1.4.3-1 and 4.3.1.4.3-2.

C. Processing Requirements. The whole vector update task shall be initiated by the uplink processing software by setting OP_CODE equal to 0001001. The whole vector update task (during operation of the entry navigation principal function) shall be performed before and in place of state propagation, prior to entry sensor selection when the value of OP_CODE is 0001001. OP_CODE shall be checked at a rate as specified by the entry navigation sequencer principal function.

D. Constraints. The requirements expressed make no provision and provide no explicit protection against having the uplink buffer inadvertently overwritten by subsequent uplink before the required data processing is performed. If the testing for uplink information and processing of data cannot be assured before the buffer must be cleared or before an additional uplink could occur, it will be necessary to supply software external to the navigation function to test for the state vector uplink and save the necessary input data for processing by the navigation function.

E. Supplemental Information: The whole vector update task should be performed only during periods of unperturbed coasting flight as any venting or thrusting will result in degraded performance. The variables $\underline{G}$_ONE_OLD, $\underline{G}$_TWO_OLD, $\underline{G}$_THREE_OLD, $\underline{V}$_LAST_LAST and T_LAST_FILT are saved off, since no state vector propagation is performed if the whole vector is to be invoked. A suggested implementation in the form of a detailed flow chart (WHOLE_VECTOR_UPDATE) may be found in Appendix B.

TABLE 4.3.1.4.3-1.- WHOLE VECTOR UPDATE INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Step size for entry precise predictor	DEL_TIME_STEP	**	F	S		sec	As needed
Uplinked position vector (M50)	R_GND	*	V	DP		ft	As needed
Uplinked velocity vector (M50)	V_GND	*	V	S		ft/sec	As needed
Time tag of uplinked vectors	T_GND	*	F	DP		sec	As needed
Time tag of filter state vectors	T_CURRENT_FILT	IMU data snap	F	DP		sec	As needed
Shuttle position at end of prediction	R_FINAL	*	V	DP		ft	As needed
Shuttle velocity at end of prediction	V_FINAL	*	V	S		ft/sec	As needed
Acceleration vector at end of prediction	G_FINAL	*	V	S		ft/sec^2	As needed

NOTE: Input constants associated with the acceleration models are identified in Section 4.2.1.2 for the entry operations computer load.

*See entry navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.4.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Diagonal terms used to reinitialize the covariance matrix (UVW coordinates)	SIG_DIAG_ UPDATE_M50	**	V	DP		ft, ft/sec	As needed
Off-diagonal terms used to reinitialize the covariance matrix (UVW co-ord.)	CORR_COEFF_ UPDATE_M50	**	V	DP		--	As needed
Current value of selected accumulated IMU velocity	V_CURRENT_ FILT	IMU data snap	V	S		ft/sec	Filter rate

**See Section 4.9.

TABLE 4.3.1.4.3-2.- WHOLE VECTOR UPDATE OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector for three state configuration, state one	R_FILT_ONE	1,2,3	V	DP		ft	As needed
Current Shuttle position vector for three state configuration, state two	R_FILT_TWO	1,2,3	V	DP		ft	As needed
Current Shuttle position vector for three state configuration, state three	R_FILT_THREE	1,2,3	V	DP		ft	As needed
Shuttle velocity vector, state one	V_FILT_ONE	1,3,2,4	V	S		ft/sec	As needed
Shuttle velocity vector, state two	V_FILT_TWO	1,3,2,4	V	S		ft/sec	As needed
Shuttle velocity vector, state three	V_FILT_THREE	1,3,2,4	V	S		ft/sec	As needed
Gravitational acceleration vector	G_ONE_OLD	2	V	S		ft/sec^2	As needed
Gravitational acceleration vector	G_TWO_OLD	2	V	S		ft/sec^2	As needed
Gravitational acceleration vector	G_THREE_OLD	2	V	S		ft/sec^2	As needed
State error covariance matrix	E	2,3	M	DP		-	As needed

1. NAV state propagation.
2. Entry nav state and covariance measurement incorporation.
3. Entry nav covariance propagation.
4. Entry nav measurement selection.

TABLE 4.3.1.4.3-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Time of filter state vectors	T_LAST_FILT	5,*,1	F	DP		sec	As needed
Previous value of selected accumulated IMU velocity	V _LAST_FILT	1,*	V	S		ft/sec	As needed
Command uplink identification code	OP_CODE	*	B(7)	-	-	-	As needed
Maximum allowable step size for entry precise predictor	DT_MAX	*	F	S		sec	As needed
Flag indicating the degree of the gravity model	GMD_PRED	*	I	S	0-4	-	As needed
Flag indicating the order of the gravity model	GMO_PRED	*	I	S	0-4	-	As needed
Time at beginning of prediction	T_INIT	*	F	DP		sec	As needed
Time at which state is desired	T_FINAL	*	F	DP		sec	As needed
Shuttle position vector at T_INIT	R _INIT	*	V	DP		ft	As needed
Shuttle velocity vector at T_INIT	V _INIT	*	V	S		ft/sec	As needed

1. NAV state propagration.
5. Delta state update.

*Entry navigation principal function out list (Appendix G).

4.3.1.5 State Propagation

The state propagation subfunction that is active during operation of the entry navigation principal function will be invoked for the operation of propagating orbiter position and velocity vectors. In portions of the entry phase in which appreciable nongravitational accelerations are present, IMU data are snapped and used along with modeled gravitational acceleration by the super-g integration task for position and velocity propagation. In the higher altitude coasting flight regions during which the entry navigation principal function is active, IMU data are ignored, and modeled gravitational and drag accelerations are used by the super-g integration task for position and velocity propagation. Since the entry navigation principal function requires a three-state configuration, all propagation will be performed separately for each of the three state vectors.

A. Detailed Requirements. Propagation of Shuttle position and velocity vectors will be performed as follows:

(1) Acquire three sets of current, IMU-sensed, total accumulated velocity, and the selected sensed accumulated velocity along with the associated time tag:

$\underline{V}$ _CURRENT_FILT_ONE

$\underline{V}$ _CURRENT_FILT_TWO

$\underline{V}$ _CURRENT_FILT_THREE

$\underline{V}$ _CURRENT_FILT

T_CURRENT_FILT

Detailed requirements for this IMU data snap task are given in Section 4.2.1.1 (three-state configuration).

(2) Compute the difference between the current and the previous time tags associated with the IMU snaps. This will be the interval over which state propagation is desired:

DT_FILT = T_CURRENT_FILT - T_LAST_FILT

(3) Determine whether drag modeling or IMU data shall be employed in computing vehicle acceleration. The decision to incorporate IMU data will be based upon the magnitude of sensed acceleration being larger than a premission-determined constant. The following equation is required for the implementation:

ACC_SENSED = $|\underline{V}$ _CURRENT_FILT - $\underline{V}$ _LAST_FILT$|$ /DT_FILT F3

F3-This equation shall be protected against division by zero (reference 3.6.3).

After computation of ACC_SENSED, save the selected IMU velocity for use on the next cycle:

$\underline{V}$ _LAST_FILT = $\underline{V}$ _CURRENT_FILT

If ACC_SENSED > ACC_PROP_MIN, then USE_IMU_DATA = ON, GM_DEG = 2, and GM_ORD = 0; otherwise USE_IMU_DATA = OFF, GM_DEG = 4 and GM_ORD = 4.

(4) Perform three separate integrations of the position/velocity equations of motion with use of the super-g task (refer to Section 4.2.1.3 for detailed requirements), once for each state vector. The position/velocity vectors shall be propagated to the current time of IMU data collection T_CURRENT_FILT:

$\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, $\underline{R}$ _FILT_THREE

$\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, $\underline{V}$ _FILT_THREE

and the current IMU-accumulated, sensed velocity vectors will be saved for the next cycle (refer to Section 4.2.1.3):

$\underline{V}$ _LAST_FILT_ONE

$\underline{V}$ _LAST_FILT_TWO

$\underline{V}$ _LAST_FILT_THREE

The difference between accumulated sensed IMU readings on the present cycle and the previous cycle for all the IMU's along with the gravitational acceleration vectors will be saved:

$\underline{DV}$_FILT_ONE, $\underline{DV}$_FILT_TWO, $\underline{DV}$_FILT_THREE

$\underline{G}$ _ONE_OLD, $\underline{G}$ _TWO_OLD, $\underline{G}$ _THREE_OLD

(5) Save the current time tag for the next cycle:

T_LAST_FILT = T_CURRENT_FILT

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.1.5-1 and 4.3.1.5-2, respectively.

C. Processing Requirements. The state propagation subfunction will be performed before the covariance propagation subfunction. This subfunction will be performed each cycle at the entry navigation rate. This subfunction will not be performed if a whole vector update is indicated, or if a time tag update is performed.

D. Constraints. None.

E. Supplementary Information: A suggested implementation in the form of the following detailed flow charts may be found in Appendix B.

NAV_ENTRY, IMU data snap

NAV_STATE_PROP

SUPER_G_NAV

ACCEL

TABLE 4.3.1.5-1.- ENTRY STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current accumulated IMU 1 velocity counts reserved for measurement processing	V_CURRENT_FILT_ONE	Entry control	V	S		ft/sec	Filter rate
Current accumulated IMU 2 velocity counts reserved for measurement processing	V_CURRENT_FILT_TWO	Entry control	V	S		ft/sec	Filter rate
Current accumulated IMU 3 velocity counts reserved for measurement processing	V_CURRENT_FILT_THREE	Entry control	V	S		ft/sec	Filter rate
MTU or clock time when IMU was read	T_CURRENT_FILT	Entry control	F	DP		sec	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	-	OFF/ON	--	Filter rate
Time of filter state vectors	T_LAST_FILT	Entry control, *	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate

*Refer to entry navigation principal function input list (Appendix G).

TABLE 4.3.1.5-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate
Current selected sensed accumulated IMU velocity	V _CURRENT_ FILT	Entry control	V	S		ft/sec	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V _FILT_ONE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate

*Refer to entry navigation principal function input list (Appendix G).

TABLE 4.3.1.5-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector, state two	V _FILT_TWO	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V _FILT_THREE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate
Previously read accumulated IMU 1 velocity	V _LAST_FILT_ ONE	*	V	S		ft/sec	Filter rate
Acceleration function (force model) related constants	**	**					
Acceleration magnitude above which IMU data instead of drag modeling are employed in computing acceleration	ACC_PROP_MIN	**	F	DP		ft/sec^2	Filter rate

*See entry navigation principal function in list (Appendix G).

TABLE 4.3.1.5-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Angle of attack used in computing drag coefficient	ALPHA	Entry control	F	DP		rad	Filter rate
Sideslip angle used in computing drag coefficient	BETA	Entry control	F	DP		rad	Filter rate
Previously read accumulated IMU 2 velocity	V_LAST_FILT_TWO	*	V	S		ft/sec	Filter rate
Previously read accumulated IMU 3 velocity	V_LAST_FILT_THREE	*	V	S		ft/sec	Filter rate
Previous value of mid selected accumulated IMU velocity	V_LAST_FILT	*, Entry control	V	S		ft/sec	Filter rate

*See entry navigation principal function in list (Appendix G).

TABLE 4.3.1.5-2.- ENTRY STATE PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector for three state configuration, state one	R _FILT_ONE	Entry control, entry state and covariance measurement incorporation, entry navigation covariance prop	V	DP		ft	Filter rate
Current Shuttle position vector for three state configuration, state two	R _FILT_TWO	Entry control, entry state and covariance measurement incorporation, entry navigation covariance prop	V	DP		ft	Filter rate
Current Shuttle position vector for three state configuration, state three	R _FILT_THREE	Entry control, entry state and covariance measurement incorporation, entry navigation covariance prop	V	DP		ft	Filter rate

TABLE 4.3.1.5-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Shuttle velocity vector, state one	V_FILT_ONE	Entry control, entry state and covariance measurement incorporation, delta state update, entry sensor selection	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V_FILT_TWO	Entry control, entry state and covariance measurement incorporation, delta state update, entry sensor selection	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	Entry control, entry state and covariance measurement incorporation, delta state update, entry sensor selection	V	S		ft/sec	Filter rate

TABLE 4.3.1.5-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU 1 during three-state configuration	DV_FILT_ONE	Entry state and covariance measurement incorporation,	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU 2 during three-state configuration	DV_FILT_TWO	Entry state and covariance measurement incorporation,	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU 3 during three-state configuration	DV_FILT_THREE	Entry state and covariance measurement incorporation,	V	S		ft/sec	Filter rate
Time difference between T_CURRENT_ and T_LAST_FILT	DT_FILT	Entry covariance matrix propagation, entry drag measurement	F	DP		sec	Filter rate
Gravitational acceleration vector	G _ONE_OLD	Entry control TACAN range measurement, bearing measurement, BARO altimeter measurement incorp	V	S		ft/sec^2	Filter rate

TABLE 4.3.1.5-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Gravitational acceleration vector	G _TWO_OLD	Entry control TACAN range measurement, bearing measurement, BARO altimeter measurement incorp	V	S		ft/sec^2	Filter rate
Gravitational acceleration vector	G _THREE_OLD	Entry control TACAN range measurement, bearing measurement, BARO altimeter measurement incorp	V	S		ft/sec^2	Filter rate
Time of the filter state vectors	T_LAST_FILT	Delta state update, *, entry control	F	DP		sec	Filter rate
Flag indicating (ON) that IMU data should be employed in computing acceleration	USE_IMU_DATA	Entry navigation covariance propagation, *	D	--	OFF/ON	--	Filter rate

*Refer to entry navigation principal function output list (Appendix G).

4.3.1.6 Covariance Propagation

The covariance matrix propagation subfunction propagates the covariance matrix forward in time. The covariance matrix is propagated by utilizing the state transition matrix. Additive process noise is incorporated to account for unmodeled state and dynamic errors.

A. Detailed Requirements. A 6 by 6 covariance matrix shall be propagated with the entry navigation principal function. This covariance matrix defines the uncertainty in the state vector, which consists of position and velocity of the vehicle. The method of propagation is described in Section 4.2.2.

Since the entry navigation principal function maintains three state vectors (i.e., NAV_THREE_STATE is ON), the current selected filter position vector, $\underline{R}$ _FILT, which is required in the covariance propagation, is obtained by

$\underline{R}$ _FILT = VECTOR SELECTION OF ($\underline{R}$ _FILT_ONE,

$\underline{R}$ _FILT_TWO, $\underline{R}$ _FILT_THREE)

where vector selection is performed as described in Section 4.2.5.

B. Interface Requirements. The input and output data are shown in Table 4.3.1.6-1 and 4.3.1.6-2.

C. Processing Requirements. This subfunction will be called after the IMU sensor data have been read and after the state propagation subfunction has been executed.

D. Constraints. Prestored data are to be used for initialization. The propagated covariance matrix must remain symmetric.

E. Supplementary Information. A possible implementation of this subfunction is shown in the flow charts COVEXTRAP_PF and GRAVITY_GRADIENT in Appendix B.

TABLE 4.3.1.6-1.- ENTRY COVARIANCE MATRIX PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interval over which to propagate the covariance matrix	DT_FILT	Entry navigation state propagation	F	DP		sec	Filter rate
Filter covariance matrix	E	Entry covariance propagation entry state and covariance measurement incorporation, *	M	DP		vary	Filter rate
Gravitational constant of Earth	EARTH_MU	**	F	S		ft^3/sec^2	Filter rate
Identity matrix (3x3)	ID_MATRIX_3x3	**	M	S		--	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	S		OFF/ON	--	Filter rate
Updated vehicle position vector associated with current covariance matrix	R _COV_LAST	Entry control, *	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	Entry navigation state propagation	V	DP		ft	Filter rate

*Refer to entry navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.6-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	Entry navigation state propagation	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	Entry navigation state propagation	V	DP		ft	Filter rate
State noise error variance during unpowered flight	VAR_ACC_QUANT_COAST	**	F	S		ft^2/sec^2	Filter rate
Variance of unmodeled acceleration times scale time during unpowered flight	VAR_UNMOD_ACC_DT_COAST	**	F	S		ft^2/sec^3	Filter rate
Accelerometer quantization error variance during powered flight	VAR_ACC_QUANT_IMU	**	F	S		ft^2/sec^2	Filter rate
Variance of unmodeled acceleration times scale time during powered flight	VAR_UNMOD_ACC_DT_IMU	**	F	S		ft^2/sec^3	Filter rate
Flag indicating (ON) the IMU data is being used in state propagation	USE_IMU_DATA	Entry navigation state propagation	D	--	OFF/ON	--	Filter rate

*Entry navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.6-2.- ENTRY COVARIANCE MATRIX PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter covariance matrix	E	Entry state and covariance measurement incorporation	M	DP		vary	Filter rate
Current Shuttle position vector	R_FILT	Delta state update, TACAN range, measurement, entry drag measurement, entry sensor selection	V	DP		ft	Filter rate

4.3.1.7 State and Covariance Measurement Incorporation

The state and covariance measurement incorporation subfunction updates the three state vectors and covariance matrix with drag altitude pseudo-measurements or barometric altitude measurements and/or TACAN sensor measurements by using a 6-state process noise Kalman filter. The six elements of the state vector are navigation base Shuttle position and velocity in M50 coordinates.

A. Detailed Requirements. The state and covariance measurement incorporation subfunction is exercised only if data are available for processing as determined by the sensor measurement selection subfunction (Section 4.3.1.3) and the respective measurement subfunctions (Sections 4.3.1.7.1 through 4.3.1.7.4). The sensor measurement selection subfunction determines which measurement types are to be considered for processing. The measurement subfunctions process sensor data that are labeled as valid.

The measurement subfunctions shall compute a measurement residual for each of three state vectors. The subfunction then calculates the first partial derivatives of the estimated measurement with respect to the middle selected state, as well as the appropriate variance to model instrument error. Drag altitude, barometric altimeter, and TACAN range and bearing measurements will be available with the ENTRY navigation principal function.

Once a particular measurement subfunction has completed processing valid data, the filter control flags shall be set as follows:

Drag:

MANUAL_EDIT_OVERRIDE = DRAG_EDIT_OVERRIDE

STAT_FLAG = DRAG_STAT

TACAN:

MANUAL_EDIT_OVERRIDE = TACAN_EDIT_OVERRIDE

STAT_FLAG = TACAN_STAT

BARO:

MANUAL_EDIT_OVERRIDE = BARO_EDIT_OVERRIDE

STAT_FLAG = BARO_STAT

The state and covariance measurement incorporation subfunction shall then update the state and covariance matrix provided that either the residual edit criterion is met or the crew edit override is active, as described in Section 4.2.4.

The following TACAN data shall then be stored after the particular measurement type has been processed for subsequent computation of measurement processing statistics as described in Section 4.3.1.8:

$SENSOR\_EDIT_{1 \text{ and } 2} = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_{1 \text{ and } 2} = RESID\_TEST$

$SENSOR\_DELQ_{1 \text{ and } 2} = DELQ$

where the subscript 1 corresponds to bearing and 2 to range.

The following drag data shall be stored after the drag altitude pseudo-measurement has been processed, for subsequent computation of measurement processing statistics:

$SENSOR\_EDIT_4 = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_4 = RESID\_TEST$

$SENSOR\_DELQ_4 = DELQ$

Similarly, the barometric data shall be stored after the barometric altimeter altitude measurement has been processed, for subsequent computation of measurement processing statistics:

$SENSOR\_EDIT_3 = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_3 = RESID\_TEST$

$SENSOR\_DELQ_3 = DELQ$

B. Interface Requirements. The input and output for this function are given in Tables 4.3.1.7-1 and 4.3.1.7-2, respectively.

C. Processing Requirements. This subfunction is not exercised until the external sensor data snap, sensor measurement selection, navigation reconfiguration, and state and covariance propagation subfunctions have been performed. The measurement processing statistics subfunction cannot be initiated until this subfunction is completed.

D. Constraints. There is no requirement in the state and covariance measurement incorporation subfunction to perform updating if the data-validity flag indicates bad data. No manual override of this flag exists in this subfunction. If it is desired to process a particular measurement, the data-validity flag must be made to indicate that the data are valid.

E. Supplementary Information. A possible implementation of the state and covariance measurement incorporation subfunction is presented in the flow charts of Appendix B, NAV_ENTRY, NAV_FILTER, and STATE_UPDATE.

TABLE 4.3.1.7-1.- ENTRY MEASUREMENT INCORPORATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state two	R_FILT_TWO	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R_FILT_THREE	1,2,3,4	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V_FILT_ONE	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V_FILT_TWO	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	1,2,3,4	V	S		ft/sec	Filter rate
Filter covariance matrix	E	1,3, entry nav covariance prop	M	DP		vary	Filter rate
Value of filter mean squared position error below which no measurement underweighting is used	MS_POS_UND_WGT	**	F	S		ft**2	Filter rate
Scale factor used in measurement underweighting equation	K_UND_WGT	**	F	S		--	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Measurement subfunctions	F	S		--	Filter rate

1. Entry control.
2. Entry state propagation.
3. Delta state update.
4. Entry state and cov measurement incorporation.

**See Section 4.9.

TABLE 4.3.1.7-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Measurement first partials with respect to filter state	B	Measurement subfunctions	V	DP		vary	Filter rate
General sensor variance	VAR	Measurement subfunctions	F	S		vary	Filter rate
Switch used to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating TACAN data processed only for statistical display	TACAN_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Middle selected measurement residual	DELQ	Measurement subfunctions	F	S		vary	Filter rate
Measurement residual corresponding to state one	DELQ_ONE	Measurement subfunctions	F	S		vary	Filter rate
Measurement residual corresponding to state two	DELQ_TWO	Measurement subfunctions	F	S		vary	Filter rate
Measurement residual corresponding to state three	DELQ_THREE	Measurement subfunctions	F	S		vary	Filter rate
Switch used to override drag residual edit test	DRAG_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that drag data were processed only for statistical display	DRAG_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate

TABLE 4.3.1.7-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch used to override BARO residual edit test	BARO_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that BARO data were processed for statistical display	BARO_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate

TABLE 4.3.1.7-2.- ENTRY MEASUREMENT INCORPORATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	Entry state propagation, entry control, 4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state two	R_FILT_TWO	Entry state propagation, entry control, 4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R_FILT_THREE	Entry state propagation, entry control, 4	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V_FILT_ONE	Entry state propagation, entry control, 4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V_FILT_TWO	Entry state propagation, entry control, 4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	Entry state propagation, entry control, 4	V	S		ft/sec	Filter rate

4. Entry nav state and covariance measurement incorporation.
*Entry nav principal function outlist (Appendix G).

TABLE 4.3.1.7-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter covariance matrix	E	Entry nav covariance propagation	M	DP		vary	Filter rate
Edit indicators for measurements	SENSOR_EDIT	Entry nav measurement processing statistics	V	S		--	Filter rate
Value of criterion used in nav filter for residual edit tests for the sensor measurements	SENSOR_RESID_TEST	Entry nav measurement processing statistics	V	S		vary	Filter rate
Measurement residuals	SENSOR_DELQ	Entry nav measurement processing statistics	V	S		vary	Filter rate
Residual edit test quantity	RESID_TEST	TACAN measurement subfunction	F	S		vary	Filter rate

4.3.1.7.1 Drag altitude. The drag altitude measurement subfunction constructs a pseudo-altitude measurement, an estimated altitude measurement, and a measurement residual for each of three state vectors. The pseudo-altitude measurement is calculated from accelerometer outputs, a model of air density as a function of altitude, and a model of drag as a function of the angle of attack. The subfunction also calculates the first partial derivatives of the estimated measurement with respect to the middle selected state vector, as well as the appropriate variance to model the instrument error.

A. Detailed Requirements. A description of symbols used in the following equations may be found in Tables 4.3.1.7.1-1 and 4.3.1.7.1-2.

Drag Residual. The subfunction shall compute the drag altitude estimate by using the equation

$$Q = H\_ELLIPSOID(\underline{R})$$

where the function H_ELLIPSOID generates the height above the reference ellipsoid, as described in Section 4.4.5.1.

A four-layer atmospheric model shall be used to compute the pseudo-altitude measurement. The scale height, H_S, and the density at the base, RHO ZERO, used in the equations of pseudo-altitude measurement shall be selected as a function of the estimated altitude, Q. Also, the deterministic drag bias shall be selected as a function of the altitude.

DO FOR I = 1,4:

If $Q > DENSITY\_LIMIT_I$, then LAYER = I.

Then:

$$H\_S = SCALE\_HT_{LAYER},$$

$$RHO\_ZERO = BASE\_DEN_{LAYER} \text{ and}$$

$$BIAS\_DRAG = BIAS\_DRAG\_LAYER_{LAYER}$$

where DENSITY_LIMIT, SCALE_HT, BASE_DEN and BIAS_DRAG_LAYER are premission-determined constants.

This subfunction shall then compute the pseudo-altitude measurement with the equations

$$\underline{V}\_RHO = \underline{V}\_REL\ (\underline{V}, \underline{R})$$

$$\underline{I}\_V\_RHO = UNIT\ (\underline{V}\_RHO)$$

$$\underline{V}\_RHO\_BODY = M\_SBODYM50^T\ \underline{V}\_RHO$$

$$ALPHAR = |ARCTAN\ (V\_RHO\_BODY_3/V\_RHO\_BODY_1)| \qquad (F7,F3)$$

$$C\_DRAG = C\_DRAG\_ZERO + ALPHAR\ (C\_DRAG\_ONE + ALPHAR\ C\_DRAG\_TWO)$$

$$Q\_DRAG = H\_S\ \ell n\ (C\_DRAG\ DRAG\_CONST\ RHO\_ZERO$$

$$DT\_FILT\ (\underline{V}\ \_RHO \cdot \underline{V}\ \_RHO)/|(\underline{V}\ \_RHO \cdot \underline{D}V)|) \qquad F3$$

where

$\underline{V}$ _REL($\underline{V}$, $\underline{R}$) is described in Section 4.4.5.2.

and

M_SBODYM50 is obtained by executing the coordinate transformation subfunctin SBODY_TO_M50 (Section 4.4.3.7)

DRAG_CONST will be defined as the vehicle reference area divided by twice the vehicle mass. Initially the DRAG_CONST is premission loaded and re-computed anytime a major mass change occurs, by the deorbit/landing navigation sequencer (section 4.1.1). The residual shall then be computed by

$$DQ = Q\_DRAG - Q - BIAS\_DRAG$$

The above calculations will be performed for each state vector. The variables used in these equations shall be set equal to the following parameters prior to execution of the calculations described herein:

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{D}V$ = $\underline{D}V$_FILT_ONE, $\underline{D}V$_FILT_TWO, or $\underline{D}V$_FILT_THREE

For each state vector, the resulting residual, DQ, will be saved as DELQ_ONE, DELQ_TWO, or DELQ_THREE. The vector selection subfunction (Section 4.2.5) will reduce the three residuals to a single residual, DELQ, for subsequent use in the residual edit test.

F3-This equation shall be protected against division by zero (reference 3.6.3).
F7-This equation shall be protected against arc tangents with both arguments equal to zero (reference 3.6.7).

Drag Partials. The partial derivatives of the altitude measurement with respect to the state are to be computed as follows:

$\underline{R}$ _FILT = VECTOR SELECTION OF ($\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, $\underline{R}$ _FILT_THREE)

$\underline{B}_{1 \text{ to } 3}$ = UNIT ($\underline{R}$ _FILT)

$\underline{B}_{4 \text{ to } 6}$ = 0 .

The variance of the drag altitude measurement error will be defined by

VAR = VAR_DRAG

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, is set equal to K_EDIT_DRAG, which is a premission load.

The state and covariance matrix will then be updated, provided that the residual edit criterion is met, as described in Section 4.2.4.

B. Interface Requirements. The input and output variables for the drag measurement subfunction are given in Tables 4.3.1.7.1-1 and 4.3.1.7.1-2.

C. Processing Requirements. This subfunction shall be performed after the state and covariance propagation (Section 4.3.1.5 and 4.3.1.6), at the basic filter rate. This subfunction is performed as long as drag altitude measurements are being processed.

D. Constraints. None

E. Supplementary Information. A suggested implementation of this subfunction is shown in flow charts DRAG_NAV CODE, DRAG_COMP, H_ELLIPSOID, $\underline{V}$ _REL of Appendix B. The drag residual computations are contained in a subroutine with input and output argument lists to facilitate use with three state vectors. The flow-charts contain a combination of the requirements described in this section with some that are described in Section 4.3.1.7, namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to DRAG_EDIT_OVERRIDE and to DRAG_STAT, respectively, the call to NAV_FILTER and the setting of the display parameters SENSOR_EDIT_4, $\text{SENSOR\_RESID\_TEST}_4$ and SENSOR_DELQ_4 to EDIT_FLAG, RESID_TEST and DELQ, respectively.

TABLE 4.3.1.7.1-1.- DRAG MEASUREMENT INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interval over which to propagate the covariance matrix	DT_FILT	Entry state propagation	F	DP		sec	Filter rate
M50-to-body coordinates quaternion	Q_M50_BODY	Data snap	V(4)	DP		--	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_ZERO	**	F	S		--	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_ONE	**	F	S		1/rad	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_TWO	**	F	S		$1/rad^2$	Filter rate
Earth rotation rate	EARTH_RATE	**	F	DP		rad/sec	Filter rate
Vehicle reference area divided by twice the vehicle mass	DRAG_CONST	**	F	S		ft**2 / slugs	Filter rate
Earth ellipticity constant	ELLIPT	**	F	S		--	Filter rate
Time of filter state vector	T_LAST_FILT	State prop	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	2,3,4	V	DP		ft	Filter rate

2. Delta state update.
3. Entry state propagation.
4. Entry nav state and covariance measurement incorporation.

**See Section 4.9.

TABLE 4.3.1.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Unit vector in the direction of earth's axis of rotation	EARTH_POLE	**	V	DP		--	Filter rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	2,3,4	V	DP		ft	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	2,3,4	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V _FILT_ONE	2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V _FILT_TWO	2,3,4	V	S		ft/sec	Filter rate
Earth equatorial radius	EARTH_RADIUS_ EQUATOR	**	F	DP		ft	Filter rate
Shuttle velocity vector, state three	V _FILT_THREE	2,3,4	V	S		ft/sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for drag measurement	K_EDIT_DRAG	**	F	S		--	Filter rate

2. Delta state update.
3. Entry state prop.
4. Entry nav state and covariance measurement incorp.
**See Section 4.9.

TABLE 4.3.1.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration	DV_FILT_ONE	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration	DV_FILT_TWO	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-3 during three-state configuration	DV_FILT_THREE	Entry state propagation	V	S		ft/sec	Filter rate
Vector of deterministic drag biases for each layer, I = 1,4	$BIAS\_DRAG\_LAYER_I$	**	V	S		ft	Filter rate
Vector of scale heights for each layer, I = 1,4	$SCALE\_HT_I$	**	V	S		ft	Filter rate
Vector of base densities for each layer, I = 1,4	$BASE\_DEN_I$	**	V	S		slug/ft**3	Filter rate
Altitudes defining atmosphere model layers, I = 1,4	$DENSITY\_LIMIT_I$	**	V	S		ft	Filter rate
Drag altitude measurement error variance	VAR_DRAG	**	F	S		ft**2	Filter rate

**See Section 4.9.

TABLE 4.3.1.7.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Filter covariance matrix	E	2, entry covariance propagation	M	DP		vary	Filter rate
Flag used (ON) to override drag residual edit test	DRAG_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that drag data are to be processed for statistical display purposes only	DRAG_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate

2. Delta state update.

TABLE 4.3.1.7.1-2.- DRAG MEASUREMENT OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Drag altitude measurement residual	DELQ	Entry nav state and covariance measurement incorporation	F	S		ft	Filter rate
General sensor variance	VAR	Entry nav state and covariance measurement incorporation	F	S		ft^2	Filter rate
Measurement first partials with respect to filter state	B	Entry nav state and covariance measurement incorporation	V	DP		vary	Filter rate
Drag measurement residual associated with the first state vector	DELQ_ONE	Entry nav state and covariance measurement incorporation	F	S		ft	Filter rate
Drag measurement residual associated with the second state vector	DELQ_TWO	Entry nav state and covariance measurement incorporation	F	S		ft	Filter rate

TABLE 4.3.1.7.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Drag measurement residual associated with the third state vector	DELQ_THREE	Entry nav state and covariance measurement incorporation	F	S		ft	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Entry nav state and covariance measurement incorporation	F	S		--	Filter rate

4.3.1.7.2 TACAN range. The TACAN range measurement subfunction computes an estimated range from the Shuttle to the TACAN station and a range residual for each of the three state vectors. The subfunction also calculates the first partial derivatives of the estimated measurement with respect to the middle selected state vector and selects the appropriate variance to model the instrument error. It is assumed that TACAN range data will be provided by the TACAN RM by way of the sensor data snap.

A. Detailed Requirements. A description of the symbols used in the following equations may be found in Tables 4.3.1.7.2-1 and 4.3.1.7.2-2.

The following calculations shall be performed for each state vector. The variables used in these calculations shall be set equal to the following parameters prior to execution of the calculations.

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{DV}$ = $\underline{DV}$_FILT_ONE, $\underline{DV}$_FILT_TWO, or $\underline{DV}$_FILT_THREE

$\underline{G}$ = $\underline{G}$ _ONE_OLD, $\underline{G}$ _TWO_OLD, Or $\underline{G}$ _THREE_OLD

First, the position vector shall be interpolated to the time of the TACAN sensor measurement, if required, as described in Section 4.2.3. The range residual shall then be calculated as described in Section 4.2.7.1

For each state vector, the interpolated position vector, $\underline{R}$ _RESID, shall be saved as $\underline{R}$ _RESID_ONE, $\underline{R}$ _RESID_TWO, or $\underline{R}$ _RESID_THREE, and the resulting residual, DQ, shall be saved as DELQ_ONE, DELQ_TWO, or DELQ_THREE. The vector selection subfunction (Section 4.2.5) shall reduce the three interpolated position vectors to a single position vector, $\underline{R}$ _RESID, for subsequent use in the partial computations and the three residuals to a single residual, DELQ, for subsequent use in the residual edit test.

The partial derivatives of the range measurement with respect to the state shall be computed, and the variance shall be selected as described in Section 4.2.7.1.

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_TACR, which is a premission load.

The state vector and covariance matrix shall then be updated as described in Section 4.3.1.7.

The quantity RESID_TEST, computed by the filter, shall be compared to the design dependent parameter TACAN_RNG_CONVERG_TEST. Depending on the outcome of this comparison, the flag ONE_RANGE_LOCK shall be set to ON or OFF: ON if RESID_TEST < TACAN_RNG_CONVERG_TEST, OFF otherwise. The flag ONE_RANGE LOCK shall then be output for use by the TACAN redundancy management.

B. Interface Requirements. The inputs and outputs for the TACAN range measurement subfunction are given in Tables 4.3.1.7.2-1 and 4.3.1.7.2-2.

C. Processing Requirements. This subfunction shall be performed after the measurement reconfiguration subfunction (Section 4.3.1.4.1) at the basic filter rate. This subfunction shall be performed as long as TACAN range measurements are being processed.

D. Constraints. This subfunction shall be executed only if the data are indicated valid (i.e., the TAC_RNG_DATA_GOOD flag is ON) and the TACAN channel data as provided by TACAN site lookup (Section 4.5.2.2) are indicated valid (i.e. the TAC_CHAN_VALID flag is ON). ONE_RANGE_LOCK shall be initialized to 'OFF'.

E. Supplementary Information. The location of the TACAN antenna has been neglected in calculating the range measurement estimate since this error is less than that associated with the measurement. A possible implementation of this subfunction is shown in a portion of the flow chart TACAN_NAV and the flow chart TACAN_RANGE_COMP in Appendix B. The TACAN residual computations are contained in a subroutine with input and output argument lists to facilitate use with either three state vectors or one state vector. The flow charts also show some of the requirements described in Section 4.3.1.7, namely, the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to TACAN_EDIT_OVERRIDE and TACAN_STAT respectively, the call to NAV_FILTER, and the setting of the display parameters $SENSOR\_EDIT_{1 \text{ or } 2}$, $SENSOR\_RESID\_TEST_{1 \text{ or } 2}$, and $SENSOR\_DELQ_{1 \text{ or } 2}$ to EDIT_FLAG, RESID_TEST and DELQ, respectively.

TABLE 4.3.1.7.2-1.- TACAN RANGE MEASUREMENT SUBFUNCTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current range data good discrete for TACAN measurement processing	TAC_RNG_DATA_GOOD	Entry nav external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of TACAN_CHAN_VALID_SL for TACAN station used by nav filter	TAC_CHAN_VALID	Entry nav measurement reconfigure	D	--	OFF/ON	--	Filter rate
Time at which TACAN was read	T_TACAN	Entry nav external sensor data snap	F	DP		sec	Filter rate
Copy of R_TACAN_EF_SL for TACAN station used by nav filter	R_TACAN_EF	Entry nav measurement reconfigure	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state two	R_FILT_TWO	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R_FILT_THREE	1,2,3,4	V	DP		ft	Filter rate

1. Entry control
2. Delta state update.
3. State propagation.
4. Entry nav state and covariance measurement incorporation.

TABLE 4.3.1.7.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector, state one	V _FILT_ONE	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V _FILT_TWO	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V _FILT_THREE	1,2,3,4	V	S		ft/sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for TACAN range measurement	K_EDIT_TACR	**	F	S		-	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration	DV_FILT_ONE	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration	DV_FILT_TWO	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-3 during three-state configuration	DV_FILT_THREE	Entry state propagation	V	S		ft/sec	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU-1	G _ONE_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate

1. Entry control.
2. Delta state update.
3. State propagation.
4. Entry nav state and covariance measurement incorporation.

**See Section 4.9.

TABLE 4.3.1.7.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Gravity acceleration vector at end of integration interval associated with IMU-2	G_TWO_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU-3	G_THREE_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Current middle selected position vector	R_FILT	Entry covariance propagation	V	DP		ft	Filter rate
Deterministic TACAN range bias	BIAS_TAC_R	Entry nav measurement recon-fig..ration	F	S		ft	Filter rate
Range criterion to select TACAN range instrument variance	RNG_VAR_RNG_STEP	**	F	S		ft	Filter rate
TACAN range sensor measurement	Q_TAC_R	Entry nav external sensor data snap	F	S		ft	Filter rate
TACAN range instrument variance at range > RNG_VAR_RNG_STEP	VAR_TAC_R_HIGH	**	F	S		ft**2	Filter rate
TACAN range instrument variance at range ≤ RNG_VAR_RNG_STEP	VAR_TAC_R_LOW	**	F	S		ft**2	Filter rate

**See Section 4.9.

TABLE 4.3.1.7.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interpolated position vector associated with the first state vector	R _RESID_ONE	State vector interp	V	S		ft	Filter rate
Interpolated position vector associated with the second state vector	R _RESID_TWO	State vector interp	V	S		ft	Filter rate
Interpolated position vector associated with the third state vector	R _RESID_THREE	State vector interp	V	S		ft	Filter rate
Vector selected from three interpolated position vectors	R _RESID	Vector selection	V	S		ft	Filter rate
Flag used (ON) to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data are to be procured for statistical display only	TACAN_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Copy of M_EFTOTD_TACAN_SL from site lookup	M_EFTOTD_TACAN	Entry measurement recon- figuration	M	S		--	Filter rate
Filter covariance matrix	E	1,2, entry covariance propagation	M	DP		vary	Filter rate

1. Entry control.
2. Delta state update.

TABLE 4.3.1.7.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Threshold for residual test quantity, below which data from one LRU alone are accepted	TACAN_RNG CONVERG_TEST	**	F	S		ft^2	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_ STATE	*	D	--	OFF/ON	--	Filter rate
General residual test variable	RESID_TEST	State and covariance measurement incorporation	F	S		ft^2	Filter rate

*See entry nav principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.7.2-2 - TACAN RANGE MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN range measurement residual	DELQ	Entry nav state and covariance measurement incorpora-tion	F	S		ft	Filter rate
General sensor variance	VAR	Entry nav state and covariance measurement incorpora-tion	F	S		ft**2	Filter rate
Measurement first partials with respect to filter state	B	Entry nav state and covariance measurement incorpora-tion	V	DP		vary	Filter rate
TACAN range measurement residual associated with the first state vector	DELQ_ONE	Entry nav state and covariance measurement incorpora-tion	F	S		ft	Filter rate
TACAN range measurement residual associated with the second state vector	DELQ_TWO	Entry nav state and covariance measurement incorpora-tion	F	S		ft	Filter rate

TABLE 4.3.1.7.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN range measurement residual associated with the third state vector	DELQ_THREE	Entry nav state and covariance measurement incorporation	F	S		ft	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Entry nav state and covariance measurement incorporation	F	S		--	Filter rate
Flag indicating the filter can accept data from one TACAN LRU	ONE_RANGE_LOCK	Entry nav state and covariance measurement incorporation	D	--	OFF/ON	--	Filter rate

4.3.1.7.3 TACAN bearing. The TACAN bearing measurement subfunction computes an estimated bearing measurement with respect to the TACAN station and a measurement residual for each of the three state vectors. The subfunction also calculates the first partial derivatives of the estimated measurement with respect to the middle selected state vector and selects the appropriate variance to model the instrument error. It is assumed that the TACAN bearing data referenced to magnetic north are available from the TACAN RM by way of the sensor data snap.

A. Detailed Requirements. A description of the symbols used in the following equations may be found in Tables 4.3.1.7.3-1 and 4.3.1.7.3-2.

The position vector of the TACAN station in M50 coordinates $\underline{R}$ _SCANNER is to be computed by

M_EFTOM50 = EARTH_FIXED_TO_M50_COORD(T_TACAN)

$\underline{R}$ _SCANNER = M_EFTOM50 $\underline{R}$ _TACAN_EF

The transformation from M50 to topodetic coordinates is obtained by

$$M\_M50TOTD = M\_EFTOTD\_TACAN\ M\_EFTOM50^T$$

where M_EFTOTD_TACAN and $\underline{R}$ _TACAN_EF were obtained from the measurement reconfiguration subfunction (Section 4.3.1.4.1).

The flags, IN_CONE_FLAG (which, when set to ON, indicates the vehicle is inside the TACAN's cone of confusion) and TAC_BRG_DATA_GOOD (which indicates the validity of bearing data) shall be checked.

The following calculations shall be performed for each state vector only if the data are indicated valid (i.e., the TAC_BRG_DATA_GOOD flag is ON and the IN_CONE_FLAG is OFF). The variables used in these calculations shall be set equal to the following parameters prior to execution of the calculations.

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{DV}$ = $\underline{DV}$_FILT_ONE, $\underline{DV}$_FILT_TWO, or $\underline{DV}$_FILT_THREE

$\underline{G}$ = $\underline{G}$ _ONE_OLD, $\underline{G}$ _TWO_OLD, or $\underline{G}$ _THREE_OLD

First, the position vector shall be interpolated to the time of the TACAN sensor measurement, if required, as described in Section 4.2.3. The bearing residual shall then be calculated as described in Section 4.2.7.2. For each state vector, the interpolated position vector, $\underline{R}$ _RESID, shall be saved as $\underline{R}$ _RESID_ONE, $\underline{R}$ _RESID_TWO, or $\underline{R}$ _RESID_THREE, and the resulting residual, DQ, shall be saved as DELQ_ONE, DELQ_TWO, or DELQ_THREE.

The vector selection subfunction (Section 4.2.5) shall reduce the three interpolated position vectors to a single position vector, $\underline{R}$ _RESID, for subsequent use in the partial derivative computation and the three residuals to a single residual, DELQ, for subsequent use in the residual edit test.

The partial derivatives of the bearing measurement with respect to the state shall be computed, and the variance shall be selected as described in Section 4.2.7.2.

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_TACBR, which is a premission load.

The state vector and covariance matrix shall then be updated as described in Section 4.3.1.7.

The quantity RESID_TEST, computed by the filter, shall be compared to the parameter TACAN_BRG_CONVERG_TEST. Depending on the out come of this comparison, the flag ONE_BRG_LOCK shall be set to ON or OFF: ON if RESID_TEST < TACAN_BRG_CONVERG_TEST, OFF otherwise. The flag ONE_BRG_LOCK shall then be output for use by the TACAN redundancy management.

B. Interface Requirements. The input and outputs for the TACAN bearing measurement subfunction are given in Tables 4.3.1.7.3-1 and 4.3.1.7.3-2.

C. Processing Requirements. The subfunction shall be performed after the measurement reconfiguration subfunction (Section 4.3.1.4.1) at the basic filter rate. This subfunction shall be performed as long as TACAN measurements are being processed.

D. Constraints. This subfunction shall be executed if the TACAN channel validity flag, as provided by TACAN site lookup (Section 4.5.2.2), is indicated valid (i.e., the TAC_CHAN_VALID flag is ON), and if the Shuttle is not in TACAN station's cone of confusion (i.e., the IN_CONE_FLAG is OFF) and if the data are indicated valid (i.e., the TAC_BRG_DATA_GOOD flag is ON). ONE_BRG LOCK shall be initialized to 'OFF'.

E. Supplementary Information. The location of the TACAN antenna has been neglected in calculating the bearing measurement estimate since this error is less than that associated with the error in the measurement itself. A possible implementation of this subfunction is shown in a portion of the flow chart TACAN_NAV and the flow chart TACAN_BRG_COMP in Appendix B. The TACAN residual computations are contained in a subroutine with input and output argument lists to facilitate use with either three state vectors or one state vector. The flow charts also show some of the requirements described in Section 4.3.1.7, namely, the setting of the filter control flag MANUAL_EDIT_OVERRIDE and STAT_FLAG to TACAN_EDIT_OVERRIDE and TACAN_STAT respectively, the call to NAV_FILTER, and the setting of the display parameters $\text{SENSOR\_EDIT}_{1 \text{ or } 2}$, $\text{SENSOR\_RESID\_TEST}_{1 \text{ or } 2}$, and $\text{SENSOR\_DELQ}_{1 \text{ or } 2}$ to EDIT_FLAG, RESID_TEST, and DELQ, respectively.

TABLE 4.3.1.7.3-1.- TACAN BEARING MEASUREMENT SUBFUNCTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current bearing data good discrete for TACAN measurement processing	TAC_BRG_DATA_GOOD	Entry nav external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of TACAN_CHAN_VALID_SL for TACAN station used by nav filter	TAC_CHAN_VALID	Entry nav measurement reconfigure	D	--	OFF/ON	--	Filter rate
Time at which TACAN was read	T_TACAN	Entry nav external sensor data snap	F	DP		sec	Filter rate
Copy of R _TACAN_EF_SL for TACAN station used by nav filter	R _TACAN_EF	Entry nav measurement reconfigure	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	1,2,3	V	DP		ft	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	Filter rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	1,2,3	V	DP		ft	Filter rate

1. Entry control.
2. Delta state update.
3. State propagation.

*See entry nav principal function in list (Appendix G).

TABLE 4.3.1.7.3-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state three	R_FILT_THREE	1,2,3	V	DP		ft	Filter rate
Flag indicating (ON) that the vehicle is in the cone of confusion of selected TACAN station	IN_CONE_FLAG	*	D	--	OFF/ON	--	Filter rate
Shuttle velocity vector, state one	V_FILT_ONE	1,2,3	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V_FILT_TWO	1,2,3	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	1,2,3	V	S		ft/sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for TACAN BRG measurement	K_EDIT_TACBR	**	F	S		--	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration	DV_FILT_ONE	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration	DV_FILT_TWO	Entry state propagation	V	S		ft/sec	Filter rate

1. Entry control.
2. Delta state update.
3. State propagation.

*See entry nav principal function in list (Appendix G).

**See Section 4.9.

TABLE 4.3.1.7.3-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-3 during three-state configuration	DV_FILT_THREE	Entry state propagation	V	S		ft/sec	Filter rate
Gravity acceleration vector at beginning of integration interval associated with IMU-1	G _ONE_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Gravity acceleration vector at beginning of integration interval associated with IMU-2	G _TWO_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Gravity acceleration vector at beginning of integration interval associated with IMU-3	G _THREE_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Current middle selected position vector	R _FILT	Entry covariance propagation	V	DP		ft	Filter rate
Deterministic TACAN bearing bias	BIAS_TAC_BRG	Entry nav measurement reconfigur-ation	F	S		rad	Filter rate
Interpolated position vector associated with the first state vector	R _RESID_ONE	State vector interp	V	S		ft	Filter rate
Interpolated position vector associated with the second state vector	R _RESID_TWO	State vector interp	V	S		ft	Filter rate
Interpolated position vector associated with the third state vector	R _RESID_THREE	State vector interp	V	S		ft	Filter rate

TABLE 4.3.1.7.3-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Vector selected from three interpolated position vectors	R _RESID	Vector selection	V	S		ft	Filter rate
Range criterion to select TACAN azimuth instrument variance	RNG_VAR_ BEARING_STEP	**	F	S		ft	Filter rate
Copy of M_EFTOTD_TACAN_SL from site lookup	M_EFTOTD_ TACAN	Entry nav measurement reconfigure	M	S		--	Filter rate
Switch used to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Copy of ANGLE_CORR_TNTOMAG_SL for navigation processing	ANGLE_CORR_ TNTOMAG	Entry nav measurement reconfigure	F	S	0 two PI	rad	Filter rate
The constant PI	PI	**	F	S	--	--	Filter rate
TACAN bearing sensor measurement	Q_TAC_BRG	Entry nav external sensor data snap	F	S		rad	Filter rate
TACAN azimuth instrument variance at range > RNG_VAR_BEARING_STEP	VAR_TAC_BRG_ HIGH	**	F	S		rad**2	Filter rate
TACAN azimuth instrument variance at ≤ RNG_VAR_BEARING_STEP	VAR_TAC_BRG_ LOW	**	F	S		rad**2	Filter rate

**See Section 4.9.

TABLE 4.3.1.7.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that TACAN data are to be processed for statistical display only	TACAN_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Filter covariance matrix	E	1,2, entry covariance propagation	M	DP		vary	Filter rate
Time of filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Threshold for residual test quantity, below which data from one LRU alone are accepted	TACAN_BRG_CONVERG_TEST	**	F	S		rad^2	Filter rate
General residual test variable	RESID_TEST	State and covariance measurement incorporation	F	S		rad^2	Filter rate

1. Entry control
2. Delta state update.

**See Section 4.9.

TABLE 4.3.1.7.3-2.- TACAN BEARING MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN azimuth measurement residual	DELQ	Entry nav state and covariance measurement incorporation	F	S		rad	Filter rate
General sensor variance	VAR	Entry nav state and covariance measurement incorporation	F	S		rad^2	Filter rate
Measurement first partials with respect to filter state	B	Entry nav state and covariance measurement incorporation	V	DP		vary	Filter rate
TACAN azimuth measurement residual associated with the first state vector	DELQ_ONE	Entry nav state and covariance measurement incorporation	F	S		rad	Filter rate
TACAN azimuth measurement residual associated with the second state vector	DELQ_TWO	Entry nav state and covariance measurement incorporation	F	S		rad	Filter rate

TABLE 4.3.1.7.3-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN azimuth measurement residual associated with the third state vector	DELQ_THREE	Entry nav state and covariance measurement incorporation	F	S		rad	Filter rate
Scale factor on filter mean square residual used in residual edit test vector	K_RES_EDIT	Entry nav state and covariance measurement incorporation	F	S		--	Filter rate
Flag indicating the filter can accept data from one TACAN LRU	ONE_BRG_LOCK	Entry nav state and covariance measurement incorporation	D	--	OFF/ON	--	Filter rate

4.3.1.7.4 Barometric altimeter. The barometric altimeter measurement subfunction calculates the estimated altitude and a residual for each of the three state vectors. The subfunction also calculates the first partial derivatives of the estimated measurement with respect to the selected state vector and the appropriate variance to model the instrument error. It is assumed that, the barometric altitude data will be provided by the ADTA SOP via the sensor data snap.

A. Detailed Requirements. A description of the symbols used in the following equations may be found in Tables 4.3.1.7.4-1 and 4.3.1.7.4-2.

The following calculations shall be performed for each state vector. The variables used in these calculations shall be set to the following parameters prior to execution of the calculations.

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _ FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{DV}$ = $\underline{DV}$_FILT_ONE, $\underline{DV}$_FILT_TWO, or $\underline{DV}$_FILT_THREE

$\underline{G}$ = $\underline{G}$ _ONE_OLD, $\underline{G}$ _TWO_OLD, or $\underline{G}$ _THREE_OLD

First, the position vector shall be interpolated to the time of the BARO altimeter sensor measurement, if required, as described in Section 4.2.3. The residual shall then be calculated as described in Section 4.2.7.3.

For each state vector, the residual DQ, shall be saved as DELQ_ONE, DELQ_TWO, or DELQ_THREE. The vector selection subfunction (Section 4.2.5) shall reduce the three residuals to a single residual, DELQ, for subsequent use in the residual edit test. The estimated measurement, Q, will be saved for each state vector as Q_ONE, Q_TWO, and Q_THREE and the vector selection subfunction will reduce the three measurements to one for subsequent use in the calculation of Q and the variance.

The vector selection subfunction is also invoked to reduce the three position vectors to one for use in the calculation of the partial derivatives. The partial derivatives of the range measurement with respect to the state and the variance shall be computed as described in Section 4.2.7.3.

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, is set equal to K_EDIT_BARO, which is a premission load.

The state vector and covariance matrix shall then be updated as described in Section 4.3.1.7.

B. Interface Requirements. The input and output variables for the barometric measurement subfunction are given in Table 4.3.1.7.4-1 and 4.3.1.7.4-2.

C. Processing Requirements. This subfunction will be performed after the navigation reconfiguration subfunction (Section 4.3.1.4) at the basic filter rate. This subfunction is performed as long as barometric altitude measurements are being processed.

D. Constraints. This subfunction will only be executed if the data are indicated valid (i.e., the BARO_DATA_GOOD flag is ON).

E. Supplementary Information. The assumption is made, for simplification, that the barometric probe is located at the navigation base. This is a valid assumption since the error involved in mislocating the probe is less than the errors associated with the barometric measurement.

A possible implementation of this subfunction is shown in the flow charts BARO_NAV, BARO_COMP and H_ELLIPSOID in Appendix B. Note that the flow charts also contain some requirements described in Section 4.3.1.7, namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to BARO_EDIT_OVERRIDE and BARO_STAT, respectively, the call to NAV_FILTER, and the setting of the display parameters $SENSOR\_EDIT_3$, $SENSOR\_RESID\_TEST_3$, and $SENSOR\_DELQ_3$ to EDIT_FLAG, RESID_TEST, and DELQ, respectively.

TABLE 4.3.1.7.4-1.- BAROMETRIC ALTIMETER INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Copy of current data good discrete reserved for measurement processing (navigation)	BARO_DATA_GOOD	Entry sensor data read	D	--	OFF/ON	--	Filter rate
Time tag associated with barometric measurement	T_BARO	Entry sensor data read	F	DP		sec	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolation	V	DP		ft	Filter rate
Barometric deterministic bias	BIAS_BARO	**	F	S		ft	Filter rate
Altitude of mean sea level above reference ellipsoid at the runway	DELH_MSL_ELLIPSOID_RW	*	F	S		ft	Filter rate
Barometric altimeter sensor measurement	Q_BARO	Entry sensor data read	F	S		ft	Filter rate
Altitude above reference ellipsoid of runway reference point	ALT_RW	*	F	S		ft	Filter rate
Earth ellipticity constant	ELLIPT	**	F	S	--	--	Filter rate
Earth equatorial radius	EARTH_RADIUS_EQUATOR	**	F	DP	--	--	Filter rate
Barometric altimeter instrument variance constant	VAR_H1	*	F	S		ft**2	Filter rate

*See entry nav principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.7.4-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Barometric altimeter instrument variance constant	VAR_H2	*	F	S			Filter rate
Unit vectors in direction of Earth's axis of rotation	EARTH_POLE	**	V	S		--	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_EDIT_BARO	**	F	S		--	Filter rate
Time of the filter state vector	T_LAST_FILT	State prop	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State prop	F	DP		sec	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration	DV_FILT_ONE	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration	DV_FILT_TWO	Entry state propagation	V	S		ft/sec	Filter rate

*See entry nav principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.7.4-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Difference between accumulated sensed-IMU readings on present cycle and previous cycle for IMU-3 during three-state configuration	DV_FILT_THREE	Entry state propagation	V	S		ft/sec	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU-1	G _ONE_OLD	Entry state propagation	V	S		ft/sec^2	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU-2	G _ONE_TWO	Entry state propagation	V	S		ft/sec^2	Filter rate
Gravity acceleration vector at end of integration interval associated with IMU-3	G _ONE_THREE	Entry state propagation	V	S		ft/sec^2	Filter rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	1,2,3,4	V	DP		ft	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	1,2,3,4	V	DP		ft	Filter rate

1. Entry control.
2. State propagation.
3. Delta state update.
4. Entry nav state and covariance measurement incorporation.

TABLE 4.3.1.7.4-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector, state one	V _FILT_ONE	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V _FILT_TWO	1,2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V _FILT_THREE	1,2,3,4	V	S		ft/sec	Filter rate

1. Entry control.
2. State propagation.
3. Delta state update.
4. Entry nav state and covariance measurement incorporation.

TABLE 4.3.1.7.4-2.- BAROMETRIC ALTIMETER OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Barometric measurement residual	DELQ	Entry state and covariance measurement incorporation	F	S		ft	Filter rate
Measurement first partials with respect to filter state	B	Entry state and covariance measurement incorporation	V	DP		vary	Filter rate
General sensor variance	VAR	Entry state and covariance measurement incorporation	F	S		ft^2	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Entry state and covariance measurement incorporation	F	S		--	Filter rate
BARO measurement residual associated with the first state vector	DELQ_ONE	Entry state and covariance measurement incorporation	F	S		ft	Filter rate

TABLE 4.3.1.7.4-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
BARO measurement residual associated with the second state vector	DELQ_TWO	Entry state and covariance measurement incorporation	F	S		ft	Filter rate
BARO measurement residual associated with the third state vector	DELQ_THREE	Entry state and covariance measurement incorporation	F	S		ft	Filter rate

4.3.1.8 Measurement Processing Statistics

During the entry navigation principal function, the measurement processing statistics subfunction will compute, for display on the horizontal situation cathode-ray-tube display page, certain parameters that are indicative of the health of the navigation filter. It will also compute a discrete signal to be used by user parameter processing to drive the nav event lamp.

A. Detailed Requirements. For both TACAN range and bearing, barometric altitude and drag derived altitude measurements, three parameters are to be computed to show how well the navigation filter is processing these measurements. The processing required is described fully in Section 4.2.8.2, Measurement Statistics. Since, during entry, MSBLS measurements will not be processed by the navigation filter, the processing described in Section 4.2.8.2 will be done for the case I = 1 through 4.

This subfunction will also evaluate edit flags for the three measurement types to compute the sensors' status discrete. Detailed requirements for this calculation may be found in Section 4.2.8.1.

A further capability will be provided by this subfunction to generate the residual and ratio parameters described in Section 4.2.8.2 for display under certain circumstances (determined by the entry sensor measurement selection subfunction) when the filter would not normally be attempting to process data. If the sensor edit indicators are found to have the value "STAT", this shall indicate to the measurement processing subfunction that this filter cycle was performed only for the production of filter statistics and that the calculations leading to the edit history indicator shall ignore this "statistics only" filter cycle.

B. Interface Requirements. Inputs and outputs are listed in Tables 4.3.1.8-1 and 4.3.1.8-2.

C. Processing Requirements. Prior to beginning the measurement processing statistics for the first time (prior to the entry navigation processing principal function), the following initialization must be performed.

EDIT_ARRAY = 0	(matrix)
$\underline{S}$UM = 0	(vector)
$\underline{J}$ = 0	(array)

D. Constraints. None.

E. Supplementary Information. A suggested implementation for this subfunction may be found in the detailed flow chart of Appendix B.

MEAS_PROCESSING_STATISTICS_ENTRY_CODE

TABLE 4.3.1.8-1.- ENTRY MEASUREMENT PROCESSING STATISTICS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Orbiter altitude above reference ellipsoid	ALT	*	F	S		ft	0.25
Altitude regions for event lamp processing	ALT_EL	**	V	S		ft	0.25
Altitude of Orbiter nav base above runway altitude	ALT_WHEELS	*	F	S		ft	0.25
Flag indicating (ON) that altitude data have been inhibited	H_INHIB	Entry nav sensor selection	D	--	OFF/ON	--	0.25
Flag indicating (ON) that vehicle is in selected TACAN station's cone of confusion	IN_CONE_FLAG	*	D	--	OFF/ON	--	0.25
Value of criterion used to set the edit history indicators	K_MAX	**	I				0.25
Flag indicating the availability of MSBLS transmitters at the runway	MLS_AVAIL	*	D	--	OFF/ON	--	0.25
Number of nautical miles per foot	NAUTMI_PER_FT	**	F	S		nm/ft	0.25
Number of sequential failures of the test criteria allowed before activating the nav event light	N_SEQ_MAX	**	I				0.25
Radar altimeter processing flag	RAW_RA_PROC	*	D	--	OFF/ON	--	0.25

*Entry nav principal input list (Appendix G).
**See Section 4.9.

TABLE 4.3.1.8-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Measurement residual for TACAN bearing data	SENSOR_DELQ(1)	Entry navigation state and covariance measurement incorporation	F	S		rad	0.25
Measurement residual for TACAN range data	SENSOR_DELQ(2)	Entry navigation state and covariance measurement incorporation	F	S		ft	0.25
Four-valued flag defining use of TACAN bearing data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(1)	Entry navigation state and covariance measurement incorporation	CHAR	S			0.25
Four-valued flag defining use of TACAN range data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(2)	Entry navigation state and covariance measurement incorporation	CHAR	S			0.25

TABLE 4.3.1.8-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Value of criterion used in navigation filter for residual edit test for TACAN bearing measurement	SENSOR_RESID_TEST(1)	Entry navigation state and covariance measurement incorporation	F	S		rad^2	0.25
Value of criterion used in navigation filter for residual edit test for TACAN range measurement	SENSOR_RESID_TEST(2)	Entry navigation state and covariance measurement incorporation	F	S		ft^2	0.25
Measurement residual for barometric altitude data	SENSOR_DELQ(3)	Entry navigation state and covariance measurement incorporation	F	S		ft	0.25
Four-valued flag defining use of barometric altitude data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(3)	Entry navigation state and covariance measurement incorporation	CHAR	S			0.25

TABLE 4.3.1.8-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Value of criterion used in navigation filter for residual edit test for barometric altitude measurement	SENSOR_RESID_TEST(3)	Entry navigation state and covariance measurement incorporation	F	S		ft^2	0.25
Measurement residual for drag altitude data	SENSOR_DELQ(4)	Entry navigation state and covariance measurement incorporation	F	S		ft	0.25
Four-valued flag defining use of drag altitude data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(4)	Entry navigation state and covariance measurement incorporation	CHAR	S			0.25
Value of criterion used in navigation filter for residual edit test for drag altitude measurement	SENSOR_RESID_TEST(4)	Entry navigation state and covariance measurement incorporation	F	S		ft^2	0.25

TABLE 4.3.1.8-2.- ENTRY MEASUREMENT PROCESSING STATISTICS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Display measurement residual for TACAN bearing	DISP_DELQ(1)	*	F	S		rad	0.25
Display measurement residual for TACAN range	DISP_DELQ(2)	*	F	S		nmi	0.25
Display edit history indicator for TACAN bearing measurement	DISP_EDIT(1)	*	CHAR	S			0.25
Display edit history indicator for TACAN range measurement	DISP_EDIT(2)	*	CHAR	S			0.25
Display residual edit ratio for TACAN bearing	DISP_SIG(1)	*	F	S			0.25
Display residual edit ratio for TACAN range	DISP_SIG(2)	*	F	S			0.25
Display measurement residual for barometric altitude	DISP_DELQ(3)	*	F	S		ft	0.25
Display edit history indicator for barometric altitude measurement	DISP_EDIT(3)	*	CHAR	S			0.25
Display residual edit ratio for barometric altitude	DISP_SIG(3)	*	F	S			0.25
Display measurement residual for drag altitude	DISP_DELQ(4)	*	F	S		ft	0.25
Display edit history indicator for drag altitude measurement	DISP_EDIT(4)	*	CHAR	S			0.25

*Entry navigation principal function output list (Appendix G).

TABLE 4.3.1.8-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Display residual edit ratio for drag altitude	DISP_SIG(4)	*	F	S			0.25

*Entry navigation principal function output list (Appendix G).

4.3.2 Preland Navigation

The preland navigation principal function is to provide an up-to-date estimate of the Shuttle's position, velocity, and other parameters for software users such as guidance and displays. This principal function will be scheduled by the deorbit/landing navigation sequencer. Variables interfacing with this principal function are identified in the principal function in list and out list, Appendix G.

Preland navigation will use IMU attitude and sensed velocity data as provided by the selection filter to maintain a current estimate of one state vector. Before initiating this principal function, the multiple state configuration that may exist from the exercise of the entry navigation principal function will have been reduced to a single-state configuration.

A Kalman filtering technique will be used when updating the inertial state vector. This update will be based upon a combination of TACAN and barometric altimeter data, MSBLS data, or any one of these data types. The data type(s) used will depend on availability, geometry constraints, and crew control. The state and covariance matrix will be propagated to current time. The state at measurement time will be determined by interpolation, and the estimated measurement value will be computed. An update to the state and covariance matrix will be made, on the basis of the Kalman gain and the measurement residual, if the residual edit test is passed or crew overrride is indicated. This updated state will be superimposed on the current user parameter state for subsequent propagation and use in computing guidance and control user parameters and display parameters.

4.3.2.1 Preland Control

The preland navigation principal function is to provide the capability to control state and covariance matrix propagation and filter updates. A single state vector will be maintained.

A. Detailed Requirements. Preland control will perform the following tasks in the order indicated. For definitions of variables, see input and output Tables 4.3.2.1-1 and 4.3.2.1-2.

(1) The accumulated IMU sensed velocity and the corresponding time tag will be obtained as described in Section 4.3.2.5.

(2) An external sensor data snap will be performed as described in Section 4.3.2.2.

(3) The state vector will be propagated as described in Section 4.3.2.5.

(4) The covariance matrix propagation subfunction will propagate the covariance matrix as described in Section 4.3.2.6.

(5) The preland sensor measurement selection subfunction will determine which measurements are to be presented to the filter for processing, as described in Section 4.3.2.3.

(6) The delta state update subfunction will update the onboard state vector with information supplied by the ground, if so required, and will also reinitialize the covariance matrix. A description of these operations is contained in Section 4.3.2.4.2.

(7) The state and covariance measurement incorporation subfunction will update the state vector and covariance matrix for each of the measurements being processed, as described in Section 4.3.2.7. This subfunction is exercised for each measurement type only if data are to be processed as determined by the preland sensor selection subfunction. In the case of TACAN, the current ground station identifier shall be tested to determine if a new station has been selected, and, if so, the measurement reconfiguration subfunction (Section 4.3.2.4.1) will supply the filter with the pertinent station information. A counter (MLS_MARK_NUM, TACAN_MARK_NUM, or BARO_MARK_NUM) will be incremented for each measurement processed to indicate the mark number for post mission analysis purposes.

(8) The user parameter state propagator subfunction reset parameters will be stored as described in Section 4.2.10.

(9) Finally, the measurement processing statistics subfunction will be performed as described in Section 4.3.2.8.

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.2.1-1 and 4.3.2.1-2.

C. Processing Requirements. Preland control will be executed at a premission-determined rate when the preland navigation principal function is scheduled.

D. Constraints. None.

E. Supplemental Information. A suggested implementation of preland control is illustrated by NAV_PRELAND in Appendix B.

TABLE 4.3.2.1-1.- PRELAND CONTROL INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Time of the filter state vector	T_LAST_FILT	Preland state propagation	F	DP		sec	Filter rate
Previously read selected accumulated IMU velocity	V _LAST_FILT	Preland state propagation	V	DP		ft/sec	Filter rate
Flag indicating (ON) that MLS data is to be processed	DO_MLS_NAV	Preland sensor selector	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data are to be processed	DO_TACAN_NAV	Preland sensor selector	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that baro altimeter data are to be processed	DO_BARO_NAV	Preland sensor selector	D	--	OFF/ON	--	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state and covariance measurement incorporation	V	DP		ft	Filter rate
Shuttle velocity vector	V _FILT	Preland state and covariance measurement incorporation	V	DP		ft/sec	Filter rate

TABLE 4.3.2.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Conversion factor from degrees to radians	RAD_PER_DEG	**	F			-	Filter rate
Flag indicating (ON) that a delta state update is to be performed	DO_DELTA_ UPDATE	*	D		OFF/ON	-	Filter rate
Acceleration vector in M50 coordinates	G _OLD	Preland state propagation	V	DP		ft/sec^2	Filter rate

*See preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.1-2.- PRELAND CONTROL OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Vehicle position vector after all navigation updates reserved for reset of guidance integrator position vector	R_RESET	*	V	DP		ft	Filter rate
Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector	V_RESET	*	V	S		ft/sec	Filter rate
Time associated with reserved reset state	T_RESET	*	F	DP		sec	Filter rate
Switch indicating (ON) that current measurement processing is complete	FILT_UPDATE	*	D	--	OFF/ON	--	Filter rate
Updated vehicle position vector associated with current covariance matrix	R_COV_LAST	Preland covariance propagation	V	DP		ft	Filter rate
Copy of V_LAST_FILT reserved as velocity count at start of extrapolation interval when guidance integrator is reset	V_IMU_RESET	*	V	DP		ft/sec	Filter rate
Copy of G_OLD reserved for reset of guidance integrator acceleration vector	G_RESET	*	V	S		ft/sec^2	Filter rate

*See preland navigation principal function output list (Appendix G).

TABLE 4.3.2.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Counter indicating the particular MLS measurement processed by the filter	MLS_MARK_NUM	*	I	S		-	Filter rate
Counter indicating the particular TACAN measurement processed by the filter	TACAN_MARK_ NUM	*	I	S		-	Filter rate
Counter indicating the particular BARO measurement processed by the filter	BARO_MARK_NUM	*	I	S		-	Filter rate

*See preland navigation principal function output list (Appendix G).

4.3.2.2 External Sensor Data Snap

The purpose of this subfunction during the preland navigation phase is to collect sensor data and store the data for subsequent use in the state and covariance measurement incorporation subfunction. Included in the sensor data are the measurements, their data-good flags (which indicate the validity of the measurements), and the measurements' time tags. This subfunction is required to ensure that the data sets used in the navigation processing are properly saved for use in the state and covariance measurement incorporation subfunction, whereas the actual data may continue to be refreshed by hardware sensor reading, sensor SOP processing, and selection filter unification. For the MSBLS elevation measurement, where the correction for antenna displacement from the navigation base is significant, the Shuttle vehicle's pitch angle will be obtained from the attitude processing principal function and stored for subsequent use, together with the elevation measurement. Time tags of the data collected from sensors are adjusted according to premission biases.

A. Detailed Requirements. During the preland phase, external sensor data will be collected in three groups: (1) barometric altimeter data (air data system), (2) TACAN data, and (3) MSBLS data. Barometric altimeter and TACAN data collection are required at the navigation filter rate. Since the hardware refreshment rate for the MSBLS sensors is rather infrequent, it is desirable to sample the data frequently to determine whether the data have changed so that, if they have, the time of change may be assumed to be the time tag of a new measurement. (Mechanization of this process is in the MSBLS SOP.) The pertinent navigation sensors and their measurement sets are defined below:

(1) Barometric altimeter - the Shuttle's barometric altitude, the Mach discontinuity indicator, the data-good flag, and the associated time tag, adjusted by a premission-loaded time bias, will be collected and stored:

SNAP BARO ALTIMETER (Q_BARO, MACH_JUMP, BARO_DATA_GOOD, T_BARO)

T_BARO = T_BARO - TIME_BIAS_BARO

(2) TACAN - The magnetic bearing of the TACAN station from the Shuttle and the slant range distance from the TACAN ground beacon, together with the data-good flags, shall be collected and stored. The associated time tag will be collected, adjusted by a premission-loaded time bias, and stored. The current TACAN line replacement unit (LRU) number will also be collected and stored. The following equations define the parameters necessary to accomplish the above requirements:

SNAP TACAN (Q_TAC_BRG, Q_TAC_R, TAC_RNG_DATA_GOOD,

TAC_BRG_DATA_GOOD, T_TACAN, SEL_LRU_ID)

T_TACAN = T_TACAN - TIME_BIAS_TACAN

(3) MSBLS - The Shuttle's azimuth, slant-range distance from the DME antenna, and elevation (given as a wedge angle) will be collected and stored, together with the data-good flags. The associated time tags will be collected, adjusted by a premission-loaded time bias, and stored. The Shuttle's pitch angle will also be collected, converted to radians, and stored. The following equations define the parameters necessary to accomplish the above requirements:

```
SNAP MSBLS (Q_RANGE, Q_AZMLS, Q_ELMLS, MLSRANGE_DATA_GOOD,

MLSAZ_DATA_GOOD, MLSEL_DATA_GOOD, T_EF_RMLS, T_EF_AZMLS,

T_EF_ELMLS)
T_EF_RMLS = T_EF_RMLS - TIME_BIAS_MLS,

T_EF_AZMLS = T_EF_AZMLS - TIME_BIAS_MLS

T_EF_ELMLS = T_EF_ELMLS - TIME_BIAS_MLS

PITCH_M = THETA  RAD_PER_DEG
```

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.2.2-1 and 4.3.2.2-2. All output time tags are assumed to have been associated with the sensors' measurements (the time FCOS commands the read, adjusted by applying time bias corrections).

C. Processing Requirements. It is required that the navigation sensor data (measurements, validity flags, and time tags) be made available for the collection and storing processes. The collection rates (not necessarily sensor interrogations) are indicated by the navigation sequencers. However, these rates assume the available data are fresh. This implies that SOP's processing and RM selection filtering must be at a rate equal to or greater than the collection rate. It is also required that the vehicle pitch angle from the attitude processing principal function be available when MSBLS data are collected.

D. Constraints. The data collections should occur after a complete current set is available and just prior to use in navigation in order to supply current data.

E. Supplementary Information. A suggested implementation of the preland external sensor data snap subfunction, in the form of a detailed flow chart, may be found in Appendix B (NAV_PRELAND). The SNAP statements above imply the assignment of current values to the variable names shown in parentheses.

TABLE 4.3.2.2-1.- PRELAND EXTERNAL SENSOR DATA SNAP INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Barometric altimeter sensor measurement	Q_BARO	*	F	S		ft	Filter rate
Copy of current data good discrete reserved for measurement processing (navigation)	BARO_DATA_GOOD	*	D	--	OFF/ON	--	Filter rate
Time tag associated with barometric measurement	T_BARO	*	F	DP		sec	Filter rate
Pad loaded bias used to correct barometric time tag	TIME_BIAS_BARO	**	F	S		sec	Filter rate
TACAN bearing sensor measurement	Q_TAC_BRG	*	F	S		ft	Filter rate
TACAN range sensor measurement	Q_TAC_R	*	F	S		ft	Filter rate
Current data good discrete for TACAN range measurement processing	TAC_RNG_DATA_GOOD	*	D	--	OFF/ON	--	Filter rate
Current data good discrete for TACAN bearing measurement processing	TAC_BRG_DATA GOOD	*	D	--	OFF/ON	--	Filter rate
Time at which TACAN was read	T_TACAN	*	F	DP		sec	Filter rate
Pad loaded bias used to correct TACAN time tag	TIME_BIAS_TACAN	**	F	S		sec	Filter rate
MSBLS range sensor measurement	Q_RANGE	*	F	S		ft	Filter rate
MSBLS azimuth sensor measurement	Q_AZMLS	*	F	S		ft	Filter rate

*See the preland navigation principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS elevation sensor measurement	Q_ELMLS	*	F	S		ft	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_ DATA_GOOD	*	D	--	OFF/ON	--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	*	D	--	OFF/ON	--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSEL_DATA_ GOOD	*	D	--	OFF/ON	--	Filter rate
Time at which MSBLS range measurement was read	T_EF_RMLS	*	F	DP		sec	Filter rate
Time at which MSBLS azimuth was read (adjusted)	T_EF_AZMLS	*	F	DP		sec	Filter rate
Time tag of current MSBLS elevation measurement	T_EF_ELMLS	*	F	DP		sec	Filter rate
Pad loaded bias used to correct MSBLS time tag	TIME_BIAS_MLS	**	F	S		sec	Filter rate
Euler angle from body to TD frame (pitch)	THETA	*	F	S	-PI/2 PI/2	deg	Filter rate
LRU number which the selection filter picked, and which identifies the site parameter list (No. 1, 2, 3)	SEL_LRU_ID	*	I	S	1, 2, or 3	-	Filter rate

*See preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that the velocity of the vehicle is in the MACH discontinuity region	MACH_JUMP	*	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function input list (Appendix G).

TABLE 4.3.2.2-2.- PRELAND EXTERNAL SENSOR DATA SNAP OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Barometric altimeter sensor measurement	Q_BARO	Preland barometric altimeter meas incorp, *	F	S		ft	Filter rate
Copy of current data good discrete reserved for measurement processing (navigation)	BARO_DATA_GOOD	Preland barometric altimeter meas incorp, *	D	--	OFF/ON	--	Filter rate
Time tag associated with barometric measurement	T_BARO	Preland barometric altimeter meas incorp, *	F	DP		sec	Filter rate
TACAN bearing sensor measurement	Q_TAC_BRG	Preland TACAN bearing meas incorp, *	F	S		ft	Filter rate
TACAN range sensor measurement	Q_TAC_R	Preland TACAN range meas incorp, *	F	S		ft	Filter rate
Current data good discrete for TACAN range measurement processing	TAC_RNG_DATA_GOOD	Preland TACAN range data incorp, *	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function output (Appendix G).

TABLE 4.3.2.2-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Time at which TACAN was read	T_TACAN	Preland TACAN range meas incorp, preland TACAN bearing meas incorp, *	F	DP		sec	Filter rate
Current data good discrete for TACAN bearing measurement processing	TAC_BRG_DATA_GOOD	Preland TACAN bearing meas incorp, *	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that the velocity of the vehicle is in the MACH discontinuity region	MACH_JUMP	Preland sensor selection	D	--	OFF/ON	--	Filter rate
MSBLS range sensor measurement	Q_RANGE	Preland MSBLS range meas incorp, *	F	S		ft	Filter rate
MSBLS azimuth sensor measurement	Q_AZMLS	Preland MSBLS range meas incorp, *	F	S		ft	Filter rate
MSBLS elevation sensor measurement	Q_ELMLS	Preland MSBLS range meas incorp, *	F	S		ft	Filter rate

*See preland navigation principal function output list (Appendix G).

TABLE 4.3.2.2-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_ DATA_GOOD	Preland MSBLS range meas incorp, *	D	--	OFF/ON	--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	Preland MSBLS range meas incorp, *	D	--	OFF/ON	--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSEL_DATA_ GOOD	Preland MSBLS range meas incorp, *	D	--	OFF/ON	--	Filter rate
Time at which MSBLS range measurement was read	T_EF_RMLS	Preland MSBLS range meas incorp, *	F	DP		sec	Filter rate
Time at which MSBLS azimuth was read (adjusted)	T_EF_AZMLS	Preland MSBLS azimuth meas incorp, *	F	DP		sec	Filter rate
Time tag of current MSBLS elevation measurement	T_EF_ELMLS	Preland MSBLS elevation meas incorp, *	F	DP		sec	Filter rate

*See preland navigation principal function output list (Appendix G).

TABLE 4.3.2.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Copy of pitch-store reserved for MLS elevation processing	PITCH_M	Preland MSBLS elevation meas incorp, *	F	S		rad	Filter rate
LRU number which the selection filter picked, and which identifies the site parameter list (No. 1, 2, or 3)	SEL_LRU_ID	Preland measurement reconfiguration, *	I	S	1, 2, or 3	-	Filter rate

*See preland navigation principal function output list (Appendix G).

4.3.2.3 Sensor Measurement Selection

A capability, designated as the preland sensor measurement selection subfunction, is required for the selection of external sensor measurement data to be presented to the state and covariance measurement incorporation subfunction (Section 4.3.2.7) when the preland navigation principal function is active. Selection of a sensor data type will also mean that knowledge of this measurement data selection will be presented to the measurement reconfiguration subfunction (Section 4.3.2.4.1) to cause proper initialization of TACAN site data.

A. Detailed Requirements. The requirements for this subfunction are given as a set of necessary sensor measurement selection capabilities. Only the following measurement types will be employed while the preland navigation principal function is active: barometric altimeter, MSBLS, and TACAN. The following capabilities will be provided:

(1) There will be both manual (crew) and automatic control of TACAN and barometric altimeter measurement selection.

(2) The crew will be able to manually force or inhibit TACAN and barometric altimeter sensor data or select the automatic mode.

(3) Manual control (force or inhibit) will override automatic sensor selection; that is, if a crewman desires to force TACAN or barometric altimeter data, then these data will be sent to the state and covariance measurement incorporation subfunction (data may not be incorporated if indicated to be invalid), with one exception (see Item 5 below). The force or inhibit will stay in effect across major modes and will be removed by reverting to automatic sensor measurement selection.

(4) The forcing of sensor data will override the residual edit for that particular sensor type.

(5) Neither the crew nor the automatic selection criteria will be able to simultaneously select any of the following combinations:

a. TACAN and MSBLS data

b. MSBLS and barometric altimeter data

(6) If TACAN is in the automatic selection mode and MSBLS range and azimuth data are indicated as valid, then MSBLS data will be selected. TACAN data will be selected if no valid MSBLS range and azimuth data have been snapped for the last k (premission constant) executions of the preland navigation principal function and MSBLS range or azimuth data are indicated as invalid during the current execution.

(7) When MSBLS data are first selected, or are reselected after having been deselected, portions of the covariance matrix shall be reinitialized by setting all the cross-correlation terms between position and velocity to zero.

(8) If MSBLS is not selected and barometric altimeter data are indicated as valid, baro data will be selected for processing (for statistics only) if the crew has inhibited the use of baro data for state updates. If baro has not been inhibited and the vehicle is not in the 'MACH jump' region, baro will be selected for processing. The 'MACH jump' velocity region shall override the auto and force modes of selection.

(9) The state of the TACAN and barometric altitude measurement selection configuration will be indicated to the crew display.

(10) If MSBLS is indicated as not available at the current (crew) selected landing site, MSBLS data will not be selected.

This subfunction will also perform sensor measurement selection when the data are employed only to compute TACAN and barometric altimeter statistics for display purposes. The following capabilities will be provided:

(1) A maximum of three pieces of sensor measurement data (e.g., MSBLS range, azimuth, and elevation or TACAN range and azimuth and barometric altimeter) will be processed on any one execution of the preland navigation principal function.

(2) Selection of TACAN and barometric altimeter measurement for computation of measurement statistics will be subordinate to selection of MSBLS for possible state and covariance incorporation.

The result of selection of sensor measurements for processing of data or for computation of measurement statistics will be provided as indicated in Tables 4.3.2.3-1 and 4.3.2.3-2. The terminology "process" means that the state and covariance measurement incorporation subfunction may incorporate the measurement data into the state estimation. The terminology "display" means that the state and covariance measurement incorporation subfunction may perform the processing of data for display of measurement statistics, but is prohibited from incorporating the data into the state estimation.

Finally, this subfunction will initialize the measurement edit indicators to off for subsequent use by the state and covariance measurement incorporation subfunction.

B. Interface Requirements. The input and output for this function are given in Tables 4.3.2.3-3 and 4.3.2.3-4.

C. Processing Requirements. This function will be performed after a complete set of the external sensor measurement data to be used (while the preland navigation principal function is active) has been saved and before the measurement reconfiguration subfunction is executed.

D. Constraints. None.

TABLE 4.3.2.3-1.- MSBLS VERSUS TACAN

	MSBLS AVAILABLE		MSBLS NOT AVAILABLE
	DATA GOOD (Range and AZ)	DATA BAD (k Cycles)	
	PROCESS MSBLS	PROCESS TACAN*	PROCESS TACAN*
	PROCESS TACAN*	PROCESS TACAN*	PROCESS TACAN*
	PROCESS MSBLS	DISPLAY TACAN	DISPLAY TACAN

*Will not result in update if DATA_GOOD = OFF

TABLE 4.3.2.3-2.- BAROMETRIC ALTIMETER*

Auto		Inhibit	Force
In MACH Jump region	Outside MACH Jump region		
No Selection	Process**	Display	Process***

*This table is used only if the outcome of Table 4.3.2.3-1 is to not process MSBLS
**Will not result in update if DATA_GOOD = OFF
***Will not result in update if DATA_GOOD = OFF or if MACH_JUMP indicator = ON

E. Supplemental Information. The foregoing requirements indicate the existence of a three-position software switch associated with the TACAN and baro altimeter sensor measurements; that is, an AUTO/INHIBIT/FORCE switch for each of these sensor measurement types. Display requirements indicate the existence of a return signal three position software switch for these sensors to activate the HSD processor according to the actual conditions.

A candidate implementation of this subfunction is shown in PRELAND_SENSOR_SELECT code in Appendix B. This code is executed by NAV_PRELAND, the candidate implementation of the preland navigation control subfunction.

TABLE 4.3.2.3-3.- PRELAND SENSOR MEASUREMENT SELECTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_ DATA_GOOD	Preland sensor data snap	D	--	OFF/ON	--	Filter rate
Running count of number of consecutive MLS azimuth and range measurements failing data good test	R_AZ_COUNT	Preland sensor measurement selection	I	S		--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	Preland sensor data snap	D	--	OFF/ON	--	Filter rate
Prescribed number of consecutive MLS azimuth measurement data good "fails" to force inhibit of MLS processing and allow TACAN processing	R_AZ_COUNT_ MAX	**	I	S		--	Filter rate
Auto-inhibit-force switch for TACAN sensor selection	TACAN_AIF	*	CHAR	S		--	Filter rate
Auto-inhibit-force switch for barometric altitmeter sensor selection	BARO_AIF	*	CHAR	S		--	Filter rate
Altitude above the Fischer ellipsoid	ALT	*	F	S		ft	Filter rate
Flag indicating (ON) that vehicle speed is in the MACH discontinuity region	MACH_JUMP	Preland sensor data snap	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.3-3.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating if ON that MSBLS data are available at the selected landing site	MLS_AVAIL	*	D	--	OFF/ON	--	Filter rate

*Preland navigation input list (Appendix G).

TABLE 4.3.2.3-4.- PRELAND SENSOR MEASUREMENT SELECTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag indicating (ON) that barometric altimeter data is to be processed	DO_BARO_NAV	Preland baro measurement incorporation, *	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that TACAN data is to be processed	DO_TACAN_NAV	Preland TACAN measurement incorporation and reconfiguration, *	D	--	OFF/ON	--	Filter rate
General edit indicator for I-th sensor measurement, I = 1, 7	SENSOR_ EDIT(I)	Preland state and covariance measurement incorporation, *, preland measurement processing statistics	V	S			Filter rate
Switch used to force incorporation of barometric data regardless of residual edit test	BARO_EDIT_ OVERRIDE	Preland barometric altimeter data processing	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function output list (Appendix G).

TABLE 4.3.2.3-4.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Switch used to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	Preland TACAN range data processing preland TACAN bear- ing data processing	D	--	OFF/ON	--	Filter rate
Flag indicating stat-flag setting for barometric measurements	BARO_STAT	Preland barometric altimeter data processing	D	--	OFF/ON	--	Filter rate
Flag indicating TACAN data proc- essed only for statistical display	TACAN_STAT	Preland TACAN range data processing, preland TACAN bear- ing data processing	D	--	OFF/ON	--	Filter rate
Covariance matrix	E	Covariance matrix propagation, state and covariance measurement incorpora- tion	M	DP		vary	Filter rate

*See preland navigation principal function output list (Appendix G).

TABLE 4.3.2.3-4.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag indicating which TACAN_AIF command is in effect	TAC_AIF_RECD	*	CHAR	S		--	Filter rate
Flag indicating which BARO_AIF command is in effect	BARO_AIF_RECD	*	CHAR	S		--	Filter rate
Auto/inhibit/force switch for TACAN sensor selection	TACAN_AIF	*	CHAR	S		--	Filter rate
Auto/inhibit/force switch for barometric altimeter selection	BARO_AIF	*	CHAR	S		--	Filter rate
Flag indicating (ON) that MSBLS data are to be processed	DO_MLS_NAV	*	D	--	OFF/ON	--	Filter rate

*Preland navigation output list (Appendix G).

4.3.2.4 Preland Navigation Reconfiguration

A capability shall be provided for initialization or reinitialization of certain navigation variables when events occur which require reconfiguration of the navigation software. These events include the initialization of TACAN station information when the TACAN ID changes, and ground updates to the onboard navigated state vector and associated covariance matrix reinitializations.

4.3.2.4.1 Measurement reconfiguration. A capability will be provided for initialization of the TACAN station information when TACAN processing begins or when the TACAN station ID has changed.

A. Detailed Requirements. The preland sensor measurement selection subfunction will provide a capability for determining when TACAN measurements are to be processed. The measurement reconfiguration subfunction will be executed when TACAN measurements are first available and when the TACAN station ID has changed. This subfunction will obtain the following information from the site lookup principal function (Section 4.5.2) only if the selected TACAN channel is indicated valid.

TACAN station information:

$$TACAN\_ID\_LAST = TACAN\_ID_{SEL\_LRU\_ID}$$

$$TAC\_CHAN\_VALID = TACAN\_CHAN\_VALID\_SL_{SEL\_LRU\_ID}$$

$$\underline{R}\_TACAN\_EF = \underline{R}\_TACAN\_EF\_SL_{SEL\_LRU\_ID}$$

$$M\_EFTOTD\_TACAN = M\_EFTOTD\_TACAN\_SL_{SEL\_LRU\_ID}$$

$$ANGLE\_CORR\_TNTOMAG = ANGLE\_CORR\_TNTOMAG\_SL_{SEL\_LRU\_ID}$$

$$BIAS\_TAC\_R = BIAS\_TAC\_R\_SL_{SEL\_LRU\_ID}$$

$$BIAS\_TAC\_BRG = BIAS\_TAC\_BRG\_SL_{SEL\_LRU\_ID}$$

B. Interface Requirements. The input and output variables for this subfunction are described in Tables 4.3.2.4.1-1 and 4.3.2.4.1-2.

C. Processing Requirements. The measurement reconfiguration subfunction shall be performed prior to processing of TACAN measurements and after the execution of the preland sensor selection subfunction.

D. Constraints. It is required that the TACAN redundancy management selection filtering, and the preland navigation principal function execute in the following sequence:

(1) TACAN RM selection filtering.

(2) Preland navigation.

The site lookup principal function TACAN-related output parameters may not be changed during the time interval starting with the initiation of TACAN RM selection filtering and ending with the completion of the preland NAV execution.

E. Supplementary Information. Although the detailed requirements show data being copied from the site lookup principal function into specific navigation variables, there is no reason why the site lookup data could not be used directly by the filter if the above constraint is realized. A suggested implementation of the measurement reconfiguration subfunction is illustrated by the flow charts NAV_SENSOR_INIT in Appendix B.

TABLE 4.3.2.4.1-1.- PRELAND MEASUREMENT RECONFIGURATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Initial TACAN station range bias for each LRU. I = 1, 2, 3	BIAS_TAC_R_SL$_I$	*	F	S		ft	As needed
Initial TACAN station bearing bias for each LRU. I = 1, 2, 3	BIAS_TAC_BRG_SL$_I$	*	F	S	-PI,PI	rad	As needed
ID for TACAN LRU selected by RM	SEL_LRU_ID	External sensor data snap	I	S	1,2,3	--	As needed
Switch for each LRU indicating (ON) a valid TACAN channel has been selected. I = 1, 2, 3	TACAN_CHAN_VALID_SL$_I$	*	D	S	OFF/ON	--	As needed
TACAN station position vector in earth-fixed coordinates for each LRU. I = 1, 2, 3	$\underline{R}$_TACAN_EF_SL$_I$	*	V	DP		ft	As needed
Transformation from earth-fixed to topodetic at TACAN station for each LRU. I = 1, 2, 3	M_EFTOTD_TACAN_SL$_I$	*	M	S		--	As needed
Angle correction from true north to magnetic north for each LRU. I = 1, 2, 3	ANGLE_CORR_TNTOMAG_SL$_I$	*	F	S		rad	As needed
TACAN channel/mode identifier for each LRU. I = 1, 2, 3	TACAN_ID$_I$	*	I	S		--	As needed

*See preland navigation principal function input list (Appendix G).

TABLE 4.3.2.4.1-2.- PRELAND MEASUREMENT RECONFIGURATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN station position vector in earth-fixed coordinates	R_TACAN_EF	Preland state and covariance measurement incorporation	V	DP		ft	As needed
Transformation from earth-fixed to topodetic at TACAN station	M_EFTOTD_TACAN	Preland state and covariance measurement incorporation	M	S			As needed
Angle correction from true north to magnetic	ANGLE_CORR_TNTOMAG	Preland state and covariance measurement incorporation	F	S		rad	As needed
Flag indicating valid TACAN channel data	TAC_CHAN_VALID	Preland state and covariance measurement incorporation	D	--	OFF/ON	--	As needed

TABLE 4.3.2.4.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Copy of BIAS_TAC_R_SL for TACAN station used by filter	BIAS_TAC_R	Preland state and covariance measurement incorporation	F	S		ft	As needed
Copy of BIAS_TAC_BRG_SL for TACAN station used by filter	BIAS_TAC_BRG	Preland state and covariance measurement incorporation	F	S		rad	As needed

4.3.2.4.2 Delta state update. During operation of the preland navigation principal function, a capability for a delta state update of the orbiter's onboard navigated state and reconfiguration of the covariance matrix shall be provided.

A. Detailed Requirements. Detailed requirements for the performance of the delta state update task are described in Section 4.2.6. After execution of the delta state update task, the covariance initialization task described in Section 4.2.9 shall be invoked to reconfigure the onboard covariance matrix. Input values of sigmas and correlation coefficients are peculiar to and associated with the delta state update reconfiguration.

B. Interface Requirements. Input and output requirements for the delta state update task are shown in tables 4.3.2.4.2-1 and 4.3.2.4.2-2 respectively.

C. Processing Requirements. The delta state update task and covariance matrix reconfiguration will be initiated from inputs supplied by either the HSD specialist function processing software or by the ground uplink processing software. The delta state update subfunction and the covariance matrix reconfiguration shall be performed after the state propagation and measurement selection subfunctions have been completed, and only upon detection of an ON value in the DO_DELTA_UPDATE flag. This flag is checked by the Preland Control subfunction in every cycle of the preland navigation principal function.

D. Constraints. None.

E. Supplementary Information. Procedures will be established to inhibit redesignation of the runway and the incorporation of measurement data into the onboard state vector during the time interval between (1) the time of the difference vectors computation and (2) the time of their application to the onboard state vector. Correction terms, rather than the total vector, are used because the correction terms are less sensitive to errors between the time of their computation and the time that they are actually applied to correct the onboard state vector during powered flight.

A suggested implementation in the form of the detailed flow charts OPS_3_DELTA_UPDATE AND COVINIT may be found in Appendix B.

TABLE 4.3.2.4.2-1.- DELTA STATE UPDATE INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating whether the mode of operation is single state or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	As needed
Time of the filter state vectors	T_LAST_FILT	Preland navigation state propagation	F	DP		sec	As needed
Ground computed position deviations to update on-board state vector	DR_RW	*	V	DP		ft	As needed
Ground computed velocity deviations to update on-board state vector	DV_RW	*	V	S		ft/sec	As needed
Earth fixed to prime RW transformation matrix	M_EFTORW	*	M	S		--	As needed
Earth rotation rate	EARTH_RATE	**	F	S		rad/sec	As needed
Unit vector in direction of Earth's axis of rotation	EARTH_POLE	**	V	DP		--	As needed
Vehicle position and velocity standard deviations used when manual state update is invoked	SIG_DIAG_UPDATE	**	V	DP		ft**2	As needed
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state propagation	V	DP		ft	As needed

*See the preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.4.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Filter current Shuttle velocity vector in M50 coordinates	V_FILT	Preland state propagation	V	S		ft/sec	As needed
Covariance correlation coefficients	CORR_COEFF_UPDATE	**	V	S		vary	As needed
Flag indicating (ON) that a delta update is to be performed	DO_DELTA_UPDATE	*	D	--	OFF/ON	--	Filter rate

*See the preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.4.2-2.- DELTA STATE UPDATE OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter current Shuttle position vector in M50 coordinates	R_FILT	Preland state propagation, preland state and covariance measurement incorporation	V	DP		ft	As needed
Filter current Shuttle velocity vector in M50 coordinates	V_FILT	Preland state propagation, preland state and covariance measurement incorporation	V	S		ft/sec	As needed
Filter covariance matrix	E	Preland covariance propagation	S	DP		vary	As needed
Flag indicating (ON) that a delta update is to be performed	DO_DELTA_UPDATE	*	D	--	OFF/ON	--	Filter rate
Ground computed deviations to update on-board position vector (zeroed out for display)	DR_RW	*	V	S		ft	Filter rate

*See the preland navigation principal function output list (Appendix G).

TABLE 4.3.2.4.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Ground computed deviations to update on-board velocity vector (zeroed out for display)	DV_RW	*	V	S		ft/sec	As needed

*See the preland navigation principal function output list (Appendix G).

4.3.2.5 State Propagation

The state propagation subfunction that is active during operation of the preland navigation principal function will be invoked for the purpose of propagating orbiter position and velocity vectors. This subfunction will also snap IMU-sensed accelerations to be used together with modeled gravitational accelerations by the super-g integration task.

A. Detailed Requirements. Propagation of position and velocity vectors will be performed as follows:

(1) Acquire current IMU-sensed total accumulated velocity and associated time tag.

$\underline{V}$ _CURRENT_FILT

T_CURRENT_FILT

Detailed requirements for this IMU data snap task are given in Section 4.2.1.1 (one-state configuration).

(2) Compute the difference between the current and the previous time tag associated with the IMU data snap. This will be the interval over which state propagation is desired.

DT_FILT = T_CURRENT_FILT - T_LAST_FILT

(3) Perform integration of the position/velocity equations of motion with use of the super-g task (see Section 4.2.1.3 for detailed requirements). Position/velocity vectors will be propagated to the current time of the IMU data snap (T_CURRENT_FILT),

$\underline{R}$ _FILT

$\underline{V}$ _FILT

and the current IMU accumulated sensed velocity vectors will be saved for the next cycle (see Section 4.2.1.3).

$\underline{V}$ _LAST_FILT

(4) Save the current time tag for the next cycle.

T_LAST_FILT = T_CURRENT_FILT

B. Interface Requirements. The input and output parameters are listed in Tables 4.3.2.5-1 and 4.3.2.5-2.

C. Processing Requirements. The state propagation subfunction will be performed before the sensor measurement selection subfunction and before the covariance propagation subfunction. This subfunction will be performed each cycle at the preland navigation rate.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of detailed flow charts may be found in Appendix B:

NAV_PRELAND, IMU data snap

NAV_STATE_PROP

SUPER_G_NAV

ACCEL

TABLE 4.3.2.5-1.- PRELAND STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Copy of V_IMU_CURRENT raw velocity counts reserved for measurement processing	V_CURRENT_FILT	*	V	S		ft/sec	Filter rate
MTU or clock time when IMU was read	T_CURRENT_FILT	*	F	DP		sec	Filter rate
Time of the filter state vectors	T_LAST_FILT	Preland state propagation,*	F	DP		sec	Filter rate
Flag indicating whether the mode of operation is single state or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	Filter rate
Filter current Shuttle position vector in M50 coordinates	R_FILT	Preland state propagation, preland delta state update, preland state and covariance measurement incorporation,*	V	DP		ft	Filter rate

*See preland navigation principal function input list (Appendix G).

TABLE 4.3.2.5-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector	V_FILT	Preland state propagation, preland delta state update, preland state and covariance measurement incorporation,*	V	S		ft/sec	Filter rate
Previously read selected accumulated IMU velocity	V_LAST_FILT	Preland state propagation,*	V	S		ft/sec	Filter rate
Acceleration function related constants	***	**	vary	vary		vary	Filter rate
Minimum nongravitational acceleration magnitude to use IMU data	ACC_PROP_MIN	*	F	S		ft/sec^2	Filter rate

*See preland navigation principal function input list (Appendix G).
**See Section 4.9.
***See Section 4.2.1.2 for list and descriptions.

TABLE 4.3.2.5-2.- PRELAND STATE PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter current Shuttle position vector in M50 coordinates	R_FILT	Preland state propagation, preland delta state update, preland state and covariance measurement incorporation, preland covariance propagation, preland MSBLS range meas incorp	V	DP		ft	Filter rate

TABLE 4.3.2.5-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Shuttle velocity vector	V_FILT	Preland state propagation, preland delta state update, preland state and covariance measurement incorporation, preland covariance propagation, preland MSBLS range meas incorp	V	S		ft/sec	Filter rate
Gravitational acceleration vector	G_OLD	Preland MSBLS range meas incorp	V	S		ft/sec^2	Filter rate
Time of the filter state vectors	T_LAST_FILT	Preland NAV state prop, preland delta state update, preland MSBLS range meas incorp	F	DP		sec	Filter rate

TABLE 4.3.2.5-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Previously read selected accumulated IMU velocity	V_LAST_FILT	Preland state propagation	V	S		ft/sec	Filter rate
Difference between present and previous accumulated sensed velocities	DV_FILT	Preland covariance propagation, Preland MSBLS range meas incorp	V	S		ft/sec	Filter rate
Flag indicating (ON) to use IMU data in state propagation	USE_IMU_DATA	*	D	S	OFF/ON	--	Filter rate

*See preland navigation principal function output list (Appendix G).

4.3.2.6 Covariance Propagation

The covariance matrix propagation subfunction propagates the covariance matrix forward in time. The covariance matrix is propagated by utilizing the state transition matrix. Additive process noise is incorporated to account for unmodeled state and dynamic errors.

A. Detailed Requirements. A 6 by 6 covariance matrix will be propagated with the preland navigation principal function. This covariance matrix defines the uncertainty in the state vector, which consists of position and velocity of the vehicle. The method of propagation is described in Section 4.2.2.

   The preland navigation principal function maintains a single state vector (i.e., the NAV_THREE_STATE flag is OFF); so the current filter position vector, $\underline{R}$ _FILT, required in the covariance propagation is obtained directly from the state propagation subfunction.

B. Interface Requirements. The input and output data are shown in Tables 4.3.2.6-1 and 4.3.2.6-2.

C. Processing Requirements. This subfunction will be called after the IMU sensor data have been read and after the state propagation subfunction has been executed.

D. Constraints. Prestored data are to be used for initialization. The propagated covariance matrix must remain symmetric.

E. Supplementary Information. A possible implementation of this subfunction is shown in the flow chart COVEXTRAP_PF in Appendix B.

TABLE 4.3.2.6-1.- PRELAND COVARIANCE MATRIX PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interval over which to propagate the covariance matrix	DT_FILT	Preland state propagation	F	S		sec	Filter rate
Filter covariance matrix	E	Preland state and covariance measurement incorporation, preland covariance propagation	M	DP		vary	Filter rate
Gravitational constant of earth	EARTH_MU	**	F	S		ft^3/sec	Filter rate
Identity matrix (3x3)	ID_MATRIX_3x3	**	M	S		--	Filter rate
Flag indicating whether the mode of operation in single state or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	Filter rate
Updated vehicle position vector associated with current covariance matrix	R _COV_LAST	Preland control	V	DP		ft	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state propagation	V	DP		ft	Filter rate

*See preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.6-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Accelerometer quantization error variance during powered flight	VAR_ACC_QUANT_IMU	**	F	S		ft^2/sec^4	Filter rate
Variance of unmodeled acceleration times scale time during powered flight	VAR_UNMOD_ACC_DT_IMU	**	F	S		ft^2/sec^3	Filter rate
Flag indicating (ON) that IMU data is being used in state propagation	USE_IMU_DATA	Preland state propagation	D	--	OFF/ON	--	Filter rate
Variance of unmodeled acceleration times scale time during unpowered flight	VAR_UNMOD_ACC_DT_COAST	**	F	S		ft^2/sec^3	Filter rate
State noise error variance during unpowered flight	VAR_ACC_QUANT_COAST	**	F	S		ft^2/sec^4	Filter rate

**See Section 4.9.

TABLE 4.3.2.6-2.- PRELAND COVARIANCE MATRIX PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter covariance matrix	E	Preland state and covariance measurement incorporation, preland covariance propagation	M	DP		vary	Filter rate

4.3.2.7 State and Covariance Measurement Incorporation

The state and covariance measurement incorporation subfunction updates the state vector and covariance matrix with navigation data with the use of a 6-state process noise Kalman filter. The six elements of the state vector are navigation base Shuttle position and velocity in M50 coordinates.

A. Detailed Requirements. The state and covariance measurement incorporation subfunction is exercised only if data are available for processing as determined by the sensor measurement selection subfunction (Section 4.3.2.3) and the respective measurement subfunctions (Sections 4.3.2.7.1 through 4.3.2.7.6). The sensor measurement selection subfunction determines which measurement types are to be considered for processing. The measurement subfunctions process sensor data that are labeled as valid.

The measurement subfunctions will compute the measurement residual and partials of the estimated measurement with respect to the state vector. The proper a priori measurement variance describing the error will also be selected. The following measurement types will be available with the preland navigation principal function: TACAN range and bearing, barometric altimeter, and MSBLS range, azimuth, and elevation.

Once a particular measurement subfunction has completed processing valid data, the filter control flags will be set as follows.

TACAN

MANUAL_EDIT_OVERRIDE = TACAN_EDIT_OVERRIDE

STAT_FLAG = TACAN_STAT

Barometric altimeter

MANUAL_EDIT_OVERRIDE = BARO_EDIT_OVERRIDE

STAT_FLAG = BARO_STAT

MSBLS

MANUAL_EDIT_OVERRIDE = OFF

STAT_FLAG = OFF

The state and covariance measurement incorporation subfunction shall then update the state vector covariance matrix provided that either the residual edit criterion is met or the crew edit override for the sensor type is active, as described in Section 4.2.4.

The following data shall then be stored after the particular measurement type has been processed for subsequent computation of measurement processing statistics as described in Section 4.3.2.8.

TACAN

$SENSOR\_EDIT_{1 and 2} = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_{1 and 2} = RESID\_TEST$

$SENSOR\_DELQ_{1 and 2} = DELQ$

where the subscript 1 corresponds to bearing and 2 to range.

Barometric altimeter

$SENSOR\_EDIT_3 = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_3 = RESID\_TEST$

$SENSOR\_DELQ_3 = DELQ$

MSBLS

$SENSOR\_EDIT_{5,6, and 7} = EDIT\_FLAG$

$SENSOR\_RESID\_TEST_{5,6, and 7} = RESID\_TEST$

$SENSOR\_DELQ_{5,6, and 7} = DELQ$

where the subscripts 5, 6, and 7 correspond to azimuth, range, and elevation, respectively.

B. Interface Requirements. The inputs and outputs for this subfunction are given in Tables 4.3.2.7-1 and 4.3.2.7-2.

C. Processing Requirements. This subfunction is not exercised until the external sensor data snap, sensor measurement selection, navigation reconfiguration, and state and covariance propagation subfunctions have been performed; and the measurement processing statistics subfunction cannot be initiated until this subfunction is completed.

D. Constraints. There is no requirement in the state and covariance measurement incorporation subfunction to perform updating if the data-validity flag indicates bad data. No manual override of this flag exists in this subfunction. If it is desired to process a particular measurement, the data-validity flag must be made to indicate that the data are valid.

E. Supplementary Information. A possible implementation of the state and covariance measurement incorporation subfunction is presented in the flow charts of Appendix B, TACAN_NAV, BARO_NAV, MLS_NAV, MLS_RANGE_NAV, MLS_AZ_NAV, and MLS_EL_NAV codes.

TABLE 4.3.2.7-1.- PRELAND STATE AND COVARIANCE MEASUREMENT INCORPORATION INPUTS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Filter covariance matrix	E	Preland covariance propagation	M	DP		vary	Filter rate
Measurement first partials with respect to filter state	B	Measurement subfunctions	V	DP		vary	Filter rate
Value of filter mean squared position error below which no measurement underweighting is used	MS_POS_UND_WGT	**	F	S		ft**2	Filter rate
General sensor variance	VAR	Measurement subfunctions	F	S			Filter rate
Scale factor used in measurement underweighting equation	K_UND_WGT	**	F	S		vary	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Measurement subfunctions	F	S			Filter rate
Switch used to force incorporation of barometric data regardless of residual edit test	BARO_EDIT_ OVERRIDE	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate
Switch used to override TACAN residual edit test	TACAN_EDIT_ OVERRIDE	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate
General measurement residual	DELQ	Measurement subfunction	F	S		ft	Filter rate

**See Section 4.9.

TABLE 4.3.2.7-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state propagation, preland state and covariance measurement incorpora-tion	V	DP		ft	Filter rate
Shuttle velocity vector	V _FILT	Preland state propagation, preland state and covariance measurement incorpora-tion	V	S		ft/sec	Filter rate
Flag indicating stat-flag setting for barometric measurements	BARO_STAT	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating TACAN data processed only for statistical display	TACAN_STAT	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate

TABLE 4.3.2.7-2.- PRELAND STATE AND COVARIANCE MEASUREMENT INCORPORATION OUTPUTS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Filter covariance matrix	E	Preland covariance propagation	M	DP		vary	Filter rate
Filter current Shuttle position vector in M50 coordinates	R_FILT	Preland state propagation, preland state and covariance measurement incorporation	V	DP		ft	Filter rate
Shuttle velocity vector	V_FILT	Preland state propagation, preland state and covariance measurement incorporation	V	S		ft/sec	Filter rate
Edit indicators for measurements	SENSOR_EDIT	Preland NAV measurement processing statistics	Char	S		--	Filter rate

TABLE 4.3.2.7-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Measurement residuals	SENSOR_DELQ	Preland NAV measurement processing statistics	V	S		vary	Filter rate
Value of criterion used in NAV filter for residual edit tests for the sensor measurements	SENSOR_RESID_TEST	Preland NAV measurement processing statistics	V	S		vary	Filter rate
Residual edit test quantity	RESID_TEST	TACAN range and bearing measurement subfunctions	F	S		vary	Filter rate

4.3.2.7.1 TACAN range. The TACAN range measurement subfunction computes the estimated range from the Shuttle to the TACAN station, the range residual, and the range measurement partials, and selects the proper variance to model the uncorrelated instrument error. It is assumed that TACAN range data will be provided by the TACAN RM by way of the sensor data snap.

A. Detailed Requirements. The position vector, R_FILT, will be interpolated to the time of the TACAN sensor measurement, if required, as described in Section 4.2.3, and saved as the variable R_RESID for subsequent use in the partials computation. The range residual will then be calculated as described in Section 4.2.7.1 and saved as the variable DELQ for subsequent use in the residual edit test.

The partial derivatives of the range measurement with respect to the state vector will be computed and the variance will be selected as described in Section 4.2.7.1.

The scale factor on the filter mean square residual, used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_TACR, which is a premission load contained in Section 4.9.

The state vector and covariance matrix will then be updated as described in Section 4.3.2.7.

The quantity RESID_TEST, computed by the filter (see Sections 4.3.2.7 and 4.2.4), shall be compared to the design dependent parameter TACAN_RNG_CONVERG_TEST. Depending on the outcome of this comparison, the flag ONE_RANGE_LOCK shall be set to ON or OFF: ON if RESID_TEST < TACAN_RNG_CONVERG_TEST, OFF otherwise. The flag ONE_RANGE_LOCK shall then be output for use by the TACAN Redundancy Management.

B. Interface Requirements. The inputs and outputs for the TACAN range measurement subfunction are given in Tables 4.3.2.7.1-1 and 4.3.2.7.1-2.

C. Processing Requirements. This subfunction will be performed after the navigation reconfiguration subfunction (Section 4.3.2.4) at the basic filter rate. This subfunction will be performed as long as TACAN range measurements are being processed.

D. Constraints. This subfunction will only be executed if the data are indicated valid (i.e., the TAC_RNG_DATA_GOOD flag in ON) and the TACAN channel data as provided by TACAN site lookup (Section 4.5.2.2) are indicated valid (i.e., the TAC_CHAN_VALID flag is ON).

E. Supplementary Information. The location of the TACAN antenna has been neglected in calculating the range measurement estimate, since this error is less than that associated with the measurement. A possible implementation of this subfunction is shown in a portion of the flow chart TACAN_NAV CODE, in Appendix B. This flow chart contains both TACAN range and TACAN bearing computations and also some of the requirements described in Section 4.3.2.7,

namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_ FLAG to TACAN_EDIT_OVERRIDE and TACAN_STAT respectively, the call to NAV_ FILTER, and the setting of the parameters $SENSOR\_EDIT_{1 \text{ and } 2}$, SENSOR_ RESID_ $TEST_{1 \text{ and } 2}$ and $SENSOR\_DELQ_{1 \text{ and } 2}$ to EDIT_FLAG, RESID TEST, and DELQ, respectively.

TABLE 4.3.2.7.1-1.- TACAN RANGE MEASUREMENT SUBFUNCTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current range data good flag reserved for measurement processing	TAC_RNG_DATA_GOOD	Preland external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of TACAN_CHAN_VALID_SL for TACAN station used by navigation filter	TAC_CHAN_VALID	Preland measurement reconfigure	D	--	OFF/ON	--	Filter rate
Time at which TACAN was read	T_TACAN	Preland external sensor data snap	F	DP		sec	Filter rate
Copy of R_TACAN_EF_SL for TACAN station used by navigation filter	R_TACAN_EF	Preland measurement reconfigure	V	DP		ft	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R_RESID	State vector interpolate	V	DP		ft	Filter rate
Deterministic TACAN range bias	BIAS_TAC_R	Preland measurement reconfigure	F	S		ft	Filter rate
TACAN range sensor measurement	Q_TAC_R	External sensor data snap	F	S		ft	Filter rate

TABLE 4.3.2.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector in M50 coordinates	R_FILT	Preland state and covariance measurement incorporation, state propagation	V	DP		ft	Filter rate
Current Shuttle velocity vector in M50 coordinates	V_FILT	Preland state and covariance measurement incorporation, state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle	DV_FILT	Preland NAV state prop	V	S		ft/sec	Filter rate
Gravity acceleration at end of previous Shuttle state integration interval	G_OLD	Preland NAV state prop	V	S		ft	Filter rate
Range criterion to select TACAN instrument variance	RNG_VAR_RNG_STEP	**	F	S		ft	Filter rate
Variance of TACAN range instrument error at range > RNG_VAR_RNG_STEP	VAR_TAC_R_HIGH	**	F	S		ft^2	Filter rate
Variance of TACAN range instrument error at range ≤ RNG_VAR_RNG_STEP	VAR_TAC_R_LOW	**	F	S		ft^2	Filter rate

**See Section 4.9.

TABLE 4.3.2.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Scale factor on filter mean square residual edit test used for TACAN range measurement	K_EDIT_TACR	**	F	S		--	Filter rate
Threshold for residual test quantity, below which data from one LRU alone are acceptable	TACAN_RNG_CONVERG_TEST	**	F	S		ft	Filter rate
General residual test variable	RESID_TEST	State and covariance measurement incorporation	F	S		vary	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	--	OFF/ON	--	Filter rate
Flag used (ON) to override TACAN residual edit test	TACAN_EDIT_OVERRIDE	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate

*See preland nav principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that TACAN data are to be procured for statistical display only	TACAN_STAT	Preland sensor measurement selection	D	--	OFF/ON	--	Filter rate
Copy of M_EFTOTD_TACAN_SL from site lookup	M_EFTOTD_TACAN	Preland measurement reconfigur-ation	M	S		--	Filter rate
Filter covariance matrix	E	1, Preland covariance propagation	M	DP		vary	Filter rate

1. Delta state update.

TABLE 4.3.2.7.1-2.- TACAN RANGE MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN range measurement residual	DELQ	Preland state and covariance measurement incorporation, preland measurement processing statistics	F	S		ft	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		ft^2	Filter rate
Measurement first partials with respect to filter state	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
Scale factor on filter mean square residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S			Filter rate
Flag indicating the filter can accept data from one TACAN LRU	ONE_RANGE_LOCK	*	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function output list (Appendix G).

4.3.2.7.2 TACAN bearing. The TACAN bearing measurement subfunction computes the estimated bearing measurement with respect to the TACAN station, the measurement residual, and the bearing measurement partials, and selects the proper variance to model the instrument error. It is assumed that the TACAN bearing data referenced to magnetic north are available from the TACAN RM by way of the sensor data snap.

A. Detailed Requirements. A description of the symbols used in the following equations may be found in Tables 4.3.2.7.2-1 and 4.3.2.7.2-2.

The position vector of the TACAN station in M50 coordinates, $\underline{R}$ _SCANNER, is to be computed by

M_EFTOM50 = EARTH_FIXED_TO_M50_COORD (T_TACAN)

$\underline{R}$ _SCANNER = M_EFTOM50 $\underline{R}$ _TACAN_EF

The transformation from M50 to topodetic coordinates is obtained by

M_M50TOTD = M_EFTOTD_TACAN M_EFTOM50^T

where M_EFTOTD_TACAN and $\underline{R}$ _TACAN_EF were obtained from the measurement reconfiguration subfunction (Section 4.3.2.4.1).

The flags IN_CONE_FLAG (which, when set to ON, indicates the vehicle is inside the TACAN station's cone of confusion) and TAC_BRG_DATA_GOOD (which indicates the validity of the TACAN bearing data) shall be checked.

The following calculations shall be performed only if the bearing data are indicated valid (TAC_BRG_DATA_GOOD = ON) and the IN_CONE_FLAG is OFF.

First, the position vector shall be interpolated to the time of the TACAN measurement, if required, as described in Section 4.2.3 and saved as the variable $\underline{R}$ _RESID for subsequent use in the partials computation. The bearing residual shall then be calculated as described in Section 4.2.7.2 and saved as the variable DELQ for subsequent use in the residual edit test.

The partial derivatives of the bearing measurement with respect to the state vector shall then be computed and the variance shall be selected as described in Section 4.2.7.2.

The scale factor on the filter mean square residual for use in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_TACBR, which is a premission load.

The state vector and covariance matrix will then be updated as described in Section 4.3.2.7.

The quantity RESID_TEST, computed by the filter, shall be compared to the design dependent parameter TACAN_BRG_COVERG_TEST. The flag ONE_BRG LOCK shall be set to ON or OFF depending on the outcome of this comparision: ON if RESID_TEST < TACAN_BRG_CONVERG_TEST, OFF otherwise. The flag ONE_BRG_ LOCK shall then be output for use by the TACAN redundancy management.

B. Interface Requirements. The inputs and outputs for the TACAN bearing measurement subfunction are given in Tables 4.3.2.7.2-1 and 4.3.2.7.2-2.

C. Processing Requirements. The subfunction will be performed after the navigation reconfiguration subfunction (Section 4.3.2.4) at the basic filter rate. This subfunction will be performed as long as TACAN measurements are being processed.

D. Constraints. This subfunction will only be executed if the data are indicated valid (i.e., the TAC_BRG_DATA_GOOD flag is ON), if the TACAN channel data as provided by TACAN site lookup (Section 4.5.2.2) are indicated valid (i.e., the TAC_CHAN_VALID flag is ON), and if the shuttle is not in the TACAN station's cone of confusion (i.e., the IN_CONE_FLAG is OFF). ONE_ BRG_ LOCK shall be initialized to 'OFF'.

E. Supplementary Information. The location of the TACAN antenna has been neglected in calculating the bearing measurement estimate, since this error is less than that associated with the error in the measurement itself. A possible implementation of this subfunction is shown in a portion of the flow chart TACAN_NAV CODE in Appendix B. In the flow chart, computations have been combined with TACAN range data processing and with requirements shown in section 4.3.2.7, namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to TACAN_EDIT_OVERRIDE and TACAN_STAT, respectively the call to NAV_FILTER and the setting of the display parameters $SENSOR\_EDIT_{1and2}$, and $SENSOR\_RESID\_TEST_{1and2}$, and $SENSOR\_DELQ_{1and2}$ to EDIT FLAG, RESID_TEST, and DELQ, respectively.

TABLE 4.3.2.7.2-1.- TACAN BEARING MEASUREMENT SUBFUNCTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current bearing data good flag reserved for measurement processing	TAC_BRG_DATA_GOOD	Preland external sensor data snap	D	--	OFF/ON	--	Filter rate
Copy of TACAN_CHAN_VALID_SL for TACAN station used by navigation filter	TAC_CHAN_VALID	Preland measurement reconfigure	D	--	OFF/ON	--	Filter rate
Time at which TACAN was read	T_TACAN	External sensor data snap	F	DP		sec	Filter rate
Copy of R_TACAN_EF_SL for TACAN station used by navigation filter	R _TACAN_EF	Preland measurement reconfigure	V	DP		ft	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolation	V	DP		ft	Filter rate
Copy of M_EFTOTD_TACAN_SL from site lookup	M_EFTOTD_TACAN	Preland measurement reconfigure	M	S		--	Filter rate
Flag indicating (ON) that the vehicle is in the cone of confusion of selected TACAN station	IN_CONE_FLAG	*	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function inlist (Appendix G).

TABLE 4.3.2.7.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Deterministic TACAN bearing bias	BIAS_TAC_BRG	Preland measurement reconfigu-ration	F	S		rad	Filter rate
Copy of ANGLE_CORR_TNTOMAG_SL for navigation processing	ANGLE_CORR_ TNTOMAG	Preland measurement reconfigu-ration	F	S	0-2PI	rad	Filter rate
The constant PI	PI	**	F	S			Filter rate
TACAN bearing sensor measurement	Q_TAC_BRG	External sensor data snap	F	S		rad	Filter rate
Range criterion to select TACAN bearing instrument variance	RNG_VAR_ BEARING_STEP	**	F	S		ft	Filter rate
Variance of TACAN bearing instrument error at range > RNG_VAR_BEARING_STEP	VAR_TAC_BRG_ HIGH	**	F	S		rad^2	Filter rate
Variance of TACAN bearing instrument error at range ≤ RNG_VAR_BEARING_STEP	VAR_TAC_BRG_ LOW	**	F	S		rad^2	Filter rate

**See Section 4.9.

TABLE 4.3.2.7.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector in M50 coordinates	R_FILT	Preland state and covariance measurement incorporation, state propagation	V	DP		ft	Filter rate
Current Shuttle velocity vector in M50 coordinates	V_FILT	Preland state and covariance measurement incorporation, state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle	DV_FILT	Preland navigation state propagation	V	S		ft/sec	Filter rate
Gravity acceleration at end of previous Shuttle state integration interval	G_OLD	Preland navigation state propagation	V	S		ft/sec^2	Filter rate
Scale factor on filter mean square residual edit test for TACAN bearing measurement	K_EDIT_TACBR	**	F	S		--	Filter rate

**See Section 4.9.

TABLE 4.3.2.7.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Threshold for residual test quantity, below which one LRU data are acceptable	TACAN_BRG_ CONVERG_ TEST	**	F	S		rad	Filter rate
General residual test variable	RESID_TEST	State and covariance measurement incorporation	F	S		vary	Filter rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_ STATE	*	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function inlist (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.2-2.- TACAN BEARING MEASUREMENT SUBFUNCTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN azimuth measurement residual	DELQ	Preland state and covariance measurement incorporation, preland measurement processing statistics	F	S		rad	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		rad^2	Filter rate
Measurement first partials with respect to filter state	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S		--	Filter rate

TABLE 4.3.2.7.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag indicating the filter can accept data from one TACAN LRU	ONE_BRG_LOCK	*	D	--	OFF/ON	--	Filter rate

*See preland navigation principal function output list (Appendix G).

4.3.2.7.3 Barometric altimeter. The barometric altimeter measurement subfunction calculates the estimated altitude measurement, the measurement residual, the measurement partials, and the variance that models the instrument error. It is assumed that the barometric altitude data will be provided by the ADTA SOP via the sensor data snap.

A. Detailed Requirements. In Preland navigation the barometric altimeter estimated measurement, the residual, the measurement partials, and the variance shall be calculated as described in Section 4.2.7.3 for the one-state configuration.

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_BARO, which is a premission load.
The state vector and covariance matrix will then be updated as described in section 4.3.2.7.

B. Interface Requirements. The input and output variables for the barometric measurement subfunction are given in Tables 4.3.2.7.3-1 and 4.3.2.7.3-2.

C. Processing Requirements. This subfunction will be performed after the navigation reconfiguration subfunction (Section 4.3.2.4) at the basic filter rate. This subfunction is performed as long as barometric altitude measurements are being processed.

D. Constraints. This subfunction will only be executed if the data are indicated valid (i.e., the BARO_DATA_GOOD flag is ON).

E. Supplementary Information. The assumption is made, for simplification, that the barometric probe is located at the navigation base. This is a valid assumptions since the error involved in mislocating the probe is less than the errors associated with the barometric measurement.

A possible implementation of this subfunction is shown in the flow chart BARO_NAV CODE in Appendix B. The flow chart also contains some requirements described in Section 4.3.2.7, namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to BARO_EDIT_OVERRIDE and BARO_STAT, respectively, and the setting of the display parameters $SENSOR\_EDIT_3$, $SENSOR\_RESID\_TEST_3$ and $SENSOR\_DELQ_3$ to EDIT_FLAG, RESID_TEST, AND DELQ, respectively.

TABLE 4.3.2.7.3-1.- BAROMETRIC ALTIMETER INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Copy of current data good discrete reserved for measurement processing (navigation)	BARO_DATA_GOOD	Preland sensor data read	D	--	OFF/ON	--	Filter rate
Time tag associated with barometric measurement	T_BARO	Preland sensor data read	F	DP		sec	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolation	V	DP		ft	Filter rate
Barometric deterministic bias	BIAS_BARO	**	F	S		ft	Filter rate
Altitude of mean sea level above reference ellipsoid at the runway	DELH_MSL_ELLIPSOID_RW	*	F	S		ft	Filter rate
Barometric altimeter sensor measurement	Q_BARO	Preland sensor data read	F	S		ft	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state and covariance measurement incorporation, state propagation	V	DP		ft	Filter rate
Altitude of the runway above the reference ellipsoid	ALT_RW	*	F	S		ft	Filter rate

*Preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.3-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Barometric altimeter instrument variance constant	VAR_H1	*	F	S		ft**2	Filter rate
Barometric altimeter instrument variance constant	VAR_H2	*	F	S		ft**2	Filter rate
Current Shuttle velocity vector in M50 coordinates	V _FILT	Preland state and covariance measurement incorporation, state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present and previous cycle	DV_FILT	Preland state propagation	V	S		ft/sec	Filter rate
Gravity acceleration associated with current position vector	G _OLD	Preland state propagation	V	S		ft/sec^2	Filter rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate

*Preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Scale factor on filter mean square residual used in residual edit test for baro measurement	K_EDIT_BARO	**	F	S		--	Filter rate

**See Section 4.9.

TABLE 4.3.2.7.3-2.- BAROMETRIC ALTIMETER OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Barometric measurement residual	DELQ	Preland state and covariance measurement incorporation	F	S		ft	Filter rate
Measurement first partials with respect to filter state	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		vary	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S		--	Filter rate

4.3.2.7.4 MSBLS range. The MSBLS range measurement subfunction calculates the estimated range from the Shuttle to the MSBLS station, the range residual, and the measurement partials; and it selects the proper variance that models the instrument error. It is assumed that the MSBLS range measurement data will be provided by the MSBLS RM to this subfunction by way of the sensor data snap.

A. Detailed Requirements. First, the estimated range will be calculated with use of the following equation:

$$Q = |\underline{R}\_RESID - \underline{R}\_SCANNER| + BIAS\_RMLS$$

where

$$\underline{R}\_SCANNER = EARTH\_FIXED\_TO\_M50\_COORD\ (T\_EF\_RMLS)\ \underline{R}\_RMLS\_EF$$

and $\underline{R}$ _RMLS_EF is obtained from the runway/MSBLS site lookup subfunction (Section 4.5.2.1). The state vector, $\underline{R}$ _RESID, may be interpolated to the sensor measurement time if required, as described in Section 4.2.3. The residual will then be computed by

$$DELQ = Q\_RANGE - Q$$

The variance of the MSBLS measurement error is then set equal to the design dependent parameter VAR_RMLS (Section 4.9.3):

$$VAR = VAR\_RMLS$$

The MSBLS range measurement partials are to be computed by using the equations

$$B_{1to3} = \underline{U}NIT\ (\underline{R}\_RESID - \underline{R}\_SCANNER)$$

$$B_{4\ to\ 6} = 0.$$

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_MLSR, which is a premission load.

Finally, the state vector and the covariance matrix will be updated as described in Section 4.3.2.7.

B. Interface Requirements. The inputs and outputs for the MSBLS range measurement subfunction are given in Tables 4.3.2.7.4-1 and 4.3.2.7.4-2.

C. Processing Requirements. This subfunction will be performed after the state and covariance have been propagated, at the basic filter rate.

D. Constraints. This subfunction will be executed only if the MSBLS range data are labeled valid (i.e., the MLSRANGE_DATA_GOOD flag is ON).

E. Supplementary Information. The location of the onboard MSBLS antenna may be neglected in calculating the range measurement estimate, since this error is much less than that associated with the measurement. A possible implementation of these requirements is illustrated in flow charts MLS_NAV and MLS_RANGE_NAV CODE in Appendix B. The flow chart MLS_NAV also contains equations described in Section 4.3.2.7, namely the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to OFF. The flow chart MLS_RANGE_NAV also contains some requirements from Section 4.3.2.7: the call to NAV_FILTER, and the setting of the display parameters $SENSOR\_EDIT_6$, $SENSOR\_RESID\_TEST_6$, and $SENSOR\_DELQ_6$ to EDIT_FLAG, RESID_TEST, and DELQ, respectively.

TABLE 4.3.2.7.4-1.- MSBLS RANGE MEASUREMENT INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS range measurement bias	BIAS_RMLS	*	F	S		ft	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_DATA_GOOD	Preland sensor data read	D	--	OFF/ON	--	Filter rate
MSBLS range sensor measurement	Q_RANGE	Preland sensor data read	F	S		ft	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolate	V	DP		ft	Filter rate
Earth-fixed position vector of MLS range scanner	R _RMLS_EF	*	V	DP		ft	Filter rate
Time at which MSBLS range measurement was read	T_EF_RMLS	Preland sensor data read	F	DP		sec	Filter rate
MSBLS range measurement instrument variance	VAR_RMLS	**	F	S		ft^2	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state propagation, measurement incorp	V	DP		ft	Filter rate

*Preland navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.4-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle velocity vector in M50 coordinates	V _FILT	Preland state propagation, measurement incorp	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present and previous cycle	DV_FILT	Preland state propagation	V	S		ft/sec	Filter rate
Gravity acceleration associated with current position vector	G _OLD	Preland state propagation	V	S		ft/sec^2	Filter rate
Scale factor on filter mean square residual used in residual edit test for MSBLS range measurement	K_EDIT_MLSR	**	F	S		--	Filter rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the data is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate

**See Section 4.9.

TABLE 4.3.2.7.4-2.- MSBLS RANGE MEASUREMENT OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Measurement first partials with respect to filter state	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
MLS range measurement residual	DELQ	Preland state and covariance measurement incorporation	F	S		ft	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		ft^2	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S		--	Filter rate

4.3.2.7.5 MSBLS azimuth. The MSBLS azimuth measurement subfunction calculates the estimated MSBLS azimuth measurement, the residual, and the measurement partials, and it selects the proper variance that models the instrument error. It is assumed that the MSBLS azimuth measurement data will be provided to this subfunction by the MSBLS RM by way of the sensor data snap.

A. Detailed Requirements. Descriptions of symbols used in the following equations may be found in Tables 4.3.2.7.5-1 and 4.3.2.7.5-2.

First, a transformation matrix from the M50 coordinates to the MSBLS azimuth radar coordinates will be computed at the time tag of the MSBLS azimuth measurement, T_EF_AZMLS.

M_EFTOM50 = EARTH_FIXED_TO_M50_COORD (T_EF_AZMLS)

M_M50_TO_SCANNER = M_EFTORAD_R_AZ $M\_EFTOM50^T$

where M_EFTORAD_R_AZ will be provided by the runway/MSBLS site lookup subfunction (Section 4.5.2.1). The relative position of the Shuttle with respect to the MSBLS azimuth station will then be computed by

$\underline{R}$ = M_50_TO_SCANNER($\underline{R}$ _RESID - $\underline{R}$ _AZMLS)

where $\underline{R}$ _AZMLS is computed by using the equation

$\underline{R}$ _AZMLS = M_EFTOM50 $\underline{R}$ _AZMLS_EF

and $\underline{R}$ _AZMLS_EF will be obtained from the runway/MSBLS site lookup subfunction. The state vector used, $\underline{R}$ _RESID, may be interpolated to the sensor measurement time, if required, as described in Section 4.3.2.

The estimated MSBLS azimuth measurement will then be computed by

$Q = ARCTAN(R_2/R_1) + BIAS\_AZMLS$ F7,F3

and the residual will be computed by

DELQ = Q_AZMLS - Q

The variance of the MSBLS azimuth measurement error is then to be set equal to the mission dependent parameter VAR_AZMLS (Section 4.9)

VAR = VAR_AZMLS

F7 This equation shall be protected against arc tangents with both arguments equal to zero (Reference 3.6.7).
F3 This equation shall be protected against division by zero (Reference 3.6.3).

The MSBLS azimuth partials are next to be computed by using the function ANGLE_PARTIALS (described in Section 4.4.5.3), with $\underline{R}$ _AZMLS and the third row of the transformation matrix from M50 to MSBLS azimuth radar coordinates as inputs:

CALL: ANGLE_PARTIALS

IN LIST: $\underline{R}$ _AZMLS, $M\_M50\_TO\_SCANNER_{3,1to3}$

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_MLSAZ, which is a premission load.

Finally, the state vector and the covariance matrix will be updated as described in Section 4.3.2.7.

B. Interface Requirements. The inputs and outputs for the MSBLS azimuth measurement subfunction are given in Tables 4.3.2.7.5-1 and 4.3.2.7.5-2.

C. Processing Requirements. This subfunction will be performed after the state and covariance matrix have been propagated, at the basic filter rate.

D. Constraints. This subfunction will be executed only if the MSBLS azimuth data are labeled valid (i.e., the MLSAZ_DATA_GOOD flag is ON).

E. Supplementary Information. The location of the onboard MSBLS antenna may be neglected in calculating the azimuth measurement estimate, since this error is much less than that associated with the measurement.

A possible implementation of these requirements is illustrated in flow charts MLS_NAV and MLS_AZ_NAV CODE in Appendix B. Note that these flow charts also contain equations described in Section 4.3.2.7. MLS_NAV shows the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to OFF. MLS_AZ_NAV contains the call to NAV_FILTER and the setting of the display parameters $SENSOR\_EDIT_5$, $SENSOR\_RESID\_TEST_5$ and $SENSOR\_DELQ_5$ to EDIT_FLAG, RESID_TEST and DELQ, respectively.

TABLE 4.3.2.7.5-1.- MSBLS AZIMUTH MEASUREMENT INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS azimuth measurement bias	BIAS_AZMLS	*	F	S		rad	Filter rate
Transformation matrix from earth-fixed to AZ/range MSBLS radar coordinate frame	M_EFTORAD_R_AZ	*	M	S		--	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_GOOD	Data snap	D	--	OFF/ON	--	Filter rate
MSBLS azimuth sensor measurement	Q_AZMLS	Data snap	F	S		rad	Filter rate
Earth-fixed MLS azimuth scanner position vector	R _AZMLS_EF	*	V	DP		ft	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolate	V	DP		ft	Filter rate
Time at which MSBLS azimuth was read	T_EF_AZMLS	Data snap	F	DP		sec	Filter rate
MSBLS azimuth measurement instrument variance	VAR_AZMLS	**	F	S		rad^2	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state and covariance measurement incorporation, state propagation	V	DP		ft	Filter rate

*See navigation principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.5-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle velocity vector in M50 coordinates	V_FILT	Preland state and covariance measurement incorporation, state propagation	V	S		ft/sec	Filter rate
Difference between accumulated several IMU readings on present and previous cycle	DV_FILT	Preland state propagation	V	S		ft/sec	Filter rate
Gravity acceleration associated with current position vector	G_OLD	Preland state propagation	V	S		ft/sec	Filter rate
Time of the filter state vector	T_LAST_FILT	State propagation	F	DP		sec	Filter rate
Interval over which the state is propagated	DT_FILT	State propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for MSBLS azimuth measurement	K_EDIT_MLSAZ	*	F	S		--	Filter rate

*See principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.5-2.- MSBLS AZIMUTH MEASUREMENT OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Measurement first partials with respect to filter state	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
MLS azimuth measurement residual	DELQ	Preland state and covariance measurement incorporation	F	S		rad	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		rad^2	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S		--	Filter rate

4.3.2.7.6 MSBLS elevation. The MSBLS elevation measurement subfunction calculates the estimated MSBLS elevation measurement, the residual, and the measurement partials, and it selects the proper variance that models the instrument error. It is assumed that the MSBLS elevation measurement data will be provided to this subfunction by the MSBLS RM by way of the sensor data snap.

A. Detailed Requirements. Descriptions of symbols used in the following equations may be found in Tables 4.3.2.7.6-1 and 4.3.2.7.6-2.

First, a transformation matrix from M50 to MSBLS elevation radar coordinates will be computed at the time tag of the MSBLS elevation measurement, T_EF_ELMLS.

M_EFTOM50 = EARTH_FIXED_TO_M50_COORD (T_EF_ELMLS)

M_M50_TO_SCANNER = M_EFTORAD_EL $M\_EFTOM50^T$

where M_EFTORAD_EL will be provided by the runway/MSBLS site lookup subfunction (Section 4.5.2.1). The relative position of the Shuttle with respect to the MSBLS elevation radar will then be calculated as

$\underline{R}$ = M_M50_TO_SCANNER ($\underline{R}$ _RESID - $\underline{R}$ _ELMLS)

where $\underline{R}$ _ELMLS is computed by using the equation

$\underline{R}$ _ELMLS = M_EFTOM50 $\underline{R}$ _ELMLS_EF

and $\underline{R}$ _ELMLS_EF will be obtained from the runway/MSBLS site lookup subfunction. The state vector, $\underline{R}$ _RESID, may be interpolated to the sensor measurement time, if required, as described in Section 4.2.3.

The subfunction will then compute the estimated elevation measurement by

$Q = ARCTAN(R_3/R_1) + BIAS\_ELMLS$ F3,F7

and will compensate for antenna displacement by

$Q = Q + MLSANT\_NB\_DIST\ SIN(Q + PITCH\_M - MLSANT\_ANG)/R\_RHO$ F3,F5

where R_RHO is equal to the magnitude of $\underline{R}$, MLSANT_NB_DIST is the distance from the navigation base to the MSBLS antenna location on the vehicle, MLSANT_ANG is the angle between the navigation base to the MSBLS antenna vector and the vehicle's X body-axis, and PITCH_M is the pitch angle.

Finally, the residual will be computed by

DELQ = Q_ELMLS - Q

The variance of the MSBLS elevation measurement is to be then set equal to the design dependent parameter VAR_ELMLS (Section 4.9.3):

VAR = VAR_ELMLS

The elevation measurement partials are to be computed by using the function ANGLE_PARTIALS (described in Section 4.4.5.3) with $\underline{R}$ _ELMLS and the negative of the second row of the transformation matrix from M50 to the MSBLS elevation radar coordinates as inputs:

CALL: ANGLE_PARTIALS

IN LIST: $\underline{R}$ _ELMLS, $-M\_M50\_TO\_SCANNER_{2,1to3}$

The scale factor on the filter mean square residual used in the residual edit test, K_RES_EDIT, shall be set equal to K_EDIT_MLSEL, which is a premission load.

F3 This equation shall be protected against division by zero (Reference 3.6.3).
F7 This equation shall be protected against arc tangents with both arguments equal to zero (Reference 3.6.7).
F5 This equation shall be protected against arc sine of arguments with magnitudes greater than unity (Reference 3.6.5).

Finally, the state vector and the covariance matrix will be updated as described in Secion 4.3.2.7.

B. Interface Requirements. The inputs and outputs for the MSBLS elevation measurement subfunction are given in Tables 4.3.2.7.6-1 and 4.3.2.7.6-2.

C. Processing Requirements. This subfunction will be performed after the state and covariance matrix have been propagated, at the basic filter rate.

D. Constraints. This subfunction will be executed only if MSBLS elevation data are labeled valid (i.e., the MLSEL_DATA_GOOD flag is ON).

E. Supplementary Information. It is assumed that all vehicle-mounted MSBLS antennas are collocated.

A possible implementation of this subfunction is shown in flow charts MLS_NAV and MLS_EL_NAV CODE in Appendix B. These flow charts also contain equations described in Section 4.3.2.7. MLS_NAV shows the setting of the filter control flags MANUAL_EDIT_OVERRIDE and STAT_FLAG to OFF; MLS_EL_NAV shows the call to NAV_FILTER, and the setting of the display parameters $SENSOR\_EDIT_7$, $SENSOR\_RESID\_TEST_7$, and $SENSOR\_DELQ_7$ to EDIT_FLAG, RESID_TEST and DELQ, respectively.

TABLE 4.3.2.7.6-1.- MSBLS ELEVATION MEASUREMENT INPUT PARAMTERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS elevation measurement bias	BIAS_ELMLS	*	F	S		rad	Filter rate
Transformation matrix from earth-fixed to MSBLS elevation radar coordinates	M_EFTORAD_EL	*	M	S			Filter rate
Distance from navigation base to MLS antenna	MLSANT_NB_DIST	**	F	S		ft	Filter rate
Angle between navigation base-to-MLS antenna vector and positive vehicle X-body axis	MLSANT_ANG	**	F	S		rad	Filter rate
Copy of current data good discrete reserved for measurement processing	MLSEL_DATA_GOOD	Preland sensor data read	D	--	OFF/ON	--	Filter rate
Copy of pitch-store reserved for MLS elevation processing	PITCH_M	Preland sensor data read	F	S		rad	Filter rate
MSBLS elevation sensor measurement	Q_ELMLS	Preland sensor data read	F	S		rad	Filter rate
Vehicle position vector used in measurement residual calculation after interpolation to time of measurement	R _RESID	State vector interpolation	V	DP		ft	Filter rate
Earth-fixed MLS elevation scanner position vector	R _ELMLS_EF	*	V	DP		ft	Filter rate

*Refer to principal function in list (Appendix G).
**See Section 4.9.

TABLE 4.3.2.7.6-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Time tag of current MSBLS elevation measurement	T_EF_ELMLS	Sensor data snap	F	DP		sec	Filter rate
MSBLS elevation instrument variance	VAR_ELMLS	**	F	S		rad^2	Filter rate
Filter current Shuttle position vector in M50 coordinates	R _FILT	Preland state and covariance measurement incorporation, state propagation	V	DP		ft	Filter rate
Current Shuttle velocity vector in M50 coordinates	V _FILT	Preland state and covariance measurement incorporation, state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present and previous cycle	DV_FILT	Preland state propagation	V	S		ft/sec	Filter rate
Gravity acceleration associated with current position vector	G _OLD	Preland state propagation	V	S		ft/sec^2	Filter rate
Time of the filter state vector	T_LAST_FILT	Preland state propagation	F	DP		sec	Filter rate

**See Section 4. 9.

TABLE 4.3.2.7.6-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interval over which the state is propagated	DT_FILT	Preland state propagation	F	DP		sec	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for MSBLS elevation measurement	K_EDIT_MLSEL	**	F	S		--	Filter rate

*See Section 4.9.

TABLE 4.3.2.7.6-2.- MSBLS ELEVATION MEASUREMENT OUTPUT VARIABLES

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Measurement first partials with respect to filter rate	B	Preland state and covariance measurement incorporation	V	DP		vary	Filter rate
MLS elevation measurement residual	DELQ	Preland state and covariance measurement incorporation	F	S		rad	Filter rate
General sensor variance	VAR	Preland state and covariance measurement incorporation	F	S		rad^2	Filter rate
Scale factor on filter mean square residual used in residual edit test	K_RES_EDIT	Preland state and covariance measurement incorporation	F	S		--	Filter rate

4.3.2.8 Measurement Processing Statistics

During the preland navigation principal function, the measurement processing statistics subfunction will compute for downlist and for display on the horizontal situation cathode-ray-tube display page certain parameters that are indicative of the health of the navigation filter. It also will compute a discrete signal to be used by user parameter processing to drive the navigation event light.

A. Detailed Requirements. For each of the following external measurement types, three parameters are to be computed to show how well the navigation filter is processing external measurements of that particular type. The external measurement types for which processing statistics will be computed are as follows:

TACAN bearing
TACAN range
Barometric altitude
MSBLS azimuth
MSBLS range
MSBLS elevation

Additional detailed requirements concerning the three parameters to be computed for each measurement type above may be found in Section 4.2.8.2. Since, during preland navigation, drag derived altitude measurements will not be processed by the navigation filter, the three display parameters associated with drag altitude measurements will be given the value "BLANK" in accordance with display requirements.

This subfunction also will evaluate edit flags for the three MSBLS measurement types to compute the sensors' status discrete. Detailed requirements for this calculation may be found in Section 4.2.8.1.

A further capability will be provided by this subfunction to generate the residual and ratio parameters described in Section 4.2.8.2 for display under certain circumstances (determined by the preland sensor measurement selection subfunction) when the filter would not normally be attempting to process data. If the sensor edit indicators are found to have the value "STAT", this shall indicate to the measurement processing subfunction that this filter cycle was performed only for the production of filter statistics and that the calculations leading to the edit history indicator shall ignore this "statistics only" filter cycle.

B. Interface Requirements. Inputs and outputs are listed in Tables 4.3.2.8-1 and 4.3.2.8-2.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation for this subfunction may be found in the detailed flow chart MEAS_PROCESSING_STATISTICS_PRELAND code of Appendix B.

TABLE 4.3.2.8-1.- PRELAND MEASUREMENT PROCESSING STATISTICS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Value of criterion used to set the edit history indicators	K_MAX	**	I	S			Filter rate
Measurement residual for TACAN bearing data	SENSOR_DELQ(1)	Preland navigation state and covariance measurement incorporation	F	S		rad	Filter rate
Measurement residual for TACAN range data	SENSOR_DELQ(2)	Preland navigation state and covariance measurement incorporation	F	S		ft	Filter rate
Measurement residual for baro altitude	SENSOR_DELQ(3)	Preland navigation state and covariance measurement incorporation	F	S		ft	Filter rate

**See Section 4.9.

TABLE 4.3.2.8-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Measurement residual for MSBLS azimuth	SENSOR_DELQ(5)	Preland navigation state and covariance measurement incorporation	F	S		rad	Filter rate
Measurement residual for MSBLS range data	SENSOR_DELQ(6)	Preland navigation state and covariance measurement incorporation	F	S		ft	Filter rate
Measurement residual for MSBLS elevation	SENSOR_DELQ(7)	Preland navigation state and covariance measurement incorporation	F	S		ft	Filter rate
Four-valued flag defining use of TACAN bearing data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(1)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate

TABLE 4.3.2.8-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Four-valued flag defining use of TACAN range data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(2)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate
Four-valued flag defining use of BARO altimeter data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(3)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate
Four-valued flag defining use of MSBLS azimuth data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(5)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate
Four-valued flag defining use of MSBLS range data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(6)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate

TABLE 4.3.2.8-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Four-valued flag defining use of MSBLS elevation data by the navigation filter. OFF - no processing attempted. ON - rejected by residual edit test. PROCESSED - used to update state vector. STAT - used only for stat display purpose	SENSOR_EDIT(7)	Preland navigation state and covariance measurement incorporation	Char	S			Filter rate
Value of criterion used in navigation filter for residual edit test for TACAN bearing measurement	SENSOR_RESID_TEST(1)	Preland navigation state and covariance measurement incorporation	F	S		rad^2	Filter rate
Value of criterion used in navigation filter for residual edit test for TACAN range measurement	SENSOR_RESID_TEST(2)	Preland navigation state and covariance measurement incorporation	F	S		ft^2	Filter rate
Value of criterion used in navigation filter for residual edit test for baro altimeter measurement	SENSOR_RESID_TEST(3)	Preland navigation state and covariance measurement incorporation	F	S		ft^2	Filter rate

TABLE 4.3.2.8-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Value of criterion used in navigation filter for residual edit test for MSBLS azimuth measurement	SENSOR_RESID_TEST(5)	Preland navigation state and covariance measurement incorporation	F	S		rad^2	Filter rate
Value of criterion used in navigation filter for residual edit test for MSBLS range measurement	SENSOR_RESID_TEST(6)	Preland navigation state and covariance measurement incorporation	F	S		ft^2	Filter rate
Value of criterion used in navigation filter for residual edit test for MSBLS elevation measurement	SENSOR_RESID_TEST(7)	Preland navigation state and covariance measurement incorporation	F	S		ft^2	Filter rate
Radar altimeter processing flag	RAW_RA_PROC	*	Bit				Filter rate
Number of sequential failures of the test criteria allowed before activating the nav event lamp	N_SEQ_MAX	**	I				Filter rate
Number of nautical miles per foot	NAUTMI_PER_FT	**	F	S		nm/ft	Filter rate

*Preland nav principal function input list.
**See Section 4.9.

TABLE 4.3.2.8-2.- PRELAND MEASUREMENT PROCESSING STATISTICS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Display measurement residual for TACAN bearing	DISP_DELQ(1)	*	F	S		rad	Filter rate
Display measurement residual for TACAN range	DISP_DELQ(2)	*	F	S		nmi	Filter rate
Display measurement residual for BARO altimeter	DISP_DELQ(3)	*	F	S		ft	Filter rate
Display measurement residual for MSBLS bearing	DISP_DELQ(5)	*	F	S		rad	Filter rate
Display measurement residual for MSBLS range	DISP_DELQ(6)	*	F	S		ft	Filter rate
Display measurement residual for MSBLS elevation	DISP_DELQ(7)	*	F	S		rad	Filter rate
Display edit history indicator for TACAN bearing measurement	DISP_EDIT(1)	*	Char	S			Filter rate
Display edit history indicator for TACAN range measurement	DISP_EDIT(2)	*	Char	S			Filter rate
Display edit history indicator for BARO altimeter measurement	DISP_EDIT(3)	*	Char	S			Filter rate
Display edit history indicator for MSBLS azimuth measurement	DISP_EDIT(5)	*	Char	S			Filter rate
Display edit history indicator for MSBLS range measurement	DISP_EDIT(6)	*	Char	S			Filter rate

*Preland navigation principal function output list.

TABLE 4.3.2.8-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Display edit history indicator for MSBLS elevation measurement	DISP_EDIT(7)	*	Char	S			Filter rate
Display residual edit ratio for TACAN bearing	DISP_SIG(1)	*	F	S			Filter rate
Display residual edit ratio for TACAN range	DISP_SIG(2)	*	F	S			Filter rate
Display residual edit ratio for BARO altimeter	DISP_SIG(3)	*	F	S			Filter rate
Display residual edit ratio for MSBLS bearing	DISP_SIG(5)	*	F	S			Filter rate
Display residual edit ratio for MSBLS range	DISP_SIG(6)	*	F	S			Filter rate
Display residual edit ratio for MSBLS elevation	DISP_SIG(7)	*	F	S			Filter rate
Navigation validity indicator for event lamp processing	NAV_EL_FLAG	*	Bit				Filter rate

*Preland navigation principal function output list.

4.4 SUBFUNCTIONS COMMON TO SEVERAL NAVIGATION-RELATED PRINCIPAL FUNCTIONS

This section documents detailed requirements for subfunctions identified as being common to two or more navigation-related principal functions or their major subfunctions. The detailed requirements specified here will be referenced from the section to which they are common and, where referenced, may be regarded as inserts to paragraph A - Detailed requirements - in these sections.

4.4.1 User Parameter State Propagation

During the entry operational sequence (OPS-3), the navigation state propagation subfunction advances the navigation state vector at relatively large intervals, at the end of which external measurement data processed by the filter are incorporated when appropriate. Since users such as guidance and displays, require a knowledge of the state vector at shorter intervals, the user parameter state propagation subfunction will perform the integration of the equations of motion in a M50 coordinate system over shorter intervals than that of the navigation propagation. It will employ the most recent navigation-computed acceleration vector and the accumulated IMU-sensed velocity (snapped at each step from the accelerometers). During those periods when drag accelerations are being modeled, the accelerometer readings shall be ignored. In this case, the gravity acceleration vector $\underline{G}$ _OLD is actually the total acceleration since it is the sum of the accelerations due to both gravitational forces and aerodynamic forces (Section 4.2.1.2). These integration processes shall be restarted at the completion of each navigation cycle with the navigation state.

The initial value of the state that is to be advanced (integrated forward in time) may be from either one of the following two sources:

1. If an update from the filter is not available (FILT_UPDATE = OFF), the propagated state, saved from the previous cycle, is used as the initial value of the state to be advanced. On the previous cycle, the IMU-sensed velocity was also saved, whereas a constant value of gravity acceleration is used between updates.

2. If an update from the filter is available (FILT_UPDATE = OFF), the navigation filter updated state, together with its time tag and associated accumulated sensed velocity, replaces the previous user parameter propagated state, time tag, and accumulated velocity. A value of gravity acceleration computed with the filter state is available through COMPOOL. Advancement is to be the same as in item 1.

This mechanization permits independent computation rates for the user parameter state propagator and the navigation state propagator. It also provides the necessary synchronization between these functions when required. For the case when an update from the filter is available, the filter update and reset equations are as follows: If FILT_UPDATE = ON, then

$\underline{G}$ _OLD = $\underline{G}$ _RESET

$\underline{R}$ _AVGG = $\underline{R}$ _RESET

$\underline{V}$ _AVGG = $\underline{V}$ _RESET

$\underline{V}$ _IMU_OLD = $\underline{V}$ _IMU_RESET

T_STATE = T_RESET

FILT_UPDATE = OFF

UPP_UPDATE = ON

The FILT_UPDATE flag is set to OFF to inhibit a reset until it is again set to ON by the navigation filter. The UPP_UPDATE flag is set to ON to indicate that the UPP state has been updated by the navigation filter.

The computational sequence for state advancement follows:

1. Compute the interval over which advancement is required:

   SNAP IMU ($\underline{V}$ _IMU_CURRENT, T_IMU)

   DT_IMU = T_IMU - T_STATE

2. If IMU data are being used (USE_IMU_DATA = ON), compute the change in IMU-sensed velocity

   $\underline{DV}$_S = $\underline{V}$ _IMU_CURRENT - $\underline{V}$ _IMU_OLD

   otherwise let

   $\underline{DV}$_S = 0

3. Compute the advanced position vector:

   $\underline{R}$ _AVGG = $\underline{R}$ _AVGG + DT_IMU [$\underline{V}$ _AVGG + 0.5 ($\underline{DV}$_S + DT_IMU $\underline{G}$ _OLD)]

4. Compute the advanced velocity vector:

   $\underline{V}$ _AVGG = $\underline{V}$ _AVGG + $\underline{DV}$_S + DT_IMU $\underline{G}$ _OLD

5. Save the time tag for output and/or for use in the next cycle:

   T_STATE = T_IMU

6. Determine the earth-relative velocity vector in M50 coordinates using the V_REL subfunction

   $\underline{V}$ _RHO = V_REL($\underline{V}$ _AVGG, $\underline{R}$ _AVGG)

7. Save the IMU-sensed velocity for output and for use in the next cycle:

   $\underline{V}$ _IMU_OLD = $\underline{V}$ _IMU_CURRENT

4.4.2 ENTRY/TAEM/AUTOLAND Guidance Parameters

Guidance and other systems require that certain navigation-related calculations be accomplished during the ENTRY and TAEM/Landing major modes. Since many of the required parameters are common to both modes, one subfunction called GUIDECOMP is designed to handle the calculations. It should be expected that the commonality existing in these two major modes is not perfect and therefore we find that certain parameters required during ENTRY are not needed in the TAEM/Landing major mode. In the same manner, the reverse is also true. The main differences between the two modes are basically two in nature:

(a) Lift-to-drag ratio, total sensed acceleration and inertial speed are required for ENTRY but not for TAEM/Landing, while flight path angle is required for TAEM/Landing but not for ENTRY.

(b) Calculation of h, $\dot{h}$ and h is with reference to runway coordinates when Autoland guidance is active, while, for ENTRY and TAEM guidance, calculation is with respect to topodetic coordinates. The latter computations are made in a separate subfunction called H_HDOT_ACCVERT.

With these two differences in mind the sequence of the calculations is fairly straightforward.

The subfunction, H_HDOT_ACCVERT, performs the computation of altitude, altitude rate and altitude acceleration during the ENTRY major mode and the TAEM guidance phase of TAEM/Landing major mode. These parameters are calculated by employing position and velocity vectors in M50 coordinates as input data. First, the absolute value of the position vector $\underline{R}$ _AVGG is computed:

R_VEH_MAG = ABVAL($\underline{R}$ _AVGG)

Then, the parameters A_O and FLATCON, which are related to the earth's ellipticity, ELLIPT, are defined

A_O = $(1.0 - \text{ELLIPT})^2$

FLATCON = 1.0 - A_O

Next, a unit vector along the Shuttle position vector is determined:

$\underline{V}$NOR = - $\underline{R}$ _AVGG/R_VEH_MAG

Then, certain quantities are computed in order to obtain a topodetic unit vector in the Z_{TD} - direction:

UK = $\underline{V}$NOR · $\underline{E}$ARTH_POLE

TEMP = $(\text{A\_O} + \text{FLATCON UK}^2)$

RAD_P = EARTH_RADIUS_EQUATOR $(\text{A\_O/TEMP})^{1/2}$

The fourth quantity required varies slowly with time and hence is calculated only when the UPP state is updated by the navigation filter; that is, when

UPP_UPDATE = ON

then

$\underline{U}X$ = (EARTH_POLE - UK $\underline{V}$NOR) (FLATCON UK RAD_P)/(TEMP R_VEH_MAG)

If UPP_UPDATE = OFF, $\underline{U}X$ is held to its previous value.

The altitude and altitude rate are computed from:

ALT = R_VEH_MAG - RAD_P

H_DOT_ELLIPSOID = -$\underline{V}$ _RHO · ($\underline{U}X$ + $\underline{V}$NOR)

and the altitude above the runway is determined by:

ALT_WHEELS = ALT-ALT_RW

A test will be made to determine if the major mode is TAEM/Landing, denoted by MM_CODE_305. If MM_CODE_305 = ON, then altitude and altitude rate will be modified to account for rotation about the pitch axis of the navigation base with respect to the c.g. as follows:

ALT_WHEELS = ALT_WHEELS - (X_NB_WH SINTH + Z_NB_WH COSTH)

H_DOT_ELLIPSOID = H_DOT_ELLIPSOID

- WBR_2 RAD_PER_DEG (X_NB_CG COSTH - Z_NB_CG SINTH)

where X_NB_CG and Z_NB_CG are the (positive) X and Z structural body axis distances between the navigation base and the vehicle cg and X_NB_WH and Z_NB_WH are the (positive) X and Z structural body axis distances between the navigation base and the bottom of the rear wheels. The term WBR_2 is the vehicle pitch rate in degrees per second, and SINTH and COSTH are the sine and cosine of the pitch angle. If MM_CODE_305 = OFF, then these modifications to ALT_WHEELS and H_DOT_ELLIPSOID are by-passed.

Next, the vertical acceleration will be determined in one of two ways:

(a) If the navigation filter has updated the state, denoted by UPP_UPDATE = ON, then the vertical acceleration will be comuted by extrapolating the previous values:

$$\text{ACC\_VERT} = \text{ACC\_VERT\_OLD} + \frac{\text{DELTA\_ACC\_VERT}}{\text{DELTA\_T}} (\text{T\_STATE} - \text{T\_STATE\_LAST})$$

where ACC_VERT_OLD is the previous value of ACC_VERT, DELTA_ACC_VERT is the difference between the two most recent values of ACC_VERT excluding any navigation filter update value, and DELTA_T is the difference between

the times associated with those values of ACC_VERT employed to compute DELTA_ACC_VERT. The update flag, UPP_UPDATE, is subsequently set to OFF.

(b) If the update flag, UPP_UPDATE = OFF, indicating no navigation update of the state, then, the vertical acceleration is computed as follows:

ACC_VERT = (H_DOT_ELLIPSOID - H_DOT_LAST)/(T_STATE - T_STATE_LAST)

Also, when UPP_UPDATE = OFF, the values of ACC_VERT and T_STATE are employed to calculate current values of DELTA_ACC_VERT and DELTA_T as well as values of T_STATE_OLD and ACC_VERT_OLD

DELTA_ACC_VERT = ACC_VERT - ACC_VERT_OLD

DELTA_T = T_STATE - T_STATE_OLD

T_STATE_OLD = T_STATE

ACC_VERT_OLD = ACC_VERT

Finally, the previous values of altitude rate and state time are set to current values:

H_DOT_LAST = H_DOT_ELLIPSOID

T_STATE_LAST = T_STATE

The subfunction, GUIDECOMP, is employed throughout ENTRY and TAEM/AUTOLAND major modes. First, the earth-fixed-to-M50 coordinate transformation will be transposed to form a M50-to-earth-fixed transformation:

M_TEMP_TXPOS = EARTH_FIXED_TO_M50_COORD(T_STATE)^T

Then the Shuttle position vector and relative velocity will be transformed into EF coordinates

$\underline{R}$ _EF = M_TEMP_TXPOS $\underline{R}$ _AVGG

$\underline{V}$ _RHO_EF = M_TEMP_TXPOS $\underline{V}$ _RHO

and the magnitude of the relative velocity will be calculated:

REL_VEL_MAG = ABVAL($\underline{V}$ _RHO)

Next, by using the earth-fixed-to-runway transformation, the position and velocity in runway coordinates will be computed:

$\underline{P}$OSITION_WRT_RUNWAY = M_EFTORW ($\underline{R}$ _EF - $\underline{R}$ _LS_EF)

$\underline{V}$ELOCITY_WRT_RUNWAY = M_EFTORW $\underline{V}$ _RHO_EF

where $\underline{R}$ _LS_EF is the raduis vector to the landing site reference point.

The components of these vectors are

downrange position = $POSITION\_WRT\_RUNWAY_1$

crossrange position = $POSITION\_WRT\_RUNWAY_2$

altitude position = $-POSITION\_WRT\_RUNWAY_3$

downrange velocity = $VELOCITY\_WRT\_RUNWAY_1$

crossrange velocity = $VELOCITY\_WRT\_RUNWAY_2$

altitude rate = $-VELOCITY\_WRT\_RUNWAY_3$

A test will be made to determine if the transition to AUTOLAND guidance has occurred. If TG_END = ON, AUTOLAND guidance is in effect and all subsequent calculations will be done with respect to the landing runway coordinate system.

Radar altimeter data, consisting of the altitude of the Shuttle, the data good flag, and the time tag (which will subsequently be adjusted by a premission-loaded time bias) will be collected:

SNAP RADAR ALTIMETER (Q_RADALT, DG_RADALT, T_RADALT)

All data are to be saved in one uninterrupted operation by the transfer of the parameters from working locations that are constantly being updated by hardware data reads and other operations into special locations. It will then be determined whether the third component of the vector, POSITION_WRT_RUNWAY will be replaced with a value derived directly from the radar altimeter measurement of altitude. If RAW_RA_PROC = ON and if DG_RADALT = ON, the following computations will be performed:

$$T\_RADALT = T\_RADALT - TIME\_BIAS\_RADALT$$

$$POSITION\_WRT\_RUNWAY_3 = -Q\_RADALT + BIAS\_RADALT + (T\_STATE - T\_RADALT)\ VELOCITY\_WRT\_RUNWAY_3 - SIN(RADALT\_ANG - THETA\ RAD\_PER\_DEG)\ RADALT\_NB\_DIST$$

where DG_RADALT is the data validity indicator for the radar altimeter altitude measurement and RAW_RA_PROC indicates whether the vehicle position is within the zone of radar altimeter use. If the first part of the test fails, that is, if RAW_RA_PROC = OFF, then the following test shall be made to determine whether the vehicle is close enough to the runway threshold to permit radar altimeter utilization:

$$\text{If } POSITION\_WRT\_RUNWAY_1^2 + POSITION\_WRT\_RUNWAY_2^2 < R\_GO\_RAMP^2$$

then set

RAW_RA_PROC = ON.

The altitude of the rear wheels (corrected for the pitch plane altitude difference between the navigation base and the rear wheels), the altitude above the ellipsoid and the altitude rate (corrected for pitch rate of the navigation base with respect to the cg) shall be calculated:

$$ALT\_WHEELS = -POSITION\_WRT\_RUNWAY_3 - (X\_NB\_WH\ SINTH + Z\_NB\_WH\ COSTH)$$

$$ALT = ALT\_WHEELS + ALT\_RW$$

$$H\_DOT\_ELLIPSOID = -VELOCITY\_WRT\_RUNWAY_3 - WBR_2\ RAD\_PER\_DEG$$

$$(X\_NB\_CG\ COSTH - Z\_NB\_CG\ SINTH)$$

where X_NB_CG and Z_NB_CG are the (positive) X and Z structural body axis distances between the navigation base and the vehicle cg and X_NB_WH and Z_NB_WH are the (positive) X and Z structural body axis distances between the navigation base and the bottom of the rear wheels. The term WBR_2 is the vehicle pitch rate in degrees per second, and SINTH and COSTH are the sine and cosine at the ptich angle. These last three terms are obtained from the attitude processing principal function. The vertical acceleration is then obtained from

$$ACC\_VERT = (H\_DOT\_ELLIPSOID - H\_DOT\_LAST)/(T\_STATE - T\_STATE\_LAST)$$

Subsequently, previous values are set equal to current values:

$$H\_DOT\_LAST = H\_DOT\_ELLIPSOID$$

$$T\_STATE\_LAST = T\_STATE$$

If TG_END = OFF, Entry or TAEM guidance is in effect and two separate tests will be made to establish the values of the LD_GR_HYDR flag and the VNT_DR_SEQ_INIT flag. First, a flag, TEST_LD_GR, is tested; if it is ON then a further test is made on the relative velocity. If the relative velocity is less than a presecribed threshold value, LDGR_VEL_THRSH, then the landing gear hydraulic conditioning flag, LD_GR_HYDR, is turned ON and the flag, TEST_LD_GR, is subsequently turned OFF; that is, if TEST_LD_GR = ON, then test REL_VEL_MAG;

$$\text{If } REL\_VEL\_MAG < LDGR\_VEL\_THRSH$$

then

$$LD\_GR\_HYDR = ON$$

and

$$TEST\_LD\_GR = OFF.$$

In a similar manner, a flag, TEST_VNT_DR, is tested; if it is ON; then a further test is made on the relative velocity. If the relative velocity is less than a prescribed threshold value, VNTDR_VEL_THRSH, then the open vent door flag, VNT_DR_SEQ_INIT is turned ON and the flag TEST_VNT_DR is subsequently turned OFF; that is,

If REL_VEL_MAG < VNTDR_VEL_THRSH

then

VNT_DR_SEQ_INIT = ON

and

TEST_VNT_DR = OFF.

Returning now to calculations common to both modes, the heading of the Shuttle navigation base with respect to the runway centerline will be computed:

$$\text{COURSE\_WRT\_RW} = \text{ARCTAN2}(\text{VELOCITY\_WRT\_RUNWAY}_2, \text{VELOCITY\_WRT\_RUNWAY}_1)$$

A test will be made to determine if the computed course is a negative number:

COURSE_WRT_RW < 0

If this statement is true, 2π radians will be added to the computed value:

COURSE_WRT_RW = COURSE_WRT_RW + 2 PI

Finally the value is converted to degrees

COURSE_WRT_RW = COURSE_WRT_RW DEG_PER_RAD

The primary runway ID is to be renamed for use by ENTRY and TAEM guidance.

RW_ID_UPP = RW_NAME

Next, the vehicle groundspeed will be determined:

$$\text{V\_GROUNDSPEED} = (\text{REL\_VEL\_MAG}^2 - \text{H\_DOT\_ELLIPSOID}^2)^{1/2}$$

A test will be made to determine if there has been a change in status of the IMU's, (for instance, an IMU failure). If the current value of $\underline{\text{I}}$MU_SFC is the same as the previous value, $\underline{\text{I}}$MU_SFC_PREV, indicating no change in the status of the IMU's, that is, if

$\underline{\text{I}}$MU_SFC = $\underline{\text{I}}$MU_SFC_PREV

then the total sensed acceleration vector, $\underline{\text{T}}$CG, is computed from the IMU-measured velocities:

$\underline{\text{T}}$CG = ($\underline{\text{V}}$ _IMU_OLD - $\underline{\text{V}}$ _IMU_PREV)/(T_STATE - T_STATE_PREV).

Next, the drag acceleration magnitude follows from

$$ACC\_DRAG = -(\underline{T}CG \cdot \underline{V}\_RHO)/REL\_VEL\_MAG$$

and previous values are set equal to current values:

$$T\_STATE\_PREV = T\_STATE$$

$$\underline{V}\_IMU\_PREV = \underline{V}\_IMU\_OLD$$

$$\underline{I}MU\_SFC\_PREV = \underline{I}MU\_SFC$$

A test will be made to determine if the major mode is ENTRY or TAEM/AUTOLAND. If the major mode is ENTRY, that is, if

$$MM\_CODE\_305 = OFF$$

then the lift-to-drag ratio, magnitude of total sensed acceleration, and inertial speed are calculated.

In order to compute the lift-to-drag ratio, the lift acceleration and a +Y body axis unit vector in M50 coordinates must first be determined. The components of this unit vector are calculated from the M50 to body quaternion as follows:

$$Y\_BD\_UNIT_1 = Q\_B\_I_3\ (Q\_B\_I_2 + Q\_B\_I_2) + Q\_B\_I_1\ (Q\_B\_I_4 + Q\_B\_I_4)$$

$$Y\_BD\_UNIT_2 = 1 - Q\_B\_I_2\ (Q\_B\_I_2 + Q\_B\_I_2) - Q\_B\_I_4\ (Q\_B\_I_4 + Q\_B\_I_4)$$

$$Y\_BD\_UNIT_3 = Q\_B\_I_4\ (Q\_B\_I_3 + Q\_B\_I_3) - Q\_B\_I_1\ (Q\_B\_I_2 + Q\_B\_I_2)$$

Acceleration lift, lift-to-drag ratio, magnitude of the total sensed acceleration and inertial speed will then be computed:

$$ACC\_LIFT = \underline{T}CG \cdot \left((\underline{Y}\_BD\_UNIT \times \underline{V}\_RHO)/ABVAL(\underline{Y}\_BD\_UNIT \times \underline{V}\_RHO) \right)$$

$$LOD = ACC\_LIFT/ACC\_DRAG$$

$$LOAD\_TOTAL = ABVAL(\underline{T}CG)$$

$$V\_MAG = ABVAL(\underline{V}\_AVGG)$$

If the major mode is TAEM/Landing, that is, if

$$MM\_CODE\_305 = ON$$

the flight path angle shall be calculated as

$$FLT\_PATH\_ANG = SIN^{-1}(H\_DOT\_ELLIPSOID/REL\_VEL\_MAG)$$

Next, the value of the navigation event lamp indicator, EVENT_LAMP_FIVE, will be established. If ALT_WHEELS > ALT_EL_3, set

EVENT_LAMP_FIVE = NAV_EL_FLAG

where NAV_EL_FLAG indicates the status of external sensor data processing by either the ENTRY or PRELAND navigation principal function.

If the above test fails (i.e., if ALT_WHEELS $\leq$ ALT_EL_3) then the radar altimeter data validity indicator, DG_RADALT, shall be tested and the value of an additional indicator, RA_FLAG, shall be established. If DG_RADALT = ON, then set RA_FLAG to OFF and initialize the sequential counter, N_SEQ_RA, to a value of one (1). If DG_RADLT = OFF, increment N_SEQ_RA by one and then if N_SEQ_RA exceeds a maximum allowable value, N_SEQ_MAX, set RA_FLAG to ON. Finally, the value for EVENT_LAMP_FIVE shall be established as follows:

If NAV_EL_FLAG = ON or RA_FLAG = ON, set EVENT_LAMP_FIVE = ON, otherwise set EVENT_LAMP_FIVE = OFF.

These calculations have been simplified to conserve memory locations and execution time. The assumptions are as follows:

1. Position and velocity are defined with respect to the vehicle navigation base rather than the cg.

2. A correction factor has been applied to the altitude and altitude rate calculation to correct for pitch and pitch rate errors introduced because of the first assumption. Roll and roll rate are not included.

3. Flightpath angle is computed at the navigation base. Thus, errors will be introduced whenever pitch rate is not zero.

4. The SNAP statement above implies the assignment of current values to the variable names shown in parentheses.

The terms X_NB_CG and Z_NB_CG used in the altitude rate correction are positive numbers equal to the X and Z structural body axis distance between the navigation base and the vehicle cg.

X_NB_CG = X_CG - X_NB

Z_NB_CG = Z_NB - Z_CG

The terms X_NB_WH and Z_NB_WH used in the rear wheel altitude correction are positive numbers equal to the X and Z structural body axis distance between the navigation base and the bottom of the rear wheels.

X_NB_WH = X_WHEELS - X_NB

Z_NB_WH = Z_NB - Z_WHEELS

4.4.3 Coordinate Transformations

These nine subfunctions provide the capability for transforming parameters specified (or computed) in one coordinate system to another coordinate system. Coordinate system definitions are provided in Appendix C.

Each of the nine subfunctions described in Sections 4.4.3.1 through 4.4.3.9 may be executed separately. The subfunctions do not actually perform the coordinate transformation; only the rotation matrix is computed.

For consistency, it is assumed that all coordinate systems located on the surface of the earth are specified in terms of geodetic parameters (i.e., geodetic latitude, longitude, and altitude above the reference ellipsoid) and that all azimuth angles are referenced to true (not magnetic) north.

Input and output parameters for all subfunctions are listed in Tables 4.4.3-1 and 4.4.3-2.

TABLE 4.4.3-1.- COORDINATE TRANSFORMATIONS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
EARTH_FIXED_TO_M50_COORD							
Earth rotation rate	EARTH_RATE	**	F	S			As needed
Time tag for M_M50TOEF_AT_EPOCH, Greenwich hour angle, and EARTH_POLE measured in seconds from the beginning of the year-of-date	T_EPOCH	**	F	DP		sec	As needed
Transformation matrix from M50 to Earth-fixed at T_EPOCH	M_M50TOEF_AT_EPOCH	**	M	S			As needed
General time variable measured in seconds from beginning of the year-of-date	TIME	User sub-function	F	DP		sec	As needed
EF_TO_TOPDET							
Geodetic latitude of R _EF	LAT_GEOD	User sub-function	F	S		rad	As needed
Geodetic longitude of Shuttle's position vector	LON	User sub-function	F	S		rad	As needed
EF_TO_RUNWAY							
Geodetic latitude of R _EF	LAT_GEOD	User sub-function	F	S		rad	As needed
Geodetic longitude of Shuttle's position vector	LON	User sub-function	F	S		rad	As needed

**See Section 4.9.

TABLE 4.4.3-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Bearing from true north	AZ	User sub-function	F	S		rad	As needed
EF_TO_SCANNER							
Geodetic latitude of R _EF	LAT_GEOD	User sub-function	F	S		rad	As needed
Geodetic longitude of Shuttle's position vector	LON	User sub-function	F	S		rad	As needed
Bearing from true north	AZ	User sub-function	F	S		rad	As needed
EF_TO_GEODETIC							
General position vector in earth-fixed coordinates	R _EF	User sub-function	V	DP		ft	As needed
Earth ellipticity constant	ELLIPT	Constant	F	DP			
Earth equatorial radius	EARTH_RADIUS_ EQUATOR	**	F	DP		ft	As needed
GEODETIC_TO_EF							
Geodetic latitude of R _EF	LAT_GEOD	User sub-function	F	S		rad	As needed
Geodetic longitude of Shuttle's position vector	LON	User sub-function	F	S		rad	As needed

**See Section 4.9.

TABLE 4.4.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Orbiter altitude above reference ellipsoid	ALT	User sub-function	F	S		ft	As needed
Earth ellipticity constant	ELLIPT	**	F	DP			As needed
UVW_TO_M50							
Input position vector in M50 coords	R	User sub-function	V	DP		ft	As needed
Input velocity vector in M50 coords	V	User sub-function	V	S		ft/sec	As needed
SBODY_TO_M50							
Quaternion representing the orientation of the Orbiter body with respect to M50 coordinates	Q_FIFTY_BODY	User sub-function	V	DP		-	As needed

**See Section 4.9.

TABLE 4.4.3-2.- COORDINATE TRANSFORMATIONS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
EARTH_FIXED_TO_M50_COORD							
Earth-fixed to M50 coordinate transformation matrix	M_EFTOM50	User sub-function	M	DP		--	As needed
EF_TO_TOPDET							
Transformation from earth-fixed to topodetic coordinates	M_EFTOTD	User sub-function	M	S		--	As needed
EF_TO_RUNWAY							
Earth-fixed to RW transformation matrix	M_EFTORW	User sub-function	M	S		--	As needed
EF_TO_SCANNER							
Transformation matrix from earth-fixed to scanner coordinates	M_EF_TO_SCANNER	User sub-function	M	S		--	As needed
EF_TO_GEODETIC							
Geodetic latitude of R _EF	LAT_GEOD	User sub-function	F	S		rad	As needed
Geodetic longitude of Shuttle's position vector	LON	User sub-function	F	S		rad	As needed
Current Orbiter altitude above reference ellipisoid	ALT	User sub-function	F	S		ft	As needed

TABLE 4.4.3-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
GEODETIC_TO_EF							
General position vector in earth-fixed coordinates	R _EF	User sub-function	V	S		ft	As needed
UVW_TO_M50							
UVW to M50 coordinate transformation matrix	M_UVW_TO_M50	User sub-function	M	S		--	As needed
SBODY_TO_M50							
Structural body to M50 coordinates transformation	MAT	User sub-function	M	S		--	As needed

4.4.3.1 Transformation From Aries Mean of 1950 to Earth-Fixed

The purpose of this subfunction is to provide a transformation matrix (M_M50TOEF_AT_EPOCH) from Aries M50 coordinates to earth-fixed coordinates, that accounts for the nutation, precession and rotation of the earth from the beginning of the besselian year 1950.0 to a specified time T_EPOCH.

For a nominal entry the matrix M_M50TOEF_AT_EPOCH (usually referred to in the literature as the RNP matrix) will be supplied via I-load. The time, T_EPOCH, is the time of nominal touchdown expressed in seconds since the beginning of the year in which the mission was launched. This, too, is an I-load.

Both T_EPOCH and M_M50TOEF_AT_EPOCH are contained in section 4.9.2, where the mission dependent parameters are listed.

The software will not be designed to preclude any particular value of T_EPOCH, whether future or past, subject only to the restriction that if the time desired is in a year other than the one in which the mission was launched, the general time variable will be continuous over the year-end/year-beginning transition.

4.4.3.2 Earth-Fixed to M50

The purpose of this subfunction is to propagate the matrix M_M50TOEF_AT_EPOCH from the last epoch time to the time of interest. This propagation accounts for the earth's daily rotation effects only.

The nutation/precession computations are lengthy, and it is assumed that suitable accuracy can be maintained by employing the approximation of earth motion described in this section.

Formulation: A simple Z-axis rotation is performed through the angle defined by the product of the earth's mean rotational rate (EARTH_RATE) relative to the mean-of-date system, and the difference between the time (T_EPOCH) associated with the matrix (M_M50TOEF_AT_EPOCH) and the time (TIME) of this requested matrix. Thus, for the defined

DELT = TIME - T_EPOCH

the angle of rotation is

LAM = (EARTH_RATE) DELT

and the rotatin matrix, M, is defined by the equation

$$M = \begin{pmatrix} \cos(LAM) & -\sin(LAM) & 0 \\ \sin(LAM) & \cos(LAM) & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad \text{F9}$$

F9

The variable TIME, provided by the user of the earth-fixed to M50 transformation, is a year-of-date time tag in seconds and is referenced to the beginning of the same year for which T_EPOCH is referenced. The parameter EARTH_RATE is a constant (see Section 4.9.1).

The matrix is then used to compute a current transformation matrix from earth-fixed to M50 coordinates:

$$\text{EARTH\_FIXED\_TO\_M50\_COORD} = \text{M\_M50TOEF\_AT\_EPOCH}^T \; M$$

Because of the sparseness of the matrix M, both core and execution time will be conserved by use of the following formulation. For notational convenience, let N denote the matrix M_M50TOEF_AT_EPOCH. The sine and cosine of LAM will be computed once and denoted by CLAM = COS (LAM) and SLAM = SIN (LAM). Then EARTH FIXED_TO_M50_COORD will be computed as follows:

$$\text{EARTH\_FIXED\_TO\_M50\_COORD}_{1,1} = N_{1,1} \; CLAM + N_{2,1} \; SLAM$$

F9 This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9)

$$EARTH\_FIXED\_TO\_M50\_COORD_{1,2} = N_{1,1}\ SLAM + N_{2,1}\ CLAM$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{1,3} = N_{3,1}$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{2,1} = N_{1,2}\ CLAM + N_{2,2}\ SLAM$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{2,2} = N_{1,2}\ SLAM + N_{2,2}\ CLAM$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{2,3} = N_{3,2}$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{3,1} = N_{1,3}\ CLAM + N_{2,3}\ SLAM$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{3,2} = -N_{1,3}\ SLAM + N_{2,3}\ CLAM$$

$$EARTH\_FIXED\_TO\_M50\_COORD_{3,3} = N_{3,3}$$

This subfunction may be executed as needed. The time (TIME) at which the output transformation matrix (EARTH_FIXED_TO_M50-COORD) is desired must be supplied by the user in elapsed seconds in the year of date consistant with the time T_EPOCH.

A valid M_M50TOEF_AT_EPOCH must be available before this subfunction can be executed.

The Aries mean of 1950 and the earth-fixed coordinate systems are shown in Appendix C.

4.4.3.3 Geodetic to Earth-Fixed

This submodule accepts the geodetic parameters of a point and computes the earth-fixed Cartesian coordinates of that point.

Formulation: The input angles must be in radians. The equations necessary to transform geodetic parameters to earth-fixed coordinates are as follows:

$$R\_EF_1 = \left[\frac{EARTH\_RADIUS\_EQUATOR}{(\cos^2 (LAT\_GEOD) + (1 - ELLIPT)^2 \sin^2 (LAT\_GEOD))^{1/2}} + ALT\right] \quad F9$$

$$\cos (LAT\_GEOD) \cos (LON) \quad F3,F4$$

$$R\_EF_2 = \left[\frac{EARTH\_RADIUS\_EQUATOR}{(\cos^2 (LAT\_GEOD) + (1 - ELLIPT)^2 \sin^2 (LAT\_GEOD))^{1/2}} + ALT\right] \quad F9$$

$$\cos (LAT\_GEOD) \sin (LON) \quad F3,F4$$

$$R\_EF_3 = \left[\frac{(1 - ELLIPT)^2 \quad EARTH\_RADIUS\_EQUATOR}{(\cos^2 (LAT\_GEOD) + (1 - ELLIPT)^2 \sin^2 (LAT\_GEOD))^{1/2}} + ALT\right] \quad F9$$

$$\sin (LAT\_GEOD) \quad F3,F4$$

F3 This equation shall be protected against division by zero (Reference 3.6.3)
F4 This equation shall be protected against square roots of a negative number (Reference 3.6.4)
F9 This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9)

4.4.3.4 Earth-Fixed to Topodetic

This subfunction accepts the geodetic latitude and longitude of a point and computes the rotation matrix from earth-fixed coordinates to a topodetic coordinate system for the input location.

Formulation: This subfunction creates the rotation matrix as an Euler Z, Y sequence through the longitude angle (LON) and the geodetic latitude angle plus 90 degrees (LAT_GEOD + $\pi/2$), respectively. The necessary equation is

$$M = \begin{bmatrix} -\cos(LON)\sin(LAT\_GEOD) & -\sin(LON)\sin(LAT\_GEOD) & \cos(LAT\_GEOD) \\ -\sin(LON) & \cos(LON) & 0 \\ -\cos(LON)\cos(LAT\_GEOD) & -\sin(LON)\cos(LAT\_GEOD) & -\sin(LAT\_GEOD) \end{bmatrix} \text{F9}$$

F9 This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9)

4.4.3.5 Earth-Fixed to Runway

This subfunction accepts the geodetic latitude, longitude, and azimuth of the runway and computes the rotation matrix from the earth-fixed coordinate system to the runway coordinate system.

Formulation: The earth-fixed to topodetic subfunction is used to obtain an earth-fixed to topodetic rotation matrix. Then the earth-fixed to topodetic matrix is multiplied by an Euler Z rotation matrix through the runway azimuth angle (AZ). The equation is

$$M = \begin{bmatrix} (\cos AZ) & (\sin AZ) & 0 \\ (-\sin AZ) & (\cos AZ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \text{F9}$$

where AZ is the runway azimuth angle measured clockwise from true north to the +X-axis of the runway. Then the transformation matrix is computed by

EF_TO_RUNWAY = M EF_TO_TOPDET

Input angles must be in radians.

The runway and topodetic coordinate systems are shown in Appendix C.

F9 This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9)

4.4.3.6 Earth-Fixed to Scanner

The purpose of this subfunction is to compute the rotation matrix from earth-fixed to scanner coordinates.

Formulation: The earth-fixed to runway subfunction is executed, with use of the geodetic latitude and longitude of the scanner and the azimuth of the scanner boresight (AZ) from the true north to obtain a rotation matrix.

The rotation matrix is then multiplied by a rotation matrix representing a 180-degree rotation about the X-axis. The necessary equation is

$$\text{EF\_TO\_SCANNER} = \text{M\_XROTPI EF\_TO\_RUNWAY}$$

where

$$\text{M\_XROTPI} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

and EF_TO_RUNWAY is the rotation matrix computed by the earth-fixed to runway subfunction.

All computations are performed in double precision.

Input angles must be in radians.

The scanner and earth-fixed coordinates systems are shown in Appendix C.

4.4.3.7 Body to M50

The transformation matrix from structural body to M50 coordinates (MAT) is computed by post-multiplying the transformation matrix from body to M50 coordinates by a matrix representing a 180° rotation about the Y-axis.

The transformation from body to M50 coordinates is derived from the quaternion Q_FIFTY_BODY, by employing the general purpose matrix function QUAT_TO_MAT.

QUAT_TO_MAT computes the transformation matrix, A, associated with a quaternion, Q, as QUAT_TO_MAT (Q) = A, where A is computed by

$$P2 = Q_2 + Q_2$$

$$P3 = Q_3 + Q_3$$

$$P4 = Q_4 + Q_4$$

$$P5 = P2\ Q_2$$

$$P6 = P4\ Q_4$$

$$Temp = 1.0 - P3\ Q_3$$
$$A_{1,1} = Temp - P6$$

$$A_{2,2} = 1.0 - P5 - P6$$

$$A_{3,3} = Temp - P5$$

$$P5 = P2\ Q_3$$

$$P6 = P4\ Q_1$$

$$A_{1,2} = P5 - P6$$

$$A_{2,1} = P5 + P6$$

$$P5 = P2\ Q_4$$

$$P6 = P3\ Q_1$$

$$A_{1,3} = P5 + P6$$

$$A_{3,1} = P5 - P6$$

$$P5 = P3\ Q_4$$

$$P6 = P2\ Q_1$$

$$A_{2,3} = P5 - P6$$

$$A_{3,2} = P5 + P6$$

The structural body to M50 coordinates, MAT, is then computed as

$$MATRIX = QUAT\_TO\_MAT\ (Q\_FIFTY\_BODY)$$

$$MAT_{1,1} = -MATRIX_{1,1}$$

$$MAT_{1,2} = MATRIX_{2,1}$$

$$MAT_{1,3} = -MATRIX_{3,1}$$

$$MAT_{2,1} = -MATRIX_{1,2}$$

$$MAT_{2,2} = MATRIX_{2,2}$$

$$MAT_{2,3} = -MATRIX_{3,2}$$

$$MAT_{3,1} = -MATRIX_{1,3}$$

$$MAT_{3,2} = MATRIX_{2,3}$$

$$MAT_{3,3} = -MATRIX_{3,3}$$

This subfunction may be executed as needed; however, no extrapolation or interpolation of Q_FIFTY_BODY is performed.

Coordinate system definitions and the suggested implementation are shown in Appendix C.

4.4.3.8 Earth-Fixed to Geodetic

This function is required to transform a Cartesian position vector in the earth-fixed (Greenwich) coordinate system to the geodetic parameters: Geodetic altitude, longitude, and geodetic latitude.

Formulation: The equations necessary to transform the Cartesian position vector to geodetic parameters are as follows:

The computation for longitude is:

$$LON = ARCTAN\left(\frac{R\_EF_2}{R\_EF_1}, \; 0 \leq LON < 2\pi\right) \qquad F3,F7$$

Computations for geodetic latitude, LAT_GEOD, and height above the reference ellipsoid, ALT, are as follows:

$$R\_XY = R\_EF_1^2 + R\_EF_2^2$$

$$R = (R\_XY + R\_EF_3^2)^{1/2}$$

$$SIN\_P = R\_EF_3/R$$

$$COS\_P = (R\_XY)^{1/2}/R$$

$$RAD\_P = \frac{EARTH\_RADIUS\_EQUATOR}{\sqrt{1 + FLATCON\ SIN\_P^2/(1.0 - FLATCON)}} \qquad F3,F4$$

$$DEL = \frac{FLATCON\ SIN\_P\ COS\_P}{1.0 - FLATCON\ COS\_P^2} \qquad F3$$

$$DEL\_LAT = \frac{RAD\_P\ DEL}{R} \qquad F3$$

F3 This equation shall be protected against division by zero (Reference 3.6.3)
F7 This equation shall be protected against arc tangents with both arguments equal to zero (Reference 3.6.7)
F4 This equation shall be protected against square roots of a negative number (Reference 3.6.4)

PHI = ARCTAN (SIN_P/COS_P) F7,F3

LAT_GEOD = PHI + DEL_LAT

ALT = (R - RAD_P) (1.0 - 0.50 DEL DEL_LAT)

where

LAT_GEOD = geodetic latitude in radians

LON = geodetic longitude in radians

ALT = geodetic altitude in feet

ELLIPT = flattening of the reference ellipsoid

EARTH_RADIUS_EQUATOR = equatorial radius of the reference ellipsoid

FLATCON = $1.0 - (1.0 - \text{ELLIPT})^2$, the eccentricity squared of the ellipsoid

This subfunction may be executed on demand.

The earth-fixed coordinate system and geodetic parameters are defined in Appendix C.

F3 This equation shall be protected against division by zero (Reference 3.6.3)
F7 This equation shall be protected against arc tangents with both arguments equal to zero (Reference 3.6.7)

4.4.3.9 UVW to M50

The purpose of this subfunction is to compute the transformation matrix from UVW coordinates to Aries M50 coordinates, given the position and velocity of the vehicle.

Formulation: The orientation of the U, V, W system is determined by the orbiter inertial position and velocity vectors ($\underline{R}$, $\underline{V}$) at the point (or time) of interest. Define

$$\underline{U} = \underline{R} / |\underline{R}| \qquad \text{F3}$$

$$\underline{W} = (\underline{R} \times \underline{V}) / |\underline{R} \times \underline{V}| \qquad \text{F3}$$

$$\underline{Z} = \underline{W} \times \underline{U}$$

The transformation matrix from UVW coordinated to Aries mean of 1950 is then given by

$$\begin{pmatrix} \underline{U} & \underline{Z} & \underline{W} \end{pmatrix}$$

F3 This equation shall be protected against division by zero (Reference 3.6.3)

4.4.4 TACAN Display Computations

During the ENTRY, TAEM and GLIDE RTLS portions of the Shuttle flight, the Horizontal Situation Display (HSD) provides the crew with spacecraft position and heading information with respect to the ground plane. In addition to the graphical display of the Shuttle's position with respect to the runway and heading alignment circle, other tabular data are displayed. This subfunction provides tabular data for the TACAN portion of the display. Data for each of the three TACAN LRU's is displayed.

For each TACAN there is a display of TAC AZ as either the absolute magnetic azimuth in degrees from the vehicle to the ground station as measured by the TACAN, or the delta azimuth in degrees formed by subtracting the nav derived azimuth to the ground station from the TACAN measured azimuth to the station. In addition, for each TACAN there is a display of range as either the absolute slant range in nautical miles from the vehicle to the ground station as measured by the TACAN, or the delta slant range in nautical miles formed by subtracting the nav derived range to the ground station from the TACAN measured range to the ground station. Two mutually exclusive items, ABS and DELTA, are provided on the HSD to allow the crew to select absolute or delta values of TACAN azimuth and range.

The computational sequence for the ABS mode is to convert data from the TACAN SOP to the proper units for display as follows,

$$TAC\_AZ_I = TACBEARO_I \ DEG\_PER\_RAD$$

$$TAC\_RNG_I = TACRANGEO_I \ NAUTMI\_PER\_FT$$

If the TAC_MODE is not ABS and the $TACAN\_CHAN\_VALID\_SL_I$ is "off", then both TAC_AZ_I and TAC_RNG_I shall be set to "BLANK" for display. If the TAC_MODE is not ABS and the $TACAN\_CHAN\_VALID\_SL_I$ is "on", then the computational sequence is for the DELTA_MODE and the differences between the nav derived range and azimuth and the TACAN measured range and azimuth are computed. The range difference for each TACAN is computed as follows:

$$\underline{R}\_EST = \underline{R}\_EF - \underline{R}\_TACAN\_EF\_SL_I$$

$$\underline{R}\_TEMP = M\_EFTOTD\_TACAN\_SL_I \ \underline{R}\_EST$$

$$TAC\_RNG_I = (TACRANGEO_I - ABVAL(\underline{R}\_EST)) \ NAUTIMI\_PER\_FT$$

The azimuth difference for each TACAN is computed as follows:

$$TEMP = (TACBEARO_I - (ARCTAN2(R\_TEMP_2, R\_TEMP_1)$$

$$- ANGLE\_CORR\_TNTOMAG\_SL_I + PI)) \ DEG\_PER\_RAD$$

This base delta azimuth (TEMP) is then adjusted for the event where the two angles span the 360° or 0° radial as follows:

If ABVAL (TEMP) > 180°

then set

$$TAC\_AZ_I = TEMP - SIGN(TEMP)\ 360^\circ$$

If not, set

$$TAC\_AZ_I = TEMP$$

Finally, independently of the status of the TAC_MODE flag, it is renamed for output purposes as TAC_MODE_DISP.

4.4.5 Utility Subfunctions

The following subfunctions are utilized by various users. They are mutually independent, that is, the execution of any one of these functions neither requires the previous execution nor precludes the future execution of another. They may be utilized at regular intervals or only upon request.

Input and output parameters for these subfunctions are contained in tables 4.4.5-1 and 4.4.5-2 respectively.

TABLE 4.4.5-1.- UTILITY SUBFUNCTIONS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Earth's gravitational constant	EARTH_MU	**	F	DP		ft^3/sec^2	As needed
Unit vector in the direction of the Earth's axis of rotation	EARTH_POLE	**	V(3)	S		-	As needed
Equatorial radius of the Earth	EARTH_RADIUS_EQUATOR	**	F	DP		ft	As needed
Rotational rate of the Earth	EARTH_RATE	**	F	DP		rad/sec	As needed
Earth's ellipticity constant	ELLIPT	**	F	DP		-	As needed
Identity matrix (3x3)	ID_MATRIX_3x3	**	M(3)	S		-	As needed
Unit vector of reference direction	I_Z	User function	V(3)	S		-	As needed
Generic position vector	R	User function	V(3)	DP		ft	As needed
Position vector of vehicle at time of measurement	R_RESID	User function	V(3)	DP		ft	As needed
Position vector of sensor at time of measurement	R_SENSOR	User function	V(3)	DP		ft	As needed
Generic velocity vector	V	User function	V(3)	DP		ft/sec	As needed

**See Section 4.9.

TABLE 4.4.5-2.- UTILITY SUBFUNCTIONS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Partial derivative of angular measurement w.r.t. state vector	B	User function	V(6)	DP		vary	As needed
Gradient of central gravity w.r.t. position vector	GRAVITY_GRADIENT	User function	M(3)	DP		sec^{-2}	As needed
Altitude above reference ellipsoid	H_ELLIPSOID	User function	F	DP		ft	As needed
Velocity relative to rotating, windless atmosphere	V_REL	User function	V(3)	DP		ft/sec	As needed

4.4.5.1 Altitude Above the Reference Ellipsoid

The purpose of this subfunction is to calculate the altitude, above the Fischer ellipsoid, of a point with M50 position vector $\underline{R}$. The altitude obtained is approximate, with the error increasing with altitude. The accuracy obtained in near earth work (and this covers the range of orbiter altitudes) is considered adequate. The equation is

$$\text{H\_ELLIPSOID}(\underline{R}) = |\underline{R}| - \frac{(1 - \text{ELLIPT})\ \text{EARTH\_RADIUS\_EQUATOR}}{1 + \left((1 - \text{ELLIPT})^2 - 1\right)\left(1 - (\underline{\text{U}}\text{NIT}(\underline{R}) \cdot \underline{\text{E}}\text{ARTH\_POLE})^2\right)}$$

where ELLIPT and EARTH_RADUIS_EQUATOR are the ellipticity constant (or "flattening") and the equatorial radius of the 1960 Fischer ellipsoid respectively, and EARTH_POLE is the unit vector in the direction of the Earth's span axis, expressed in M50 coordinates. All the above parameters are I-load constants contained in Section 4.9.

A flow chart for this function may be found in Appendix B, under the name H_ELLIPSOID.

4.4.5.2 Velocity Relative to the Windless, Rotating Atmosphere

This function computes the velocity, relative to the atmosphere, of a vehicle with M50 position and velocity vectors respectively $\underline{R}$ and $\underline{V}$. The following assumptions are made: there are no winds and the atmosphere rotates rigidly with the earth at all altitudes. The relative velocity is expressed in M50 coordinates.

The equation that accomplishes this is:

$$\underline{V}\_REL\ (\underline{V}, \underline{R}) = \underline{V} - EARTH\_RATE\ (\underline{E}ARTH\_POLE \times \underline{R})$$

where EARTH_RATE is the Earth's angular velocity with respect to the M50 (inertial) axes and $\underline{E}$ARTH_POLE is the unit vector in the direction of the Earth's axis of rotation, expressed in M50 coordinates. Both of these parameters are I-load constants contained in section 4.9.

A flow chart for this function may be found in Appendix B under the name $\underline{V}$ _REL.

4.4.5.3 Partial Derivatives of an Angular Measurement With Respect to the State Vector

This routine calculates a 6 component vector, $\underline{B}$, the components of which are the partial derivatives of an angular measurement (a scalar) with respect to the components of the position and velocity vectors of the vehicle relative to the measurement device.

The function takes as inputs the M50 position vector of the vehicle at the time of the measurement ($\underline{R}$ _RESID), the M50 position vector of the measurement device at the same time ($\underline{R}$ _SENSOR) and a unit vector ($\underline{I}$ _Z) that represents, in the M50 coordinate system, the direction relative to which the angular measurement is taken (local north for azimuth, zenital direction for the complement of elevation).

The following calculations are then made:

$$\underline{REL\_R} = \underline{R}\ \_RESID - \underline{R}\ \_SENSOR$$

$$\underline{REL\_R\_HORZ} = \underline{REL\_R} - (\underline{REL\_R} \cdot \underline{I}\ \_Z)\ \underline{I}\ \_Z$$

$$B_{1to3} = (\underline{I}\ \_Z \times \underline{REL\_R\_HORZ})/|\underline{REL\_R\_HORZ}|^2$$

The other three components of the 6-vector $\underline{B}$ are identically zero.

$$B_{4\ to\ 6} = 0$$

A flow chart for this function, with the name ANGLE_PARTIALS, may be found in Appendix B. The flow chart contains equations derived from those above but optimized for computation in that they eliminate the calculation of the intermediate vector $\underline{REL\_R\_HORZ}$ and thereby avoid the calculation of the zero vector obtained by the cross product of $\underline{I}$ _Z and ($\underline{REL\_R} \cdot \underline{I}$ _Z) $\underline{I}$ _Z.

4.4.5.4 Derivative of the Gravitational Acceleration With Respect to the Position Vector

This function calculates a 3 x 3 matrix, the components of which are the partial derivatives of the gravitational acceleration vector with respect to the position vector $\underline{R}$. This is used in the generation of the state transition matrix, which is required for covariance matrix propagation. The dominant part of the gravitational acceleration vector is the central term, which computes the earth's attraction as if all its mass were concentrated at the center. This is the only term utilized in the calculation of the partial derivatives. A vehicle moving under the influence of such a gravity field would travel in a conic orbit. The state transition matrix obtained is based on Keplerian motion as the reference trajectory.

The equation is:

$$\text{GRAVITY\_GRADIENT}\ (\underline{R}) = (\text{EARTH\_MU}/|\underline{R}|^5)\ (3\ \underline{R}\ \underline{R}^T - |\underline{R}|^2\ \text{ID\_MATRIX\_3x3})$$

where EARTH_MU is the Earth's gravitational constant and ID_MATRIX_3x3 is the 3x3 identity matrix. Both are I-load constants contained in Section 4.9.

A flow chart for this function, with the name GRAVITY_GRADIENT, way be found in Appendix B.

4.5 GENERAL REQUIREMENT PRINCIPAL FUNCTIONS

This section delineates software requirements in the category of services available to single or multiple users, that are not specifically function related. The general requirement principal functions include, but are not limited to, the following:

1. Entry Precise Predictor principal function (section 4.5.1)
2. Entry Site Lookup principal function (section 4.5.2)
3. Entry Auto TACAN Selection principal function (section 4.5.3)

4.5.1 Entry Precise Predictor

A capability will be provided for predicting the position and velocity of the orbiter at some time in the future or past when an initial state and time are given.

The entry precise predictor principal function will make no use of the IMU-accumulated sensed velocities and therefore is a free-flight prediction process even though it may be performed during periods of flight in which navigation is using accumulated sensed velocities.

Tables 4.5.1-1 and 4.5.1-2 show data flow between the entry precise predictor and other principal functions.

A. Detailed Requirements. The position and velocity of the orbiter at the end of a given interval of time shall be computed in an M50 coordinate system by integration of the equations of motion, including gravity and drag accelerations (when appropriate).

The accuracy requirements and type of the atmosphere and gravity potential models used by this prediction function may vary according to the orbiter's distance to the surface of the earth and utilization for the prediction being requested. The user of the entry predictor function specifies the environmental models desired by means of input arguments, as described in the paragraphs that follow.

The entry precise predictor function will be called after the following variables have been initialized:

1. T_FINAL, the time at which the final state is desired.

2. GMD_PRED, GMO_PRED indicators of the gravitational and drag acceleration model that will be considered valid for the duration of the prediction interval.

3. $\underline{R}$ _INIT, $\underline{V}$ _INIT, and T_INIT, the initial state and time.

4. DT_MAX, an upper bound for the integration step size.

It will then perform as follows:

1. Obtain $\underline{R}$ _INIT, $\underline{V}$ _INIT, and T_INIT and rename them as $\underline{R}$ _FINAL, $\underline{V}$ _FINAL, and T.

2. Establish the fixed integration STEP_SIZE by dividing the time interval into the smallest number (NUMBER_STEPS) of subintervals consistent with DT_MAX:

$$\text{NUMBER\_STEPS} = \text{MAX}\left(\text{ROUND}\ \frac{|\text{T\_FINAL} - \text{T\_INIT}|}{\text{DT\_MAX}}\right), 1\Bigg)$$

$$\text{STEP\_SIZE} = \frac{\text{T\_FINAL} - \text{T\_INIT}}{\text{NUMBER\_STEPS}}$$

3. Check the input parameter GMD_PRED. If the value of this parameter is zero (a setting which indicates the user wants to use a conic approximation), the acceleration vector G _PREVIOUS will contain only the central force term. This will be achieved by a call to a special routine, CENTRAL (which is documented in Section 4.2.1.2)

   CALL: CENTRAL
   INLIST: R _FINAL
   OUTLIST: G _PREVIOUS, R_INV

   If GMD_PRED has a non-zero value (a setting that indicates a more complete gravity model and possibly a drag model are desired by the user), the angles of attack and sideslip will be obtained from the Attitude Processing Principal Function and converted to radians:

   SNAP ATTITUDE: ALPHAIN, BETAIN
   ALPHA = ALPHAIN RAD_PER_DEG
   BETA = BETAIN RAD_PER_DEG

   and the acceleration vector G _PREVIOUS will be obtained by a call to the ACCEL function (instead of the function CENTRAL). Detailed requirements for the ACCEL function are contained in Section 4.2.1.2.

   G _PREVIOUS = ACCEL (GMD_PRED, GMO_PRED, R _FINAL, V _FINAL, T)

   Next, for the necessary number of times to cover the whole prediction interval, this function will perform as follows:

1. Advance the time by an amount equal to STEP_SIZE

   (T = T + STEP_SIZE)

   and advance the position by means of the equation

   R _FINAL = R _FINAL + STEP_SIZE V _FINAL

   + 0.5 $(\text{STEP\_SIZE})^2$ G _PREVIOUS

2. Obtain a new value (G _FINAL) for the acceleration corresponding to the new position. Again, the subfunction called to provide this acceleration will depend on the value of the flag GMD_PRED: if GMD_PRED = 0, the function CENTRAL will be called. Otherwise, the function ACCEL will compute the acceleration. In this last case, if a drag acceleration is required, it will be computed on the basis of the ALPHA and BETA angles obtained previously. In other words, the model assumes a fixed attitude.

   G _FINAL = ACCEL (GMD_PRED, GMO_PRED, R _FINAL, V _FINAL, T)

3. Advance the velocity:

   V _FINAL = V _FINAL + STEP_SIZE 0.5 (G _PREVIOUS + G _FINAL)

4. Obtain a corrected value for the position by the "super-g" algorithm:

   R _FINAL = R _FINAL + STEP_SIZE^2 (G _FINAL - G _PREVIOUS)/6.

5. Save the value of G for the next cycle: G _PREVIOUS = G _FINAL. The values of R _FINAL, V _FINAL, and G _FINAL after these operations have been performed the appropriate number of times (NUMBER_STEPS), being the desired position, velocity and approximate acceleration vectors at T_ FINAL, will be output.

B. Interface Requirements. The input and otput variables are listed in Tables 4.5.1-1 and 4.5.1-2, respectively. The interfaces with other principal functions are contained in Appendix G.

C. Processing Requirements. None.

D. Constraints. If the precision prediction algorithm is not implemented as a reentrant procedure, execution of the algorithm may not be interrupted by calls from subsequent users. Users of the precision prediction algorithm are required to initialize the input parameters DT_MAX, GMD_PRED, GMO_PRED, R _INIT, V _INIT, T_INIT, and T_FINAL prior to the call, and are required to off-load or snap the output parameters R _FINAL, V _FINAL, and G _FINAL after execution is complete. The parameter DT_MAX must be greater than zero.

   The acceleration consisting of the central force term alone (required in conic prediction cases) could be obtained by calling the function ACCEL with the parameter GMD_PRED set equal to zero. The reason for the existence of the special routine CENTRAL for conic prediction is that its use will optimize the predictor for CPU (if the ACCEL function is implemented as a reentrant procedure, additional CPU would be involved in a call to ACCEL instead of a call to CENTRAL). This CPU optimization is a requirement only in the conic prediction mode.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart may be found in Appendix C.

The following table is intended for general information concerning how to set up the various flags for use of the predictor:

Type of prediction desired	GMD_PRED	GMO_PRED	DT_MAX (sec)
CONIC (Central gravity, only)	0	0	4.
SIMPLIFIED (Central + J_2 gravity, only)	2	0	4.
PRECISE (4x4 gravity plus drag)	4	4	4.

TABLE 4.5.1-1.- ENTRY PRECISE PREDICTOR INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Maximum allowable step size	DT_MAX	*	F	S		sec	As needed
Flag indicating the degree of the gravity potential model	GMD_PRED	*	I	S	0-4	--	As needed
Shuttle position vector at T_INIT	R_INIT	*	V	DP		ft	As needed
Flag indicating the order of the gravity potential model	GMO_PRED	*	I	S	0-4	--	As needed
Time at which state is desired	T_FINAL	*	F	DP		sec	As needed
Time at beginning of prediction	T_INIT	*	F	DP		sec	As needed
Shuttle velocity vector at T_INIT	V_INIT	*	V	S		ft/sec	As needed
Angle of attack	ALPHAIN	*	F	S		deg	As needed
Angle of sideslip	BETAIN	*	F	S		deg	As needed
Degrees to radians conversion	RAD_PER_DEG	**	F	S		rad/deg	As needed
Acceleration function related constants	***	**	vary	vary		vary	As needed

*See entry precise prediction principal function input list (Appendix G).
**See Section 4.9.
***See Section 4.2.1.2 for symbols.

TABLE 4.5.1-2.- ENTRY PRECISE PREDICTOR OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Shuttle position vector at end of prediction	R_FINAL	*	V	DP		ft	As needed
Shuttle velocity vector at end of prediction	V_FINAL	*	V	S		ft/sec	As needed
Gravity vector at end of prediction	G_FINAL	*	V	S		ft/sec^2	As needed

*See precision state prediction principal function output list (Appendix G).

4.5.2 Entry Site Lookup

This principal function provides the capability to retrieve specified information from an appropriate site location table and to perform necessary computations to obtain the site position vector(s) and/or associated transformation matrix.

Section 4.5.2.1 describes the site lookup subfunction that retrieves all necessary information related to a specified primary runway. Section 4.5.2.2 describes the site lookup subfunction that retrieves all necessary information related to a specified TACAN receiver (i.e., information is output as a function of LRU number, as well as TACAN station ID). Section 4.5.2.3 describes the site lookup subfunction which initializes runway/MSBLS parameters for primary runway and for secondary runway as well as initializing TACAN station parameters. The input to and output from site lookup are given in Appendix G.

In all instances where I-LOAD data is input, default values (corresponding to an AOA) may be overwritten during OPS-2 for OPS-3 usage to support the nominal entry.

4.5.2.1 Entry Runway/MSBLS Site Lookup

The purpose of this subfunction is to retrieve information related to a specified primary runway. For purposes of designation, there are three choices of runways available referred to as the site lookup prime, site lookup secondary, and site lookup alternate. Any one of these may be identified as the prime runway; however, the default designation will be site lookup prime. The site lookup prime and site lookup secondary runway data shall include parameters for the associated set of MSBLS sites if available. This information will not be available for the site lookup alternate runway.

A. Detailed Requirements. Formulation: This subfunction will accept from keyboard support software an index (PRIME_RUNWAY_INDEX) which indicates which of the three runway choices has been identified as the prime runway according to the following table:

PRIME_RUNWAY_INDEX VALUE	Runway Selected as Prime
1	Site lookup prime
2	Site lookup secondary
3	Site lookup alternate

The following parameters will be redefined for the designated selection:

RW_NAME
ALT_RW
AZIMUTH_RW
DELH_MSL_ELLIPSOID_RW
ANGLE_CORR_TNTOMAG_RW

RW_NAME is a positive feedback indication to the HSD to indicate positioning of the asterisk next to the runway azimuth representing the current selection of landing site. It has a value of 1, 2, or 3 representing crew selection of site lookup prime, secondary, or alternate choices.

The earth-fixed position vector and earth-fixed to prime runway transformation matrix shall be computed:

$\underline{R}$ _LS_EF = GEODETIC_TO_EF (LAT, LON, ALT_RW)

M_EFTORW = EF_TO_RUNWAY (LAT, LON, AZIMUTH_RW)

where LAT = geodetic latitude of the selected runway, and LON = geodetic longitude of the selected runway.

Then the position vector (originating at the origin of the EF coordinate system) of the HAC center for both sides of the runway centerline will be determined in earth-fixed coordinates:

$\underline{R}$ _CC_L_PRI = $\underline{R}$ _LS_EF + M_EFTORW^T $\underline{R}$ _HAC_RW_L

$\underline{R}$ _CC_R_PRI = $\underline{R}$ _LS_EF + M_EFTORW^T $\underline{R}$ _HAC_RW_R

Where $\underline{R}$ _HAC_RW_L and $\underline{R}$ _HAC_RW_R are the position vectors (originating at the origin of the RW coordinate system) of these two points in runway coordinates (see section 4.9).

Finally, the magnitude of these two position vectors will be determined:

R_CC_LMAG_PRI = |$\underline{R}$ _CC_L_PRI|

R_CC_RMAG_PRI = |$\underline{R}$ _CC_R_PRI|

If either the site lookup prime or site lookup secondary has been selected, the following parameters associated with MSBLS sites will be redefined for the designated selection:

MLS_AVAIL
LAT_MLS_R_AZ
LONG_MLS_R_AZ
ALT_MLS_R_AZ
R_AZ_SCANNER_BEARING
LAT_MLSEL
LONG_MLSEL
ALT_MLSEL
EL_SCANNER_BEARING
BIAS_MLSRANGE
BIAS_AZMLS
BIAS_ELMLS
X_DMEAZ_RW
X_EL_RW
Y_DMEAZ_RW

If either the site lookup prime or site lookup secondary has been selected and MSBLS sites are indicated as available, an earth-fixed position vector and earth-fixed to scanner transformation matrix shall be computed for each of the MSBLS range-azimuth and MSBLS elevation transmitter locations.

M_EFTORAD_R_AZ = EF_TO_SCANNER (LAT_MLS_R_AZ, LONG_MLS_R_AZ,
R_AZ_SCANNER_BEARING)

M_EFTORAD_EL = EF_TO_SCANNER (LAT_MLSEL, LONG_MLSEL, EL_SCANNER_BEARING)

$\underline{R}$ _RMLS_EF = GEODETIC_TO_EF (LAT_MLS_R_AZ, LONG_MLS_R_AZ,
ALT_MLS_R_AZ)

R _AZMLS_EF = R _RMLS_EF

R _ELMLS_EF = GEODETIC_TO_EF (LAT_MLSEL, LONG_MLSEL, ALT_MLSEL)

B. Interface Requirements. The input and output parameters are shown in Tables 4.5.2.1-1 and 4.5.2.1-2.

C. Processing Requirements. The runway/MSBLS site lookup subfunction may not interrupt navigation processing of MSBLS data.

D. Constraints. No error checking is performed. The primary runway selected must be indicated by an integer from 1 to 3 and must be properly derived and limited by software external to this subfunction.

E. Supplementary Information. A suggested implementation of these requirements is illustrated in Appendix C, ENTRY_RUNWAY_SITE_LOOKUP.

TABLE 4.5.2.1-1.- ENTRY RUNWAY/MSBLS SITE LOOKUP INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current landing site selection	PRIME_RUNWAY_INDEX	*	I	S		--	As needed
The following parameters are for the site lookup prime runway:							
Landing site selection symbol for display	RUNWAY_NAME_PSL	**	Char	S		--	As needed
Bearing from true north of runway coordinate system +X axis	RW_AZIMUTH_PSL	**	F	S		rad	As needed
Altitude above reference ellipsoid of runway reference point	RUNWAY_ALT_PSL	**	F	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at the runway	RW_DELH_PSL	**	F	S		ft	As needed
Variation of runway magnetic north from true north	RW_MAG_VAR_PSL	**	F	S		rad	As needed
Runway geodetic latitude	RW_LAT_PSL	**	F	S		rad	As needed
Runway longitude	RW_LON_PSL	**	F	S		rad	As needed
MSBLS azimuth antenna measurement bias	BIAS_AZMLS_PSL	**	F	S		rad	As needed
MSBLS elevation antenna measurement bias	BIAS_ELMLS_PSL	**	F	S		rad	As needed

*Entry site lookup principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.5.2.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS range antenna measurement bias	BIAS_MLSRANGE_PSL	**	F	S		ft	As needed
X component of range/azimuth antenna in runway coordinates	X_DMEAZ_RW_PSL	**	F	S		ft	As needed
Y component of range/azimuth antenna in runway coordinates	Y_DMEAZ_RW_PSL	**	F	S		ft	As needed
X component of elevation antenna - RW coordinates	X_EL_RW_PSL	**	F	S		ft	As needed
MSBLS range/azimuth geodetic latitude	LAT_MLS_R_AZ_PSL	**	F	S		rad	As needed
MSBLS range/azimuth longitude	LONG_MLS_R_AZ_PSL	**	F	S		rad	As needed
Geodetic altitude of MSBLS range/azimuth	ALT_MLS_R_AZ_PSL	**	F	S		ft	As needed
MSBLS azimuth boresight relative to true north	R_AZ_RADAR_BEARING_PSL	**	F	S		rad	As needed
Position vector of HAC center for the left side of the runway centerline	R _HAC_RW_R	**	V(3)	S		ft	As needed
Position vector of HAC center for the right side of the runway centerline	R _HAC_RW_R	**	V(3)	S		ft	As needed

**See Section 4.9.

TABLE 4.5.2.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS elevation antenna boresight relative to true north	EL_SCANNER_ BEARING_PSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic latitude	LAT_MLSEL_PSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic longitude	LONG_MLSEL_PSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic altitude	ALT_MLSEL_PSL	**	F	S		ft	As needed
Flag indicating (ON) the availability of MSBLS sites at the site lookup primary runway	MLS_AVAIL_PSL	**	D	S	OFF/ON	--	As needed
The following parameters are for the site lookup secondary runway:							
Landing site selection symbol for display	RUNWAY_NAME_ SSL	**	Char	S		-	As needed
Bearing from true north of runway coordinate system +X axis	RW_AZIMUTH_SSL	**	F	S		rad	As needed
Altitude above reference ellipsoid of runway reference point	RUNWAY_ALT_SSL	**	F	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at the runway	RW_DELH_SSL	**	F	S		ft	As needed
Variation of runway magnetic north from true north	RW_MAG_VAR_SSL	**	F	S		rad	As needed

**See Section 4.9.

TABLE 4.5.2.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Runway geodetic latitude	RW_LAT_SSL	**	F	S		rad	As needed
Runway geodetic longitude	RW_LON_SSL	**	F	S		rad	As needed
MSBLS azimuth antenna measurement bias	BIAS_AZMLS_SSL	**	F	S		rad	As needed
MSBLS elevation antenna measurement bias	BIAS_ELMLS_SSL	**	F	S		rad	As needed
MSBLS range antenna measurement bias	BIAS_MLS_ RANGE_SSL	**	F	S		ft	As needed
X component of range/azimuth antenna in runway coordinates	X_DMEAZ_RW_SSL	**	F	S		ft	As needed
Y component of range/azimuth antenna in runway coordinates	Y_DMEAZ_RW_SSL	**	F	S		ft	As needed
X component of elevation antenna - RW coordinates	X_EL_RW_SSL	**	F	S		ft	As needed
MSBLS range/azimuth geodetic latitude	LAT_MLS_R_AZ_ SSL	**	F	S		rad	As needed
MSBLS range/azimuth geodetic longitude	LONG_MLS_R_ AZ_SSL	**	F	S		rad	As needed
Geodetic altitude of MSBLS range/azimuth	ALT_MLS_R_AZ_ SSL	**	F	S		ft	As needed
MSBLS azimuth boresight relative to true north	R_AZ_RADAR_ BEARING_SSL	**	F	S		rad	As needed

**See Section 4.9.

TABLE 4.5.2.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
MSBLS elevation antenna boresight relative to true north	EL_SCANNER_ BEARING_SSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic latitude	LAT_MLSEL_SSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic longitude	LONG_MLSEL_SSL	**	F	S		rad	As needed
MSBLS elevation antenna geodetic altitude	ALT_MLSEL_SSL	**	F	S		ft	As needed
Flag indicating (ON) the availability of MSBLS sites at the site look-up secondary runway	MLS_AVAIL_SSL	**	D	S	OFF/ON	--	As needed
The following parameters are for the site lookup alternate runway:							
Landing site selection symbol for display	RUNWAY_NAME_ ASL	**	Char	S		--	As needed
Bearing from true north of runway coordinate system +X axis	RW_AZIMUTH_ASL	**	F	S		rad	As needed
Altitude above reference ellipsoid of runway reference point	RUNWAY_ALT_ASL	**	F	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at the runway	RW_DELH_ASL	**	F	S		ft	As needed
Variation of runway magnetic north from true north	RW_MAG_VAR_ASL	**	F	S		rad	As needed

**See Section 4.9.

TABLE 4.5.2.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate/sec
Runway geodetic latitude	RW_LAT_ASL	**	F	S		rad	As needed
Runway geodetic longitude	RW_LON_ASL	**	F	S		rad	As needed

**See Section 4.9.

TABLE 4.5.2.1-2.- ENTRY RUNWAY/MSBLS SITE LOOKUP OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current landing site selection index	RW_NAME	*	I	S	1,2,3	--	As needed
Bearing from true north of runway coordinate system +X axis	AZIMUTH_RW	*	F	S		rad	As needed
Altitude above reference ellipsoid of runway reference point	ALT_RW	*	F	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at the runway	DELH_MSL_ ELLIPSOID_RW	*	F	S		ft	As needed
Variation of runway magnetic north from true north	ANGLE_CORR_ TNTOMAG_RW	*	F	S	0 two PI	rad	As needed
Earth fixed MLS elevation scanner position vector	R _ELMLS_EF	*	V	DP		ft	As needed
Initial MLS azimuth antenna measurement bias	BIAS_AZMLS	*	F	S		rad	As needed
Initial MLS elevation antenna measurement bias	BIAS_ELMS	*	F	S		rad	As needed
Initial MLS range antenna measurement bias	BIAS_MLSRANGE	*	F	S		ft	As needed
X component of range/azimuth antenna in runway coordinates	X_DMEAZ_RW	*	F	S		ft	As needed
Y component of range/azimuth antenna in runway coordinates	Y_DMEAZ_RW	*	F	S		ft	As needed

*Entry site lookup principal function output list (Appendix G).

TABLE 4.5.2.1-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Earth fixed to prime RW transformation matrix	M_EFTORW	*	M	S		--	As needed
Position vector of landing site in Earth-fixed coordinates	R _LS_EF	*	V	DP		ft	As needed
Transformation matrix from earth-fixed to azimuth/range MSBLS radar coordinate frame	M_EFTORAD_R_AZ	*	M	S		--	As needed
Transformation matrix from earth-fixed to MSBLS elevation radar coordinates	M_EFTORAD_EL	*	M	S		--	As needed
Earth fixed position vector of MLS range scanner	R _RMLS_EF	*	V	DP		ft	As needed
Earth fixed MLS azimuth scanner position vector	R _AZMLS_EF	*	V	DP		ft	As needed
X component of elevation antenna - RW coordinates	X_EL_RW	*	F	S		ft	As needed
Flag indicating (ON) the availability of MSBLS sites at the currently chosen runway	MLS_AVAIL	*	D	S	OFF/ON	--	As needed
Position vector of HAC center on the left side of the runway centerline in EF coordinates	R _CC_L_PRI	*	V	S		ft	As needed

*See entry site lookup principal function output list (Appendix G).

TABLE 4.5.2.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Position vector of the HAC center on the right side of the runway centerline in EF coordinates	R_CC_R_PRI	*	V	S		ft	As needed
Magnitude of R_CC_L_PRI	R_CC_LMAG_PRI	*	F	S		ft	As needed
Magnitude of R_CC_R_PRI	R_CC_RMAG_PRI	*	F	S		ft	As needed

*See entry site lookup principal function output list (Appendix G).

4.5.2.2 Entry TACAN Site Lookup

The purpose of this subfunction is to retrieve information for a specified NEW_STATION_ID and LRU number from the TACAN site location table and to compute an earth-fixed position vector and an earth-fixed to topodetic transformation matrix for the specified TACAN site and LRU number.

There will be a maximum of ten TACAN sites available for selection.

A. Detailed Requirements. Formulation: A search is performed to locate the specified TACAN ID in the TACAN site location table. If the TACAN ID is not found, the TACAN channel valid (TAC_CHAN_VALID) is turned OFF and the present TACAN information is not updated; thus, the current TACAN is kept in use. If the TACAN ID is found, the following tasks are performed:

1. The parameters listed in Table 4.5.2.2-2 are redefined for the new TACAN from values supplied by the TACAN site location table.

2. The flag $TAC\_CHAN\_VALID_{LRU\ ID}$ is turned ON.

3. An earth-fixed to topodetic transformation matrix is computed by the following:

$$M\_EFTOTD\_TACAN\_SL_{LRU\ ID} = EF\_TO\_TOPDET\ (LAT\_TACAN\_SL_{LRU\ ID},\ LONG\_TACAN\_SL_{LRU\ ID})$$

B. Interface Requirements. The input and output parameters are shown in Tables 4.5.2.2-1 and 4.5.2.2-2, respectively.

C. Processing Requirements. Output parameters from this subfunction are employed by a variety of users. Consequently, an invoking thereof is limited to the TACAN SOP.

D. Constraints. The TACAN SOP must invoke this subfunction only when no interference with user routines is possible, and it is responsible for checking validity of input data.

E. Supplementary Information. A suggested implementation of these requirements is illustrated in Appendix C, ENTRY_TACAN_SITE_LOOKUP. The outputs of this section are needed as a consistent set by the users. Protection should therefore be provided to insure that these parameters are not updated while a user is in the process of saving off these data.

TACAN site constants: the TACAN transmitters/receivers (T/R) provide a selection of 126 X-mode channels and 126 Y-mode channels; the TACAN control head permits the crew to manually select any one of these 252 T/R frequency paris. However, a selection is of no value to the onboard software unless the ground station location for the tuned channel is available to the software. Consequently, a table of limited size is provided to supply this information for as many as ten unique channels/modes. Any one of the channels/modes can be premission-assigned

to several ground stations. To avoid ambiguous selection from the TACAN site table, a channel/mode must appear only once in the TACAN table. (Software resolution of an ambiguity could be formulated but should be avoided unless it is shown that unique channels cannot feasibly be selected).

TABLE 4.5.2.2-1.- ENTRY TACAN SITE LOOKUP INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current TACAN channel/mode identifier	NEW_STATION_ ID	*	I	S		--	As needed
LRU number for output parameters	LRU_ID	*	I	S	1-3	--	As needed
Available site data:							
TACAN channel/mode identifier	TAC_ID	**	V	S			As needed
Geodetic latitude of TACAN site	LATITUDE_ GEODETIC	**	V	S	-Pi/2 Pi/2	rad	As needed
Longitude of TACAN site	LONGITUDE_EAST	**	V	S	-Pi Pi	rad	As needed
Altitude of TACAN station	ALT_ABOVE_ ELLIPSOID	**	V	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at TACAN station	MSL_ABOVE_ ELLIPSOID	**	V	S		ft	As needed
Variation of magnetic north from true north at TACAN site	MAGNETIC_ VARIATION	**	V	S	0. 2Pi	rad	As needed
TACAN station bearing bias	BIAS_TAC_BRG	**	V	S	0. 2Pi	rad	As needed
TACAN station range bias	BIAS_TAC_R	**	V	S		ft	As needed
Geodetic radius at the TACAN site	RD_TAC	Site lookup initializa- tion	V	D		ft	As needed

*Entry site lookup principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.5.2.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Position vector of TACAN site in Earth fixed coordinates	R_TAC_EF	Site lookup initialization	V	D		ft	As needed

TABLE 4.5.2.2-2.- ENTRY TACAN SITE LOOKUP OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
TACAN station identifier code	$TACAN\_ID_{LRU\_ID}$	*	I	S	±126	-	As needed
Geodetic latitude of TACAN site obtained from site lookup	$LAT\_TACAN\_SL_{LRU\_ID}$	*	F	S	-Pi/2 Pi/2	rad	As needed
Longitude of TACAN site obtained from site lookup	$LONG\_TACAN\_SL_{LRU\_ID}$	*	F	S	-Pi Pi	rad	As needed
Altitude of TACAN station obtained from the site lookup	$ALT\_TACAN\_SL_{LRU\_ID}$	*	F	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at TACAN station obtained from site lookup	$DH\_TACAN\_SL_{LRU\_ID}$	*	F	S		ft	As needed
Variation of magnetic north from true north at TACAN site obtained from site lookup	$ANGLE\_CORR\_TNTOMAG\_SL_{LRU\_ID}$	*	F	S	0 2Pi	rad	As needed
TACAN station bearing bias obtained from site lookup	$BIAS\_TAC\_BRG\_SL_{LRU\_ID}$	*	F	S	0 2Pi	rad	As needed
TACAN station range bias obtained from site lookup	$BIAS\_TAC\_R\_SL_{LRU\_ID}$	*	F	S		ft	As needed
TACAN station earth-fixed position vector obtained from site lookup	$R\_TACAN\_EF\_SL_{LRU\_ID}$	*	V	DP		ft	As needed
TACAN channel validity flag obtained from site lookup	$TAC\_CHAN\_VALID\_SL_{LRU\_ID}$	*	D	--	OFF/ON	--	As needed

*Entry site lookup principal function output list (Appendix G).

TABLE 4.5.2.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Transformation matrix from earth-fixed to topodetic coordinates at TACAN site obtained from site lookup	M_EFTOTD_TACAN_SL$_{LRU_ID}$	*	M	S		--	As needed
Geodetic radius at the TACAN site	RD_TAC_SL$_{LRU_ID}$	*	F	D		ft	As needed

*Entry site lookup principal function output list (Appendix G).

4.5.2.3 Entry Site Lookup Initialization

MSC will invoke the site lookup initialization subfunction after transition to OPS-3 at such a time that initialization of parameters is completed before first execution of any user of those parameters.

A. Detailed Requirements. Initialization of runway/MSBLS parameters for the primary runway will be accomplished by setting the PRIME_RUNWAY_INDEX to a value of 1 and invoking the runway/MSBLS site lookup subfunction. Initial values for the earth-fixed to runway transformation matrix and the earth-fixed position vector of the secondary runway will be computed:

M_EFTORW_SEC = EF_TO_RUNWAY (RW_LAT_SSL, RW_LON_SSL, RW_AZIMUTH_SSL)

$\underline{R}$ _LS_EF_SEC = GEODETIC_TO_EF (RW_LAT_SSL, RW_LON_SSL, RUNWAY_ALT_SSL)

The barometric altimeter variances terms and the maximum relative velocity magnitude for barometric altimeter data processing shall be computed based on the availability of MSBLS data at the prime runway. If MSBLS data is available (MLS_AVAIL = ON) then the computation is:

VAR_H1 = VAR_H1_NOM
VAR_H2 = VAR_H2_NOM
RV_MAX = RV_MAX_NOM,

otherwise (MLS_AVAIL = OFF) the computation is:

VAR_H1 = VAR_H1_CONT
VAR_H2 = VAR_H2_CONT
RV_MAX = RV_MAX_CONT.

Next the position vector (originating at the origin of the EF coordinate system) of the HAC center for both sides of the secondary runway centerline will be determined in EF coordinates:

$\underline{R}$ _CC_L_SEC = $\underline{R}$ _LS_EF_SEC + M_EFTORW_SEC^T $\underline{R}$ _HAC_RW_L

$\underline{R}$ _CC_R_SEC = $\underline{R}$ _LS_EF_SEC + M_EFTORW_SEC^T $\underline{R}$ _HAC_RW_R

Where $\underline{R}$ _HAC_RW_L and $\underline{R}$ _HAC_RW_R are the position vectors (originating at the origin of the RW coordinate system) of these two points in runway coordinates and are considered to be I-load parameters (see Section 4.9).

Then the magnitude of these latter two position vectors will be determined:

R_CC_LMAG_SEC = |$\underline{R}$ _CC_L_SEC|

R_CC_RMAG_SEC = |$\underline{R}$ _CC_R_SEC|

Finally the azimuth of the secondary runway and its associated true north to magnetic north correction will be defined:

AZIMUTH_RW_SEC = RW_AZIMUTH_SSL

ANGLE_CORR_TNTOMAG_RW_SEC = RW_MAG_VAR_SSL

Initialization of TACAN station parameters will be accomplished as follows: For each entry in the input table of TACAN data, i.e., for I = 1, NUM_TACANS the earth-fixed position vector ($\underline{R}$ _TAC_EF) and the geodetic radius at the site (RD_TAC) will be computed as:

$$\underline{R}\_TAC\_EF_I = GEODETIC\_TO\_EF\ (LATITUDE\_GEODETIC_I,\ LONGITUDE\_EAST_I,\ ALT\_ABOVE\_ELLIPSOID_I)$$

and

$$RD\_TAC_I = \frac{A}{B} + MSL\_ABOVE\_ELLIPSOID_I$$

where

$$A = (1 - ELLIPT)^2\ EARTH\_RADIUS\_EQUATOR$$

$$B = (1 + SIN^2\ (LATITUDE\_GEODETIC_I)\ ELLIPT\ (ELLIPT - 2))^{1/2}$$ F9

B. Interface Requirements. The input and output parameters are shown on Tables 4.5.2.3-1 and 4.5.2.3-2.

C. Processing Requirements. All necessary initialization will be complete before execution of any user of site-lookup data.

D. Constraints. None

E. Supplemental Information. A suggested implementation of these requirements is illustrated in Appendix C, in the flowcharts ENTRY_RUNWAY_SITE_LOOKUP_INIT and ENTRY_TACAN_SITE_LOOKUP_INIT.

F9 This equation shall be protected against return value of sine or cosine with magnitudes greater than unity (Reference 3.6.9)

TABLE 4.5.2.3-1.- ENTRY SITE LOOKUP INITIALIZATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Secondary runway geodetic latitude	RW_LAT_SSL	**	F	S	-Pi Pi	rad	As needed
Secondary runway geodetic longitude	RW_LON_SSL	**	F	S	0 2Pi	rad	As needed
Bearing from true north of secondary runway coordinate system +X axis	RW_AZIMUTH_SSL	**	F	S	0 2Pi	rad	As needed
Secondary runway altitude above ellipsoid	RUNWAY_ALT_SSL	**	F	S		ft	As needed
Geodetic latitude of TACAN site	LATITUDE_ GEODETIC	**	V(10)	S	-Pi Pi	rad	As needed
Longitude of TACAN site	LONGITUDE_EAST	**	V(10)	S	0 2Pi	rad	As needed
Altitude of TACAN site above ellipsoid	ALT_ABOVE_ ELLIPSOID	**	V(10)	S		ft	As needed
Altitude of mean sea level above reference ellipsoid at TACAN station	MSL_ABOVE ELLIPSOID	**	V(10)	S		ft	As needed
Flag indicating (ON) the availability of MSBLS sites at the currently chosen runway	MLS_AVAIL	Entry runway/MSBLS site lookup	D	--	OFF/ON	--	As needed
Position vector of the HAC center for the left side (-Y) of the runway centerline	R _HAC_RW_L	**	V(3)	S		ft	As needed

**See Section 4.9.

TABLE 4.5.2.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Position vector of the HAC center for the right side (+Y) of the runway centerline	R _HAC_RW_R	**	V(3)	S		ft	As needed
Maximum relative velocity magnitude for baro processing associated with the nominal landing site	RV_MAX_NOM	**	F	S		ft/sec	As needed
Maximum relative velocity magnitude for baro processing associated with the contingency landing site	RV_MAX_CONT	**	F	S		ft/sec	As needed
Additive variance term used in constructing the baro measurement variance associated with the nominal landing site	VAR_H1_NOM	**	F	S		ft^2	As needed
Additive variance term used in constructing the baro measurement variance associated with the contingency landing site	VAR_H1_CONT	**	F	S		ft^2	As needed
Multiplicative variance term used in computing the baro measurement variance associated with the nominal landing site	VAR_H2_NOM	**	F	S		-	As needed
Multiplicative variance term used in computing the baro measurement variance associated with the contingency landing site	VAR_H2_CONT	**	F	S		-	As needed

**See Section 4.9.

TABLE 4.5.2.3-2.- ENTRY SITE LOOKUP INITIALIZATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Earth-fixed to secondary runway transformation matrix	M_EFTORW_SEC	*	M(3)	S		--	As needed
Earth-fixed position vector of the secondary runway threshold	R _LS_EF_SEC	*	V(3)	DP		ft	As needed
Earth-fixed position vector of the Ith TACAN site; I = 1, NUM_TACANS	R _TAC_EF$_I$	TACAN site lookup	V(3)	DP		ft	As needed
Geodetic radius at the Ith TACAN site; I = 1, NUM_TACANS	RD_TAC$_I$	TACAN site lookup	F	DP	-	ft	As needed
Position vector of HAC center on left side (-Y) of the secondary runway centerline in EF coordinates	R _CC_L_SEC	*	V(3)	S		ft	As needed
Position vector of HAC center on right side (+Y) of the secondary runway centerline in EF coordinates	R _CC_R_SEC	*	V(3)	S		ft	As needed
Magnitude of the vector R _CC_L_SEC	R_CC_LMAG_SEC	*	F	S		ft	As needed
Magnitude of the vector R _CC_R_SEC	R_CC_RMAG_SEC	*	F	S		ft	As needed
Bearing from true north of the coordinate system +X - axis	AZIMUTH_RW_SEC	*	F	S		rad	As needed
Variation of secondary runway magnetic north from true north	ANGLE_CORR_TNTOMAG_SEC	*	F	S		rad	As needed

*See entry site lookup principal function output list (Appendix G).

TABLE 4.5.2.3-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Maximum relative velocity magnitude for baro processing	RV_MAX	*	F	S		ft/sec	As needed
Additive variance term used in constructing the baro measurement variance	VAR_H1	*	F	S		ft^2	As needed
Multiplicative variance term used in constructing the baro measurement variance	VAR_H2	*	F	S		ft^2	As needed

*See entry site lookup principal function output list (Appendix G).

4.5.3 Entry Auto TACAN Selection

This principal function will perform the task of selecting the preferred TACAN station to which all TACAN receivers in the automatic mode of operation will be tuned by the TACAN SOP. The criteria for selecting the preferred TACAN station will depend upon the vehicle's estimated range from the primary runway threshold. In addition, the auto TACAN selection function will respond positively to requests from TACAN RM for an alternate preferred TACAN station, and will signal TACAN RM whenever the channel/mode identifier of the preferred TACAN station has been changed. The interfaces between this and other principal functions are shown in Appendix G.

A. Detailed Requirements. Determination of the preferred TACAN station will be performed as follows:

1. The flag indicating to TACAN RM that the value of AUTO_CHANNEL_ID, the channel/mode identifier for the preferred TACAN station, has been changed will be set to the OFF position at the start of each auto TACAN selection cycle:

   AUTO_ID_CHANGED = OFF

2. The estimated range of the vehicle from the primary runway threshold will be calculated:

   $$R\_GO\_LS = |\underline{R}\_EF - \underline{R}\_LS\_EF|$$

3. If the range of the vehicle from the runway threshold is greater than a premission-determined value (R_GO_LS > OUTER_RADIUS), the vehicle is said to be in the "outer" or "early acquisition" TACAN region. While the vehicle is in the early acquisition TACAN region, the value of the preferred or selected TACAN station ID will not be changed unless TACAN RM has requested a change by setting the flag ID_CHANGE_REQUEST to the ON position. If TACAN RM has requested a change, the value of AUTO_CHANNEL_ID will be reset as follows:

Old Value	New Value
TAC_ID_1	TAC_ID_2
TAC_ID_2	TAC_ID_3
TAC_ID_3	TAC_ID_1

   The change request flag will be turned off and a flag signaling the preferred station ID change will be set:

   ID_CHANGE_REQUEST = OFF

   AUTO_ID_CHANGED = ON

4. If the range of the vehicle from the runway threshold is less than a premission-determined value (R_GO_LS < INNER_RADIUS), the vehicle is said to be in the "inner" or "landing site" TACAN region. The value of the preferred TACAN station ID will be set as follows:

   If AUTO_CHANNEL_ID $\neq$ $\underline{T}AC\_ID_{10}$, then

   AUTO_CHANNEL_ID = $\underline{T}AC\_ID_{10}$

   AUTO_ID_CHANGED = ON

   During the landing site TACAN region, the ID_CHANGE_REQUEST flag will be ignored.

5. During the middle TACAN region (INNER_RADIUS $\leq$ R_GO_LS $\leq$ OUTER_RADIUS), the range of the vehicle in earth-fixed coordinates from each of six designated TACAN stations will be calculated. The channel/mode identifiers ID_TACAN_AUTO for the two TACAN stations closest to the vehicle will be determined and saved for use in the next cycle under the designation OLD_ID. The output value of AUTO_CHANNEL_ID will be derived according to Table 4.5.3-1. If the value of AUTO_CHANNEL_ID is different from its previous value, the flag AUTO_ID_CHANGED will be set to the ON position.

B. Interface Requirements. The AUTO_TACAN_SELECTION input and output parameters are listed in Tables 4.5.3-2 and 4.5.3-3.

C. Processing Requirements. MSC will initiate cyclic execution of the Entry auto TACAN selection principal function at a premission-determined rate upon transition to Major Mode 304. Prior to initiating execution of this principal function, the following parameter initialization is required:

   AUTO_CHANNEL_ID = TAC_ID_1

   AUTO_ID_CHANGED = ON

D. Constraints. The design of the AUTO_TACAN_SELECTION algorithm imposes the following constraints upon the structure and composition of the TACAN site location data tables:

1. The first three entries (indices) in the TACAN site location data tables will be reserved for the early acquisition TACAN stations.

2. The last (tenth) entry will be reserved for the TACAN station associated with or closest to the landing site.

3. The ninth entry will be reserved for a contingency TACAN station which could be employed in the manual mode of TACAN selection as a backup or alternate for landing site TACAN station. During automatic TACAN selection, this TACAN station will be included in the middle region.

4. The remaining five entries will be reserved for the middle region TACAN stations.

E. Supplemental Information. A suggested implementation of this function is illustrated by the flow charts ENTRY_AUTO_TACAN_SELECTION and ENTRY_AUTO_TACAN_SELECTION_INIT in Appendix C.

TABLE 4.5.3-1.- OUTPUT VALUE DETERMINATION FOR AUTO_CHANNEL_ID IN MIDDLE REGION

	ID_CHANGE_REQUEST = ON and AUTO_CHANNEL_ID =			ID_CHANGE_REQUEST = OFF and AUTO CHANNEL_ID =		
	$ID\_TACAN\_AUTO_1$	$ID\_TACAN\_AUTO_2$	Neither	$ID\_TACAN\_AUTO_1$	$ID\_TACAN\_AUTO_2$	Neither
$ID\_TACAN\_AUTO_1 = OLD\_ID_1$ and $ID\_TACAN\_AUTO_2 = OLD\_ID_2$	$ID\_TACAN\_AUTO_2$ *	$ID\_TACAN\_AUTO_1$ *	Case not possible	X	X	Case not possible
$ID\_TACAN\_AUTO_1 = OLD\_ID_1$ and $ID\_TACAN\_AUTO_2 \neq OLD\_ID_2$	$ID\_TACAN\_AUTO_2$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$	X	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *
$ID\_TACAN\_AUTO_1 = OLD\_ID_1$ and $ID\_TACAN\_AUTO_2 = OLD\_ID_2$	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *
$ID\_TACAN\_AUTO_1 = OLD\_ID_1$ and $ID\_TACAN\_AUTO_2 \neq OLD\_ID_2$	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$	$ID\_TACAN\_AUTO_1$	$ID\_TACAN\_AUTO_1$ *	$ID\_TACAN\_AUTO_1$ *

* Set AUTO_ID_CHANGED = ON
X No action required.

TABLE 4.5.3-2.- ENTRY AUTO TACAN SELECTION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Channel/mode identifier for automatically selected TACAN station	AUTO_CHANNEL_ID	*	I	S		--	1 Hz
Flag requesting (ON) that the value of AUTO_CHANNEL_ID be changed	ID_CHANGE_REQUEST	*	D	-	OFF/ON	--	1 Hz
TACAN channel/mode identifiers	TAC_ID	*	V(10)	S		--	1 Hz
Equatorial earth radius	EARTH_RADIUS_EQUATOR	**	F	DP		ft	1 Hz
Range threshold used to determine current TACAN region	INNER_RADIUS	**	F	S		ft	1 Hz
Range threshold used to determine current TACAN region	OUTER_RADIUS	**	F	S		ft	1 Hz
Vehicle earth-fixed position vector	$\underline{R}$ _EF	*	V(3)	DP		ft	1 Hz
Earth-fixed position of landing site	$\underline{R}$ _LS_EF	*	V(3)	DP		ft	1 Hz
Earth-fixed position vector for TACAN station, I = 1,10	$\underline{R}$ _TAC_EF$_I$	*	V(3)	DP		ft	1 Hz

*Auto TACAN selection principal function input list (Appendix G).
**See Section 4.9.

TABLE 4.5.3-3.- ENTRY AUTO TACAN SELECTION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Channel/mode identifier for automatically selected TACAN station	AUTO_CHANNEL_ID	*	I	S		--	1 Hz
Flag indicating (ON) that the value of AUTO_CHANNEL_ID has been changed	AUTO_ID_CHANGED	*	D	--	OFF/ON	--	1 Hz
Flag requesting (ON) that the value of AUTO_CHANNEL_ID be changed	ID_CHANGE_	*	D	--	OFF/ON	--	1 Hz

*Auto TACAN selection principal function output list (Appendix G).

4.6 USER PARAMETER PROCESSING PRINCIPAL FUNCTIONS

The purpose of the user parameter processing principal functions is to maintain an estimate of the vehicle state (position and velocity) and to derive from that state various related parameters required by systems such as guidance, displays, flight control, targeting, payloads, and navigation.

Within each user parameter processing principal function, the state is maintained by the user parameter state propagation subfunction. This subfunction utilizes a simple, fast-acting, single-step integrator to rapidly advance the user parameter state. The propagation interval is smaller than that used by the navigation principal functions, thus avoiding the need to wait for the next external sensor measurement processing to occur. At the end of each navigation propagation and external sensor measurement incorporation step, the navigation state is passed to the user parameter propagator, which then resets itself to that state. The value of the gravitational acceleration vector calculated by the navigation state propagator is used as a constant by the user parameter propagator between resets. Sensed changes in velocity are rapidly incorporated in the user parameter state at each integration step. In this way, the user parameter state propagation function maintains an accurate current state between navigation filter state computations.

The user parameters that are derived from the user parameter state typically provide expressions of the vehicle state in frames of reference dictated by the user; for example, (a) positions expressed in non-Cartesian frames related to landmarks, radar beacons, or selected way points for easy crew interpretation and (b) aerodynamic parameters derived from the state through the use of environmental models for guidance, displays, and flight control.

The systems that require user parameters vary as a function of mission phase, major mode, and event cues, all of which are recognized by the user parameter processing sequencer. The rates at which user parameters must be calculated also vary according to these criteria. This forces the user parameter state propagation subfunction to be performed at a rate supportive of the user parameter having the highest rate requirement during any particular user parameter phase.

The user parameter processing principal functions that perform the computations of the user parameters correspond to the major entry operations mission phases: entry, TAEM, and autoland. The detailed requirements for these phase-related principal functions are provided in their individual subsections.

Because the user parameter propagator supports all phases, the rate requirements of these phase-related user parameter processing principal functions implicitly place scheduling the rate requirements upon the user parameter state propagation subfunction. These scheduling and rate requirements are defined in Section 4.1.2, Deorbit/Landing User Parameter Processing Sequencer Principal Function.

4.6.1 Entry User Parameter Processing (4.23)

This principal function will serve as the interface between navigation and users of navigation-related data during Major Modes 301 through 304. This function will maintain the vehicle state within the user parameter state propagation subfunction and shall:

1. Provide this state to users who require vehicle state parameters in mean-of-fifty (M50) coordinates and

2. Provide the software to transform this state for users who require nav state related parameters.

This function is controlled by the deorbit/landing user parameter sequencer and is composed of the following five subfunctions:

A. User parameter state propagation (Section 4.6.1.1).

B. Basic guidance-related computations (Section 4.6.1.2).

C. Guidance and display way point computations (Section 4.6.1.3).

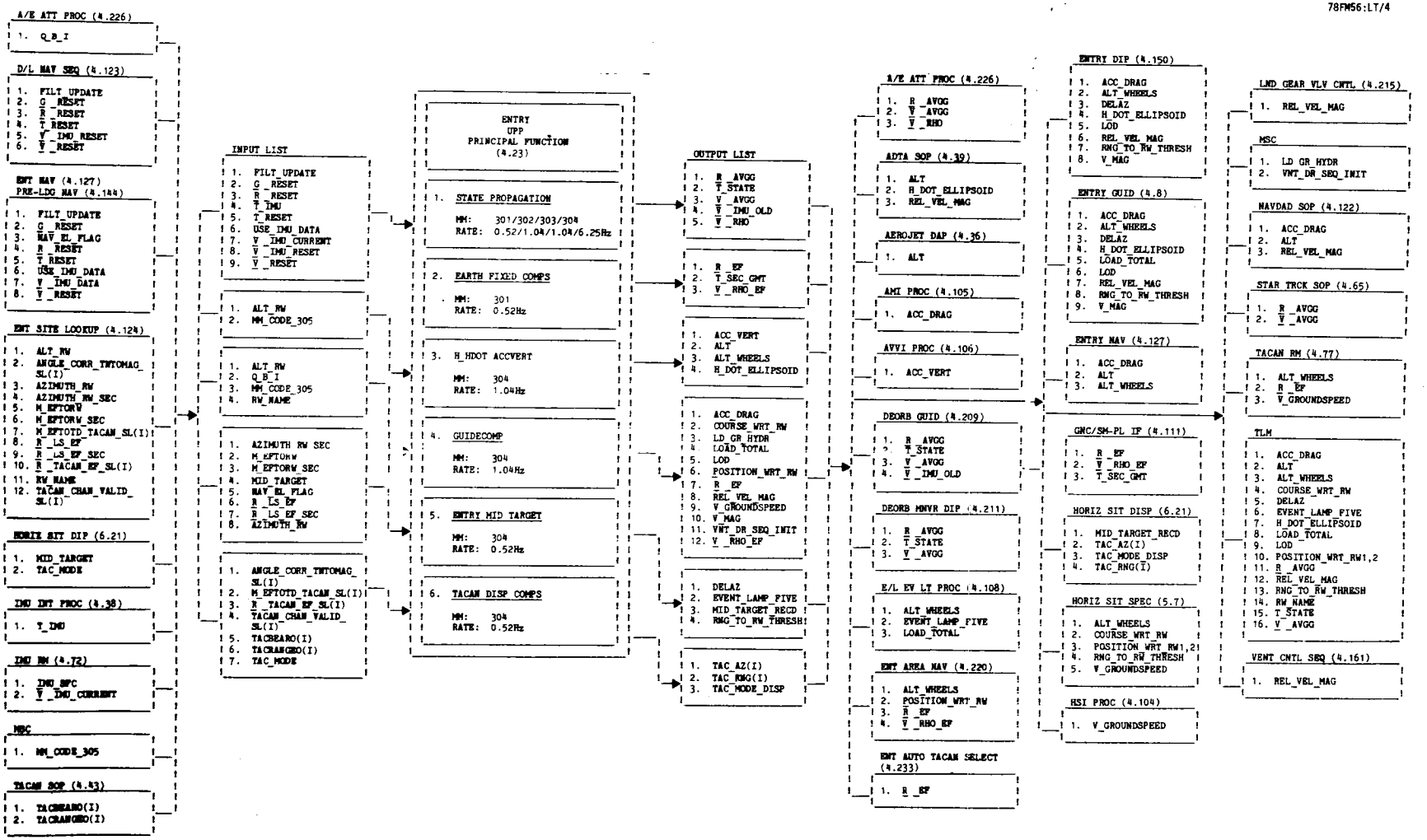
D. TACAN display computations (Section 4.6.1.4).

E. Earth-fixed coordinate system computations (Section 4.6.1.5).

The input and output lists for this principal function may be found in Appendix G, and summarized in Table 4.6.1.

TABLE 4.6.1.- TAEM USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM

78FM56:LT/4



4.6.1.1 User Parameter State Propagation

This subfunction shall provide state vector information to users such as guidance and displays during the entry phase.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.1.

B. Interface Requirements. The input and output required are listed in Tables 4.6.1.1-1 and 4.6.1.1-2, respectively.

C. Processing Requirements. None.

D. Contraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is to be found in Appendix F. USER_PARAM_PROPAGATOR.

TABLE 4.6.1.1-1.- ENTRY USER PARAMETER STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating (ON) that current nav cycle is complete	FILT_UPDATE	*	D	--	OFF/ON	--	nav rate
Modeled acceleration at start of Shuttle state integration interval	G _RESET	*	V	S		ft/sec^2	nav rate
Vehicle position vector after all navigation updates reserved for reset of user parameter integrator position vector R _AVGG	R _RESET	*	V	DP		ft	nav rate
Time associated with currently read IMU velocity counts from the IMU detection filter (RM)	T_IMU	*	F	DP		sec	As per sequencer
Time associated with reserved reset state	T_RESET	*	F	DP		sec	nav rate
Current selected accumulated IMU velocity	V _IMU_CURRENT	*	V	DP		ft/sec	As per sequencer
Copy of V _CURRENT_FILT reserved as velocity count at start of extrapolation interval when user parameter integrator is reset	V _IMU_RESET	*	V	DP		ft/sec	nav rate
Vehicle velocity vector after all navigation updates reserved for reset of user parameter integrator velocity vector V _AVGG	V _RESET	*	V	S		ft/sec	nav rate
Flag indicating use of IMU data	USE_IMU_DATA	*	D	--	OFF/ON	--	

*See entry user parameter processing principal function input parameters (Appendix G).

TABLE 4.6.1.1-2.- ENTRY USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector	R_AVGG	*, Entry UPP GUIDECOMP, Entry UPP EARTH_FIXED_COMPS	V	DP		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	*, Entry UPP GUIDECOMP, Entry UPP EARTH_FIXED_COMPS	F	DP		sec	As per sequencer
Current Shuttle velocity vector	V_AVGG	*, Entry UPP GUIDECOMP	V	S		ft/sec	As per sequencer
Current selected accumulated IMU velocity	V_IMU_OLD	*, Entry UPP GUIDECOMP	V	DP		ft/sec	As per sequencer
Vehicle relative velocity vector in M50 coordinates	V_RHO	*, Entry UPP GUIDECOMP, Entry UPP EARTH_FIXED_COMPS	V	S		ft/sec	As per sequencer
Flag indicating UPP state has been updated by navigation filter	UPP_UPDATE	H_HDOT_ACCVERT	D	--	OFF/ON	--	As per sequencer

*See entry user parameter processing principal function output parameters (Appendix G).

4.6.1.2 Basic Guidance-Related Computations (H_HDOT_ACCVERT and GUIDECOMP)

These subfunctions will provide the required software to transform the user parameter state into nav related parameters during the Entry major mode.

A. Detailed Requirements. The detailed requirements for these subfunctions are provided in Section 4.4.2.

B. Interface Requirements. The input and output requirements for the entry guidance parameters are listed in Tables 4.6.1.2-1 and 4.6.1.2-2.

C. Processing Requirements. The performance of these subfunctions is under the control of the deorbit/landing user parameter processing sequencer principal function.

D. Constraints. The flags VNT_DR_SEQ_INIT, LD_GR_HYDR and TG_END must be initialized to OFF and the flags TEST_VNT_DR and TEST_LD_GR to ON. The parameters ACC_VERT_OLD, DELTA_ACC_VERT and H_DOT_LAST must be initialized to zero; T_STATE_LAST, T_STATE_OLD and T_STATE_PREV must be initialized to an extremely large negative number; DELTA_T must be initialized to a non-zero value; N_SEQ_RA must be initialized to one; V _IMU_PREV to (0, 0, 0); IMU SFC_PREV to (1, 1, 1) and ALT and ALT_WHEELS must be initialized to the anticipated altitude at the beginning of Major Mode 304 (approximately 600 000 feet). Execution of the subfunction H_HDOT_ACCVERT must preceed execution of the subfunction GUIDECOMP.

E. Supplementary Information. A suggested implementation of the H_HDOT_ACCVERT and GUIDECOMP subfunctions are in the form of detailed flow charts in Appendix F. The parameters A_0 and FLATCON, although appearing here as inline code, may be derived from the earth ellipticity constant, ELLIPT, and implemented as pad loaded constants.

TABLE 4.6.1.2-1.- INPUT PARAMETERS FOR ENTRY BASIC GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Altitude above reference ellipsoid of runway reference point	ALT_RW	*	F	S		ft	As per sequencer
Current Shuttle position vector	R _AVGG	UPP state propagation	V	DP		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	UPP state propagation	F	DP		sec	As per sequencer
Current Shuttle velocity vector	V _AVGG	UPP state propagation	V	S		ft/sec	As per sequencer
M50 to body quaternion	Q_B_I	*	Q	S			As per sequencer
Vehicle relative velocity vector in M50 coordinates	V _RHO	UPP state propagation	V	S		ft/sec	As per sequencer
Unit vector in direction of Earth's axis of rotation	EARTH_POLE	Constant	V	S			As per sequencer
Earth equatorial radius	EARTH_RADIUS_ EQUATOR	Constant	F	DP		ft	As per sequencer
Earth ellipticity constant	ELLIPT	Constant	F	DP			As per sequencer
The constant PI	PI	Constant	F	S			As per sequencer
Current selected accumulated IMU velocity	V _IMU_OLD	UPP state propagation	V	DP		ft/sec	As per sequencer

*See entry user parameter processing principal function input list (Appendix G).

TABLE 4.6.1.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating UPP state has been updated by navigation filter	UPP_UPDATE	UPP state propagation	D	--	OFF/ON	--	As per sequencer
Current landing site selection index	RW_NAME	*	I	S	1,2,3		As per sequencer
IMU selection filter control vector	IMU_SFC	*	V	S	0, 1		As per sequencer
Position vector of runway in Earth-fixed coordinates	R _LS_EF	*	V	DP		ft	As per sequencer
Number of degrees per radian	DEG_PER_RAD	Constant	F	S			As per sequencer
Major Mode 305 flag	MM_CODE_305	*	D	--	OFF/ON	--	As per sequencer
Earth-fixed to prime RW transformation matrix	M_EFTORW	*	M	S			As per sequencer
Threshold value of relative velocity below which the flag VNT_DR_SEQ_INIT is set ON	VNTDR_VEL_ THRSH	Design dependent	F	S		ft/sec	As per sequencer
Threshold value of relative velocity below which the flag LD_GR_HYDR is set ON	LDGR_VEL_ THRSH	Design dependent	F	S		ft/sec	As per sequencer

*See entry user parameter processing principal function input list (Appendix G).

TABLE 4.6.1.2-2.- OUTPUTS FROM ENTRY BASIC GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Vehicle drag acceleration	ACC_DRAG	*	F	S		ft/sec^2	As per sequencer
Altitude of Orbiter nav base above runway altitude	ALT_WHEELS	*	F	S		ft	As per sequencer
Total load factor	LOAD_TOTAL	*	F	S			As per sequencer
Vehicle lift-over-drag ratio	LOD	*	F	S			As per sequencer
Shuttle position vector in Earth-fixed coordinates	R _EF	Entry UPP guidance and display way point comps, *	V	DP		ft	As per sequencer
Magnitude of vehicle relative velocity	REL_VEL_MAG	*	F	S		ft/sec	As per sequencer
Vehicle inertial speed	V_MAG	*	F	S		ft/sec	As per sequencer
Vertical component of vehicle acceleration WRT earth rotating frame	ACC_VERT	*	F	S		ft/sec^2	As per sequencer
Current Orbiter altitude above reference ellipsoid	ALT	*	F	S		ft	As per sequencer

*See entry user parameter processing principal function output list (Appendix G).

TABLE 4.6.1.2-2.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Estimated topodetic altitude rate	H_DOT_ ELLIPSOID	*	F	S		ft/sec	As per sequencer
Vehicle relative velocity vector in Earth-fixed coordinates	V _RHO_EF	Entry UPP guidance and display way point comps, *	V	S		ft/sec	As per sequencer
Vehicle velocity direction with respect to runway centerline	COURSE_WRT_RW	*	F	S	0 to 360	deg	As per sequencer
Current landing site selection index for use by guidance	RW_ID_UPP	*	I	S	1,2,3		As per sequencer
Vehicle groundspeed WRT reference ellipsoid	V_GROUNDSPEED	*	F	S		ft/sec	As per sequencer
Downrange position with respect to the runway	POSITION_WRT_ $RUNWAY_1$	*	F	S		ft	As per sequencer
Crossrange position with respect to the runway	POSITION_WRT_ $RUNWAY_2$	*	F	S		ft	As per sequencer
Magnitude of the Shuttle position vector	R_VEH_MAG	ENTRY_MID_ TARGET	F	S		ft	As per sequencer
Altitude position with respect to the runway	POSITION_WRT_ $RUNWAY_3$	*	F	S		ft	As per sequencer

*See entry user parameter processing principal function output list (Appendix G).

TABLE 4.6.1.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Flag sent to MSC to initiate VENT DOOR CNTL SEQ	VNT_DR_SEQ_INIT	*	D	--	OFF/ON	--	As per sequencer
Flag sent to MSC to initiate LND GEAR VLV CNTL	LD_GR_HYDR	*	D	--	OFF/ON	--	As per sequencer

*See entry user parameter processing principal function output list (Appendix G).

4.6.1.3 Guidance and Displays Way Point Computations

This subsection documents the detailed requirements necessary to compute the targeting-related navigation parameters required by return-sequence graphical CRT-display pages and by guidance during the entry phase of Shuttle flight.

A. Detailed Requirements. Two subfunctions are required to perform this task. The ENTRY_MID_TARGET subfunction shall first compute the parameter P which indicates the position of the Shuttle relative to the centerline of the runway

$$P = SIGN(POSITION\_WRT\_RW_2)$$

Next, it will call the ENT_RNG_BEAR subfunction with input parameters corresponding to the crew selected primary runway: $\underline{R}$ _LS_EF, M_EFTORW, AZIMUTH_RW, P. This results in the computation of range to the primary runway threshold (RNG_TO_RW_THRESH), and heading error with respect to the primary runway heading alignment circle tangent point (DELAZ). Next, the flag, MID_TARGET, will be tested and if MID_TARGET = ON, then the Y-component of the Shuttle position vector with respect to the secondary runway will be computed:

$$Y\_VEH\_RW\_SEC = M\_EFTORW_{2,1to3} \cdot (\underline{R}\ \_EF - \underline{R}\ \_LS\_EF\_SEC)$$

Subsequently, a parameter P_SEC indicative of the position of the Shuttle with respect to the secondary runway centerline is determined:

$$P\_SEC = SIGN(Y\_VEH\_RW\_SEC)$$

Then, the subfunction ENT_RNG_BEAR will be called a second time with inputs corresponding to the secondary runway: $\underline{R}$ _LS_EF_SEC, M_EFTORW_SEC, AZIMUTH_RW_SEC, P_SEC. This results in the computation of the following parameters with respect to the secondary runway: RNG_TO_RW_THRESH_SEC, and DELAZ_SEC. The parameters RNG_TO_RW_THRESH and DELAZ will then be redefined as follows:

$$RNG\_TO\_RW\_THRESH = 0.5\ (RNG\_TO\_RW\_THRESH + RNG\_TO\_RW\_THRESH\_SEC)$$

$$DELAZ = 0.5\ (DELAZ + DELAZ\_SEC)$$

The relative velocity magnitude is then tested and, if REL_VEL_MAG < VEL_TGT_SWITCH, set MID_TARGET to OFF. If the flag MID_TARGET has the value OFF, calculations with respect to the secondary runway are bypassed and the parameters RANGE_TO_RW_THRESH and DELAZ correspond only to the primary runway. The value of the flag MID_TARGET will be copied for feedback purposes:

$$MID\_TARGET\_RECD = MID\_TARGET$$

The nav event lamp indicator flag is then set using the nav validity indicator flag from the navigation principal functions.

EVENT_LAMP_FIVE = NAV_EL_FLAG

The ENT_RNG_BEAR subfunction shall accept as inputs the following parameters: $\underline{R}$ _LS_EF, M_EFTORW, AZIMUTH_RW, P. Outputs shall be: RNG_TO_RW_THRESH and DELAZ. This subfunction will first select the y position of the center of the nearest heading alignment circle in runway coordinates; then, the position vector of the heading alignment circle center is transformed from runway coordinates to earth-fixed coordinates:

$$R\_HAC\_RW_2 = P\ RADIUS\_NEP$$

$$\underline{R}\ \_CC\_EF = \underline{R}\ \_LS\_EF + M\_EFTORW^T\ \underline{R}\ \_HAC\_RW$$

Next, the magnitude of the heading alignment circle position vector and the sine of the earth-centered angle subtended by the radius of the heading alignment circle are computed:

$$R\_CC\_MAG = |\underline{R}\ \_CC\_EF|$$

$$SIN\_B = RADIUS\_NEP/R\_CC\_MAG$$

The vector, $\underline{V}$ _NORM, normal to the great circle plane containing the Shuttle and heading alignment circle center will be determined:

$$\underline{V}\ \_NORM = \underline{R}\ \_EF \times \underline{R}\ \_CC\_EF$$

Then, the bearing of this great circle plane with respect to true north at the Shuttle position and at the circle center is calculated:

$$BEAR\_VEH = ARCTAN2(V\_NORM_3\ R\_VEH\_MAG,$$
$$(V\_NORM_1\ R\_EF_2 - V\_NORM_2\ R\_EF_1))$$

$$BEAR\_CC = ARCTAN2(V\_NORM_3\ R\_CC\_MAG,$$
$$(V\_NORM_1\ R\_CC\_EF_2 - V\_NORM_2\ R\_CC\_EF_1))$$

If BEAR_CC < 0, then BEAR_CC = BEAR_CC + 2 PI. The cosine and sine of the central angle between the position of the Shuttle and the center of the heading alignment circle are determined:

$$COS\_THET\_VEH\_CC = \underline{R}\ \_EF \cdot \underline{R}\ \_CC\_EF/(R\_VEH\_MAG\ R\_CC\_MAG)$$

$$SIN\_THET\_VEH\_CC = (1 - COS\_THET\_VEH\_CC^2)^{1/2}$$

The cosine of the central angle between the Shuttle position and the tangent point, Way Point 1 (WP-1), is then computed and the great circle surface range from the Shuttle to WP-1 is determined:

COS_THET_VEH_WP1 = COS_THET_VEH_CC + 0.5 SIN_B SIN_B COS_THET_VEH_CC

DIST_VEH_WP1 = ARCCOS(COS_THET_VEH_WP1) R_CC_MAG

Next, the sine of the bearing correction angle and the bearing from the Shuttle to WP-1 are determined:

SIN_BEAR_CORR = SIN_B/SIN_THET_VEH_CC

BEAR_VEH_WP1 = BEAR_VEH - P ARCSIN(SIN_BEAR_CORR)

The arc length around the heading alignment circle from WP-1 to the normal entry point will be determined:

A2 = ARCCOS(COS_THET_VEH_WP1 SIN_BEAR_CORR)

A3 = 0.5 PI - A2 + P (AZIMUTH_RW - BEAR_CC)

If A3 < A3_TOL, A3 = A3 + 2 PI

D_ARC = A3 RADIUS_NEP

Next, the surface range from the Shuttle to the target point on the primary runway is computed via Way Point 1 and converted for output:

RNG_TO_RW_THRESH = (DIST_VEH_WP1 + D_ARC - X_NEP) NAUTMI_PER_FT

Another vector, $\underline{V}$ _NORM, which is normal to the plane containing the Shuttle position vector and relative velocity is calculated:

$\underline{V}$ _NORM = $\underline{R}$ _EF x $\underline{V}$ _RHO_EF

Finally, the heading angle of the relative velocity vector and the azimuth error (heading minus bearing to Way Point 1) are determined:

$$PSI = ARCTAN2(V\_NORM_3\ R\_VEH\_MAG,\ (V\_NORM_1\ R\_EF_2 - V\_NORM_2\ R\_EF_1))$$

DELAZ = PSI - BEAR_VEH_WP1

If |DELAZ| > PI, DELAZ = DELAZ - 2 PI SIGN(DELAZ)

B. Interface Requirements. The input and output requirements for the guidance and displays way point computations are listed in Tables 4.6.1.3-1 and 4.6.1.3-2, respectively.

C. Processing Requirements. The X and Z components of the heading alignment circle position vector, $\underline{R}$ _HAC_RW, are defined as part of the premission load according to $R\_HAC\_RW_1$ = X_NEP and $R\_HAC\_RW_3$ = 0. The performance of this subfunction and its cyclic repetition rate are under the control of the deorbit/landing user parameter processing sequencer, as described in Section 4.1.2.

D. Constraints. None.

E. Supplementary Information. A suggested implementation of the guidance and displays way point computation subfunctions may be found in Appendix F, subfunctions ENT_RNG_BEAR and ENTRY_MID_TARGET.

TABLE 4.6.1.3-1.- INPUT FOR ENTRY GUIDANCE AND DISPLAYS WAY POINT COMPUTATIONS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Earth-fixed to prime RW transformation matrix	M_EFTORW	*	M	S			As per sequencer
Feet to nautical miles	NAUTMI_PER_FT	Constant	F	S		nm/ft	As per sequencer
Constant PI	PI	Constant	F	S			As per sequencer
Radius of nominal entry point heading alignment circle	RADIUS_NEP	Mission dependent	F	S		ft	As per sequencer
Shuttle position vector in Earth-fixed coordinates	R_EF	Entry UPP GUIDECOMP	V	DP		ft	As per sequencer
Position vector of HAC center in runway coordinates	R_HAC_RW	Mission dependent	V	S		ft	As per sequencer
Position vector of landing site in Earth-fixed coordinates	R_LS_EF	*	V	DP		ft	As per sequencer
Runway X-component of the HAC center	X_NEP	Mission dependent	F	S		ft	As per sequencer
Bearing from true north of runway coordinate system +X axis	AZIMUTH_RW	*	F	S	0, 2Pi	rad	As per sequencer
Tolerance for correcting the range of values for the angle A3	A3_TOL	Design dependent	F	S		rad	As per sequencer
Vehicle relative velocity vector in Earth-fixed coordinates	V_RHO_EF	Entry UPP GUIDECOMP	V	S		ft/sec	As per sequencer

*See entry UPP principal function input list (Appendix G).

TABLE 4.6.1.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Transformation matrix from Earth-fixed to secondary runway	M_EFTORW_SEC	*	M	S			As per sequencer
Earth-fixed position vector of secondary runway threshold	R _LS_EF_SEC	*	V	DP		ft	As per sequencer
Azimuth of secondary runway measured from true north	AZIMUTH_RW_SEC	*	F	S	0, 2Pi	rad	As per sequencer
Flag which indicates whether averaging of primary and secondary targeting parameters is to be performed	MID_TARGET	*	D	--	OFF/ON	--	As per sequencer
Relative velocity value below which the flag MID_TARGET is set to OFF	VEL_TGT_SWITCH	Design dependent	F	S		ft/sec	As per sequencer
Nav validity flag for event lamp processing	NAV_EL_FLAG	*	Bit	--	OFF/ON	--	As per sequencer
Magnitude of the Shuttle position vector	R_VEH_MAG	Entry UPP H_HDOT_ACCVERT	F	DP		ft	As per sequencer
Crossrange position WRT the runway	POSITION_WRT_RUNWAY$_2$	Entry UPP GUIDECOMP	F	S		ft	As per sequencer
Magnitude of vehicle relative velocity	REL_VEL_MAG	*	F	S		ft/sec	As per sequencer

*See entry UPP principal function input list (Appendix G).

TABLE 4.6.1.3-2.- OUTPUT FOR ENTRY GUIDANCE AND DISPLAYS WAY POINT COMPUTATIONS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Azimuth error (heading of relative velocity vector minus bearing to WP1)	DELAZ	*	F	S	-PI, PI	rad	As per sequencer
Surface range from Shuttle to runway threshold	RNG_TO_RW_THRESH	*	F	S		nm	As per sequencer
Value of MID_TARGET for feedback	MID_TARGET_RECD	*	D				As per sequencer
Nav event lamp indicator flag	EVENT_LAMP_FIVE	*	Bit	--	OFF/ON	--	As per sequencer

*Entry UPP principal function output list (Appendix G).

4.6.1.4 TACAN Display Computations

This subfunction provides TACAN data for the Horizontal Situation Display (HSD) during the ENTRY and TAEM flight phases.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.4.

B. Interface Requirements. The inputs and outputs required are listed in Tables 4.6.1.4-1 and 4.6.1.4-2, respectively.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is given in Appendix F, TACAN_DISP_COMPS.

TABLE 4.6.1.4-1.- TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating "ON" when ABS_MODE is selected for HSD display and "OFF" when DELTA_MODE is selected	TAC_MODE	*	Bit				As per sequencer
Switch indicating (ON) when a valid TACAN channel has been selected	TACAN_CHAN_VALID_SL$_I$	*	Bit				As per sequencer
TACAN range data obtained from the SOP for each receiver, I = 1,3	TACRANGEO$_I$	*	Arr	S		ft	As per sequencer
TACAN bearing data obtained from the SOP for each receiver, I = 1,3	TACBEARO$_I$	*	Arr	S	0, 2Pi	rad	As per sequencer
Conversion factor from radians to degrees	DEG_PER_RAD	Constant	F	S		deg/rad	As per sequencer
Conversion factor from feet to nautical miles	NAUTMI_PER_FT	Constant	F	S		n.mi/ft	As per sequencer
Shuttle position vector in Earth-fixed coordinates	$\underline{R}$ _EF	GUIDECOMP	V	DP		ft	As per sequencer
TACAN station Earth-fixed position vector obtained from Site Lookup for Ith receiver	$\underline{R}$ _TACAN_EF_SL$_I$	*	Arr	S		ft	As per sequencer
Variation of magnetic north from true north at TACAN site obtained from Site Lookup for Ith receiver	ANGLE_CORR_TNTOMAG_SL$_I$	*	Arr	S		rad	As per sequencer
The constant PI	PI	Constant	F	S			As per sequencer

*Entry user parameter processing principal function input list (Appendix G).

TABLE 4.6.1.4-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Transformation matrix from Earth-fixed to topodetic coordinates at the Ith TACAN site	M_EFTOTD_ TACAN_SL$_I$	*	M(3)				As per sequencer

*Entry user parameter processing principal function input list (Appendix G).

TABLE 4.6.1.4-2.- TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Feedback switch indicating "ON" when ABS_MODE is selected on HSD DISP and "OFF" when DELTA_MODE is selected	TAC_MODE_DISP	*	D				As per sequencer
TACAN azimuth for display in the ABS_MODE or delta azimuth when in DELTA_MODE	TAC_AZ_I	*	Arr	S		deg	As per sequencer
TACAN range for display in the ABS_MODE or delta range when in the DELTA_MODE	TAC_RNG_I	*	Arr	S		n.mi	As per sequencer

*Entry user parameter processing principal function output list (Appendix G).

4.6.1.5 Earth-Fixed Coordinate System Computations (EARTH_FIXED_COMPS)

This subfunction will provide position and velocity vector coordinate system transformations for deorbit and entry.

A. Detailed Requirements. The following operations must be performed by the earth-fixed coordinate system computations subfunction from MM 301 until transition to MM 302.

Earth-fixed position and relative velocity of the Shuttle will be determined as follows:

A matrix to transform M50 to earth-fixed coordinates at the time of the current vehicle state vector ($\underline{R}$ _AVGG) will be generated.

$$M\_TEMP\_TXPOS = EARTH\_FIXED\_TO\_M50\_COORD(T\_STATE)^T$$

The earth-fixed position of the Shuttle and the Shuttle relative velocity in earth-fixed coordinates are then computed and current time is copied:

$$\underline{R}\ \_EF = M\_TEMP\_TXPOS\ \underline{R}\ \_AVGG$$

$$\underline{V}\ \_RHO\_EF = M\_TEMP\_TXPOS\ \underline{V}\ \_RHO$$

$$T\_SEC\_GMT = T\_STATE$$

B. Interface Requirements. The input and output requirements are listed in Tables 4.6.1.5-1 and 4.6.1.5-2.

C. Processing Requirements. The performance of this subfunction is under the control of the deorbit/landing user parameter processing sequencer principal function.

D. Constraints. None.

E. Supplementary Information. Reference should be made to Tables 4.6.1.5-1 and 4.6.1.5-2 for definition and source of the variables in the equations displayed.

A suggested implementation of the earth-fixed coordinate system computations subfunction is in the form of a detailed flow chart in Appendix F, EARTH_FIXED_COMPS.

TABLE 4.6.1.5-1.- INPUT PARAMETERS FOR EARTH-FIXED COORDINATE SYSTEM COMPUTATIONS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector	R_AVGG	UPP state propagation	V	DP		ft	As per sequencer
Vehicle relative velocity vector in M50 coordinates	V_RHO	UPP state propagation	V	S		ft/sec	As per sequencer
Time tag for current user parameter state vectors	T_STATE	UPP state propagation	F	DP		sec	As per sequencer

TABLE 4.6.1.5-2.- OUTPUT PARAMETERS FOR EARTH-FIXED COORDINATE SYSTEM COMPUTATIONS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Shuttle position vector in Earth-fixed coordinates	R_EF	*	V	DP		ft	As per sequencer
Vehicle relative velocity vector in Earth-fixed coordinates	V_RHO_EF	*	V	S		ft/sec	As per sequencer
Time tag associated with EF state vectors	T_SEC_GMT	*	F	DP		sec	As per sequencer

*See entry user parameter processing principal function output list (Appendix G).

4.6.2 TAEM User Parameter Processing (4.24)

This principal function will serve as the interface between navigation and users of navigation-related data during the TAEM major mode. This function will maintain the vehicle state within the user parameter state propagation subfunction and shall:

1. Provide this state to users who require vehicle state parameters in mean-of-fifty (M50) coordinates and

2. Provide the software to transform this state for users who require nav state related parameters.

This function is controlled by the deorbit/landing user parameter sequencer and is composed of the following three subfunctions

a. User parameter state propagation (Section 4.6.2.1)

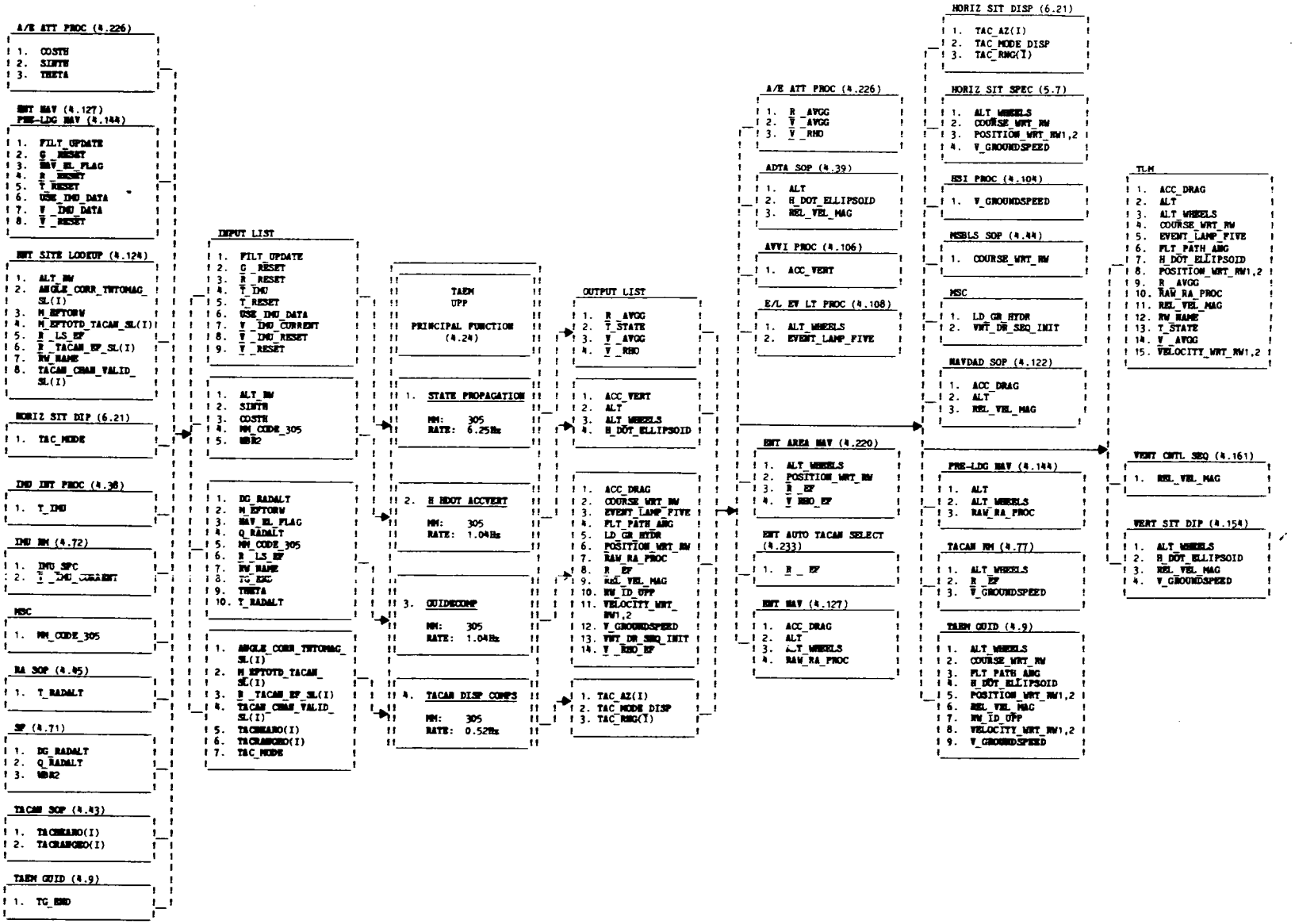
b. Basic guidance-related computations (Section 4.6.2.2)

c. TACAN display computations (Section 4.6.2.3)

The input and output lists for this principal function may be found in Appendix G, and summarized in Table 4.6.2.

TABLE 4.6.2.- TAEM USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM

78FM56:LT/5



4.6.2.1 User Parameter State Propagation

This subfunction will provide state vector information to users such as guidance and displays during the TAEM phase.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.1.

B. Interface Requirements. The input and output required are listed in Tables 4.6.2.1-1 and 4.6.2.1-2.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is to be found in Appendix F, USER_PARAM_PROPAGATOR.

TABLE 4.6.2.1-1.- TAEM USER PARAMETER STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating (ON) that the current nav cycle is complete	FILT_UPDATE	*	D	--	OFF/ON	--	nav rate
Modeled acceleration at start of Shuttle state integration interval	G _RESET	*	V	S		ft/sec^2	nav rate
Vehicle position vector after all navigation updates reserved for reset of user parameter integrator position vector R _AVGG	R _RESET	*	V	DP		ft	nav rate
Time associated with currently read IMU velocity counts from the IMU detection filter (RM)	T_IMU	*	F	DP		sec	As per sequencer
Time associated with reserved reset state	T_RESET	*	F	DP		sec	nav rate
Current selected accumulated IMU velocity	V _IMU_CURRENT	*	V	DP		ft/sec	As per sequencer
Copy of V _CURRENT_FILT reserved as velocity count at start of extrapolation interval when user parameter is reset	V _IMU_RESET	*	V	DP		ft/sec	nav rate
Vehicle velocity vector after all navigation updates reserved for reset of user parameter integrator velocity vector V _AVGG	V _RESET	*	V	S		ft/sec	nav rate
Flag indicating use of IMU data	USE_IMU_DATA	*	D	--	OFF/ON	--	

*See TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.1-2.- TAEM USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector	R_AVGG	*, TAEM UPP GUIDECOMP	V	DP		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	*, TAEM UPP GUIDECOMP	F	DP		sec	As per sequencer
Current Shuttle velocity vector	V_AVGG	*, TAEM UPP GUIDECOMP	V	S		ft/sec	As per sequencer
Earth-relative velocity in M50 coordinates	V_RHO	*, TAEM UPP GUIDECOMP	V	S		ft/sec	As per sequencer
Current selected accumulated IMU velocity	V_IMU_OLD	TAEM UPP GUIDECOMP	V	DP		ft/sec	As per sequencer
Flag indicating UPP state has been updated by navigation filter	UPP_UPDATE	H_HDOT_ ACCVERT	D	--	OFF/ON	--	As per sequencer

*See TAEM user parameter processing principal function output list (Appendix G).

4.6.2.2 Basic Guidance-Related Computations (H_HDOT_ACCVERT and GUIDECOMP)

These subfunctions will provide the required software to transform the user parameter state into the related parameters required by users of navigation-derived data during the TAEM guidance phase.

A. Detailed Requirements. It is required to calculate the parameters detailed in Section 4.4.2 during the TAEM guidance phase.

B. Interface Requirements. The input and output requirements for the TAEM guidance parameters are listed in Tables 4.6.2.2-1 and 4.6.2.2-2.

C. Processing Requirements. The performance and cyclic repetition rates of these subfunctions will be under the control of the deorbit/landing user parameter processing sequencer (Section 4.1.2).

D. Constraints. The parameter RAW_RA_PROC must be initialized to OFF.

E. Supplementary Information. All assumptions and explanations applicable to this section are defined in Section 4.4.2.

Suggested implementations of the H_HDOT_ACCVERT and GUIDECOMP subfunctions are in the form of detailed flow charts in Appendix F.

TABLE 4.6.2.2-1. INPUT PARAMETERS FOR BASIC TAEM GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Altitude above reference ellipsoid of runway reference point	ALT_RW	*	F	S		ft	As per sequencer
Earth-fixed to prime RW transformation matrix	M_EFTORW	*	M	S			As per sequencer
The constant PI	PI	Constants	F	S			As per sequencer
Cosine of Shuttle's pitch Euler angle (TD to body)	COSTH	*	F	S			As per sequencer
Sine of Shuttle's pitch Euler angle (TD to body)	SINTH	*	F	S			As per sequencer
Current Shuttle position vector	R_AVGG	UPP state propagation	V	DP		ft	As per sequencer
Position vector of runway in Earth-fixed coordinates	R_LS_EF	*	V	DP		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	UPP state propagation	F	DP		sec	As per sequencer
Body rate in degrees/second	WBR	*	V	S		deg/sec	As per sequencer
X_STRUCT_BODY distance from navigation base to cg	X_NB_CG	Mission dependent	F	S		ft	As per sequencer
Earth-relative velocity in M50 coordinates	V_RHO	UPP state propagation	V	S		ft/sec	As per sequencer

*TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Nav validity flag for event lamp processing	NAV_EL_FLAG	*	Bit				nav rate
TAEM guidance termination flag	TG_END	*	Bit				As per sequencer
Current selected accumulated IMU velocity	V _IMU_OLD	UPP state propagation	V	DP		ft/sec	As per sequencer
Flag indicating UPP state has been updated by navigation filter	UPP_UPDATE	UPP state propagation	D	--	OFF/ON	--	As per sequencer
X_STRUCT_BODY distance from navigation base to rear wheels	X_NB_WH	Hard code	F	S		ft	As per sequencer
Z_STRUCT_BODY distance from cg to navigation base	Z_NB_CG	Mission dependent	F	S		ft	As per sequencer
Z_STRUCT_BODY distance from rear wheels to navigation base	Z_NB_WH	Hard code	F	S		ft	As per sequencer
Current landing site selection index	RW_NAME	*	I	S	1,2,3	--	As per sequencer
Correction factor from radians to degrees	DEG_PER_RAD	Constant	F	S			As per sequencer
Altitude regions for nav event lamp processing	ALT_EL	Design dependent	V	S		ft	As per sequencer

*TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Number of sequential failures of the test criteria allowed before activating the nav event lamp	N_SEQ_MAX	Design dependent	I	S			As per sequencer
Unit vector in direction of Earth's axis of rotation	EARTH_POLE	Constant	V	S			As per sequencer
Earth equatorial radius	EARTH_RADIUS_ EQUATOR	Constant	F	DP		ft	As per sequencer
Earth ellipticity constant	ELLIPT	Constant	F	DP			As per sequencer
IMU selection filter control vector	IMU_SFC	*	V	S	0, 1		As per sequencer
Number of radians per degreee	RAD_PER_DEG	Constant	F	S			As per sequencer
Major Mode 305 flag	MM_CODE_305	*	D	--	OFF/ON	--	As per sequencer
Data good flag for radar altimeter	DG_RADALT	*	D	S	OFF/ON	--	As per sequencer
Threshold value of relative velocity below which the flag VNT_DR_SEQ_ INIT is set ON	VNTDR_VEL_ THRSH	Design dependent	F	S		ft/sec	As per sequencer
Threshold value of relative velocity below which the flag LD_GR_HYDR is set ON	LDGR_VEL_ THRSH	Design dependent	F	S		ft/sec	As per sequencer

*TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.2-2.- OUTPUT PARAMETERS FROM BASIC TAEM GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Vertical component of vehicle cg acceleration WRT earth rotating frame	ACC_VERT	*	F	S		ft/sec^2	As per sequencer
Current Orbiter altitude above reference ellipsoid	ALT	*	F	S		ft	As per sequencer
Vehicle velocity direction WRT runway centerline	COURSE_WRT_RW	*	F	S	0 to 360	deg	As per sequencer
Component of relative velocity normal to RW local ellipsoid	H_DOT_ ELLIPSOID	*	F	S		ft/sec	As per sequencer
Downrange position WRT the runway	POSITION_WRT_ $RUNWAY_1$	*	F	S		ft	As per sequencer
Crossrange position WRT the runway	POSITION_WRT_ $RUNWAY_2$	*	F	S		ft	As per sequencer
Altitude position WRT the runway	POSITION_WRT_ $RUNWAY_3$	*	F	S		ft	As per sequencer
Shuttle position vector in Earth-fixed coordinates	R _EF	*	V	DP		ft	As per sequencer
Magnitude of vehicle relative velocity	REL_VEL_MAG	*	F	S		ft/sec	As per sequencer
Downrange velocity WRT the runway	VELOCITY_WRT_ $RUNWAY_1$	*	F	S		ft/sec	As per sequencer
Crossrange velocity WRT the runway	VELOCITY_WRT_ $RUNWAY_2$	*	F	S		ft/sec	As per sequencer

*TAEM UPP principal function output list (Appendix G).

TABLE 4.6.2.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Vehicle relative velocity in EF coordinates	V_RHO_EF	*	V	S		ft/sec	As per sequencer
Vehicle cg groundspeed WRT runway (A/L), reference ellipsoid (TAEM)	V_GROUNDSPEED	*	F	S		ft/sec	As per sequencer
Drag acceleration	ACC_DRAG	*	F	S		ft/sec^2	As per sequencer
Flight path angle	FLT_PATH_ANG	*	F	S		rad	As per sequencer
Altitude of rear wheels above the altitude of the runway	ALT_WHEELS	*	F	S		ft	As per sequencer
Nav event lamp indicator flag	EVENT_LAMP_FIVE	*	D	--	OFF/ON	--	As per sequencer
Current landing site selection index for use by guidance	RW_ID_UPP	*	I	S	1,2,3		As per sequencer
Radar altimeter processing flag	RAW_RA_PROC	*	D	--	OFF/ON	--	As per sequencer
Flag sent to MSC to initiate VENT DOOR CNTL SEQ	VNT_DR_SEQ_INIT	*	D	--	OFF/ON	--	As per sequencer
Flag sent to MSC to initiate LND GEAR VLV CNTL	LD_GR_HYDR	*	D	--	OFF/ON	--	As per sequencer

*TAEM UPP principal function output list (Appendix G).

4.6.2.3 TACAN Display Computations

This subfunction provides TACAN data for the Horizontal Situation Display (HSD) during the ENTRY and TAEM flight phases.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.4.

B. Interface Requirements. The inputs and outputs required are listed in Tables 4.6.2.3-1 and 4.6.2.3-2 respectively.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is given in Appendix F, TACAN_DISP_COMPS.

TABLE 4.6.2.3-1.- TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating "ON" when ABS_MODE is selected for HSD display and "OFF" when DELTA_MODE is selected	TAC_MODE	*	Bit				As per sequencer
Switch indicating (ON) when a valid TACAN channel has been selected	TACAN_CHAN_VALID_SL$_I$	*	Bit				As per sequencer
TACAN range data obtained from the SOP for each receiver, I = 1,3	TACRANGEO$_I$	*	Arr	S		ft	As per sequencer
TACAN bearing data obtained from the SOP for each receiver, I = 1,3	TACBEARO$_I$	*	Arr	S	0, 2Pi	rad	As per sequencer
Conversion factor from radians to degrees	DEG_PER_RAD	Constant	F	S		deg/rad	As per sequencer
Conversion factor from feet to nautical miles	NAUTMI_PER_FT	Constant	F	S		nmi/ft	As per sequencer
Shuttle position vector in Earth-fixed coordinates	$\underline{R}$ _EF	GUIDECOMP	V	DP		ft	As per sequencer
TACAN station Earth-fixed position vector obtained from Site Lookup for Ith receiver	$\underline{R}$ _TACAN_EF_SL$_I$	*	Arr	S		ft	As per sequencer
Variation of magnetic north from true north at TACAN site obtained from Site Lookup for Ith receiver	ANGLE_CORR_TNTOMAG_SL$_I$	*	Arr	S		rad	As per sequencer
The constant PI	PI	Constant	F	S			As per sequencer

*TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Transformation matrix from Earth-fixed to topodetic coordinates at the Ith TACAN site	$M\_EFTOTD\_TACAN\_SL_I$	*	M(3)				As per sequencer

*TAEM user parameter processing principal function input list (Appendix G).

TABLE 4.6.2.3-2.- TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Feedback switch indicating "ON" when ABS_MODE is selected on HSD DISP and "OFF" when DELTA_MODE is selected	TAC_MODE_DISP	*	D				As per sequencer
TACAN azimuth for display in the ABS_MODE or delta azimuth when in DELTA_MODE	TAC_AZ_I	*	Arr	S		deg	As per sequencer
TACAN range for display in the ABS_MODE or delta range when in the DELTA_MODE	TAC_RNG_I	*	Arr	S		nmi	As per sequencer

*TAEM user parameter processing principal function output list (Appendix G).

4.6.3 Autoland User Parameter Processing (4.25)

This principal function will serve as the interface between navigation and users of navigation-related data during the approach/landing major mode. This function will maintain the vehicle state within the user parameter state propagation subfunction and shall:

1. Provide this state to users who require vehicle state parameters in mean-of-fifty (M50) coordinates and

2. Provide the software to transform this state for users who require nav state related parameters.

This function is controlled by the deorbit/landing user parameter sequencer and is composed of the following three subfunctions:

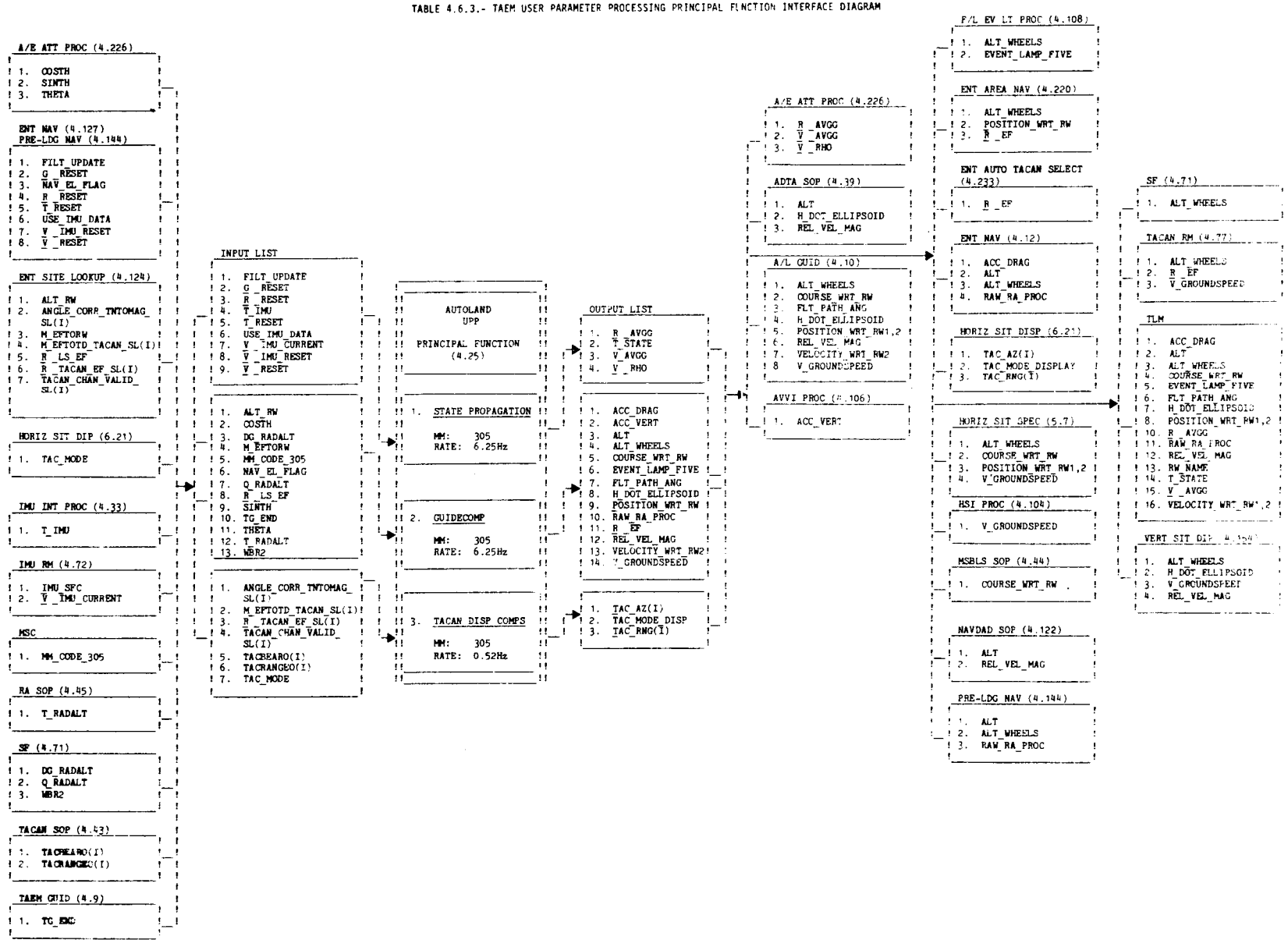
a. User parameter state propagation (Section 4.6.3.1)

b. Basic guidance-related computations (Section 4.6.3.2)

c. TACAN display computations (Section 4.6.3.3)

The input and output lists for this principal function may be found in Appendix G, and summarized in Table 4.6.2.

TABLE 4.6.3.- TAEM USER PARAMETER PROCESSING PRINCIPAL FUNCTION INTERFACE DIAGRAM



4.6.3.1 User Parameter State Propagation

This subfunction will provide state vector information to users such as guidance and displays during the autoland phase.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.1.

B. Interface Requirements. The input and output required are listed in Tables 4.6.3.1-1 and 4.6.3.1-2, respectively.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is to be found in Appendix F, USER_PARAM_PROPAGATOR.

TABLE 4.6.3.1-1.- AUTOLAND USER PARAMETER STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating (ON) that the current nav cycle is complete	FILT_UPDATE	*	D	--	OFF/ON	--	nav rate
Modeled acceleration at start of Shuttle state integration interval	G _RESET	*	V	S		ft/sec^2	nav rate
Vehicle position vector after all navigation updates reserved for reset of user parameter integrator position vector R _AVGG	R _RESET	*	V	DP		ft	nav rate
Time associated with currently read IMU velocity counts from the IMU detection filter (RM)	T_IMU	*	F	DP		sec	As per sequencer
Time associated with reserved reset state	T_RESET	*	F	DP		sec	nav rate
Current selected accumulated IMU velocity	V _IMU_CURRENT	*	V	DP		ft/sec	As per sequencer
Copy of V _CURRENT_FILT reserved as velocity count at start of extrapolation interval when user parameter integrator is reset	V _IMU_RESET	*	V	DP		ft/sec	nav rate
Vehicle velocity vector after all navigation updates reserved for reset of user parameter integrator velocity vector V _AVGG	V _RESET	*	V	S		ft/sec	nav rate

*See autoland user parameter processing principal function input list (Appendix G).

TABLE 4.6.3.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating use of IMU data	USE_IMU_DATA	*	D	--	OFF/ON	--	

*See autoland user parameter processing principal function input list (Appendix G).

TABLE 4.6.3.1-2.- AUTOLAND USER PARAMETER STATE PROPAGATION OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Shuttle position vector	R_AVGG	*, AUTOLAND UPP GUIDECOMP	V	DP		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	*, AUTOLAND UPP GUIDCOMP GUIDECOMP	F	DP		sec	As per sequencer
Current Shuttle velocity vector	V_AVGG	*, AUTOLAND UPP GUIDECOMP	V	S		ft/sec	As per sequencer
Vehicle relative velocity vector in M50 coordinates	V_RHO	*, AUTOLAND UPP GUIDECOMP	V	S		ft/sec	As per sequencer
Current selected accumulated IMU velocity	V_IMU_OLD	AUTOLAND UPP GUIDECOMP	V	DP		ft/sec	As per sequencer

*See autoland user parameter principal function output list (Appendix G).

4.6.3.2 Basic Guidance-Related Computations (GUIDECOMP)

This subfunction will provide the required software to transform the user parameter state into related parameters required by users of navigation-derived data during the Autoland guidance phase.

A. Detailed Requirements. It is required to calculate the parameters in the Guidecomp subfunction detailed in Section 4.4.2 during the Autoland guidance phase.

B. Interface Requirements. The input and output requirements for the Autoland and rollout guidance parameters are listed in Tables 4.6.3.2-1 and 4.6.3.2-2.

C. Processing Requirements. This subfunction will be performed at the repetition rate specified by the deorbit/landing user parameter processing sequencer (Section 4.1.2).

D. Constraints. The parameter, N_SEQ_RA, must be initialized to a value of one.

E. Supplementary Information. All assumptions and explanations applicable to this section are defined in Section 4.4.2.

A suggested implementation of the GUIDECOMP subfunction in the form of a detailed flow chart is shown in Appendix F.

TABLE 4.6.3.2-1.- INPUT PARAMETERS FOR BASIC AUTOLAND GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Earth-fixed to prime RW transformation matrix	M_EFTORW	*	M	S			As per sequencer
The constant PI	PI	Constants	F	S			As per sequencer
Cosine of Shuttle's pitch Euler angle (TD to body)	COSTH	*	F	S			As per sequencer
Sine of Shuttle's pitch Euler angle (TD to body)	SINTH	*	F	S			As per sequencer
Current Shuttle position vector	R_AVGG	UPP state propagation	V	DP		ft	As per sequencer
Preset value of horizontal distance of vehicle from RW reference point below which radar altimeter measurements will be incorporated into altitude position WRT runway	R_GO_RAMP	Design dependent	F	S		ft	As per sequencer
Position vector of runway in Earth-fixed coordinates	R_LS_EF	*	V	DP		ft	As per sequencer
Altitude of runway WRT reference ellipsoid	ALT_RW	*	F	S		ft	As per sequencer
Time tag for current user parameter state vector	T_STATE	UPP state propagation	F	DP		sec	As per sequencer
Body rate in degrees/second	WBR	*	V	S		deg/sec	As per sequencer

*Autoland user parameter principal function input list (Appendix G).

TABLE 4.6.3.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
X_STRUCT_BODY distance from navigation base to cg	X_NB_CG	Mission dependent	F	S		ft	As per sequencer
X_STRUCT_BODY distance from navigation base to rear wheels	X_NB_WH	Hard code	F	S		ft	As per sequencer
Z_STRUCT_BODY distance from cg to navigation base	Z_NB_CG	Mission dependent	F	S		ft	As per sequencer
Z_STRUCT_BODY distance from rear wheels to navigation base	Z_NB_WH	Hard code	F	S		ft	As per sequencer
Pitch angle	THETA	*	F	S		deg	As per sequencer
Conversion from radians to degrees	DEG_PER_RAD	Constants	F	S		deg/rad	As per sequencer
Earth-relative velocity in M50 coordinates	V _RHO	UPP state propagation	V	S		ft/sec	As per sequencer
Nav validity flag for event lamp processing	NAV_EL_FLAG	*	Bit	--	OFF/ON	--	nav rate
TAEM guidance termination flag	TG_END	*	Bit	--	OFF/ON	--	As per sequencer
Angle between body X-axis and cg to RA antenna vector	RADALT_ANG	Hard code	F	S		rad	As per sequencer
Radar altimeter measurement	Q_RADALT	*	F	S		ft	As per sequencer

*Autoland UPP principal function input list (Appendix G).

TABLE 4.6.3.2-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Radar altitude bias	BIAS_RADALT	Design dependent	F	S		ft	As per sequencer
Radar measurement time tag	T_RADALT	*	F	DP		sec	As per sequencer
Navigation base to antenna distance	RADALT_NB_DIST	Hard code	F	S		ft	As per sequencer
Pad loaded bias used to correct radar altimeter time tag	TIME_BIAS_ RADALT	Design dependent	F	S		sec	As per sequencer
Data good flag for radar altimeter	DG_RADALT	*	D	S	OFF/ON	--	As per sequencer
Altitude regions for nav event lamp processing	ALT_EL	Design dependent	V	S		ft	As per sequencer
Number of sequential failures of the test criteria allowed before activating the nav event lamp	N_SEQ_MAX	Design dependent	I	S			As per sequencer
Current selected accumulated IMU velocity	V _IMU_OLD	UPP state propagation	V	DP		ft/sec	As per sequencer
IMU selection filter control vector	IMU_SFC	*	V	S	0, 1		As per sequencer
Previous value of H_DOT_ELLIPSOID	H_DOT_LAST	H_HDOT_ ACCVERT	F	S		ft/sec	As per sequencer

*Autoland UPP principal function input list (Appendix G).

TABLE 4.6.3.2-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Number of radians per degree	RAD_PER_DEG	Constant	F	S		rad/deg	As per sequencer
Current primary landing site selection symbol	RW_NAME	*	F	S			As per sequencer
Value of T_STATE at previous pass through UPP	T_STATE_LAST	H_HDOT_ ACCVERT	F	DP		sec	As per sequencer
Major mode 305 flag	MM_CODE_305	*	D	--	OFF/ON	--	As per sequencer

*Autoland UPP principal function input list (Appendix G).

TABLE 4.6.3.2-2.- OUTPUTS FROM BASIC AUTOLAND GUIDANCE-RELATED COMPUTATIONS

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Current Orbiter altitude above ellipsoid at runway	ALT	*	F	S		ft	As per sequencer
Altitude of rear wheels above runway altitude tangent plane	ALT_WHEELS	*	F	S		ft	As per sequencer
Vehicle velocity direction WRT runway centerline	COURSE_WRT_RW	*	F	S	0 to 360	deg	As per sequencer
Angle between navigation base relative velocity vector and ellipsoid horizontal	FLT_PATH_ANG	*	F	S		rad	As per sequencer
Downrange position WRT the runway	POSITION_WRT_RUNWAY$_1$	*	F	S		ft	As per sequencer
Crossrange position WRT the runway	POSITION_WRT_RUNWAY$_2$	*	F	S		ft	As per sequencer
Altitude position WRT the runway	POSITION_WRT_RUNWAY$_3$	*	F	S		ft	As per sequencer
Magnitude of vehicle relative velocity	REL_VEL_MAG	*	F	S		ft/sec	As per sequencer
Crossrange velocity WRT the runway	VELOCITY_WRT_RUNWAY$_2$	*	F	S		ft/sec	As per sequencer
Vehicle cg groundspeed WRT runway (A/L), reference ellipsoid (TAEM)	V_GROUNDSPEED	*	F	S		ft/sec	As per sequencer

*Autoland UPP output list (Appendix G).

TABLE 4.6.3.2-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Comp rate
Component of cg relative velocity normal to RW ellipsoid	H_DOT_ ELLIPSOID	*	F	S		ft/sec	As per sequencer
Drag acceleration	ACC_DRAG	*	F	S		ft/sec^2	As per sequencer
Vertical component of vehicle cg acceleration WRT Earth rotating frame	ACC_VERT	*	F	S		ft/sec^2	As per sequencer
Shuttle position vector in Earth-fixed coordinates	R _EF	*	V	DP		ft	As per sequencer
Nav event lamp indicator flag	EVENT_LAMP_ FIVE	*	D	--	OFF/ON	--	As per sequencer
Radar altimeter processing flag	RAW_RA_PROC	*	D	--	OFF/ON	--	As per sequencer
Vehicle relative velocity in EF coordinates	V _RHO_EF	*	V	S		ft/sec	As per sequencer
Downrange velocity WRT the runway	VELOCITY_WRT_ $RUNWAY_1$	*	F	S		ft/sec	As per sequencer
Current landing site selection index for use by guidance	RW_ID_UPP	*	I	S	1,2,3		As per sequencer

*Autoland UPP output list (Appendix G).

4.6.3.3 TACAN Display Computations

This subfunction provides TACAN data for the Horizontal Situation Display (HSD) during the ENTRY and TAEM flight phases.

A. Detailed Requirements. The detailed requirements for this subfunction are contained in Section 4.4.4.

B. Interface Requirements. The inputs and outputs required are listed in Tables 4.6.3.3-1 and 4.6.3.3-2, respectively.

C. Processing Requirements. None.

D. Constraints. None.

E. Supplementary Information. A suggested implementation in the form of a detailed flow chart is given in Appendix F, TACAN_DISP_COMPS.

TABLE 4.6.3.3-1.- TACAN DISPLAY COMPUTATIONS INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Switch indicating "ON" when ABS_MODE is selected for HSD display and "OFF" when DELTA_MODE is selected	TAC_MODE	*	Bit				As per sequencer
Switch indicating (ON) when a valid TACAN channel has been selected	TACAN_CHAN_VALID_SL$_I$	*	Bit				As per sequencer
TACAN range data obtained from the SOP for each receiver, I = 1,3	TACRANGEO$_I$	*	Arr	S		ft	As per sequencer
TACAN bearing data obtained from the SOP for each receiver, I = 1,3	TACBEARO$_I$	*	Arr	S	0, 2Pi	rad	As per sequencer
Conversion factor from radians to degrees	DEG_PER_RAD	Constant	F	S		deg/rad	As per sequencer
Conversion factor from feet to nautical miles	NAUTMI_PER_FT	Constant	F	S		nmi/ft	As per sequencer
Shuttle position vector in Earth-fixed coordinates	$\underline{R}$ _EF	GUIDECOMP	V	DP		ft	As per sequencer
TACAN station Earth-fixed position vector obtained from Site Lookup for Ith receiver	$\underline{R}$ _TACAN_EF_SL$_I$	*	Arr	S		ft	As per sequencer
Variation of magnetic north from true north at TACAN site obtained from Site Lookup for Ith receiver	ANGLE_CORR_TNTOMAG_SL$_I$	*	Arr	S		rad	As per sequencer
The constant PI	PI	Constant	F	S			As per sequencer

*Autoland user parameter processing principal function input list (Appendix G).

TABLE 4.6.3.3-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Transformation matrix from Earth-fixed to topodetic coordinates at the Ith TACAN site	M_EFTOTD_ TACAN_SL$_I$	*	M(3)				As per sequencer

*Autoland user parameter processing principal function input list (Appendix G).

TABLE 4.6.3.3-2.- TACAN DISPLAY COMPUTATIONS OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Feedback switch indicating "ON" when ABS_MODE is selected on HSD DISP and "OFF" when DELTA_MODE is selected	TAC_MODE_DISP	*	D				As per sequencer
TACAN azimuth for display in the ABS_MODE or delta azimuth when in DELTA_MODE	TAC_AZ_I	*	Arr	S		deg	As per sequencer
TACAN range for display in the ABS_MODE or delta range when in the DELTA_MODE	TAC_RNG_I	*	Arr	S		nmi	As per sequencer

*Autoland user parameter processing principal function output list (Appendix G).

4.7 ENTRY AREA NAVIGATION PRINCIPAL FUNCTION (4.220)

The area navigation principal function supports the horizontal situation indicators (HSI), which are dedicated display devices located in the Shuttle cockpit that provide visual outputs of certain navigation and guidance parameters for the crew. A separate HSI, together with its associated moding and selector switches, will be provided for both the commander and the pilot; the commander's panel and a larger view of an HSI are shown in figures 4.7-1 and 4.7-2 (for reference only). The parameters to be displayed - fundamentally, directions, distances, and nominal course and glide path deviations to defined way points - have been chosen to permit the crew to adequately monitor and assess the automatic mode of GN&C on the basis of sources of data and computational software independent of that being employed in the automatic mode. Additonally, the choice of parameters provides the minimum necessary G&N information from this independent display to allow the crew to control the vehicle manually by using the HSI as a flight director. Any of three sets of display parameters will be provided for (entry, TAEM, or autoland) and selected for either HSI by its associated three-position mode switch together with certain auto switching logic. Other selector switches will provide for selection of data types used in navigationally related computations (e.g., TACAN/BARO, MSBLS, or NAV STATE) and for selection of a specific string in the case of redundant navigation sensors.* The three-position switches are shown in figure 4.7-1 for the commander's HSI. The source selection will be independent of whatever source is currently being used in the automatic navigation; the string selection will precede and be independent of the redundancy management function (except in the case of the barometric altitude); and finally, the commander's and pilot's HSI switches will function appropriately for their HSI and cause computations and displays independent of each other. The display mode will be determined based upon either manual or automatic switching logic. If the three position mode switch is set to the entry position, then the display mode is automatically switched from entry to TAEM, based upon major mode, and from TAEM to autoland, based upon altitude above the runway. For the TAEM or approach switch settings, the display mode selection is manual and the TAEM or autoland display computations, respectively, will be performed.

The intent of the requirements for the HSI displays is to provide information derived primarily from raw navigation sensor data (for its navigation parameters) and to transform that derived navigation state into guidance related target parameters. The source selection, however, will permit use of the current navigation state vector. Generally, the targeting to waypoints is consistent with the current guidance targeting parameters. Certain status flags will be displayed on the HSI to indicate cues regarding validity of selected source/string data: these include an ON/OFF flag, range flags, a bearing flag, course deviation flag, and glideslope deviation flag. The status setting of the flags will provide some means of rapid, real-time diagnosis of problems by the crew and will normally permit a crewman to select a good input source

---

*The barometric altitude used with the TACAN data will come from the redundancy management selection filter and, therefore will be unaffected by string selection.

to drive the HSI. (That, incidentally, may permit isolation of bad sources, which he may inhibit for the automatic GN&C processing.)

Through the interpretation of the displayed parameters on the HSI, the crew will be provided an independent monitor of certain GN&C parameters critical to a safe arrival near the touchdown zone and through rollout. The HSI, together with other dedicated displays, will provide the primary backup to guidance and navigation as well as a flight director function for horizontal and vertical guidance for a similar safe arrival by manual control up to a region in which transition from the steep glideslope to a shallow glide is required. Thereafter, the glideslope deviation is not computed because its use as an altitude director in a manual landing is questionable (radar altimeter altitude being preferable). The horizontal flight direction will be validly applicable throughout rollout.

The UPP sequencer principal functions will schedule the area navigation principal function to be performed during the appropriate phases of Shuttle flight at a repetition rate commensurate with the HSI processing principal function.

Interface parameters between this principal function and other GN&C principal functions are shown in the interface signal table, appendix G.

A. Detailed Requirements. HSI computations will be based upon inputs from either the tactical air navigation (TACAN) system with the air data system (ADS), the microwave scanning beam landing system (MSBLS), or the navigated state from a general-purpose computer (GPC). An HSI, with its associated switches, will be located at each side of the cockpit. Since each may be operated independently, computations will be executed independently for the left and right HSI. Cockpit switches will permit crew selection of data sources and will provide for either automatic or manual control over the display modes. A cockpit switch setting will determine which of three data sources is to be used for the computation of the HSI parameters. These data sources are (1) TACAN (range and azimuth), together with ADS (barometric altitude); (2) MSBLS (range, azimuth, and elevation); and (3) navigation solution of Shuttle's position and attitude.

Since the TACAN and MSBLS NAVAID sources are multiredundant, another cockpit switch will be used to select which of three subsources is to be used (i.e., there will be three TACAN's to choose from or three MSBLS transceivers to choose from). However, only one source for the navigated state will be used. When the source selection switch is set to the NAV position, the receiver selection switch will have no function, since the single source driving the HSI will be the user parameter state vector. Regardless of which data source is selected, the HSI parameter computation module will first transform the data to the coordinate system of the primary runway.

A third cockpit switch, together with major mode flags and altitude above the runway, will determine the display mode (ENTRY, TAEM, or A/L). The parameters computed for display will vary with the display mode selected. The parameters computed and the logic for determining the display mode are described in more detail below.

The HSI display and area navigation computation function will compute and output seven dynamic parameters for display on the HSI: primary bearing (PRI_BEAR), primary range (PRI_RANGE), secondary bearing (SEC BEAR), secondary range (SEC_RANGE), course deviation (CDI), glideslope deviation (GSI), and the heading angle (HEADING). The definitions of these parameters vary according to the display mode as indicated briefly in table 4.7-1. Their geometry is shown in figures 4.7-3 and 4.7-4.

In the ENTRY display mode, these parameters are defined as follows:

PRI_BEAR	Spherical angle in degrees (measured positive eastward) between magnetic north and the great circle direction to Way Point 1* (WP-1) for the selected HAC at the primary landing runway.
PRI_RANGE	Great circle surface distance in nautical miles from the Shuttle to Way Point 2* (WP-2) on the primary landing runway via the selected HAC WP-1. This distance includes the distance from the Shuttle to WP-1, the arc length around the normal entry heading alignment circle (HAC) from WP-1 to the normal entry point (NEP), and the distance from the NEP to WP-2.
SEC_BEAR	Same as PRI_BEAR except for secondary landing runway.
SEC_RANGE	Same as PRI_RANGE except for secondary landing runway.
GSI	Not computed for entry mode. Validity indicator set OFF (invalid).
CDI	Valid zero
HEADING	Heading of the earth-relative velocity vector with respect to magnetic north.

In the TAEM display mode, these parameters are defined as follows:

PRI_BEAR	Angle in degrees (measured positive eastward) between the direction to magnetic north and the direction to WP-1* on the selected HAC as viewed from the Shuttle.
PRI_RANGE	Horizontal distance from the Shuttle to WP-2* via WP-1 on the selected HAC (see figure 4.7-3). This distance includes the distance from the Shuttle to WP-1, the arc length around the selected HAC from WP-1 to the EP and the distance from the EP to WP-2.
SEC_BEAR	Bearing to center of selected HAC at primary landing runway.
SEC_RANGE	Horizontal distance to center of selected HAC at primary runway.

---

*Way Point 1 (WP-1) is defined as the tangential target point on the HAC. Way Point 2 (WP-2) is defined as the intersection with the runway centerline of the shallow glideslope. The runway X-component of WP-2 is a premission-determined value that nominally is expected to be on the order of 1500 feet.

CDI	The deviation in degrees (measured positive to the pilot's left on approach to the runway) of the Shuttle from the extended runway centerline. (The apex of this angle is located on the runway centerline directly opposite the MSBLS AZ/DME antenna.) The CDI display full scale is 10 degrees.
GSI	The vertical deviation in feet of the Shuttle from the guidance reference altitude (positive when Shuttle is above glide path). The GSI display full scale deflection is 5000 feet.
HEADING	Heading of the body X-axis with respect to magnetic north.

In the A/L display mode, the parameters are defined as follows:

PRI_BEAR	Angle in degrees (measured positive eastward) between the direction to magnetic north and the direction to WP-2 as viewed from the Shuttle.
PRI_RANGE	Horizontal distance from the Shuttle directly to WP-2.
SEC_BEAR	Same as PRI_BEAR.
SEC_RANGE	Same as PRI_RANGE.
CDI	Same as CDI in TAEM mode switch setting, with the exception that full scale is 2.5 degrees.
GSI	Vertical deviation in feet of the Shuttle from the linear segment reference altitude (positive when Shuttle is above glide path). Not computed for altitudes less than a prescribed value. The GSI display full scale deflection is 1000 feet.
HEADING	Same as HEADING in TAEM mode switch setting.

Note: Scale factors in the HSI Processing principal function provide conversion factors so that the least significant range digit corresponds to one nautical mile for entry; therefore, AREA NAV provides a decimal point shift for TAEM and A/L range values (by multiplying by TEN) so that the display's least significant digit indicates tenths of a n. mi.

In addition to the seven dynamic parameters described above, the HSI display and area navigation computation function will compute OFF-ON values for four display validity indicator flags that are capable of being displayed on the HSI. These four flags are the bearing flag (BRG_FLAG), the course deviation flag (CDI_FLAG), the glideslope flag (GSI_FLAG), and the heading flag (HDG_FLAG).

The meaning of the flags on the display varies according to flag grouping and the setting of the source switch as described in detail below.

The BRG and GSI flags presented as OFF: If the source switch is set to TACAN, either the TACAN range or azimuth data (or both) have been labeled invalid by the TACAN SOP. If the source switch is set to MSBLS, either the MSBLS range or azimuth data (or both) have been labeled invalid by the MSBLS SOP.

Only the GSI flag presented as OFF: If the source switch is set to TACAN, the barometric altitude data have been labeled invalid by the air data RM and a constant average altitude, or one derived from the navigation state, is being substituted for barometric altitude to drive the HSI. If the source switch is set to MSBLS, the MSBLS elevation data have been labeled invalid by the MSBLS SOP and a constant elevation angle is being substituted. Additionally, the GSI flag is OFF in the entry display mode and in the A/L display mode below a certain design dependent altitude.

The BRG, CDI, and GSI flags presented as OFF: This indicates to the crew that the station location of the beacon to which the selected TACAN receiver is tuned could not be found in the TACAN site table.

The HDG flag: This flag shall always indicate valid data (ON).

The detailed requirements for the HSI display and area navigation computation function may be described by breaking the function into the following nine subfunctions:

HSI_SEQUENCER

NAV_STATE_TO_RW

TAC_BARO_TO_RW

TAC_BARO_TO_TOPODETIC

MSBLS_TO_RW

ENTRY_HSI_COMP

TAEM_HSI_COMP

LAND_HSI_COMP

RANGE_BEAR_TO_HAC_ENTRY

The sequencing subfunction (HSI_SEQUENCER) will cycle through twice to perform the HSI computation function for both the left HSI and the right HSI. If the cycle is for the left HSI, the source, mode, and receiver switch settings for the left HSI will be obtained from the GN&C switch processor principal function and renamed for subsequent processing:

SOURCE = SOURCE_LEFT

MODE = MODE_LEFT

RCVR = RCVR_LEFT

If the cycle is for the right HSI:

SOURCE = SOURCE_RIGHT

MODE = MODE_RIGHT

RCVR = RCVR_RIGHT

The data validity flags shall then be initialized to ON:

BRG_FLAG = ON

GSI_FLAG = ON

CDI_FLAG = ON

Next, the source, mode, and receiver indicators will be tested to control subsequent calculations. If the source indicated is navigation, the NAV_STATE_TO_RW subfunction will be performed to reduce navigation state data to the runway coordinate system. If the source indicated is not navigation, the receiver indicator will be tested to determine from which redundant receiver source data will be taken; in addition, the integer, N, will be set to the desired receiver number (1, 2, or 3) for data indexing purposes. If the source indicated is TACAN, all required TACAN data for the appropriate receiver will be obtained from the TACAN SOP and barometric data will be obtained from the redundancy management selection filter. All these data, along with their corresponding comm fault/lock-on or data-good indicators, will be used in subsequent processing. The parameters to be used are as follows:

TACBEARO(N)

TACRANGEO(N)

TBRG_CMLK(N)

TRNG_CMLK(N)

HPC

ALT_DG

These data will be utilized in the TAC_BARO_TO_RW subfunction, where they will be transformed to the runway coordinate system.

If the source indicated is neither navigation nor TACAN, all appropriate MSBLS data and comm fault/lock-on indicators for the appropriate receiver will be obtained from the MSBLS SOP and used in subsequent processing. Then the MSBLS_TO_RW subfunction will be performed to reduce these data to the runway coordinate system.

The following parameters will be utilized:

MSBAZIMO(N)

MSBELEVO(N)

MSBRANGEO(N)

MRNG_CMLK(N)

MAZM_CMLK(N)

MELV_CMLK(N)

At this point, the selected data will have been reduced to the primary runway coordinate system, and mode-dependent processing will begin.

It will next be determined whether computations are to be peformed for the entry display mode, the TAEM display mode or the autoland display mode. The "ENTRY" position on the mode switch provides automatic transitions of the display modes (ENTRY, TAEM, Approach/LAND). If the mode switch setting is entry and if the major mode is ENTRY (MM_CODE_304 = ON) during OPS-3 or GLIDE RTLS 1 (MM_CODE_602 = ON) during OPS-6, then the ENTRY_HSI_COMP subfunction will be performed to generate display output parameters peculiar to the entry display mode. If the mode indicated is not entry, the angular deviation of the vehicle from the extended runway centerline (CDI) will be computed and the heading of the body X-axis with respect to magnetic north will be obtained from attitude processing and converted for output.

$$CDI = ARCTAN2(-R\_VEH\_RW_2,\ X\_DMEAZ\_RW - R\_VEH\_RW_1)\ DEG\_PER\_RAD \qquad F7$$

$$HEADING = PSI\_HSIMV\ DEG\_PER\_RAD$$

Next, two tests are made to determine certain constants which are dependent on vehicle mass and wind conditions, which are provided by crew interface. Depending on the mass of the vehicle, there are two distinct values for the final approach steep glide path angle. If the vehicle mass, M, is less

---

[F7] This equation shall be protected against arc tangents with both arguments equal to zero (reference 3.6.7).

than a threshold value, M_GSI, then the glideslope index IGS will be set equal to one corresponding to the nominal case; that is, if

$$M < M\_GSI$$

then

$$IGS = 1$$

If the mass of the vehicle is greater or equal to M_GSI, then the glide slope index IGS will be set equal to two corresponding to the high mass case; that is, if

$$M \geq M\_GSI$$

then

$$IGS = 2$$

The glideslope index is used to differentiate the constants employed in polynominal expressions relating the reference altitude and range for these two steep final approach glidepath angles, as well as the cubic-fit higher altitude profile. (These coefficients are the same as those used by the onboard guidance for reference altitude.)

Next, certain constants are calculated which are used to compute the NEP and the MEP:

$$DELX\_NEP = -HCO(IGS)/\ C1(IGS,1)$$

$$DELX\_MEP = -CO(IGS,1)/\ C1(IGS,1)$$

Since the masses used in the comparison test do not change after AREA NAV begins operating, these calculations need be performed only once. In order to handle this, a flag (MASS_FLAG) is introduced which should be initialized to ON as a first pass flag; after this one time execution, it should be turned to the OFF position:

$$MASS\_FLAG = OFF$$

A value of ALT_LAND, which is employed in the automatic switching logic, is initalized at this point to correspond to the desired altitude at the NEP; that is,

$$ALT\_LAND = HCO(IGS)$$

Depending on the wind conditions, as defined by crew interface (keyboard entries on HSD), there are two distinct values for X_GSI (X_GSI is the

distance from the glideslope intercept point on the extended runway centerline to the runway threshold). If the winds are normal, denoted by HI WINDS = OFF, then the value for this parameter is set equal to its nominal value:

X_GSI = X_GSI_NOMINAL

If the winds are determined to be high head winds, denoted by HI_WINDS = ON, then the value for this parameter is set equal to its HI_WIND value:

X_GSI = X_GSI_HI_WIND

If the mode indicated is landing, or if the mode indicated is entry and altitude above the runway, H, is less than the computed value, ALT_LAND, the LAND_HSI_COMP subfunction will be performed to generate display output parameters peculiar to the autoland display mode. Otherwise, a test is made to determine certain constants which depend on vehicle energy.

Depending on the vehicle's energy, there are two distinct HACs which the crew may select via crew interface (HSD); the nominal circle indicated by the term NEP and the low energy circle indicated by the term MEP. If guidance determines that the vehicle has low energy, it will send a signal to the crew informing them to switch from the NEP to the MEP on the HSD (item entry). This switch will be received by AREA NAV as the NEP flag, which determines whether the nominal (NEP = ON) or the minimum energy (NEP = OFF) heading alignment circles shall be used. That is:

If NEP = ON, then

X_EP = X_GSI + DELX_NEP

Since the value of ALT_LAND depends on the selected HAC, the value associated with the nominal circle is computed at this point:

ALT_LAND = HCO(IGS)

If NEP = OFF, then

X_EP = X_GSI + DELX_MEP

The value of ALT_LAND associated with the low energy circle is computed at this point:

ALT_LAND = CO(IGS,1)

Next, the TAEM_HSI_COMP subfunction will be performed to generate display outputs peculiar to the TAEM display mode, and the CDI and GSI data will be scaled for desired display range.

CDI = 0.25 CDI

GSI = 0.2 GSI

Finally, all outputs generated will be renamed according to which of the HSI's (left or right) they we destined for:

If left

PRIBEAR_LEFT = PRI_BEAR	GSI_FLAG_LEFT = GSI_FLAG
PRIRANGE_LEFT = PRI_RANGE	BRG_FLAG_LEFT = BRG_FLAG
CDI_LEFT = CDI	CDI_FLAG_LEFT = CDI_FLAG
GSI_LEFT = GSI	SECBEAR_LEFT = SEC_BEAR
HEADING_LEFT = HEADING	SECRANGE_LEFT = SEC_RANGE
	HDG_FLAG_LEFT = ON

If right

PRIBEAR_RIGHT = PRI_BEAR	GSI_FLAG_RIGHT = GSI_FLAG
PRIRANGE_RIGHT = PRI_RANGE	BRG_FLAG_RIGHT = BRG_FLAG
CDI_RIGHT = CDI	CDI_FLAG_RIGHT = CDI_FLAG
GSI_RIGHT = GSI	SECBEAR_RIGHT = SEC_BEAR
HEADING_RIGHT = HEADING	SECRANGE_RIGHT = SEC_RANGE
	HDG_FLAG_RIGHT = ON

The NAV_STATE_TO_RW subfunction will establish the Shuttle position vector in coordinates of the primary runway whenever the data source is navigation. It will be obtained from user parameter processing principal functions and renamed for HSI processing:

R _VEH_RW = POSITION_WRT_RUNWAY

The altitude of the Shuttle referenced to the runway altitude will be obtained from the appropriate UPP principal function and renamed for HSI processing:

H = ALT_WHEELS

The TAC_BARO_TO_RW subfunction, together with the TAC_BARO_TO_TOPODETIC subfunction, will transform TACAN data for the selected receiver into a vehicle position vector expressed in primary runway coordinates. To perform the required transformations, certain site-dependent parameters will be required that relate the TACAN data to the location of the TACAN beacon to which the selected (Nth) receiver is tuned. This site-dependent data will be obtained from the TACAN site look-up subfunction according to receiver number and will include the following parameters:

ALT_TACAN_SL(N), RD_TAC_SL(N), ANGLE_CORR_TNTOMAG_SL(N),

$\underline{R}$ _TACAN_EF_SL(N), DH_TACAN_SL(N), TACAN_CHAN_VALID_SL(N),

M_EFTOTD_TACAN_SL(N)

The TAC_BARO_TO_RW subfunction will first determine if either the TACAN bearing or TACAN range comm fault/lock-on indicator, TBRG_CMLK(N) or TRNG_CMLK(N), indicates invalid data. If so, both the HSI BRG and GSI flags will be set OFF accordingly:

BRG_FLAG = OFF

GSI_FLAG = OFF

and no further computations within this subfunction shall be performed.

Otherwise, the channel validity indicator, TACAN_CHAN_VALID_SL(N) will be tested by the HSI software; if it indicates that the beacon's location is not available, the HSI BRG, GSI, and CDI flags will be set to OFF. Thus, the crew will be notified of the situation, and all subsequent calculations utilizing beacon locations will be bypassed.

If the beacon's location is available, the TAC_BARO_TO_TOPODETIC subfunction will be performed to reduce the data to a topodetic coordinate system located at the TACAN beacon. The TAC_BARO_TO_TOPODETIC subfunction will compute the Shuttle position vector with respect to the TACAN site, $\underline{R}$ _VEH_TD_TAC, and will also establish the condition of the flag, GSI_FLAG, that indicates the validity of the barometric altitude data.

Finally, the position of the Shuttle will be established in both earth-fixed and runway coordinates:

$$\underline{R}\_VEH\_EF = M\_EFTOTD\_TACAN\_SL(N)^T\ \underline{R}\_VEH\_TD\_TAC + \underline{R}\_TACAN\_EF\_SL(N)$$

$$\underline{R}\_VEH\_RW = M\_EFTORW\ (\underline{R}\_VEH\_EF - \underline{R}\_LS\_EF)$$

The TAC_BARO_TO_TOPODETIC subfunction will convert TACAN range and azimuth for the selected (Nth) receiver, together with altitude data, to a vehicle position vector expressed in a topodetic system located at the TACAN beacon.

Barometric altitude data will be used for this purpose unless it is indicated to be invalid, in which case its value will be replaced with a corresponding, premission-determined, average value whenever the display mode is ENTRY. If the display mode is TAEM or approach/landing, an estimate of barometric altitude will be made on the basis of navigation-derived altitude above the runway. Also, the GSI_FLAG will be turned to OFF:

GSI_FLAG = OFF if ALT_DG = OFF

H_BARO = 85000 if MM_CODE_602 = ON or MM_CODE_304 = ON

Otherwise

H_BARO = ALT_WHEELS + ALT_RW - DELH_MSL_ELLIPSOID_RW

Whenever the barometric altitude data are indicated to be valid, barometric altitude, HPC, will be renamed for processing:

H_BARO = HPC

Finally, all data will be reduced to the topodetic coordinate system as follows:

R_TAC = RD_TAC_SL(N) + ALT_TACAN_SL(N) - DH_TACAN_SL(N)

R_VEH = RD_TAC_SL(N) + H_BARO

A = TACBEARO(N) + ANGLE_CORR_TNTOMAG_SL(N) + PI

$$\text{COSB} = \frac{\text{R\_TAC}^2 + \text{TACRANGEO(N)}^2 - \text{R\_VEH}^2}{2\ \text{R\_TAC TACRANGEO(N)}} \qquad \text{F3}$$

If COS B < - 1, then COSB = -1

$$\text{D} = \text{TACRANGEO(N)}\ (1 - \text{COSB}^2)^{1/2}$$

$$\text{R\_VEH\_TD\_TAC}_1 = \text{D COS(A)} \qquad \text{F9}$$

$$\text{R\_VEH\_TD\_TAC}_2 = \text{D SIN(A)} \qquad \text{F9}$$

$$\text{R\_VEH\_TD\_TAC}_3 = \text{TACRANGEO(N) COSB}$$

F3 This equation shall be protected against division by zero (reference 3.6.3

F9 This equation shall be protected against return value of sine or cosine with magnitude greater than unity (reference 3.6.9).

Whatever the source for H_BARO, this value of the altitude will be transformed into an altitude referenced to the runway altitude and renamed for HSI processing:

H = H_BARO - ALT_RW + DELH_MSL_ELLIPSOID_RW

The MSBLS_TO_RW subfunction will first determine if either the MLS range or MLS azimuth comm fault/lock-on indicator for the selected receiver (MRNG_CMLK(N) or MAZM_CMLK(N)) indicates invalid data. If so, both the HSI bearing (BRG) and glideslope (GSI) flags will be set accordingly to OFF:

BRG_FLAG = OFF

GSI_FLAG = OFF

and no further computations within this subfunction will be performed.

Otherwise, the MSBLS elevation comm fault/lock-on indicator, MELV_CMLK(N), will be tested. If invalid data are indicated, the elevation angle will be set to one of two assumed values and the HSI GSI flag will be set OFF (GSI_ FLAG = OFF) to indicate to the crew that invalid MSBLS elevation is being replaced with an assumed value - a change resulting in degraded performance of the HSI. The choice betwen the two assumed values for MSBLS elevation will depend upon the altitude relative to a predetermined reference value H_ GSI_SHALLOW; that is,

if H > H_GSI_SHALLOW, then EL_MSBLS = 0.33281

otherwise EL_MSBLS = 0.0

Whenever the MSBLS elevation data are indicated to be valid, the elevation angle for the selected receiver, MSBELEVO(N), will be renamed for subsequent processing:

EL_MSBLS = MSBELEVO(N)

Finally, the MSBLS data will be reduced to the runway coordinate system according to the following equations:

TAZ = TAN(MSBAZIMO(N))

TEL = TAN(EL_MSBLS)

$TEL2 = TEL^2$

$A = 1 + TEL2 + TAZ^2$ [F4]

[F4] This equation shall be protected against square roots of a negative number (reference 3.6.4).

$$B = 2\ (X\_EL\_RW - X\_DMEAZ\_RW)\ TEL2$$

$$C = (X\_EL\_RW - X\_DMEAZ\_RW)^2\ TEL2 - MSBRANGEO(N)^2$$

$$X\_VEH\_DMEAZ = \frac{B - \ B^2 - 4AC}{2A}^{1/2}$$

$$R\_VEH\_RW_1 = X\_DMEAZ\_RW + X\_VEH\_DMEAZ$$

$$R\_VEH\_RW_3 = (R\_VEH\_RW_1 - X\_EL\_RW)\ TEL$$

$$R\_VEH\_RW_2 = (X\_DMEAZ\_RW - R\_VEH\_RW_1)\ TAZ + Y\_DMEAZ\_RW$$

The negative of the third component of the position vector $\underline{R}$ _VEH_RW will be renamed for HSI processing:

$$H = -\ R\_VEH\_RW_3$$

The ENTRY_HSI_COMP subfunction will first check if the source indicated is NAV, if so, the vehicle position vector in earth-fixed coordinates ($\underline{R}$ _EF) - determined by user parameter processing principal functions (section 4.6) - will be renamed for subsequent processing, that is,

If SOURCE = NAV

then $\underline{R}$ _VEH_EF = $\underline{R}$ _EF

Heading of the relative velocity vector with respect to magnetic north is then to be determined by utilizing the vehicle position vector and relative velocity in earth-fixed coordinates obtained from appropriate user parameter processing principal functions.

First, the magnitude of the vehicle position vector and a vector, $\underline{V}$ _NORM, which is normal to the plane containing the position vector and the relative velocity are determined:

$$R\_VEH\_MAG = |\underline{R}\ \_VEH\_EF|$$

$$\underline{V}\ \_NORM = \underline{R}\ \_VEH\_EF \times \underline{V}\ \_RHO\_EF$$

Then, the heading follows from

$$PSI = ARCTAN2(V\_NORM_3\ R\_VEH\_MAG,\ (V\_NORM\ R\_VEH\_EF_2 - V\_NORM_2\ R\_VEH\_EF_1))$$

$$HEADING = (PSI - ANGLE\_CORR\_TNTOMAG\_RW)\ DEG\_PER\_RAD$$

If HEADING < 0, then

HEADING = HEADING + 360

Next, the vehicle position vector with respect to the secondary runway coordinate system will be determined:

R _VEH_RW_SEC = M_EFTORW_SEC (R _VEH_EF - R _LS_EF_SEC)

The parameters P_SEC and P will then be determined according to the position of the Shuttle with respect to the secondary runway centerline and the primary runway centerline:

$P\_SEC = SIGN(R\_VEH\_RW\_SEC_2)$

$P = SIGN(R\_VEH\_RW_2)$

The RANGE_BEAR_TO_HAC_ENTRY subfunction will then be performed with input parameters determined by the value of P_SEC. If P_SEC is positive, then the input parameters are

R _CC_R_SEC

R_CC_RMAG_SEC

If P_SEC is negative, then the input parameters are

R _CC_L_SEC

R_CC_LMAG_SEC

Regardless of the value of P_SEC, the following quantities are also required by this subfunction:

P_SEC

R _VEH_EF

R_VEH_MAG

AZIMUTH_RW_SEC

ANGLE_CORR_TNTOMAG_RW_SEC

This action results in the computation of the secondary range (SEC_RANGE) and secondary bearing (SEC_BEAR). This process will then be repeated for the primary runway. The RANGE_BEAR_TO_HAC_ENTRY subfunction will be

performed with input parameters determined by the value of P. If P is positive, then the input parameters are

R _CC_R_PRI

R_CC_RMAG_PRI

If P is negative, then the input parameters are

R _CC_L_PRI

R_CC_LMAG_PRI

Regardless of the value of P, the following quantities are also required by this subfunction:

P
R _VEH_EF

R_VEH_MAG

AZIMUTH_RW

ANGLE_CORR_TNTOMAG_RW

This action results in the calculation of the primary range (PRI_RANGE) and primary bearing (PRI_BEAR).

Finally, CDI and GSI are set to zero and the HSI glideslope valid flag is set to OFF.

CDI = 0

GSI = 0

GSI_FLAG = OFF

The RANGE_BEAR_TO_HAC_ENTRY subfunction will accept as inputs the position vector of the center of the HAC in EF coordinates, the magnitude of this vector, a parameter which is indicative of the position of the Shuttle with respect to the runway centerline, the position vector of the Shuttle in EF coordinates, the magnitude of this vector, the azimuth of the runway and the true north to magnetic north correction angle. It will then compute a range and bearing for the entry mode display.

The vector, V _NORM, normal to the great circle plane containing the Shuttle and HAC center will be determined:

V _NORM = R _VEH_EF x R _CC_EF

The bearing of this great circle plane with respect to true north at the Shuttle position and at the circle center will be computed:

$$BEAR\_VEH = ARCTAN2(V\_NORM_3\ R\_VEH\_MAG,\ (V\_NORM_1\ R\_VEH\_EF_2\ -\ V\_NORM_2\ R\_VEH\ EF_1)) \quad F7$$

$$BEAR\_CC = ARCTAN2(V\_NORM_3\ R\_CC\_MAG,\ (V\_NORM_1\ R\_CC\_EF_2\ -\ V\_NORM_2\ R\_CC\_EF_1)) \quad F7$$

If BEAR_CC < 0, then BEAR_CC = BEAR_CC + 2 PI. The sine of the central angle between the position of the Shuttle and the center of the HAC will then be calculated:

$$SIN\_THET\_VEH\_CC = |\underline{V}\ \_NORM| / (R\_VEH\_MAG\ R\_CC\_MAG)$$

Then, the great circle surface range from the Shuttle to WP1 will be approximated by:

$$DIST\_VEH\_WP1 = ARCSIN(SIN\_THET\_VEH\_CC)\ R\_CC\_MAG \quad F5$$

Next, the angle defined by the intersection of the two great circle planes (one passing through the Shuttle position and the HAC center, and the other through the Shuttle position and WP1) is given by

$$A2 = RADIUS\_EP / DIST\_VEH\_WP1$$

and the bearing from the Shuttle to WP1 follows from

$$BEAR\_VEH\_WP1 = BEAR\_VEH - P\ A2$$

The arc length around the selected HAC from WP-1 to the entry point will be determined next:

$$A3 = A2 + P\ (AZIMUTH\_RW - BEAR\_CC)$$

If

$$A3 < -0.003,\ A3 = A3 + 2\ PI$$

$$D\_ARC = A3\ RADIUS\_EP$$

Finally, the display computations will be performed:

$$RANGE = (DIST\_VEH\_WP1 + D\_ARC - X\_NEP + X\_WP2)\ NAUTMI\_PER\_FT$$

$$BEARING = (BEAR\_VEH\_WP1 - ANGLE\_CORR\_TNTOMAG\_RW)\ DEG\_PER\_RAD$$

F7 This equation shall be protected against arc tangents with both arguments equal to zero (reference 3.6.7).

F5 This equation shall be protected against arc sine of arguments with magnitudes greater than unity (reference 3.6.5).

If

$$BEARING < 0,\ BEARING = BEARING + 360$$

The LAND_HSI_COMP subfunction will first compute the bearing to WP-2 according to the following:

$$D = X\_WP2 - R\_VEH\_RW_1$$

$$PRI\_BEAR = (ARCTAN2(-\ R\_VEH\_RW_2,\ D) + AZIMUTH\_RW \qquad F7$$

$$-\ ANGLE\_CORR\_TNTOMAG\_RW)\ DEG\ PER\ RAD$$

If PRI_BEAR < 0, then PRI_BEAR = PRI_BEAR + 360

Otherwise, if PRI_BEAR > 360, then PRI_BEAR = PRI_BEAR - 360. Next, primary range will be computed:

$$DIST\_WP2 = (R\_VEH\_RW_2^2 + D^2)^{1/2}$$

$$PRI\_RANGE = (DIST\_WP2\ NAUTMI\_PER\_FT)\ 10.$$

Secondary range and bearing are then set equal to primary range and bearing:

$$SEC\_RANGE = PRI\_RANGE$$

$$SEC\_BEAR = PRI\_BEAR$$

The multiply by 10. shifts the range decimal point to provide one-tenth n. mi. resolution on the display.

In order to compute the glideslope deviation for Shuttle altitudes greater than a premission-determined value, that is, H > H_GSI_SHALLOW, the reference altitude HREF must be calculated. The reference altitude is related to the distance (R) from the vehicle ground position to the MEP

$$R = DIST\_WP2 + X\_GSI + DELX\_MEP - X\_WP2$$

by the following linear relation

$$HREF = CO(IGS,1) + C1(IGS,1)\ R$$

where CO, C1 are premission constants corresponding to guidance altitude coefficients and depend on the glideslope index. The glideslope deviation follows from

$$GSI = H - HREF$$

F7 This equation shall be protected against arc-tangents with both arguments equal to zero (reference 3.6.7).

where H is the actual vehicle altitude above the runway threshold and HREF is the desired vehicle altitude. When the Shuttle altitude is less than the premission value, H_GSI_SHALLOW, the glideslope deviation is not computed and the HSI glideslope flag is set to OFF:

GSI_FLAG = OFF

The TAEM_HSI_COMP subfunction will accept as inputs the runway X-component, X_EP, of a HAC associated with the crew selected entry point (EP) and the HAC radius, RADIUS_EP. This function will compute primary and secondary range, primary and secondary bearing, and glideslope deviation for the TAEM mode display. The primary bearing is the direction to WP1 on the selected heading alignment circle; the primary range is the distance to WP2 via the WP1; the glideslope deviation is the altitude error as compared to the reference altitude which is based on the guidance defined coefficients (a function of distance to go via the selected path). The secondary range and bearing are computed with respect to the center of the selected HAC. The ranges are scaled to represent range in tenths of nautical miles. The detailed requirements for this subfunction are as follows.

First, it will determine which side of the runway centerline the Shuttle is on; then the value of the parameter, P, will be established accordingly. Next, a coordinate system will be established whose origin is located at the Shuttle and the X-, Y- position of the center of the selected HAC will be expressed in Shuttle-centered coordinates. The distance and bearing to the center of the HAC will then be computed:

$$P = SIGN(R\_VEH\_RW_2)$$

$$Y\_CC = RADIUS\_EP - P\ R\_VEH\_RW_2$$

$$X\_CC = X\_EP - R\_VEH\_RW_1$$

$$R\_CC = (X\_CC^2 + Y\_CC^2)^{1/2}$$

$$PHI = ARCTAN2(Y\_CC, X\_CC)$$

If PHI < 0, then PHI = PHI + 2PI (PI = π)

Next, two cases will be distinguished: (1) the Shuttle is on or inside the HAC, and (2) the Shuttle is outside the HAC. In each of these cases, the distance from the Shuttle to WP-1 will be calculated, together with the bearing relative to the runway and the turn angle remaining around the HAC onto the runway centerline.

If R_CC $\leq$ RADIUS_EP, then Case 1; otherwise, Case 2.

Case 1:

DIST_VEH_WP1 = 0

BEAR_RW = PHI -0.5 PI

In case 2, the nominal case, the angle THETA will be computed, which corrects the bearing from the center of the HAC to the tangent point WP-1.

Case 2:

THETA = ARCSIN(RADIUS_EP/R_CC)

DIST_VEH_WP1 = $(R\_CC^2 - RADIUS\_EP^2)^{1/2}$

BEAR_RW = PHI - THETA

Next, for either Case 1 or 2, BEAR_RW will be tested and corrected if found to be negative. Then, the turn angle around the HAC will be determined:

If BEAR_RW < 0, then BEAR_RW = BEAR_RW + 2PI

ARC = 2PI - BEAR_RW

D_ARC = ARC RADIUS_EP

Finally, the parameter, P, will be tested; if it is found to be negative, the bearing to WP1 and to the center of the HAC will be corrected according to BEAR_RW = 2PI - BEAR_RW and PHI = 2PI - PHI. Then, the display computations will be performed:

RANGE_FT = DIST_VEH_WP1 + D_ARC - X_EP + X_WP2

PRI_RANGE = (RANGE_FT NAUTMI_PER_FT) 10.

PRI_BEAR = (BEAR_RW + (AZIMUTH_RW - ANGLE_CORR_TNTOMAG_RW)) DEG_PER_RAD

SEC_BEAR = (PHI + (AZIMUTH_RW - ANGLE_CORR_TNTOMAG_RW)) DEG_PER_RAD

SEC_RANGE = 10. R_CC NAUTMI_PER_FT

If either of the bearings exceed 360°, they shall be reduced by 360°:

If PRI_BEAR > 360, PRI_BEAR = PRI_BEAR - 360

If SEC_BEAR > 360, SEC_BEAR = SEC_BEAR - 360

In order to compute the glideslope deviation, the reference altitude HREF is first calculated. This altitude is related to the ground distance (R) from the vehicle position to the MEP along the selected path:

R = RANGE_FT + X_GSI + DELX_MEP - X_WP2

Two different polynominal expressions are employed depending on the relative distance (DR) from a predetermined distance (CUBRC) from the MEP

$$DR = R - CUBRC(IGS)$$

If DR < 0, then the expression for HREF is given by a cubic in R

$$HREF = C0(IGS,1) + C1(IGS,1)\ R + C2(IGS,1)\ R^2 + C3(IGS,1)\ R^3$$

where C0, C1, C2, C3 are premission constants and depend on the glideslope index. If DR > 0, then the expression for HREF is given by a cubic in DR

$$HREF = C0(IGS,2) + C1(IGS,2)\ DR + C2(IGS,2)\ DR^2 + C3(IGS,2)\ DR^3$$

where C0, C1, C2, C3 are premission constants and depend on the glideslope index. Subsequently, the glideslope deviation is calculated:

$$GSI = H - HREF$$

B. Interface Requirements. The input and output variables are listed in tables 4.7-3 and 4.7-4. For OPS-3, the vehicle mass is obtained from the DEORB Guidance principal function (4.209), while for OPS-6 it is obtained from a premission value defined by the guidance. Targeting parameters, which may be mission dependent or design dependent, are defined by the appropriate guidance principal function; those parameters which are used by AREA NAV are shown in tables 4.7-2 for ENTRY (OPS-3); this table shows the correspondence between AREA NAV symbols and the guidance symbols (FSSR names). Section 9 (Initialization for OPS-3 navigation parameters) contains the table of initialization parameters for AREA NAV; these are now compatible with those provided in the Guidance FSSRs.

Interfacing between the submodules of the HSI computation function may consist of call/assign lists, name-scoping rules of HAL-structured programming, or other available techniques.

C. Processing Requirements. The left side (commander's) HSI and its associated switches will be independent of those on the right side (pilot's); thus, the HSI computations must be performed for each display. Crew interface inputs via spec functions, however, effect both displays.

It is required that all floating-point computations be in single precision to provide adequate computational speed.

D. Constraints. Computation rates will be dependent on requirements for the dedicated instrument drive rates and must be compatible with the independence of the right and left HSI requirements. There will be provision in this function to inhibit the processing of data if the sensor range or azimuth comm fault/lock-on flags indicate bad data. The HSI flags will provide an indication to the crew that the data may not be valid. These flags may be used as a cue to the crew that another receiver or source might be advisable.

Navigation state, TACAN, and MLS sensor measurements must be in appropriate sequence to ensure HSI input data availability when the GPC operation (navigation filter, etc.) is using other sources (e.g., provide TACAN for HSI while nav state is using MLS data).

Prior to activating area navigation, ENTRY Site Lookup (section 4.5.2) is required to have been performed for primary and secondary runways as well as for all TACAN ground stations currently tuned by the TACAN receivers.

E. Supplementary Information. A suggested implementation of the area navigation computation function may be found in appendix D in the detailed flow charts.

The course deviation (CDI) and glideslope deviation (GSI) outputs from area navigation are utilized to drive "fly to" indicators on the HSI. Thus, a positive course deviation output will correspond to a "fly right" indication to the crew and a positive glideslope deviation output will correspond to a "fly down" indication to the crew.

TABLE 4.7-1.- HSI DISPLAY PARAMETER/MODE SWITCH MATRIX

	HSI Output Identity						
Display Mode	Primary Bearing	Primary Miles	Secondary Bearing	Secondary Miles	Course Deviation (CDI)	Glideslope Deviation (GSI)	Compass Card (Heading)
ENTRY	Spherical bearing to WP-1 for NEP at primary landing runway	Spherical surface range to WP-2 on primary runway via WP-1 for NEP (LSB = 1 n. mi.)	Spherical bearing to WP-1 for NEP at secondary landing runway	Spherical surface range to WP-2 on secondary runway via WP-1 for NEP (LSB = 1 n. mi.)	A valid software zero	Not computed GSI_FLAG set invalid	Magnetic heading of vehicle relative velocity vector
TAEM	Bearing to WP-1 on selected HAC for primary runway	Horizontal distance to WP-2 on primary runway via WP-1 for EP selected (LSB = 1/10 n. mi.)	Bearing to center of selected HAC for primary runway	Horizontal distance to center of selected HAC for primary runway (LSB = 1/10 n. mi.)	Deviation from extended runway centerline (Fullscale =±10 deg)	Deviation from TAEM reference altitude (Full scale = ±5000 ft)	Magnetic heading of body X-axis
A/L	Bearing to WP-2 at primary runway	Horizontal distance to WP-2 on primary runway (LSB = 1/10 n. mi.)	Bearing to WP-2 at primary runway (same as primary bearing)	Horizontal distance to WP-2 on primary runway (same as primary miles) (LSB = 1/10 n. mi.)	Deviation from extended runway centerline (Fullscale = ±2.5 deg)	Deviation from steep glide path; not computed for altitude less than prescribed value (Full Scale = ±1000 ft)	Magnetic heading of body X-axis

TABLE 4.7-2.- CORRESPONDENCE OF ENTRY AREA NAVIGATION MISSION DEPENDENT PARAMETERS AND TAEM & A/L GUIDANCE (4.9 & 4.10) PARAMETERS

M/S ID	Description	Area NAV Symbol	GUID Symbol	Type	Precision	Range	Units	Rate
	Coefficients used in cubic for the reference altitude versus range	CO(I,1)* CO(I,2)	HALI(I) PBHC(I)	ARR	S		ft	1.04
	Coefficients used in cubic for the reference altitude versus range	C1(I,1) C1(I,2)	-TGGS(I) PBGC(I)	ARR	S		--	1.04
	Coefficients used in cubic for the reference altitude versus range	C2(I,1) C2(I,2)	CUBIC_C3 (I) 0.0	ARR	S		ft^{-1}	1.04
	Coefficients used in cubic for the reference altitude versus range	C3(I,1) C3(I,2)	CUBIC_C4 (I) 0.0	ARR	S		ft^{-2}	1.04
	Distance between the MEP and the transition point for two analytical expressions for the reference altitude versus range for the low mass vehicle (I=1), or the high mass vehicle (I=2)	CUBRC(I)	PBRC(I)	ARR	S		ft	1.04
	Reference altitude evaluated at the NEP for low mass vehicle (I=1) or the high mass vehicle (I=2): used to compute distance to HAC	HCO(I)	HFTC(I)	ARR	S		ft	1.04
	Distance from threshold to WP2	X_WP2	X_AIM_PT	F	S		ft	1.04

*I refers to low or high vehicle mass.

TABLE 4.7-2.- Concluded

MS/ID	Description	Area NAV Symbol	GUID symbol	Type	Precision	Range	Units	Rate
	Boundary between high vehicle mass and low vehicle mass	M_GSI	WT_GSI	F	S		slugs	1.04
	Glideslope intercept point on extended runway centerline for high wind condition	X_GSI_HI_WIND	XA(2)	F	S		ft	1.04
	Glideslope intercept point on extended runway centerline for low wind condition	X_GSI_NOMINAL	XA(1)	F	S		ft	1.04
	Radius of the entry heading alignment circle	RADIUS_EP	RTURN	F	S		ft	1.04

TABLE 4.7-3.- AREA NAVIGATION INPUT PARAMETERS

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Baro data good flag	ALT_DG	*	D				1.04
Altitude above reference ellipsoid of runway reference point	ALT_RW	*	F	S		ft	1.04
Altitude above reference ellipsoid TACAN station obtained from Site Lookup for N'th receiver	ALT_TACAN_SL(N)	*	V	S		ft	1.04
Altitude of orbiter cg (entry) or rear wheels (TAEM A/L) above runway altitude	ALT_WHEELS	*	F	S		ft	1.04
Angle of magnetic variation from true north at selected runway	ANGLE_CORR_ TNTOMAG_RW	*	F	S		rad	1.04
Angle of magnetic variation from true north at selected secondary runway	ANGLE_CORR_ TNTOMAG_RW_SEC	*	F	S		rad	1.04
Variation of magnetic north from true north at TACAN site obtained from site lookup for N'th receiver	ANGLE_CORR_ TNTOMAG_SL(N)	*	V	S		rad	1.04
Bearing from true north of runway coordinate system +X-axis	AZIMUTH_RW	*	F	S		rad	1.04
Azimuth of secondary runway measured from true north	AZIMUTH_RW_SEC	*	F	S		rad	1.04
Coefficients used in cubic for the reference altitude versus range	CO(1,1) (1,2) (2,2) (2,2)	Mission depen-dent	ARR	S		ft	1.04

*See Principal Functions Input List, appendix G.

TABLE 4.7-3.- Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Coefficients used in cubic for the reference altitude versus range	C1(1,1) (1,2) (2,1) (2,2)	Mission dependent	ARR	S		-	1.04
Coefficients used in cubic for the reference altitude versus range	C2(1,1) (1,2) (2,1) (2,2)	Mission dependent	Arr	S		ft^{-1}	1.04
Coefficients used in cubic for the reference altitude versus range	C3(1,1) (1,2) (2,1) (2,2)	Mission dependent	Arr	S		ft^{-2}	1.04
Distance used in selecting which of two reference altitude versus range expressions is used	CUBRC(1) (2)	Mission dependent	Arr	S		ft	1.04
Conversion factor from radians to degrees	DEG_PER_RAD	Constant	F	S			1.04
Altitude of mean sea level above reference ellipsoid at runway	DELH_MSL_ ELLIPSOID_RW	*	F	S		ft	1.04
Altitude of mean sea level above reference ellipsoid at TACAN station obtained from site lookup for N'th receiver	DH_TACAN_SL(N)	*	V	S		ft	1.04
Reference altitude evaluated at the NEP for low mass vehicle (I=1) or high mass vehicle (I=2)	HCO(1) (2)	Mission dependent	Arr	S		ft	1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3.- Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Altitude for terminating calculation of glide slope deviation	H_GSI_SHALLOW	Design dependent	F	S		ft	1.04
Flag denoting high or low winds at runway	HI_WINDS	*	D		ON/OFF		1.04
Baro altitude obtained from the air data SOP	HPC	*	F	S		ft	1.04
Earth-fixed to prime RW transformation matrix	M_EFTORW	*	M	S			1.04
Transformation matrix from earth-fixed to secondary runway	M_EFTORW_SEC	*	M	S			1.04
Vehicle mass	M	Mission dependent	F	S		Slugs	1.04
Boundary between high vehicle mass and low vehicle mass	M_GSI	Mission dependent	F	S		Slugs	1.04
Transformation matrix from earth-fixed to topodetic coordinates at TACAN site obtained from Site Look-up for N'th receiver	M_EFTOTD_TACAN_SL(N)	*	M	S			1.04
Indicates setting of display mode switch (entry, TAEM or land) for left-side HSI	MODE_LEFT	*	Char	S			1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3.- Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Indicates setting of display mode switch (entry, TAEM or land) for right-side HSI	MODE_RIGHT	*	Char	S			1.04
MSBLS azimuth comm fault/lock-on flag for selected receiver, N = 1,3	MAZM_CMLK(N)	*	D				1.04
MSBLS azimuth for the selected receiver, N = 1,3	MSBAZIMO(N)	*	F	S		rad	1.04
MSBLS elevation comm fault/lock-on flag for selected receiver, N = 1,3	MELV_CMLK(N)	*	D				1.04
Major mode 304 flag	MM_CODE_304	*	D		ON/OFF		1.04
MSBLS elevation for the selected receiver, N = 1,3	MSBELEVO(N)	*	F	S		rad	1.04
MSBLS range comm fault/lock-on flag for the selected receiver, N = 1,3	MRNG_CMLK(N)	*	D				1.04
Flag denoting switch from NEP to MEP circle	NEP	*	D		OFF/ON		1.04
Vehicle position vector WRT runway reference point ($\underline{R}$ _LS_EF)	POSITION_WRT_ RUNWAY	*	V	S		ft	1.04
Angle between mag north and Shuttle X-axis	PSI_HSIMV	*	F	S		rad	1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3.- Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate/sec
Indicates setting of string selection switch (when source in MSBLS or TACAN) on left-side HSI	RCVR_LEFT	*	I	S			1.04
Indicates setting of string selection switch (when source in MSBLS or TACAN) on right-side HSI.	RCVR_RIGHT	*	I	S			1.04
Position vector of the HAC center on the left side (-Y) of the runway centerline	R _CC_L_PRI	*	V	S		ft	1.04
Magnitude of the vector R _CC_L_PRI	R_CC_LMAG_PRI	*	F	S		ft	1.04
Position vector of the HAC center on the left side (-Y) of the secondary runway centerline	R _CC_L_SEC	*	V	S		ft	1.04
Magnitude of the vector R _CC_L_SEC	R_CC_LMAG_SEC	*	F	S		ft	1.04
Position vector of the HAC center on the right side (+Y) of the runway centerline	R _CC_R_PRI	*	V	S		ft	1.04
Magnitude of the vector R _CC_R_PRI	R_CC_RMAG_PRI	*	F	S		ft	1.04
Position vector of the HAC center on the right side (+Y) of the secondary runway centerline	R _CC_R_SEC	*	V	S		ft	1.04
Magnitude of the vector R _CC_R_SEC	R_CC_RMAG_SEC	*	F	S		ft	1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3. Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Radius of the heading alignment circle	RADIUS_EP	Mission dependent	F	S		ft	1.04
Geodetic radius of mean sea level at TACAN site to which the N'th TACAN receiver is tuned	RD_TAC_SL(N)	*	F	S		ft	1.04
Shuttle position vector in Earth-fixed coordinates	R_EF	*	V	DP		ft	1.04
Position vector of runway in Earth-fixed coordinates	R_LS_EF	*	V	DP		ft	1.04
Earth-fixed position vector of secondary runway threshold	R_LS_EF_SEC	*	V	DP		ft	1.04
TACAN station Earth-fixed position vector obtained from Site Lookup for N'th receiver	R_TACAN_EF_SL(N)	*	V	S		ft	1.04
Indicates which data source (MSBLS, TACAN, or NAV) switch is on for left-side HSI	SOURCE_LEFT	*	Char	S			1.04
Indicates which data source (MSBLS, TACAN, or NAV) switch is on for right-side HSI	SOURCE_RIGHT	*	Char	S			1.04
TACAN bearing data obtained from the SOP for each receiver, I = 1,3	TACBEARO(I)	*	F	S		rad	1.04
TACAN azimuth comm fault/lock-on flag for the I'th receiver, I = 1,3	TBRG_CMLK(I)	*	D				1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3.- Continued

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Switch indicating (ON) a valid TACAN channel has been selected (Site Look-up output)	TAC_CHAN_VALID_SL(I)	*	D				1.04
TACAN range comm fault/lock-on flag for the I-th receiver, I = 1,3	TRNG_CMLK(I)	*	D				1.04
TACAN range data obtained from the SOP for each receiver, I = 1,3	TACRANGEO(I)	*	F	S		ft	1.04
Vehicle relative velocity vector in Earth-fixed coordinates	V _RHO_EF	*	V	S		ft/sec	1.04
X component of range/azimuth antenna in runway coordinates	X_DMEAZ_RW	*	F	S		ft	1.04
X component of elevation antenna - RW coordinates	X_EL_RW	*	F	S		ft	1.04
Glideslope intercept point on extended runway centerline for high wind condition	X_GSI_HI_WIND	Mission dependent	F	S		ft	1.04
Glideslope intercept point on extended runway centerline for low wind condition	X_GSI_NOMINAL	Mission dependent	F	S		ft	1.04
X-distance from RW threshold to HAC, used in ENTRY display mode	X_NEP	Design dependent	F	S		ft	1.04
Runway X-component of WP2	X_WP2	Mission dependent	F	S		ft	1.04

*See Principal Function Input List, appendix G.

TABLE 4.7-3.- Concluded

Description	Level C Symbol	Input Source	Type	Precision	Range	Units	Sample rate
Y component of range/azimuth antenna in runway coordinates	Y_DMEAZ_RW	*	F	S		ft	1.04

*See Principal Function Input List, Appendix G.

TABLE 4.7.4.- AREA NAVIGATION OUTPUT PARAMETERS

Description	Level C Symbol	Output Destination	Type	Precision	Range	Units	Comp rate
HSI data validity flag	BRG_FLAG_LEFT	*	D				1.04
HSI data validity flag	BRG_FLAG_RIGHT	*	D				1.04
HSI data validity flag	CDI_FLAG_LEFT	*	D				1.04
HSI data validity flag	CDI_FLAG_RIGHT	*	D				1.04
Course deviation from the extended runway center line	CDI_LEFT	*	F	S		deg	1.04
Course deviation from the extended runway center line	CDI_RIGHT	*	F	S		deg	1.04
HSI data validity flag	GSI_FLAG_LEFT	*	D				1.04
HSI data validity flag	GSI_FLAG_RIGHT	*	D				1.04
Glide slope deviation for primary runway	GSI_LEFT	*	F	S		ft	1.04
Glide slope deviation for primary runway	GSI_RIGHT	*	F	S		ft	1.04
Heading of relative velocity vector (entry) or of body X-axis (TAEM or A/L)	HEADING_LEFT	*	F	S		deg	1.04
Heading of relative velocity vector (entry) or of body X-axis (TAEM or A/L)	HEADING_RIGHT	*	F	S		deg	1.04

*See Principal Function Output List, appendix G.

TABLE 4.7.4.- Continued

Description	Level C Symbol	Output Destination	Type	Precision	Range	Units	Comp rate
Primary bearing (to WP1_ENTRY and TAEM, to WP2-LAND)	PRIBEAR_LEFT	*	F	S		deg	1.04
Primary bearing (to WP1_ENTRY and TAEM, to WP2_LAND)	PRIBEAR_RIGHT	*	F	S		deg	1.04
Primary range to WP2 (via WP1_ENTRY and TAEM, DIRECT_LAND)	PRIRANGE_LEFT	*	F	S		nm	1.04
Primary range to WP2 (via WP1_ENTRY and TAEM, DIRECT_LAND)	PRIRANGE_RIGHT	*	F	S		nm	1.04
Bearing from Shuttle to WP1 for secondary RUNWAY_ENTRY; bearing from Shuttle to center of selected HAC for primary RUNWAY_TAEM	SECBEAR_LEFT	*	F	S		deg	1.04
Bearing from Shuttle to WP1 for secondary RUNWAY_ENTRY; bearing from Shuttle to center of selected HAC for primary RUNWAY_TAEM	SECBEAR_RIGHT	*	F	S		deg	1.04
Secondary range to WP2 via WP1_ENTRY and DIRECT_LAND; horizontal distance to center of selected HAC for primary RUNWAY_TAEM	SECRANGE_LEFT_	*	F	S		nm	1.04
Secondary range to WP2 via WP1_ENTRY and DIRECT_LAND; horizontal distance to center of selected HAC for primary RUNWAY_TAEM	SECRANGE_RIGHT	*	F	S		nm	1.04

*See principal function output list, appendix G.

TABLE 4.7.4.- Concluded

Description	Level C Symbol	Output Destination	Type	Precision	Range	Units	Comp rate
Heading valid flag for left-side HSI	HDG_FLAG_LEFT	*					1.04
Heading valid flag for right-side HSI	HDG_FLAG_RIGHT	*					1.04

*See Principal Function Output List, appendix G.

CDR CONTROLS

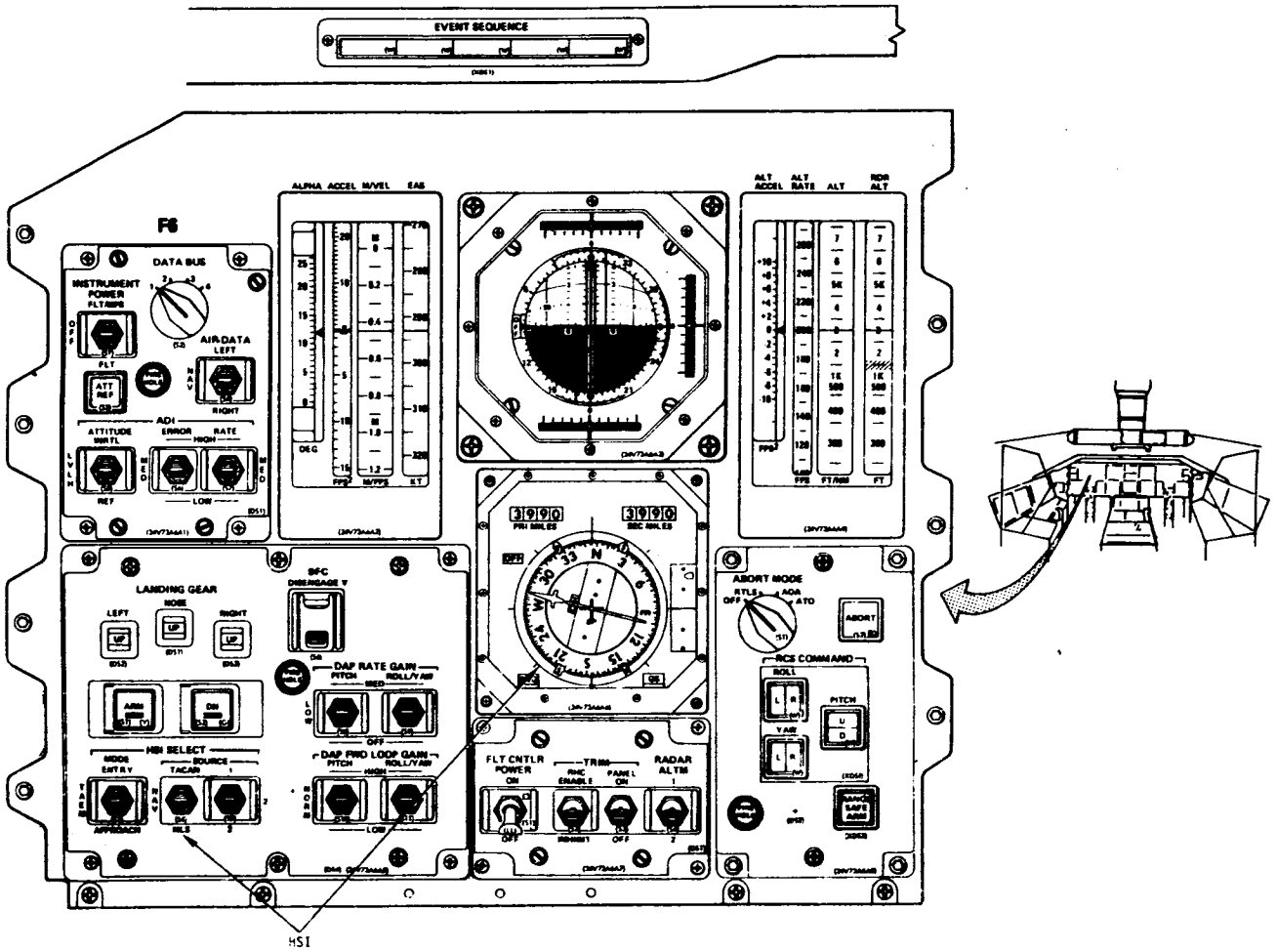


Figure 4 7-1.- Left-hand forward flight station.

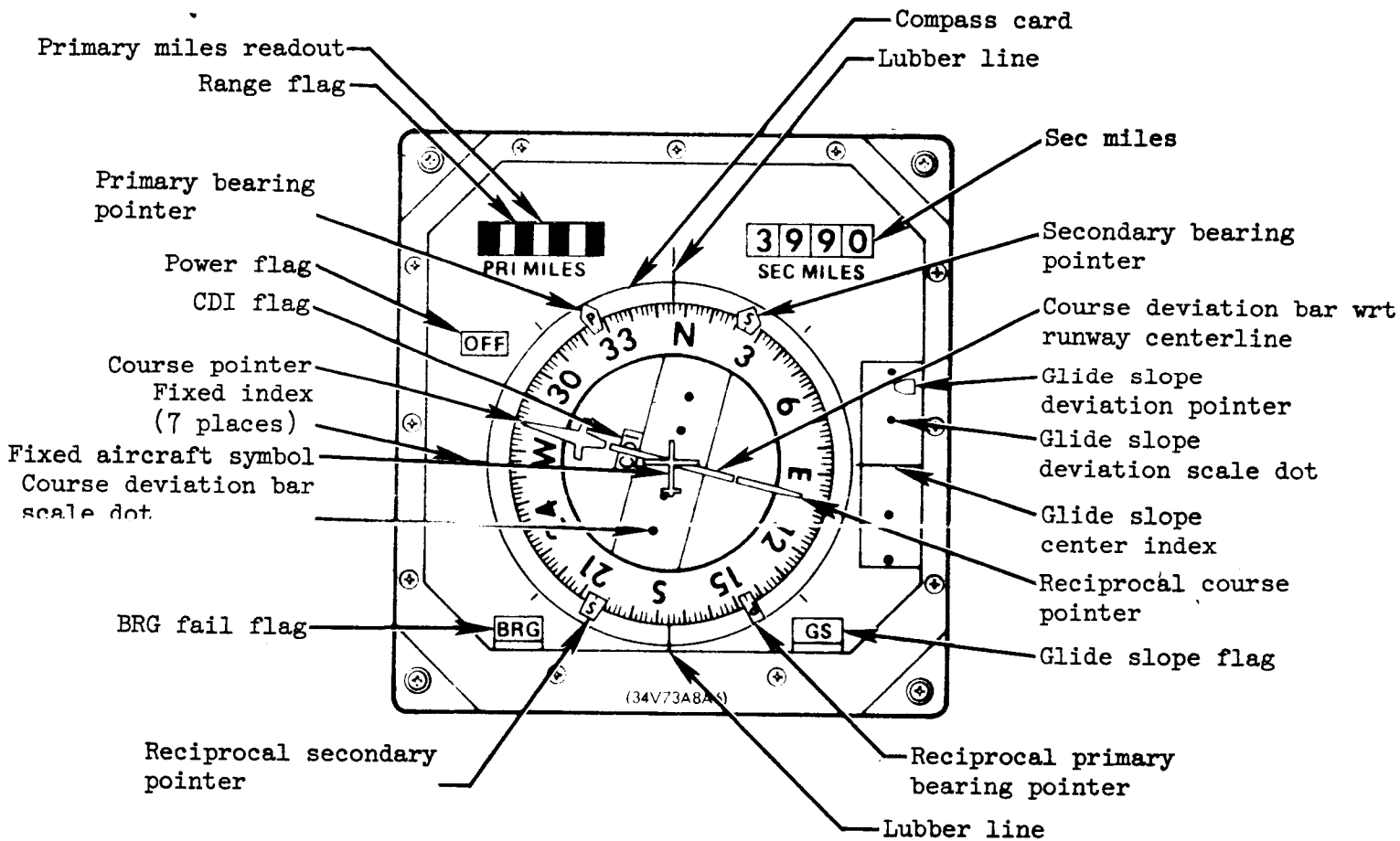


Figure 4.7-2.- HSI display.

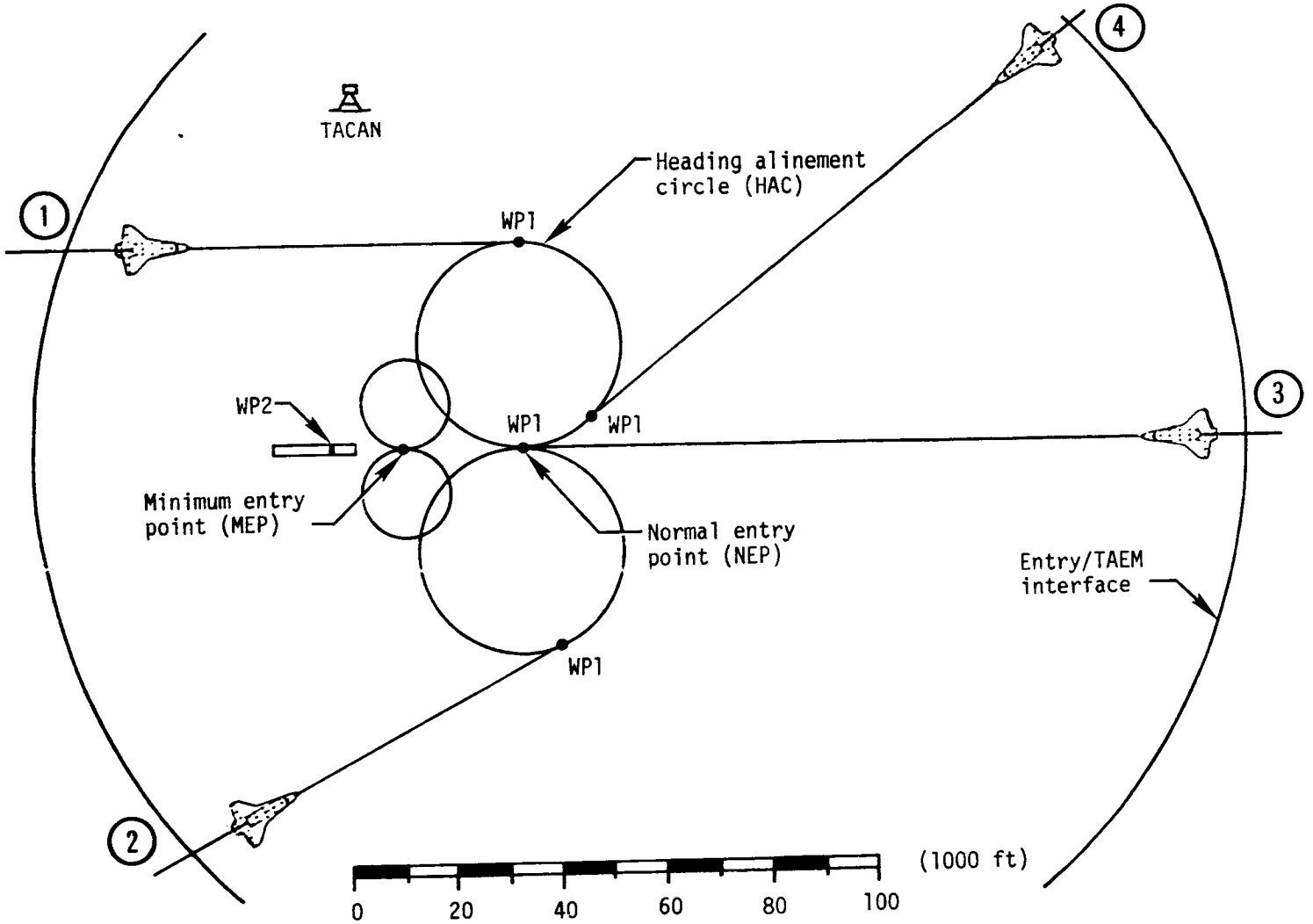


Figure 4.7-3.- Flightpath geometry plane.

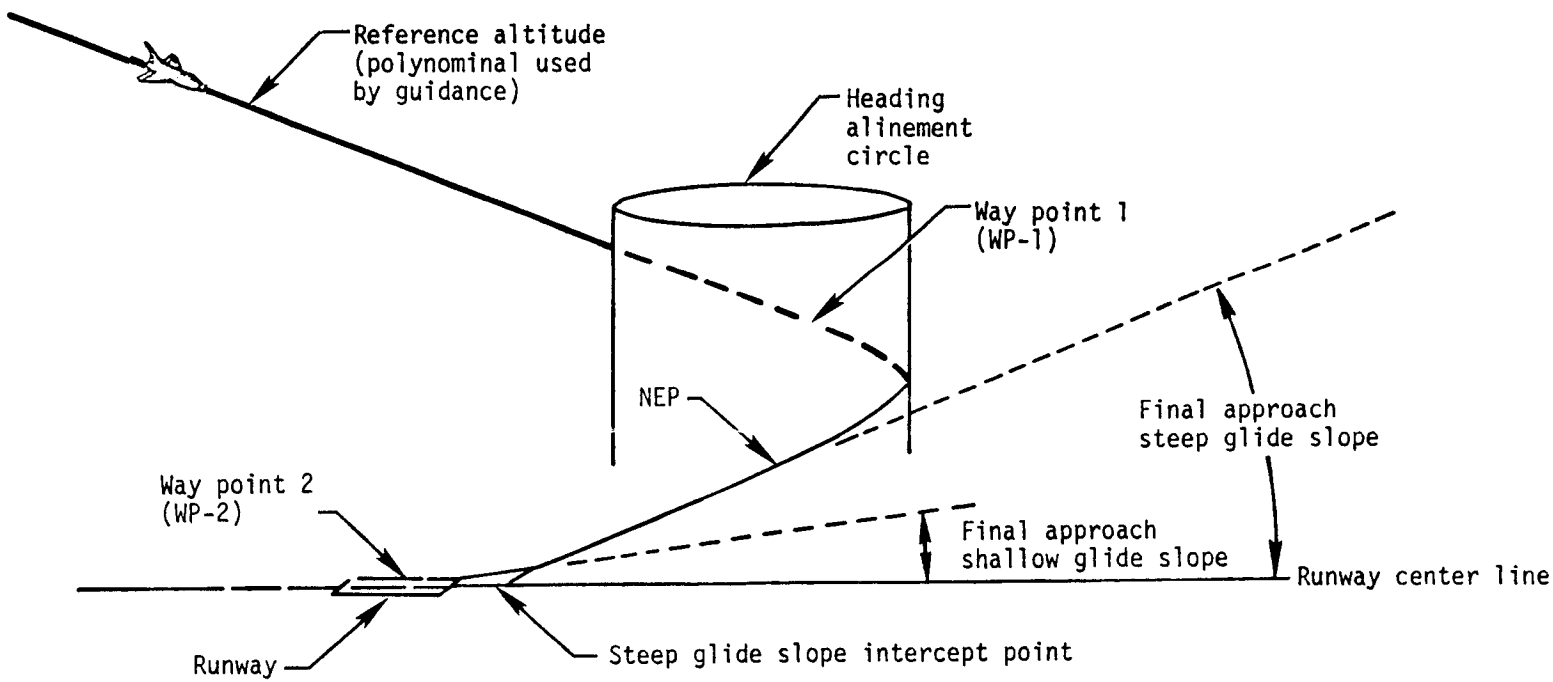


Figure 4.7-4.- Flightpath geometry - vertical.

4.8 SPECIALIST FUNCTIONS NAVIGATION SUPPORT FORMULATIONS (RUNWAY REDESIGNATION)

This section describes noncyclic navigation processing and data transfer required for the navigation system to respond to crew controls and data entered at the display keyboard, via a specialist function, and to provide the software support associated with that specialist function. Output from these formulations is not uniquely generated for the navigation system. Specialist functions navigation support formulations consist of the formulations required for prime runway redesignation.

The capability for redesignation of the prime landing site shall be provided via the horizontal situation display (HSD) specialist function, which invokes the runway redesignation subfunction (RUNWAY_REDESIGNATE). This action will cause the runway/MSBLS site lookup subfunction (section 4.5.2.1) to be invoked and update the corresponding prime runway site parameters needed by common users.

A. Detailed Requirements. The runway designation subfunction will be invoked by the HSD specialist function after input of a new prime runway selection from the three designated runway sites (primary, secondary, and alternate) available from the HSD specialist function. Input from the HSD specialist function will consist of a prime runway index number from 1 to 3. The prime runway index number (PRIME_RUNWAY_INDEX) input to the runway redesignation subfunction will be interpreted by the runway redesignation and runway/MSBLS site lookup subfunctions as follows:

PRIME_RUNWAY_INDEX value	Action
1	Redesignate primary runway selection as prime
2	Redesignate secondary runway selection as prime
3	Redesignate alternate runway selection as prime

The runway/MSBLs site lookup subfunction will then be called with this input number, and the redesignated prime runway associated parameters will be computed and stored as shown in the runway site lookup output table (4.5.2.1-2). Only the prime runway may be redesignated.

B. Interface Requirements. Input and output parameters for this subfunction are shown in tables 4.8-1 and 4.8-2.

C. Processing Requirements. Runway redesignation functions will only be accomplished by invoking the runway designation subfunction; and thereby the runway site lookup subfunction is exercised.

D. Constraints. The runway redesignation subfunction requires that a valid prime runway index number (PRIME_RUNWAY_INDEX) be transmitted by the HSD specialist function. No error checking is performed by the runway redesignation subfunction.

E. Supplemental Information. A suggested implementation for the runway redesignation subfunction is presented in appendix E.

TABLE 4.8-1.- RUNWAY REDESIGNATE INPUT PARAMETERS

Description	Symbol	Input sources	Type	Precision	Range	Units	Sample rate
Current prime landing site selection	PRIME_RUNWAY_ INDEX	Horizontal situation display spec. function	I	S	1-3		As needed

TABLE 4.8-2.- RUNWAY REDESIGNATE OUTPUT PARAMETERS

Description	Symbol	Output Destination	Type	Precision	Range	Units	Sample rate
Current prime landing site selection	PRIME_RUNWAY_INDEX	Runway/MSBLS site lookup	I	S	1-3		As needed

4.9 INITIALIZATION OF SPECIFIC OPS 3 NAVIGATION PARAMETERS

It is required that initial values for parameters be made available for use by the navigation flight software. These parameters can be divided into four categories:

1. Constants - those parameters with values that are not mission-related nor design dependent. These parameters and values are defined in Level A CPDS (SS-P-0002-170D).

2. Mission dependent parameters - those parameters with values that may change from mission to mission. The values of these parameters are defined in the I-Loads FSSR (SS-P-0002-195).

3. Design dependent parameters - those parameters whose values are considered to be a part of the software design. These parameters and values are defined in this book.

4. Hard codeable parameters - those parameters whose values must be defined but are neither mission dependent nor design dependent and are not defined by the Level A CPDS.

4.9.1 Constants

These parameters and their values are defined in the Level A CPDS. Table 4.9.1-1 is a list of those constants (with descriptions) required by the OPS 3 navigation flight software.

TABLE 4.9.1-1.- CONSTANTS

Parameter	Data Type	Precision	Definition
C_I, I = 1,9	Arr	DP	Tesseral harmonic coefficients
DEG_PER_RAD	F	S	Conversion factor, radians per degree
EARTH_MU	F	DP	Earth gravitational constant
EARTH_POLE	V(3)	S	Unit vector in direction of Earth's axis of rotation
EARTH_RADIUS_EQUATOR	F	DP	Earth equatorial radius
EARTH_RADIUS_GRAV	F	DP	Earth radius (gravitational acceleration model)
EARTH_RATE	F	DP	Earth rotational rate
ELLIPT	F	DP	Earth ellipticity constant
NAUTMI_PER_FT	F	S	Feet to nautical miles conversion factor
PI	F	S	The constant PI
RAD_PER_DEG	F	S	Number of radians per degree
S_I, I = 1,9	Arr	DP	Tesseral harmonic coefficients
$ZONAL_I$, I = 1,4	Arr	DP	Zonal harmonic coefficients

4.9.2 Mission Dependent Parameters

These parameters and their values are defined in the I-Loads FSSR (SS-P-0002-195). Table 4.9.2-1 is a list of the mission dependent parameters (with descriptions) required by the OPS 3 navigation flight software.

TABLE 4.9.2-1.- MISSION DEPENDENT PARAMETERS

Parameter	Units	Data type	Precision	Definition
NAVIGATION RELATED PARAMETERS				
BASE_DEN	slugs/ft^3	Arr	DP	Array of base densities for each layer used to model drag
BIAS_DRAG_LAYER	ft	Arr	S	Array of deterministic drag biases for each layer
C_DRAG_ONE	rad^{-1}	F	S	Polynomial terms for computing drag coefficient as function of angle of attack
C_DRAG_TWO	rad^{-2}	F	S	Polynomial terms for computing drag coefficient as function of angle of attack
C_DRAG_ZERO	--	F	S	Polynomial terms for computing drag coefficient as function of angle of attack
DENSITY_LIMIT	ft	Arr	S	Base altitudes for drag model atmospheric layers
DRAG_CONST	ft^2/slug	F	S	Drag constant equal to vehicle reference area divided by twice the vehicle mass, for Entry operations

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
NAVIGATION RELATED PARAMETERS (Continued)				
K_EDIT_BARO	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for barometric altimeter and drag measurement
K_EDIT_DRAG	--	F	S	
K_EDIT_MLSAZ	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for MSBLS azimuth, MSBLS elevation, and MSBLS measurements
K_EDIT_MLSEL	--	F	S	
K_EDIT_MLSR	--	F	S	
K_EDIT_TACBR	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for TACAN bearing and TACAN range measurements
K_EDIT_TACR	--	F	S	
K_UND_WGT	--	F	S	Scale factor used in measurement under weighting equation
M_M50TOEF_AT_EPOCH*	--	M(3)	S	Transformation matrix from M50 to earth-fixed coordinates at T_EPOCH
SCALE_HT	ft	Arr	S	Array of scale weights for each layer to model drag
REF_AREA	ft^2	F	S	Orbiter reference area

*I-LOADS for principal functions 4.15 and 4.205 in memory configuration (MC) 1; carried across subsequent computer memory reconfigurations without alteration.

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
NAVIGATION RELATED PARAMETERS (Concluded)				
T_EPOCH*	sec	F	DP	Time tag for and M_M50TOEF_AT_EPOCH
ACCELERATION MODEL PARAMETERS				
DENSE	Various	Arr	S	Density model constants
SEA_LEVEL_DENSITY	slugs/ft^3	F	S	Sea level atmospheric density
USER PARAMETER PROCESSING PARAMETERS				
RADIUS_NEP	ft	F	S	Radius of nominal entry point heading alignment circle
R _HAC_RW	ft	V(3)	S	Position vector of HAC center in runway coordinates
X_NB_CG	ft	F	S	X_STRUCT_BODY distance from navigation base to cg
X_NEP	ft	F	S	Runway X-component of the HAC center
Z_NB_CG	ft	F	S	Z_STRUCT_BODY distance from cg to navigation base

*I-LOADS for principal functions 4.15 and 4.205 in memory configuration (MC) 1; carried across subsequent computer memory reconfigurations without alteration.

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
AREA NAVIGATION PARAMETERS				
C0	ft	Arr	S	Coefficients used in cubic for the reference altitude versus range
C1	--	Arr	S	Coefficients used in cubic for the reference altitude versus range
C2	ft^{-1}	Arr	S	Coefficients used in cubic for the reference altitude versus range
C3	ft^{-2}	Arr	S	Coefficients used in cubic for the reference altitude versus range
CUBRC	ft	Arr	S	Distance between the MEP and the transition point for two analytical expressions for the reference altitude versus range for the low mass vehicle (I=1) or the high mass vehicle (I=2)
HCO	ft	Arr	S	Reference altitude evaluated at the NEP for the low mass vehicle (I=1) or the high mass vehicle (I=2)
M_GSI	slugs	F	S	Boundary between high vehicle mass and low vehicle mass
RADIUS_EP	ft	F	S	Radius of the entry heading alignment circle
X_GSI_HI_WIND	ft	F	S	Glideslope intercept point on extended runway centerline for high wind conditions

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
AREA NAVIGATION PARAMETERS (Continued)				
X_GSI_NOMINAL	ft	F	S	Glideslope intercept point on extended runway centerline for low wind conditions
X_WP2	ft	F	S	Runway X-component of WP2
SITE LOOKUP PARAMETERS				
ALT_ABOVE_ELLIPSOID	ft	Arr	S	Altitudes of the TACAN stations above the reference ellipsoid
ALT_MLSEL_PSL	ft	F	S	Altitudes of MSBLS elevation scanner above reference ellipsoid for designated prime and secondary landing sites
ALT_MLSEL_SSL	ft	F	S	
ALT_MLS_R_AZ_PSL	ft	F	S	Altitudes of MSBLS range/azimuth scanner above reference ellipsoid for designated prime and secondary landing sites
ALT_MLS_R_AZ_SSL	ft	F	S	
BIAS_AZMLS_PSL	rad	F	S	Initial MSBLS azimuth antenna measurement biases for prime and secondary landing sites
BIAS_AZMLS_SSL	rad	F	S	
BIAS_ELMLS_PSL	rad	F	S	Initial MSBLS elevation antenna measurement biases for prime and secondary landing sites
BIAS_ELMLS_SSL	rad	F	S	

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
SITE LOOKUP PARAMETERS (Continued)				
BIAS_MLSRANGE_PSL	ft	F	S	Initial MSBLS range antenna measurement biases for prime and secondary landing sites
BIAS_MLSRANGE_SSL	ft	F	S	
BIAS_TAC_BRG	rad	Arr	S	Array of biases in the bearing transmitted by the TACAN ground stations
BIAS_TAC_R	ft	Arr	S	Array of biases in the range measurements obtained from TACAN ground stations
EL_SCANNER_BEARING_PSL	rad	F	S	Bearing from true north of MSBLS elevation scanner site for designated prime and secondary landing sites
EL_SCANNER_BEARING_SSL	rad	F	S	
LATITUDE_GEODETIC	rad	Arr	S	Geodetic latitudes of the TACAN stations
LAT_MLSEL_PSL	rad	F	S	Latitude of MSBLS elevation scanner site for designated prime and secondary landing sites
LAT_MLSEL_SSL	rad	F	S	
LAT_MLS_R_AZ_PSL	rad	F	S	Latitude of MSBLS range/azimuth scanner site for designated prime and secondary landing sites
LAT_MLS_R_AZ_SSL	rad	F	S	
LONGITUDE_EAST	rad	Arr	S	Longitudes of the TACAN stations
LONG_MLSEL_PSL	rad	F	S	Longitude of MSBLS elevation scanner site for designated prime and secondary

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
LONG_MLSEL_SSL	rad	F	S	landing sites
LONG_MLS_R_AZ_PSL	rad	F	S	Longitude of MSBLS range/azimuth scanner site for designated prime and secondary landing sites
LONG_MLS_R_AZ_SSL	rad	F	S	
MAGNETIC_VARIATION	rad	Arr	S	Angle between true north and magnetic north at the TACAN stations
MLS_AVAIL_PSL	--	D	--	MSBLS data availability flag for designated prime and secondary landing sites
MLS_AVAIL_SSL	--	D	--	
MSL_ABOVE_ELLIPSOID	ft	Arr		The difference of an altitude above the reference ellipsoid and that altitude above mean sea level or geoid.
R_AZ_RADAR_BEARING_PSL	rad	F	S	Bearing from true north of MSBLS range/azimuth scanner site for designated prime and secondary landing sites
R_AZ_RADAR_BEARING_SSL	rad	F	S	
RUNWAY_ALT_PSL	ft	F	S	Altitude of runway reference point above reference ellipsoid for designated prime, secondary, and alternate landing sites, respectively
RUNWAY_ALT_SSL	ft	F	S	
RUNWAY_ALT_ASL	ft	F	S	
RUNWAY_NAME_PSL	--	CHAR	--	Landing site selection symbol for designated prime, secondary, and alternate landing sites, respectively
RUNWAY_NAME_SSL	--	CHAR	--	
RUNWAY_NAME_ASL	--	CHAR	--	

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
RV_MAX_CONT	ft/sec	F	S	Maximum relative velocity magnitude for baro processing associated with contingency landing site
RV_MAX_NOM	ft/sec	F	S	Maximum relative velocity magnitude for baro processing associated with nominal landing site
RW_AZIMUTH_PSL	rad	F	S	Bearing from true north of runway coordinate +X-axis at designated prime, secondary, and alternate landing sites, respectively
RW_AZIMUTH_SSL	rad	F	S	
RW_AZIMUTH_ASL	rad	F	S	
RW_DELH_PSL	ft	F	S	Altitude of mean sea level above reference ellipsoid at designated prime, secondary, and alternate landing sites, respectively
RW_DELH_SSL	ft	F	S	
RW_DELH_ASL	ft	F	S	
RW_LAT_PSL	rad	F	S	Geodetic latitude of runway reference point at designated prime, secondary, and alternate landing sites, respectively
RW_LAT_SSL	rad	F	S	
RW_LAT_ASL	rad	F	S	
RW_LON_PSL	rad	F	S	Longitude of runway reference point at designated prime, secondary, and alternate landing sites, respectively
RW_LON_SSL	rad	F	S	
RW_LON_ASL	rad	F	S	
RW_MAG_VAR_PSL	rad	F	S	Variation of magnetic north from true north at designated prime, secondary, and alternate landing sites, respectively
RW_MAG_VAR_SSL	rad	F	S	

TABLE 4.9.2-1.- Concluded

Parameter	Units	Data type	Precision	Definition
RW_MAG_VAR_ASL	rad	F	S	
TAC_ID	--	Arr	--	Array of TACAN station identifiers
VAR_H1_CONT	ft^2	F	S	Additive terms used in constructing the baro measurement variance associated with the contingency and nominal landing sites, respectively
VAR_H1_NOM	ft^2	F	S	
VAR_H2_CONT	--	F	S	Multiplicative terms used in constructing the baro measurement variance associated with the contingency and sites respectively
VAR_H2_NOM	--	F	S	
X_DMEAZ_RW_PSL	ft	F	S	X-component of range/azimuth antenna RW coordinates at designated prime and secondary landing sites
X_DMEAZ_RW_SSL	ft	F	S	
X_EL_RW_PSL	ft	F	S	X-component of elevation antenna in RW coordinates at designated prime and secondary landing sites
X_EL_RW_SSL	ft	F	S	
Y_DMEAZ_RW_PSL	ft	F	S	Y-component of range/azimuth antenna in RW coordinates at designated prime and secondary landing sites
Y_DMEAZ_RW_SSL	ft	F	S	

4.9.3 Design Dependent Parameters

Table 4.9.3-1 presents the design dependent parameters required by the OPS 3 navigation flight software and their values.

TABLE 4.9.3-1.- DESIGN DEPENDENT PARAMETERS

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
NAVIGATION RELATED PARAMETERS						
ACC_DRAG_MIN	F	S	11.	ft/sec^2	--	Minimum acceleration magnitude required for processing drag data
ACC_PROP_MIN	F	S	3.2E-2	ft/sec^2	--	Value for setting threshold for use of IMU data
ALT_EL	V	S	140000, 12000, 500	ft		Altitude regions for nev event lamp processing
BIAS_BARO	F	S	0.	ft	--	Barometric altimeter measurement bias
CORR_COEFF_INIT	Arr	S	-0.7, 0.9, -0.8, -0.8, 0.9, 0.9, -0.9	--	UVW	Correlation coefficients to initialize covariance matrix from OPS-2
CORR_COEFF_UPDATE	Arr	S	0.0, 0.9, 0.0, 0.0, 0.9, 0.9, 0.0	--	UVW	Correlation coefficients to initialize covariance matrix for delta update
CORR_COEFF_UPDATE_M50	Arr	S	0.0, 0.0, -0.9, -0.9, 0.0, 0.0, 0.0	--	UVW	Correlation coefficients to initialize covariance matrix for whole vector update
DEL_TIME_STEP	F	S	10.0	sec	--	Step size for prediction, used in Entry Precise Predictor
H_DRAG_LOW	F	S	85200.	ft	--	Altitude below which the drag data are not processed

TABLE 4.9.3-1.- Continued

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
INNER_RADIUS	F	S	4.6E4	ft		Range threshold used to determine the current TACAN region
K_MAX	I	S	2	--	--	Maximum number of edits allowed a measurement before display of edit warning
MLSANT_ANG	F	S	0.32686	rad	--	Angle between navigation base to MLS antenna vector and positive vehicle x-body axis
MLSANT_NB_DIST	F	S	13.89	ft	--	Distance from navigation base to MLS antenna
MS_POS_UND_WGT	F	S	1.0E+8	ft^2	--	Value of filter mean squared position error below which no measurement underweighting is used
N_SEQ_MAX	I	S	2	--	--	Number of sequential failures of the test criteria allowed before activating the new event lamp
OUTER_RADIUS	F	S	7.29E5	ft	--	Range threshold used to determine current TACAN region
R_AZ_COUNT_MAX	I	S	2	--	--	Prescribed number of consecutive MLS azimuth measurement data-good "fails" to force inhibit of MLS processing and allow TACAN processing
RNG_VAR_BEARING_STEP	F	S	911417.	ft	--	Range criterion used to select TACAN bearing variance

TABLE 4.9.3-1.- Continued

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
RNG_VAR_RNG_STEP	F	S	303805.	ft	--	Range criterion used to select TACAN range variance
SIG_DIAG_UPDATE	Arr	S	3000. 3000. 3000. 60. 60. 60.	ft ft ft ft/sec ft/sec ft/sec	UVW	Square root of diagonal elements for delta update covariance initialization
SIG_DIAG_UPDATE_M50	Arr	S	1000. 5000. 1000. 10. 1. 1.	ft ft ft ft/sec ft/sec ft/sec	UVW	Square root of diagonal elements for whole vector update covariance initialization
SIG_DIAG_UVW_INIT	Arr	S	2500. 3000. 7000. 5. 3. 6.	ft ft ft ft/sec ft/sec ft/sec	UVW	Square root of diagonal elements for OPS-3 covariance initialization
TACAN_BGR_CONVERG_TEST	F	S	0.01	rad^2	--	Expected bearing variance criterion to turn on TACAN RM bearing one-lock flag
TACAN_RNG_CONVERG_TEST	F	S	4.0E+7	ft^2	--	Expected range variance criterion to turn on TACAN RM range one-lock flag
TIME_BIAS_BARO	F	S	0.179	sec		Pad-loaded bias used to correct barometric time tag

TABLE 4.9.3-1.- Continued

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
TIME_BIAS_MLS	F	S	0.080	sec	--	Pad-loaded bias used to correct MSBLS time tags
TIME_BIAS_TACAN	F	S	0.029	sec		Pad-loaded bias used to correct TACAN time tags
VAR_ACC_QUANT_COAST	F	S	9.0E-5	ft^2/sec^2	--	Accelerometer quantization error variance for coasting flight
VAR_ACC_QUANT_IMU	F	S	9.0E-5	ft^2/sec^2	--	Accelerometer quantization error variance for powered flight
VAR_AZMLS	F	S	1.0E-6	rad^2	--	MSBLS azimuth measurement instrument variance
VAR_DRAG	F	S	1.0E+8	ft^2	--	Drag altitude measurement error variance
VAR_ELMLS	F	S	1.0E-6	rad^2	--	MSBLS elevation instrument variance
VAR_RMLS	F	S	575.0	ft^2	--	MSBLS range measurement instrument variance
VAR_TAC_BRG_HIGH	F	S	0.01	rad^2	--	TACAN bearing instrument variance at high range
VAR_TAC_BRG_LOW	F	S	4.9E-5	rad^2	--	TACAN bearing instrument variance at low range
VAR_TAC_R_HIGH	F	S	360000.	ft^2	--	TACAN range instrument variance at high range

TABLE 4.9.3-1.- Continued

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
VAR_TAC_R_LOW	F	S	160000.	ft^2	--	TACAN range instrument variance at low range
VAR_UNMOD_ACC_DT_COAST	F	S	0.0005	ft^2/sec^3	--	Variance of unmodeled acceleration multiplied by scale time, for coasting flight
VAR_UNMOD_ACC_DT_IMU	F	S	0.25	ft^2/sec^3	--	Variance of unmodeled acceleration multiplied by scale time, for powered flight
ACCELERATION MODEL PARAMETERS						
ALT_ZONE_CHANGE	F	S	5.0E+5	ft	--	Altitude where model for atmospheric density is changed
CDA	F	DP	0.64592	--	--	Constant used to model drag coefficient (additional corrective term)
CDF	F	DP	0.78590	--	--	Constant used to model drag coefficient (frontal area)
CDN	F	DP	2.41256	--	--	Constant used to model drag coefficient (top area correction)
CDS	F	DP	1.92837	--	--	Constant used to model drag coefficient (side area correction)
EXP_SHAPE_FACTOR	F	DP	0.65793	--	--	Exponential shaping factor for the drag coefficient model

TABLE 4.9.3-1.- Continued

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
USER PARAMETER PROCESSING PARAMETERS						
ALT_EL	V	S	140000 12000 500	ft		Altitude regions for nav event lamp processing
A3_TOL	F	S	-0.003	rad		Tolerance for correcting the radius of values for the angle A3
BIAS_RADALT	F	S	0.	ft		Radar altitude bias
LDGR_VEL_THRSH	F	S	19000.	ft/sec		Threshold value of relative velocity below which the flag LD_GR_HYDR is set ON
N_SEQ_MAX	I	S	2	--		Number of sequential failures of the test criteria allowed before activating the nav event lamp
R_GO_RAMP	F	S	-4000.	ft		Preset value of horizontal distance of vehicle from RW reference point below which radar altimeter measurements will be incorporated into altitude position WRT runway
TIME_BIAS_RADALT	F	S	0.015	sec		Pad loaded bias used to correct radar altimeter time tag
VEL_TGT_SWITCH	F	S	30000.	ft/sec		Relative velocity value below which the flag MID_TARGET is set to OFF

TABLE 4.9.3-1.- Concluded

Parameter	Data type	Precision	Value	Units	Coord Frame	Definition
VNTDR_VEL_THRSH	F	S	2400.	ft/sec		Threshold value of relative velocity below which the flag VNT_DR_SEQ_INIT is set ON
AREA NAVIGATION PARAMETERS						
H_GSI_SHALLOW	F	S	1500.	ft	--	Altitude below which shallow glide slope becomes the reference and GSI_FLAG = ON
X_NEP	F	S	-36245.	ft	--	Approximate distance from RW threshold to HAC; used only in entry display mode
SITE LOOKUP PARAMETERS						
R_HAC_RW_L	V(3)	DP	-36245.0 -20000.0 0.0	ft	RW	Position vector of HAC center for the left side of the runway centerline
R_HAC_RW_R	V(3)	DP	-36245.0 +20000.0 0.0	ft	RW	Position vector of HAC center for the right side of the runway centerline

4.9.4 Hard Codeable Parameters

The parameters defined in table 4.9.4-1 are needed by the OPS 3 navigation flight software but are not expected to change. These may be hard coded if desired.

TABLE 4.9.4-1.- HARD CODEABLE PARAMETERS

Parameter	Data type	Precision	Value	Units	Definition
DT_DEORB_PREP_NAV	F	S	4.0	sec	Sequencing time interval for entry nav during coasting flight prior to deorbit burn
DT_DEORB_PF_NAV	F	S	2.0	sec	Sequencing time interval for entry nav during deorbit burn
DT_ENTRY_NAV	F	S	4.0	sec	Sequencing time interval for entry nav after completion of deorbit burn
DT_LAND	F	S	2.0	sec	Sequencing time interval for preland nav (MSBLS data processing)
EPS_TAG	F	S	0.0005	sec	Criterion for difference between measurement time and state time, above which the filter state will be extrap olated for residual calculations
ID_MATRIX_3X3	M(3)	S	1, 0, 0, 0, 1, 0, 0, 0, 1	--	3X3 identity matrix
RADALT_ANG	F	S	2.005	rad	Angle between body X-axis and navigation base to RA antenna vector
RADALT_NB_DIST	F	S	12.915	ft	Naviagation base to antenna distance
X_NB_WH	F	S	62.784	ft	X_STRUCT_BODY distance from navigation base to rear wheels
Z_NB_WH	F	S	22.405	ft	Z_STRUCT_BODY distance from rear wheels to navigation base

4.10 DOWNLIST REQUIREMENTS

Downlist requirements for the Entry through Landing (OPS-3) operations computer load are discussed in the Computer Program Development Specification, Volume I, Book 4, (SS-P-0002-140D), Downlist/Uplink Software Requirements.

4.11 UPLINK REQUIREMENTS

This section is included to discuss the navigation-related uplink capabilities, data, and any special processing requirements needed to enable proper action by the appropriate navigation function. This discussion is not intended to supplant the requirements imposed by the DOWNLIST/UPLINK CPDS (SS-P-0002-140D) but rather to clarify the action necessary to provide the proper interfaces between the navigation function and other on-board software which interprets and decodes the uplinked data for applications processing. The term special processing requirement is used to identify computation, flag settings, or other actions to be performed by onboard software external to the navigation functions to provide or establish values for inputs needed by the navigation function.

This discussion is limited to the formatted uplink capabilities defined in the DOWNLIST/UPLINK CPDS.

The formated uplink capabilities are:

(1) DELTA STATE VECTOR UPDATE

(2) ORBITER STATE VECTOR UPDATE

(3) DEORBIT LANDING SITE PARAMETERS LOAD

(4) DEORBIT TACAN PARAMETERS

4.11.1 Delta State Vector Update

The delta state vector update will be performed by the navigation function as described in sections 4.2.6, 4.3.1.4.2, and 4.3.2.4.2. The proper performance of the update by the navigation function is possible only if the delta vectors DR_RW and DV_RW (see principal function input list for a description) are set to the data uplinked and the flag DO_DELTA_UPDATE is set to the ON position. The flag itself is not part of the uplinked information and must be set by the uplink processing software which decodes the uplinked command word. The flag setting is a special processing requirement and must follow the setting of DR_RW and DV_RW to the uplinked values.

Upon sensing DO_DELTA_UPDATE to be in the ON position, the navigation function will perform the update to the navigation state vector, set DR_RW and DV_RW to zero, and turn DO_DELTA_UPDATE to the OFF position to automatically inhibit multiple processing of the same uplinked data.

4.11.2 Orbiter State Vector Update

The Orbiter state vector update will be performed by the navigation function as described in section 4.3.1.4.3. The proper performance of the update by the navigation function is possible only if the update vector $\underline{R}$ _GND and $\underline{V}$ _GND and the associated time tag T_GND (see the principal function input list for a description) are set to the data uplinked and the OP_CODE is set to the proper value. The OP_CODE setting must follow the setting of $\underline{R}$ _GND, $\underline{V}$ _GND, and T_GND to the uplinked values.

Upon sensing OP_CODE to have the value 0001001, the navigation function will perform the update to the navigation state vectors and set OP_CODE to a value of 0000000 to automatically inhibit multiple processing of the same uplinked data.

4.11.3 Entry Site Lookup Data Uplink

There are two command uplink loads which affect data used by the Entry site lookup principal function:

(1) Deorbit Landing Site Parameters Load

(2) Deorbit TACAN Parameters

4.11.3.1 Deorbit Landing Site Parameters Load (OP_CODE = 0010101)

The deorbit landing site parameters load provides the capability to uplink parameters related to the table of data for the three runways maintained in OPS-3. The following list of parameters may be uplinked:

DEORBIT LANDING SITE PARAMETERS LOAD

M/S ID NO.	Nomenclature	Type	Units	CMD no.	Word (CW) BITS
	LDG SITE TABLE SLOT - RANGE (1-21)	BINARY	SCALAR	CW 1	17 - 32
	RUNWAY NAME	EBCDIC	NA	CW 2 CW 3	17 - 48 17 - 32
	GEODETIC LATITUDE OF RUNWAY (LAT)	SP	DEG	CW 4	17 - 48
	GEODETIC LONGITUDE OF RUNWAY (LONG)	SP	DEG	CW 5	17 - 48
	TRUE AZIMUTH OF RUNWAY	SP	DEG	CW 6	17 - 48
	MAG VARIATION AT RUNWAY	SP	DEG	CW 7	17 - 48
	ALT OF RUNWAY ABOVE REF ELLIPSOID	SP	FT	CW 8	17 - 48
	GEO SEPARATION (DL)	SP	FT	CW 9	17 - 48

It should be noted that although the LDG SITE TABLE SLOT parameter is indicated as having a range of 1-21 (for the OPS-2 table size), only three slots are available in OPS-3. A value of 19 for this parameter should be interpreted as referring the runway data associated with the 'site lookup primary' as described in section 4.5.2.1. A value of 20 for this parameter should be interpreted as referring the data associated with the 'site lookup secondary' and a value of 21 should be interpreted as referring to the data associated with the 'site lookup alternate'; both also described in section 4.5.2.3. It is suggested that, during OPS-3, any value of LDG SITE TABLE SLOT which is not 19, 20, or 21 should be interpreted as an error condition, and that no further action be taken to alter the on-board tabular data.

There are three special processing requirements associated with uplink into the runway site table. The first special processing requirement is that, if an uplink to either the site lookup primary or site lookup secondary runway occurs, then the associated MSBLS availability indicator (MLS_AVAIL_PSL or MLS_AVAIL_SSL, respectively) shall be set to the OFF position. This action is necessary because MSBLS site data are not included as part of the runway uplink data and

there is no way of determining a priori what new landing site the uplinked data represents. The second special processing requirement is that all angular parameters shown as having units of degrees shall be converted to radians before being stored into the runway site data table. The third special processing requirement is that after all data storage and manipulation functions have been completed, the runway site lookup 'init' subfunction (Section 4.5.33) shall be called or invoked to cause computation of derived quantities and parameters needed by various users of site lookup data. Failure to compute these derived parameters will cause an inconsistency between the various parameters maintained on-board for a given site.

The logical order of responding to an uplink is that the OP_CODE be tested to determine if it has a value of 0010101. If true, then all necessary data handling and computations shall be performed. The final necessary action is to set OP-CODE to a value of 0000000 to inhibit multiple processing of an uplinked data set.

An example implementation of the necessary logic, data handling, computations, and invoking of the initialization subfunction is shown in Appendix E, DEORBIT_LANDING_SITE_UPLINK.

4.11.3.2 Deorbit TACAN Site Parameters Load (OP_CODE = 0011111)

The deorbit TACAN parameters load provides the capability to uplink data related to the table of TACAN data for up to 10 sites in OPS-3. For each site, the following parameters may be uplinked:

DEORBIT TACAN PARAMETERS

M/S ID NO.	Nomenclature	Type	Units	CMD no.	Word (CW) BITS
	MAG VARIATION AT TACAN	SP	DEG	CW 1	17 - 48
	TACAN BEARING BIAS	SP	DEG	CW 2	17 - 48
	TACAN RANGE BIAS	SP	FT	CW 3	17 - 48
	TACAN TABLE SLOT ID (RANGE 1-60)	BINARY	NA	CW 5	17 - 32
	TACAN CHANNEL/MODE	INTEGER	NA	CW 7	17 - 48
	TACAN LATITUDE	SP	DEG	CW 8	17 - 48
	TACAN LONGITUDE	SP	DEG	CW 9	17 - 48
	TACAN ALT ABOVE REF ELLIPSOID	SP	FT	CW 10	17 - 48
	TACAN GEODIAL SEPARATION	SP	FT	CW 11	17 - 48

It should be noted that although the TACAN TABLE SLOT ID is indicated as having a range of 1-60 (for the OPS-2 table size), there are a maximum of 10 table entries available in OPS-3 indexed on the uplink as numbers 51 through 60 for compatibility with OPS-2 uplink capabilities. If the table entry index itself is not limited to a value of 1-10, inadvertent data overwrite may occur. It is suggested that an input out of this range be interpreted as an error condition and no changing of table data performed.

There are two special processing requirements associated with a TACAN parameters uplink. The first requirement is that all the (angular) parameters shown as having units of degrees must be converted from degrees to radians before the uplinked data are loaded into the TACAN data table. All subsequent manipulations and use of these data assumes that the table data are in units of radians. The second special processing requirement is that, after the units conversion and data storage into the TACAN site table is completed, the TACAN site lookup initization subfunction (Section 4.5.3.2) must be invoked to establish the

proper values for parameters derived from the table of site data. Failure to cause computation of the derived parameters will result in an inconsistency between the various parameters maintained on-board for a given TACAN ground site.

The logical order of responding to an uplink is that the OP_CODE be tested to determine if it has the value 0011111. If true, then all necessary data handling and computations shall be performed. The final necessary action is to set OP_CODE to a value of 0000000 to inhibit multiple processing of an uplinked data set.

An example implementation of the necessary logic, data handling, computations, and invoking of the initialization subfunction is shown in Appendix E, DEORBIT_TACAN_SITE_UPLINK.

APPENDIX A

VARIABLES LIST

This page intentionally left blank.

APPENDIX A

VARIABLES LIST

DEFINITIONS

Code used for variable data type

S: scalar

V(n): vector (dimension)

M(n): square matrix (dimension)

INT: integer

BIT: bit

CHAR: character

STR: structure

ARR: array

Coordinate frame code and definition

Body: (structural)	x:	parallel to the longitudinal axis (positive aft)
	y:	completes right-hand system
	z:	perpendicular to the x-axis, positive upward
EF	Earth-fixed coordinate system	
M50:	Mean of 50 reference coordinate system	
RW: (runway coordinates)	x:	down runway centerline in direction of landing
	y:	completes right-hand system
	z:	down, normal to ellipsoid

SCAN:	x:	scanner boresight axis
(MLS scanner coordinates)	y:	completes right-hand system
	z:	up, normal to ellipsoid
TD:	x:	north
(topodetic coordinates)	y:	east
	z:	down, normal to ellipsoid
UVW	Quasi-inertial, right-handed Cartesian coordinate system	

Variable List, Deorbit-Landing Computer Load

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
A	ARR	0	-	Array for temporary storage of Legendre polynomials in Pine's formulation
ACC_DRAG	S	0	-	Vehicle cg drag acceleration
ACC_DRAG_MIN	S	Pad	-	Minimum acceleration magnitude required for processing drag data
ACCEL	V(3)	0	M50	Modeled acceleration vector
ACC_PROP_MIN	S	Pad	-	Acceleration magnitude above which vent and drag models are not employed
ACC_SENSED	S	0	-	Magnitude of sensed acceleration used to determine whether to incorporate IMU data
ALPHA	S	0	-	Angle of attack for computing drag coefficient, in radiaus
ALPHAIN	S	0	-	Angle of attack in degrees from attitude snap
ALPHAR	S	0	-	Angle of attack used to compute drag altitude pseudo-measurement
ALT	S	0	-	Current orbiter altitude above reference ellipsoid
ALT_EL	V(3)	Pad	-	Altitude regions for nav event lamp processing
ALT_RW	S	0	-	Altitude above reference ellipsoid of runway reference point
ALT_WHEELS	S	0	-	Altitude of orbiter above runway altitude

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ALT_ZONE_CHANGE	S	Pad	-	Altitude where model for atmospheric density is changed
ANGLE_CORR_ TNTOMAG	S	0	-	Copy of ANGLE_CORR_TNTOMAG_SL for navigation processing
ANGLE_CORR_ TNTOMAG_SL	S	-	-	Variation of magnetic north from true north at TACAN site obtained from site lookup
AUXILIARY	S	0	-	Intermediate variable in the Pine's formulation
B	V(6)	0	-	Measurement first partials with respect to filter state
BARO_AIF	CHAR	Auto	-	Auto-inhibit-force switch for barometric sensor selection
BARO_AIF_RECD	CHAR	Auto	-	Flag indicating which BARO_AIF command is in effect
BARO_DATA_GOOD	BIT	Off	-	Copy of current data-good discrete reserved for measurement processing
BARO_EDIT_ OVERRIDE	BIT	Off	-	Switch used to force incor-poration of barometric data regardless of residual edit test
BARO_MARK_NUM	INT	0	-	Counter indicating the number of times that barometric measurement was selected for filter processing
BARO_STAT	BIT	Off	-	Flag indicating stat-flag setting for barometric measurements
BASE_DEN	V(4)	Pad	-	Vector of base densities for each layer to model drag

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
BETA	S	0	-	Sideslip angle in radian
BETAIN	S	0	-	Sideslip angle in degrees from attitude snap
BIAS_AZMLS	S	Pad	-	MLS azimuth measurement bias
BIAS_BARO	S	Pad	-	Barometric altimeter measurement bias
BIAS_DRAG	S	0	-	Drag measurement bias
BIAS_DRAG_LAYER	V(4)	Pad	-	Vector of deterministic drag biases for each layer
BIAS_ELMLS	S	Pad	-	MLS elevation measurement bias
BIAS_RMLS	S	Pad	-	MLS range measurement bias
BIAS_TAC_BRG	S	-	-	Copy of BIAS_TAC_BRG_SL for the selected TACAN station
BIAS_TAC_BRG_SL	S	Pad	-	TACAN station bearing bias obtained from site lookup
BIAS_TAC_R	S	-	-	Copy of BIAS_TAC_R_SL for the selected TACAN station
BIAS_TAC_R_SL	S	Pad	-	TACAN station range bias obtained from site lookup
BT_E_B	S	0	-	Variable used to store the calculation of B TRANSPOSE · E · B
C	V(9)	Pad	-	Tesseral harmonic coefficients
CD	S	-	-	Shuttle's drag coefficient
CDA	S	Pad	-	Constant used to model drag coefficient (additional corrective term)

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
CDF	S	Pad	-	Constant used to model drag coefficient (frontal area)
CDN	S	Pad	-	Constant used to model drag coefficient (top area correction)
C_DRAG	S	0	-	Drag coefficient
C_DRAG_ONE	S	Pad	-	Polynomial term for computing drag coefficient as function of angle of attack
C_DRAG_TWO	S	Pad	-	Polynomial term for computing drag coefficient as function of angle of attack
C_DRAG_ZERO	S	Pad	-	Polynomial term for computing drag coefficient as function of angle of attack
CDS	S	Pad	-	Constant used to model drag coefficient (side area correction)
COLUMN	INT	1	-	Indexing integer
COR	V(7)	0	-	General term for correlation coefficients
CORR_COEFF_INIT	V(7)	OPS 2	UVW	Correlation coefficients to initialize covariance matrix
CORR_COEFF_ UPDATE	V(7)	Pad	UVW	Correlation coefficients to initialize covariance matrix for Delta State update
CORR_COEFF_ UPDATE_M50	V(7)	Pad	UVW	Correlation coefficients to initialize covariance matrix for whole vector update
D	V(3)	0	M50	Drag acceleration vector

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DELH_MSL_ ELLIPSOID_RW	S	Pad	-	Altitude of mean sea level above reference ellipsoid at runway
DELQ	S	0	-	General term for measurement residual
DELQ_ONE	S	0	-	General variable for residual during three-state configuration for State 1
DELQ_TWO	S	0	-	General variable for residual during three-state configuration for State 2
DELQ_THREE	S	0	-	General variable for residual during three-state configuration for State 3
DELTA_T	S	0	-	Amount by which the state vector time tag is to be incremented for delta time tag update
DEL_TIME_STEP	S	Pad	-	Maximum step size for precise predictor for OPS 3 initialization
DENSE	V(6)	Pad	-	Density model constants
DENSITY_LIMIT	V(4)	Pad	-	Altitudes at which to change density model parameters
DEORBIT_BURN	BIT	Off	-	Flag indicating (ON) that NAV phase deorbit maneuver execute
DISP_DELQ	V(7)	0	-	Display measurement residual for I^{th} sensor measurement
DISP_EDIT	V(7)	Blank	-	Display edit history indicator for I^{th} sensor measurement

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DISP_SIG	V(7)	0	-	Display residual ratio for I^{th} sensor measurement
DNM	S	0	-	Variable used in Pine's formulation
DNSA	S	0	-	Variable used in density calculations
DNSB	S	0	-	Variable used in density calculations
DNSC	S	0	-	Variable used in density calculations
DO_BARO_NAV	BIT	Off	-	Flag indicating (on) that barometric altimeter data are to be processed
DO_DELTA_UPDATE	BIT	Off	-	Flag indicating (ON) that a delta state update is to be performed
DO_DELTA_T_ UPDATE	BIT	Off	-	Flag indicating (ON) that a time tag update is to be performed
DO_DRAG_NAV	BIT	Off	-	Flag indicating (ON) that drag altitude data are to be processed
DO_MLS_NAV	BIT	Off	-	Flag indicating (ON) that MLS data are to be processed
DO_TACAN_NAV	BIT	Off	-	Flag indicating (ON) that TACAN data are to be processed
DQ	S	0	-	General term for measurement residual

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DR	V(3)	0	M50	Ground computed position deviation to update onboard state vector (rotated to mean 50 coords)
DRAG_AIF	CHAR	Auto	-	Drag auto/inhibit/force flag
DRAG_AIF_RECD	CHAR	Auto	-	Flag indicating which DRAG_AIF command is in effect
DRAG_CONST	S	Pad,*	-	Drag constant equal to the vehicle reference area divided by twice the vehicle mass
DRAG_EDIT_OVERRIDE	BIT	Off	-	Switch used to force incorporation of drag altitude measurement regardless of residual edit test
DRAG_MARK_NUM	INT	0	-	Counter indicating the number of times that drag measurement was selected for filter processing
DRAG_STAT	BIT	Off	-	Flag indicating (ON) that drag data are processed for statistical display only
DR_RW	V(3)	0	RW	Ground computed position deviations to update onboard state vector
DT_DEORB_PF_NAV	S	Pad	-	Sequencing time interval for entry navigation during deorbit burn
DT_DEORB_PREP_NAV	S	Pad	-	Sequencing time interval for entry navigation during coasting flight prior to deorbit burn

*The DRAG_CONST is recomputed every time a major mass change occurs as described in section 4.1.1.

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DT_ENTRY_NAV	S	Pad	-	Sequencing time interval for entry navigation after completion of deorbit burn
DT_FILT	S	0	-	Interval over which to propagate the State vector(s) and covariance matrix
DT_INTERP	S	Pad	-	State vector interpolation time interval
DT_LAND	S	Pad	-	Sequencing time interval for preland external navigation sensor processing function
DT_MAX	S	0	-	Max allowable time step size for entry precise predictor
DV	V(3)	0	M50	General vector of difference between present and previous accumulated sensed velocities
DV_FILT	V(3)	0	M50	Difference between accumulated sensed IMU readings on present cycle and previous cycle
DV_FILT_ONE	V(3)	0	M50	Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration
DV_FILT_TWO	V(3)	0	M50	Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration
DV_FILT_THREE	V(3)	0	M50	Difference between present and previous accumulated sensed velocities for IMU-3 during three-state configuration

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DV_RW	V(3)	0	RW	Ground computed velocity deviations to update onboard state vector
E	M(6)	0	M50	Filter covariance matrix
EARTH_MU	S	Pad	-	Gravitational constant of earth
EARTH_POLE	V(3)	Pad	M50	Unit vector in direction of earth's axis of rotation
EARTH_RADIUS_ EQUATOR	S	Pad	-	Earth equatorial radius
EARTH_RADIUS_ GRAV	S	Pad	-	Earth radius used for gravity oblateness calculations
EARTH_RATE	S	Pad	-	Earth rotation rate
EB_COPY	V(6)	0	M50	Variable used to reserve the product of the covariance matrix and the partials vector B
EDIT_ARRAY	ARR	0	-	Array of last 4 edit flag for display processing
EDIT_FLAG	BIT	Off	-	General variable for edit flags
ELEM 1	S	0	-	Variable used by midselect to select middle element
ELEM 2	S	0	-	Variable used by midselect to select middle element
ELEM 3	S	0	-	Variable used by midselect to select middle element
ELLIPT	S	Pad	-	Earth ellipticity constant

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
EPS_TAG	S	Pad	-	Criterion for difference between measurement time and state time, above which the filter state will be extrapolated for residual calculations
E_TEMP	M(6)	0	-	Temporary matrix for covariance matrix initialization
EVENT E1	I	-	-	Flag indicating (ON) a transition from OPS-3 to OPS-2
EV_LT	BIT	Off	-	Temporary flag used to set nav validity flag
EVENT E_14A	BIT	Off	-	MSC event - OMS cutoff confirmation
EXP_SHAPE_ FACTOR	S	Pad	-	Exponential shaping factor for drag coefficient model
FIFTY	M(3)	0	-	General transformation matrix from EF to M50 coordinates
FILT_UPDATE	BIT	Off	-	Switch indicating (ON) that current measurement processing is complete for UPP propagator reset
F1	S	0	-	Auxiliary variable in Pine's formulation
F2	S	0	-	Auxiliary variable in Pine's formulation
F3	S	0	-	Auxiliary variable in Pine's formulation
F4	S	0	-	Auxiliary variable in Pine's formulation

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
G	V(3)	0	M50	Gravity acceleration
G_CENTRAL	V(3)	0	M50	Gravitational vector for central force effect
G_FINAL	V(3)	0	M50	Current gravity vector
GMD	S	0	-	General term indicating degree of modeled acceleration
GM_DEG	S	0	-	Integer indicating degree of modeled acceleration
GMD_PRED	S	0	-	Interger indicating degree of modeled acceleration in OPS-3 -INITIALIZE (code)
GMO	S	0	-	General term indicating order of modeled acceleration
GMO_PRED	S	0	-	Integer indicating order of modeled acceleration in OPS-3 -INITIALIZE (code)
GM_ORD	S	0	-	Integer indicating order of modeled acceleration
G_OLD	V(3)	0	M50	Gravity acceleration at start of Shuttle state intergration interval
G_ONE	V(3)	0	M50	Past acceleration vector due to gravity
G_ONE_OLD	V(3)	0	M50	Gravity acceleration vector at beginning of integration interval associated with IMU-1
GRAV_GRAD_NEW	M(3)	0	M50	Gravity gradient at end of transition matrix integration interval

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
GRAV_GRAD_OLD	M(3)	0	M50	Gravity gradient at start of transition matrix integration interval
G _RESET	V(3)	0	M50	Vehicle gravity acceleration vector reserved for reset of user parameter gravity acceleration vector
G _THREE_OLD	V(3)	0	M50	Gravity acceleration vector at beginning of integration interval associated with IMU-3
G _TWO	V(3)	0	M50	Current acceleration vector due to gravity
G _TWO_OLD	V(3)	0	M50	Gravity acceleration vector at teginning of integration interval associated with IMU-2
H_DRAG_LOW	S	Pad	-	Altitude below which the drag cata are not processed
H_INHIB	BIT	Off	-	Flag indicating (ON) that attitude data has been de-selected based on an automatic selection constraint
H_MID	S	0	-	Altitude above ellipsoid computed from middle selected position vector
H_S	S	0	-	Atmospheric scale height for density calculation
I	INT	1	-	Integer-subscript or iteration counter
ID_MATRIX_3x3	M(3)	Pad	-	Identity matrix (3x3)
IMU_FAIL	V(3)	0	-	$IMUFAIL_I$: Failure status of the Ith IMU for I = 1, 2, or 3

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
IMU_STATUS	S	0	-	Integer indicating combined status of 3 IMUs
IN_CONE_FLAG	BIT	Off	-	Flag indicating (ON) that vehicle is in selected TACAN station's cone of confusion
INITIATE_PWR_ FLIGHT_NAV_EVENT	BIT	Off	-	Flag indicating (ON) that the deorbit burn begins in TBD seconds
I_V_RHO	V(3)	0	-	Unit vector of V_RHO
I_Z	V(3)	0	M50	Unit vector along TACAN, MLS azimuth, or elevation scanner coordinate Z-axis
IZ_CROSS_RELR	V(3)	0	-	Temporary vector used in Angle-Partials
J	INT	1	-	Integer-subscript or iteration counter
K	INT	1	-	Integer used in Pine's formulation
K_EDIT_BARO	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for BARO measurement
K_EDIT_DRAG	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for drag measurement
K_EDIT_MLSAZ	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for MSBLS azimuth measurement

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
K_EDIT_MLSEL	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for MSBLS elevation measurement
K_EDIT_MLSR	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for MSBLS range measurement
K_EDIT_TACBR	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for TACAN bearing measurement
K_EDIT_TACR	INT	Pad	-	Scale factor on filter mean square residual used in residual edit test for TACAN range measurement
K_MAX	S	Pad	-	Maximum number of edits allowed a measurement before display of edit warning
K_RES_EDIT	S	0	-	Scale factor on filter mean square residual used in residual edit test
K_UND_WGT	S	Pad	-	Scale factor used in measurement under weighting equation
L	INT	1	-	Integer used in Pine's formulation
LAYER	INT	0	-	Atmospheric layer label
M	M(3)	0	-	General transformation matrix
MACH_JUMP	BIT	Off	-	Flag indicating (ON) that the shuttle is in the MACH jump region

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
MANUAL_EDIT_ OVERRIDE	BIT	Off	-	Flag indicating (ON) that the filter's residual edit test is to be overridden
M_EFTOM50	M(3)	0	-	Earth fixed to M50 coordinate transformation matrix
M_EFTORAD_EL	M(3)	Pad	-	Transformation matrix from earth-fixed to MSBLS elevation radar coordinates
M_EFTORAD_R_AZ	M(3)	Pad	-	Transformation matrix from earth-fixed to AZ/range MSBLS radar coordinate frame
M_EFTORW	M(3)	Pad	-	Earth-fixed to prime RW transformation matrix
M_EFTOTD_TACAN	M(3)	0	-	Copy of M_EFTOTD_TACAN_SL from site lookup
M_EFTOTD_ TACAN_SL	M(3)	Pad	-	Transformation matrix from earth-fixed to topodetic coordinates at TACAN site obtained from site lookup
MID_ELEM	S	0	-	Element selected by MID_SELECT
MLSANT_ANG	S	Pad	-	Angle between navigation base -to-MSBLS antenna vector and positive vehicle X-body axis
MLSANT_NB_DIST	S	Pad	-	Distance from navigation-base to MSBLS antenna
MLS_AVAIL	BIT	Off	-	Flag output by site lookup subfunction indicating the availability of MSBLS data
MLSAZ_DATA_GOOD	BIT	Off	-	Copy of current data-good discrete reserved for measurement processing

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
MLS_COV_INIT	BIT	Off	-	Switch to initialize portions of the covariance matrix to zero when MSBLS first acquired
MLSEL_DATA_ GOOD	BIT	Off	-	Copy of current data-good discrete reserved for measurement processing
MLS_MARK_NUM	INT	0	-	Counter indicating the number of times that MSBLS measurement was selected for filter processing
MLSRANGE_DATA_ GOOD	BIT	Off	-	Copy of current data-good discrete reserved for measurement processing
MLS_R_AZ_GOOD	BIT	Off	-	Switch which indicates when a good set of MSBLS range and azimuth data has been received
MM_CODE	INT	0	-	Major mode number (set by MSC for use by navigation)
M_M50_TO_ SCANNER	M(3)	0	-	Transformation matrix from M50 to MSBLS scanner coordinates
M_M50TOTD	M(3)	0	-	Transformation matrix from M50 topodetic coordinates
M_SBODYM50	M(3)	0	-	Structural body-to-M50 coordinate transformation
MS_DELQ	S	0	-	Filter estimated mean squared measurement residual
MS_POS_UND_WGT	S	Pad	-	Value of filter mean squared position error below which no measurement underweighting is used
M_TEMP	M(3)	0	-	Transformation matrix

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
N	INT	1	-	General indexing integer
N1	INT	1	-	General indexing integer
NAUTMI_PER_FT	S	Pad	-	Number of nautical miles per foot
NAV_EL_FLAG	BIT	Off	-	NAV validity flag for setting event lamp indicator
NAV_THREE_STATE	BIT	Off	-	Flag indicating whether the mode of operation is single-state or three-state
NOISE	S	0	-	State process noise added to velocity diagonals of filter covariance matrix
NOISE_R	S	0	-	State process noise added to position diagonals of filter covariance matrix
NOISE_RV	S	0	-	State process noise added to off diagonals of position-velocity submatrix of filter covariance matrix
N_SEQ	INT	1	-	Sequential counter for nav validity flag
N_SEQ_MAX	INIT	Pad	-	Number of sequential failures of the nav event lamp test criteria allowed before activating the nav event lamp
OMEGA	V(6)	0	-	Kalman filter gain vector
ONE_BRG_LOCK	BIT	Off	-	TACAN RM one LRU bearing lock-on requirement flag
ONE_RANGE_LOCK	BIT	Off	-	TACAN RM one LRU range lockon requirement flag

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
OP_CODE	B(7)	0	-	Command uplink identification code
OPS_3_INITIALIZE_COMPLETE	BIT	Off	-	Flag to enable scheduling of the user parameter state propagation principal function
OPS_3_RECONFIGURE	BIT	Off	-	Flag indicating (ON) that OPS-3 initialization is complete
PHI	M(6)	0	-	Transition matrix for covariance propagation
PI	S	Pad	-	The constant PI
PITCH_M	S	0	-	Copy of pitch angle reserved for MLS elevation processing
PRELAND_TRANSITION	BIT	OFF	-	Flag indicating (ON) that transition to preland navigation principal function is complete
Q	S	0	-	Measurement estimate
Q_AZMLS	S	0	-	MSBLS azimuth sensor measurement
Q_BARO	S	0	-	Barometric altimeter sensor measurement
Q_DRAG	S	0	-	Pseudo drag altitude generated sensor measurement
Q_ELMLS	S	0	-	MSBLS elevation sensor measurement
Q_M50_BODY	V(4)	0	M50	M50 body frame attitude quaternion
Q_RANGE	S	0	-	MSBLS range sensor measurement

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
Q_TAC_BRG	S	0	-	TACAN bearing sensor measurement
Q_TAC_R	S	0	-	TACAN range sensor measurement
R	V(3)	0	M50	General Shuttle position vector
RAD_PER_DEG	S	Pad	-	Conversion constant-radians per degree
RAW_RA_PROC	BIT	Off	-	Radar altimeter processing flag
R_AZ_COUNT	INT	0	-	Running count of number of consecutive MLS azimuth and range measurements failing data good test
R_AZ_COUNT_MAX	S	Pad	-	Prescribed number of consecutive MLS range/azimuth measurement data-good 'fails' to force inhibit of MLS processing and allow TACAN processing
R _AZMLS	V(3)	0	-	Position vector of MLS azimuth scanner in M50 coordinates
R _AZMLS_EF	V(3)	0	EF	Earth-fixed MLS azimuth scanner position vector
R _COV_LAST	V(3)	0	M50	Updated vehicle position vector associated with current covariance matrix
R _EF	V(3)	0	EF	General position vector in earth-fixed coordinates
REF_AREA	S	Pad	-	Orbiter reference area
R _ELMLS	V(3)	0	M50	Position vector of MLS elevation scanner in M50 coordinates

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R_ELMLS_EF	V(3)	0	EF	Earth-fixed MLS elevation scanner position vector
REL_R	V(3)	0	M50	Vector from sensor ground station to vehicle
RESID_TEST	S	0	-	General resid test variable
R_FILT	V(3)	0	M50	Filter current Shuttle position vector in M50 coordinates
R_FILT_INIT	V(3)	OPS 2	M50	Shuttle position vector for OPS 3 initialization
R_FILT_ONE	V(3)	0	M50	Current Shuttle position vector for three-State configuration, State 1
R_FILT_TWO	V(3)	0	M50	Current Shuttle position vector for three-State configuration, State 2
R_FILT_THREE	V(3)	0	M50	Current Shuttle position vector for three-State configuration, State 3
R_FINAL	V(3)	0	M50	Position vector propagated to current time
R_GND	V(3)	0	M50	Uplinked position vector for the whole vector update
RHO	S	0	-	General range variable also, atmospheric density
RHO_ZERO	S	-	-	Copy of BASE_DEN for the selected layer
R_INIT	V(3)	0	M50	Shuttle initial position vector input to predictor

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R_INV	S	0	-	Inverse of the magnitude of the position vector
R_MS_ONE	V(3)	0	M50	Vector used to represent a state for selection by VECTOR-SELECTION
R_MS_THREE	V(3)	0	M50	Vector used to represent a state for selection by VECTOR_SELECTION
R_MS_TWO	V(3)	0	M50	Vector used to represent a state for selection by VECTOR_SELECTION
RNG	S	-	-	Range from the TACAN station to the vehicle
RNG_VAR_ BEARING_STEP	S	Pad	-	Range criterion used to select TACAN bearing variance
RNG_VAR_RNG_STEP	S	Pad	-	Range criterion used to select TACAN range variance
RO_N	S	0	-	Variable used in Pine's formulation
RO_ZERO	S	0	-	Variable used in Pine's formulation
R_RESET	V(3)	0	M50	Vehicle position vector after all navigation updates reserved for reset of guidance integrator position vector
R_RESID	V(3)	0	M50	Vehicle position vector used in measurement residual calculation after interpolation to time of measurement

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R_RESID_ONE	V(3)	-	M50	Interpolated position vector associated with the first state vector during three-State TACAN processing
R_RESID_TACAN	V(3)	-	M50	General term denoting interpolated position vector during TACAN processing
R_RESID_THREE	V(3)	-	M50	Interpolated position vector associated with the third state vector during three-State TACAN processing
R_RESID_TWO	V(3)	-	M50	Interpolated position vector associated with the second state vector during three-State TACAN processing
R_RHO	S	0	-	Magnitude of general position vector R
R_RMLS_EF	V(3)	0	EF	Earth-fixed position vector of MLS range scanner
R_SCANNER	V(3)	0	M50	General M50 position vector used in range residual calculations
R_SENSOR	V(3)	0	M50	General Sensor ground station position vector
R_TACAN_EF	V(3)	-	EF	Copy of R_TACAN_EF_SL for TACAN station used by navigation filter
R_TACAN_EF_SL	V(3)	-	EF	TACAN station earth-fixed position vector obtained from site lookup
RV_MAG	S	0	-	Orbiter relative velocity magnitude

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
RV_MAX	S	Pad	-	Maximum relative velocity magnitude for baro processing
S	V(9)	Pad	-	Tesseral harmonic coefficients
SA	S	0	-	Sine of alpha
SB	S	0	-	Sine of beta
SCALE_HT	V(4)	Pad	-	Vector of scale weights for each layer to model drag
SEA_LEVEL_ DENSITY	S	Pad	-	Seal level atmospheric density
SEL_LRU_ID	INT	0	-	Integer indicating which TACAN LRU (1, 2, or 3) is selected by RM for use by navigation filter for TACAN data processing
SENSOR_DELQ	V(7)	0	-	Vector of measurement residuals for display purposes
SENSOR_EDIT	V(7)	Off	-	Edit indicator for measurement types
SENSOR_RESID_ TEST	V(7)	0	-	Vector of residual edit test values for measurements to used for display
SIG	V(6)	0	-	General term for square root of diagonal elements of covariance matrix
SIG_DIAG_UPDATE	V(6)	Pad	UVW	Square root of diagonal elements for delta update covariance initialization
SIG_DIAG_UPDATE_ M50	V(6)	Pad	UVW	Square root of diagonal elements for whole vector update covariance initialization

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
SIG_DIAG_UVW_INIT	V(6)	OPS 2	UVW	Square root of diagonal elements for covariance matrix initialization
STAT_FLAG	BIT	Off	-	Switch indicating (ON) that only filter statistics are to be generated for display with no incorporation of measurement into the filter state
SUM	V(6)	0	-	Accumulated sum of post-residual edits
S2B	S	0	-	Sine of double the sideslip angle
T	S	0	-	Time tag for Shuttle state vector
TACAN_AIF	CHAR	Inhibit	-	AUTO-INHIBIT-FORCE switch for TACAN sensor selection
TACAN_AIF_RECD	CHAR	Inhibit	-	Flag indicating which TACAN_AIF command is in effect
TACAN_BRG_CONVERG_TEST	S	Pad	-	Expected bearing variance criterion to turn on TACAN RM bearing one-lock flag
TACAN_EDIT_OVERRIDE	BIT	Off	-	Switch used to override TACAN residual edit test
TACAN_ID	V(3)	-	-	ID's of TACAN stations currently associated with the three LRU's
TACAN_ID_LAST	INT	0	-	ID of previously selected TACAN station
TACAN_MARK_NUM	INT	0	-	Counter indicating the number of times that TACAN measurement was selected for filter processing

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
TACAN_RNG_CONVERG_TEST	S	Pad	-	Expected range variance criterion to turn on TACAN RM range one-lock flag
TACAN_STAT	BIT	Off	-	Flag indicating TACAN data processed only for statistical display
TAC_BRG_DATA_GOOD	BIT	Off	-	Current data-good discrete for TACAN bearing measurement processing
TAC_CHAN_VALID	BIT	Off	-	Copy of TACAN_CHAN_VALID_SL for TACAN station used by navigation filter
TAC_CHAN_VALID_SL	BIT	Off	-	TACAN channel validity flag obtained from site lookup
TAC_RNG_DATA_GOOD	BIT	Off	-	Current data-good discrete for TACAN range measurement processing
T_BARO	S	0	-	Time tag associated with barometric altimeter measurement
T_CURRENT_FILT	S	0	-	MTU or clock time when IMU was read
T_EF_AZMLS	S	0	-	Time at which MSBLS azimuth was read (adjusted)
T_EF_ELMLS	S	0	-	Time tag of current MSBLS elevation measurement
T_EF_RMLS	S	0	-	Time at which MSBLS range measurement was read
T_FILT_INIT	S	OPS 2/0	-	Time of current filter state vector and covariance matrix for OPS 3/OPS 2 initialization

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
T_FINAL	S	0	-	End time of State vector prediction
T_GND	S	0	-	Time of uplinked State vector
THETAR	S	0	-	Pitch angle from AAM
TIME_BIAS_BARO	S	Pad	-	Pad-loaded bias used to correct barometric time tag
TIME_BIAS_MLS	S	Pad	-	Pad-loaded bias used to correct MSBLS time tag
TIME_BIAS_TACAN	S	Pad	-	Pad-loaded bias used to correct TACAN time tag
T_INIT	S	0	-	Time tag of vector input to predictor
T_LAST_FILT	S	0	-	Time of the filter state vector
T_RESET	S	0	-	Time associated with reserved reset state
T_SENSORS	S	0	-	General time tag of sensor data
T_TACAN	S	-	-	Time at which TACAN was read
$\underline{U}_R$	V(3)	0	M50	Unit vector of $\underline{R}$ position vector
USE_IMU_DATA	BIT	Off	-	Flag indicating whether IMU data are to be used for propagation
$\underline{V}$	V(3)	-	M50	General Shuttle velocity vector in M50 coordinates
VAR	S	Pad	-	General sensor variance

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
VAR_ACC_QUANT	S	Pad	-	Accelerometer quantization error variance
VAR_ACC_QUANT_COAST	S	Pad	-	Accelerometer quantization error variance during unpowered flight
VAR_ACC_QUANT_IMU	S	Pad	-	Accelerometer quantization variance during powered flight
VAR_AZMLS	S	Pad	-	MSBLS azimuth measurement instrument variance
VAR_DRAG	S	Pad	-	Drag altitude measurement error variance
VAR_ELMLS	S	Pad	-	MSBLS elevation instrument variance
VAR_H1	S	0	-	Barometric altimeter instrument variance constant
VAR_H2	S	0	-	Barometric altimeter instrument variance constant
VAR_RMLS	S	Pad	-	MSBLS range measurement instrument variance
VAR_TAC_BRG_HIGH	S	Pad	-	TACAN bearing instrument variance at high range
VAR_TAC_BRG_LOW	S	Pad	-	TACAN bearing instrument variance at low range
VAR_TAC_R_HIGH	S	Pad	-	TACAN range instrument variance at high range
VAR_TAC_R_LOW	S	Pad	-	TACAN range instrument variance at low range
VAR_UNMOD_ACC'_DT	S	0	-	Variance of unmodeled acceleration times scale time

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
VAR_UNMOD_ACC_DT_COAST	S	Pad	-	Variance of unmodeled acceleration times scale time during unpowered flight
VAR_UNMOD_ACC_DT_IMU	S	Pad	-	Variance of unmodeled acceleration times scale time during powered flight
V _CURRENT	V(3)	0	M50	General variable for current IMU accumulated velocity
V _CURRENT_FILT	V(3)	0	M50	Snap of IMU raw velocity counts reserved for measurement processing
V _CURRENT_FILT_ONE	V(3)	0	M50	Current accumulated IMU one velocity counts reserved for measurement processing
V _CURRENT_FILT_THREE	V(3)	0	M50	Current accumulated IMU three velocity counts reserved for measurement processing
V _CURRENT_FILT_TWO	V(3)	0	M50	Current accumulated IMU two velocity counts reserved for measurement processing
VEH_MASS	S	0	-	Current vehicle mass
V _FILT	V(3)	0	M50	Shuttle current velocity vector
V _FILT_INIT	V(3)	OPS 2/ OPS 3		Shuttle velocity vector for OPS 3/OPS 2 initialization
V _FILT_ONE	V(3)	0	M50	Shuttle velocity vector, State 1
V _FILT_THREE	V(3)	0	M50	Shuttle velocity vector, State 3
V _FILT_TWO	V(3)	0	M50	Shuttle velocity vector, State 2

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
V_FINAL	V(3)	0	M50	Shuttle velocity vector predicted to T_FINAL
V_GND	V(3)	0	M50	Uplinked velocity vector for whole vector update
V_IMU_RESET	V(3)	0	M50	Copy of V_last_FILT reserved as velocity count at start of extrapolation interval when guidance integrator is reset
V_INIT	V(3)	0	M50	Initial velocity vector input to predictor
V_LAST	V(3)	0	M50	General variable for previous IMU accumulated velocity
V_LAST_FILT	V(3)	0	M50	Previously read selected accumulated IMU velocity
V_LAST_FILT_ ONE	V(3)	0	M50	Previously read accumulated IMU 1 velocity
V_LAST_FILT_ THREE	V(3)	0	M50	Previously read accumulated IMU 3 velocity
V_LAST_FILT_ TWO	V(3)	0	M50	Previously read accumulated IMU 2 velocity
V_R	V(3)	0	M50	Vehicle relative velocity vector
V_RESET	V(3)	0	M50	Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector
V_RHO	V(3)	0	M50	Vehicle relative velocity vector
V_RHO_BODY	V(3)	0	Body	Vehicle relative velocity vector in body coordinates

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ZETA_IMAG	V(4)	0	-	Complex vector to account for effect of the Tesseral harmonics (imaginary portion)
ZETA_REAL	V(4)	0	-	Complex vector to account for effect of the Tesseral harmonics (real portion)
ZONAL	V(4)	Pad	-	Zonal harmonic coefficients

This page intentionally left blank.

APPENDIX B

NAVIGATION SEQUENCER PRINCIPAL FUNCTION AND NAVIGATION PRINCIPAL FUNCTIONS FLOW CHARTS

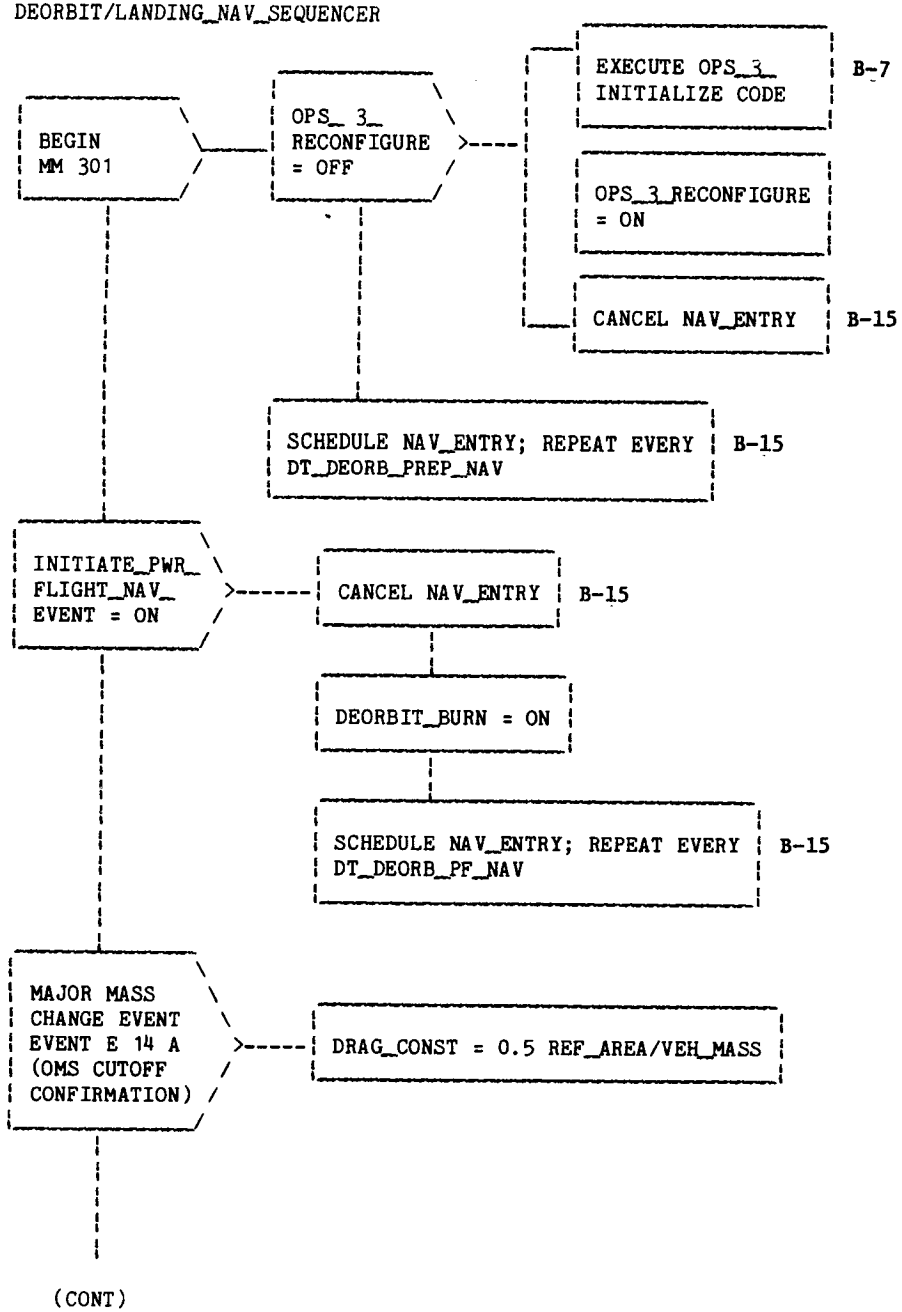
APPENDIX B CONTENTS

Subject	Page
Deorbit/Landing Navigation Sequencer Principal Function	
DEORBIT/LANDING_NAV_SEQUENCER	B-5
COVINIT	B-12
COV_INIT_UVW_INVERSE	B-14
MID_SELECT	B-11
OPS2_INIT (CODE)	B-13
OPS_3_INITIALIZE (CODE)	B-7
VECTOR_SELECTION	B-9
Entry Navigation Principal Function	
NAV_ENTRY	B-15
ACCEL (FUNCTION)	B-21
ACCEL_DRAG CODE	B-27
ACCEL_EARTH_GRAV CODE	B-23
ANGLE_PARTIALS	B-43
BARO_COMP	B-53
BARO_NAV	B-51
CENTRAL	B-22
COVEXTRAP_PF	B-29
COVINIT	B-12
DENSITY_CODE	B-25
DRAG_COMP	B-50
DRAG_NAV CODE	B-48
ENTRY_SENSOR_SELECT CODE	B-33
GRAVITY_GRADIENT (FUNCTION)	B-31
H_ELLIPSOID (FUNCTION)	B-26
MEAS_PROCESSING_STATISTICS_ENTRY CODE	B-56
MID_SELECT	B-11
NAV_FILTER	B-45
NAV_SENSOR_INIT	B-36
NAV_STATE_PROP	B-18
OPS_3_DELTA_UPDATE	B-32
STATE_UPDATE	B-47
SUPER_G_NAV	B-20
SV_INTERP	B-42
TACAN_BRG_COMP	B-41
TACAN_NAV	B-37
TACAN_RANGE_COMP	B-44
THREE_STATE_TO_ONE_STATE CODE	B-54
UPP_STATE_RESET	B-55
VECTOR_SELECTION	B-9
V _REL (FUNCTION)	B-28
WHOLE_VECTOR_UPDATE	B-17

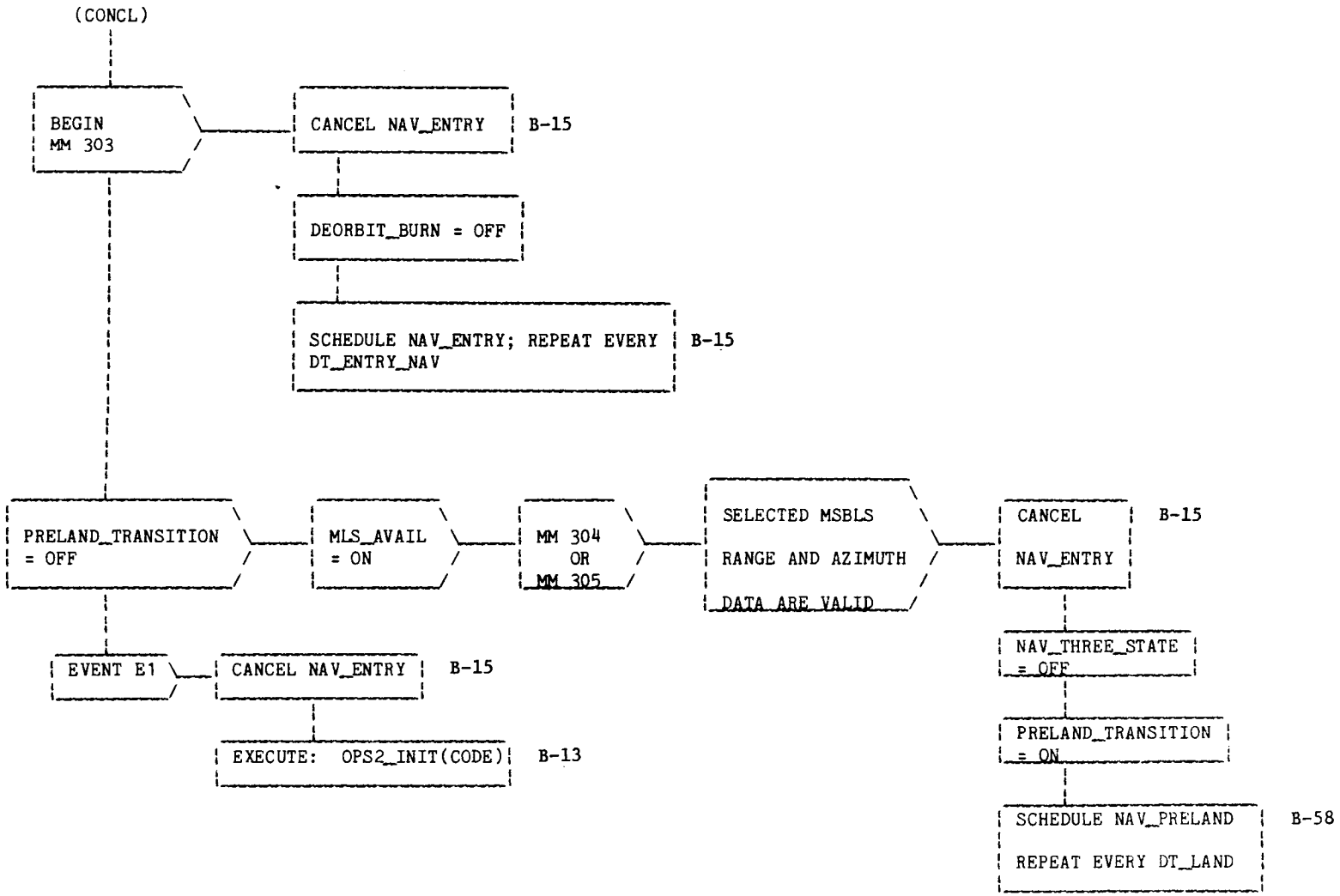
APPENDIX B CONTENTS (CONTINUED)

Subject	Page
Preland Navigation Principal Function	
NAV_PRELAND	B-58
ACCEL (FUNCTION)	B-21
ACCEL_DRAG (CODE)	B-27
ACCEL_EARTH_GRAV CODE	B-23
ANGLE_PARTIALS	B-43
BARO_COMP	B-53
BARO_NAV	B-51
CENTRAL	B-22
COVEXTRAP_PF	B-29
COVINIT	B-12
DENSITY_CODE	B-25
GRAVITY_GRADIENT (FUNCTION)	B-31
H_ELLIPSOID (FUNCTION)	B-26
MEAS_PROCESSING_STATISTICS_PRELAND CODE	B-65
MLS_EL_NAV CODE	B-64
MLS_NAV CODE	B-62
MLS_RANGE_NAV CODE	B-63
NAV_FILTER	B-45
NAV_SENSOR_INIT	B-36
NAV_STATE_PROP	B-18
OPS_3_DELTA_UPDATE	B-32
PRELAND_SENSOR_SELECT CODE	B-60
STATE_UPDATE	B-47
SUPER_G_NAV	B-20
SV_INTERP	B-42
TACAN_BRG_COMP	B-41
TACAN_NAV	B-37
TACAN_RANGE_COMP	B-44
UPP_STATE_RESET	B-55
V _REL (FUNCTION)	B-28
MLS_AZ_NAV CODE	B-67

DEORBIT/LANDING_NAV_SEQUENCER



(CONT)


(CONCL)
BEGIN MM 303
CANCEL NAV_ENTRY
B-15
DEORBIT_BURN = OFF
SCHEDULE NAV_ENTRY; REPEAT EVERY DT_ENTRY_NAV
B-15
PRELAND_TRANSITION = OFF
MLS_AVAIL = ON
MM 304 OR MM 305
SELECTED MSBLS RANGE AND AZIMUTH DATA ARE VALID
CANCEL NAV_ENTRY
B-15
NAV_THREE_STATE = OFF
PRELAND_TRANSITION = ON
SCHEDULE NAV_PRELAND REPEAT EVERY DT_LAND
B-58
EVENT E1
CANCEL NAV_ENTRY
B-15
EXECUTE: OPS2_INIT(CODE)
B-13

OPS_3_INITIALIZE (CODE)

```
SNAP IMU (V_LAST_FILT_ONE, V_LAST_FILT_TWO, V_LAST_FILT_THREE,
V_LAST_FILT, T_LAST,FILT)
```

```
R_INIT = R_FILT_INIT
V_INIT = V_FILT_INIT
T_INIT = T_FILT_INIT
T_FINAL = T_LAST_FILT
GMO_PRED = 4
GMD_PRED = 4
DT_MAX = DEL_TIME_STEP
```

```
CALL: ENTRY_PRECISE_PREDICTOR
```

C-54

```
R_FILT_ONE = R_FINAL, V_FILT_ONE = V_FINAL, G_RESET = G_FINAL
R_FILT_TWO = R_FILT_ONE, V_FILT_TWO = V_FILT_ONE
R_FILT_THREE = R_FILT_ONE, V_FILT_THREE = V_FILT_ONE
R_COV_LAST = R_FILT_ONE, R_RESET = R_FILT_ONE
V_RESET = V_FILT_ONE, T_RESET = T_LAST_FILT
NAV_THREE_STATE = ON
V_IMU_RESET = V_LAST_FILT
FILT_UPDATE = ON
```

(CONT)

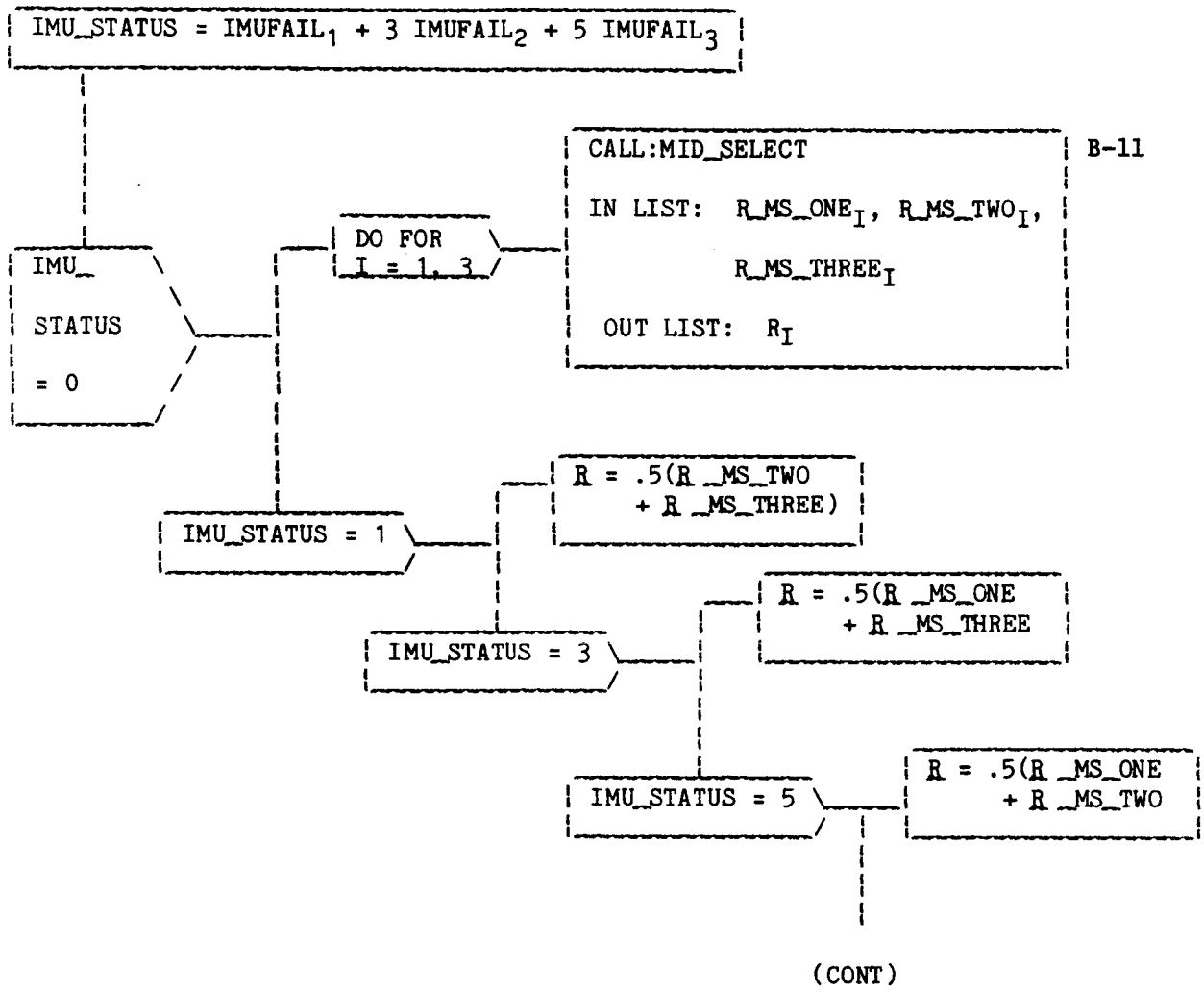
OPS_3_INITIALIZE (CODE) (CONT)

```
CALL:COVINIT

IN LIST: SIG_DIAG_UVW_INIT, CORR_COEFF_INIT, R _FILT_ONE, V _FILT_ONE   B-12

OUT LIST:  E

OPS_3_INITIALIZE_COMPLETE = ON
```

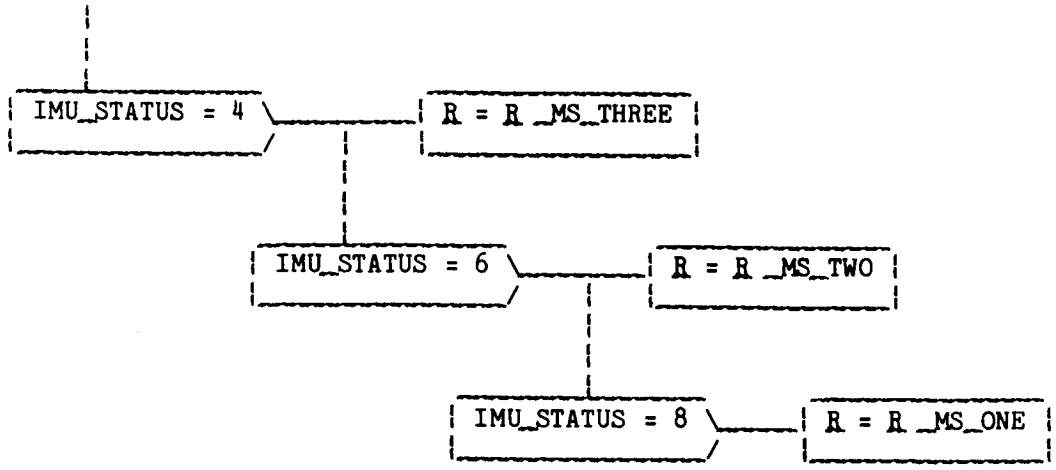
VECTOR_SELECTION

IN LIST: R_MS_ONE, R_MS_TWO, R_MS_THREE

OUT LIST: R



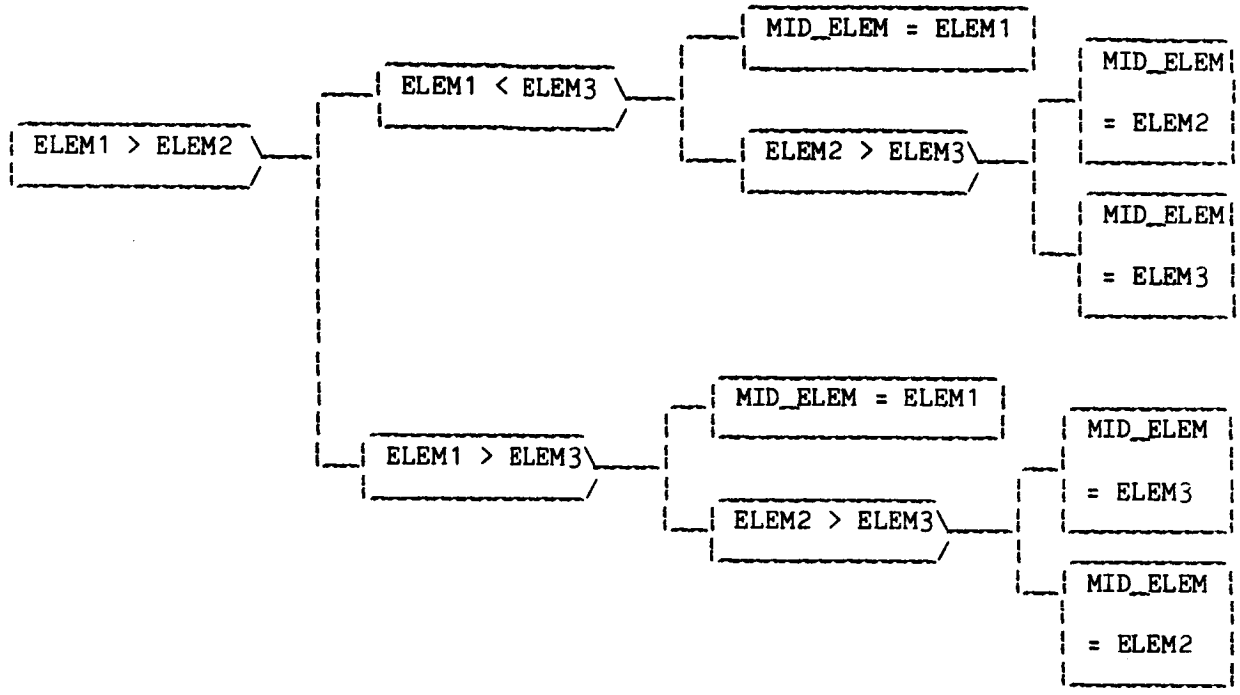
VECTOR_SELECTION (CONT)



MID_SELECT

IN LIST: ELEM1, ELEM2, ELEM3

OUT LIST: MID_ELEM



COVINIT

IN LIST: SIG, COR, R, V

OUT LIST: E_TEMP

E_TEMP = 0.

DO FOR I = 1 TO 6

$E\_TEMP_{I,I} = SIG_I \; SIG_I$

$E\_TEMP_{1,2} = COR_1 \; SIG_1 \; SIG_2$

$E\_TEMP_{1,4} = COR_2 \; SIG_1 \; SIG_4$

$E\_TEMP_{1,5} = COR_3 \; SIG_1 \; SIG_5$

$E\_TEMP_{2,4} = COR_4 \; SIG_2 \; SIG_4$

$E\_TEMP_{2,5} = COR_5 \; SIG_2 \; SIG_5$

$E\_TEMP_{3,6} = COR_6 \; SIG_3 \; SIG_6$

$E\_TEMP_{4,5} = COR_7 \; SIG_4 \; SIG_5$

$E\_TEMP_{2,1} = E\_TEMP_{1,2}$

$E\_TEMP_{5,4} = E\_TEMP_{4,5}$

M = UVW_TO_M50(R, V)

$E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3} = M \; E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3} \; M^T$

$E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6} = M \; E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6} \; M^T$

$E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6} = M \; E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6} \; M^T$

$E\_TEMP_{4 \text{ TO } 6,\ 1 \text{ TO } 3} = (E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6})^T$

C-47

OPS2_INIT (CODE)

```
R_FILT_INIT = R_FILT
V_FILT_INIT = V_FILT
T_FILT_INIT = T_LAST_FILT
```

```
CALL:  COV_INIT_UVW_INVERSE
IN LIST:  E, R_FILT_INIT, V_FILT_INIT
OUT LIST:  SIG_DIAG_UVW_INIT, CORR_COEFF_INIT
```

B-14

COV_INIT_UVW_INVERSE

IN LIST: E_TEMP, R, V

OUT LIST: SIG, COR

M = UVW_TO_M50(R, V) C-47

$E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3} = M^T\ E\_TEMP_{1 \text{ TO } 3,\ 1 \text{ TO } 3}\ M$

$E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6} = M^T\ E\_TEMP_{4 \text{ TO } 6,\ 4 \text{ TO } 6}\ M$

$E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6} = M^T\ E\_TEMP_{1 \text{ TO } 3,\ 4 \text{ TO } 6}\ M$

DO FOR I = 1, 6 → $SIG_I = \sqrt{E\_TEMP_{I,\ I}}$

$COR_1 = E\_TEMP_{1,\ 2}/(SIG_1\ SIG_2)$

$COR_2 = E\_TEMP_{1,\ 4}/(SIG_1\ SIG_4)$

$COR_3 = E\_TEMP_{1,\ 5}/(SIG_1\ SIG_5)$

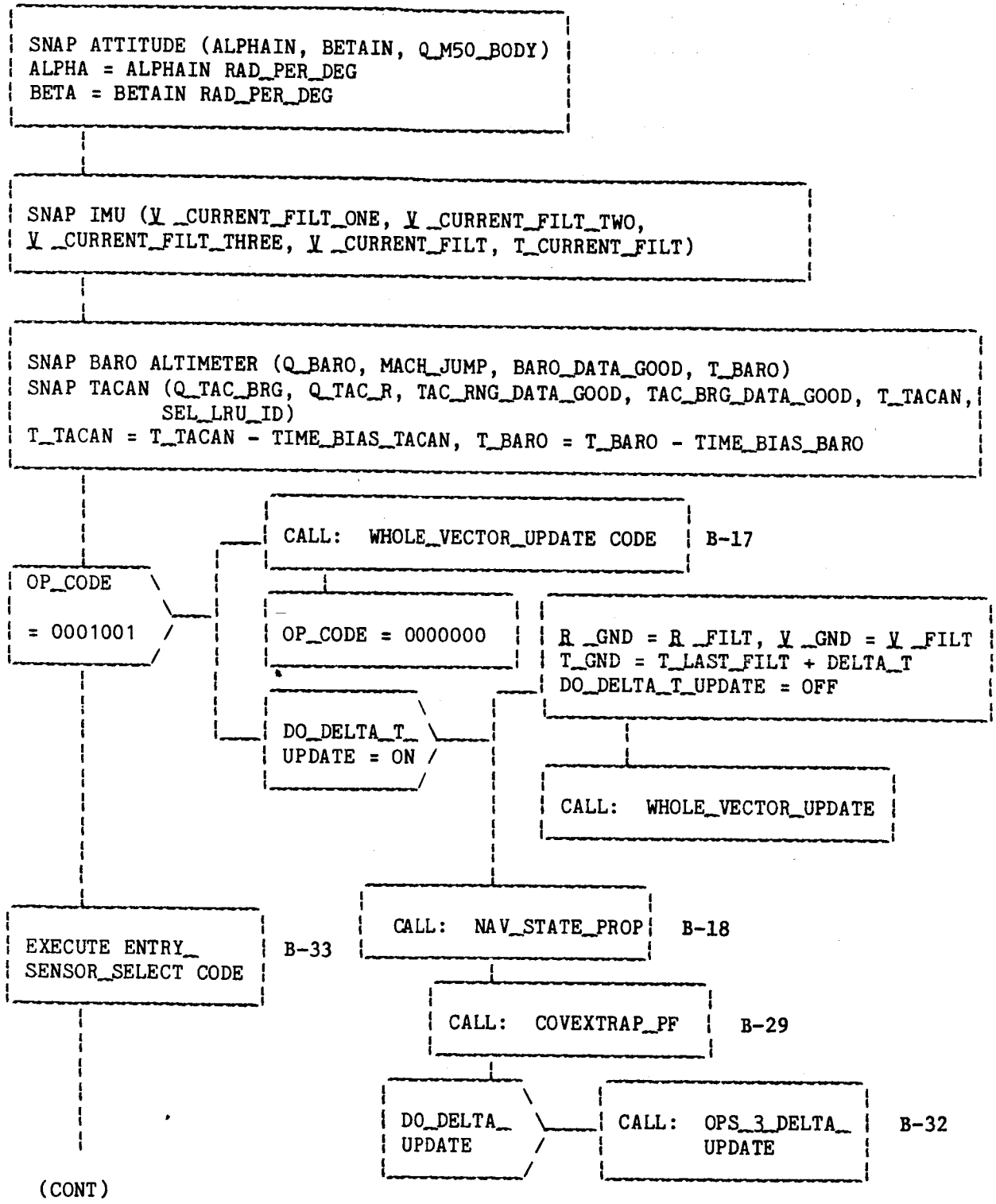
$COR_4 = E\_TEMP_{2,\ 4}/(SIG_2\ SIG_4)$

$COR_5 = E\_TEMP_{2,\ 5}/(SIG_2\ SIG_5)$

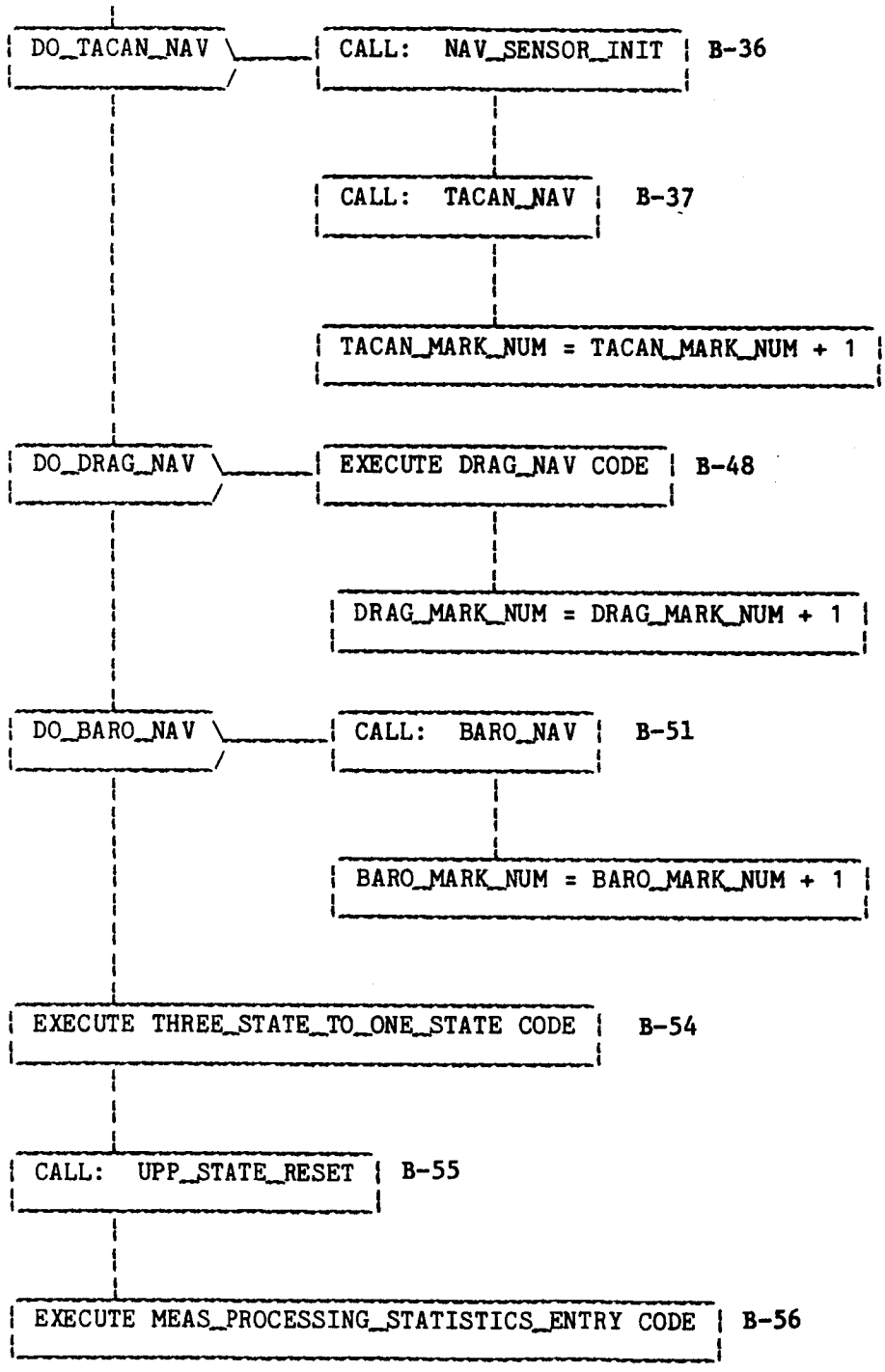
$COR_6 = E\_TEMP_{3,\ 6}/(SIG_3\ SIG_6)$

$COR_7 = E\_TEMP_{4,\ 5}/(SIG_4\ SIG_5)$

NAV_ENTRY


SNAP ATTITUDE (ALPHAIN, BETAIN, Q_M50_BODY)
ALPHA = ALPHAIN RAD_PER_DEG
BETA = BETAIN RAD_PER_DEG
SNAP IMU (V _CURRENT_FILT_ONE, V _CURRENT_FILT_TWO,
V _CURRENT_FILT_THREE, V _CURRENT_FILT, T_CURRENT_FILT)
SNAP BARO ALTIMETER (Q_BARO, MACH_JUMP, BARO_DATA_GOOD, T_BARO)
SNAP TACAN (Q_TAC_BRG, Q_TAC_R, TAC_RNG_DATA_GOOD, TAC_BRG_DATA_GOOD, T_TACAN,
SEL_LRU_ID)
T_TACAN = T_TACAN - TIME_BIAS_TACAN, T_BARO = T_BARO - TIME_BIAS_BARO
OP_CODE
= 0001001
CALL: WHOLE_VECTOR_UPDATE CODE
B-17
OP_CODE = 0000000
DO_DELTA_T_
UPDATE = ON
R _GND = R _FILT, V _GND = V _FILT
T_GND = T_LAST_FILT + DELTA_T
DO_DELTA_T_UPDATE = OFF
CALL: WHOLE_VECTOR_UPDATE
EXECUTE ENTRY_
SENSOR_SELECT CODE
B-33
CALL: NAV_STATE_PROP
B-18
CALL: COVEXTRAP_PF
B-29
DO_DELTA_
UPDATE
CALL: OPS_3_DELTA_
UPDATE
B-32
(CONT)

NAV_ENTRY (CONT)



WHOLE_VECTOR_UPDATE

```
R_INIT = R_GND
V_INIT = V_GND
T_INIT = T_GND
T_FINAL = T_CURRENT_FILT
GMO_PRED = 4
GMD_PRED = 4
DT_MAX = DEL_TIME_STEP
```

```
CALL:  ENTRY_PRECISE_PREDICTOR
```

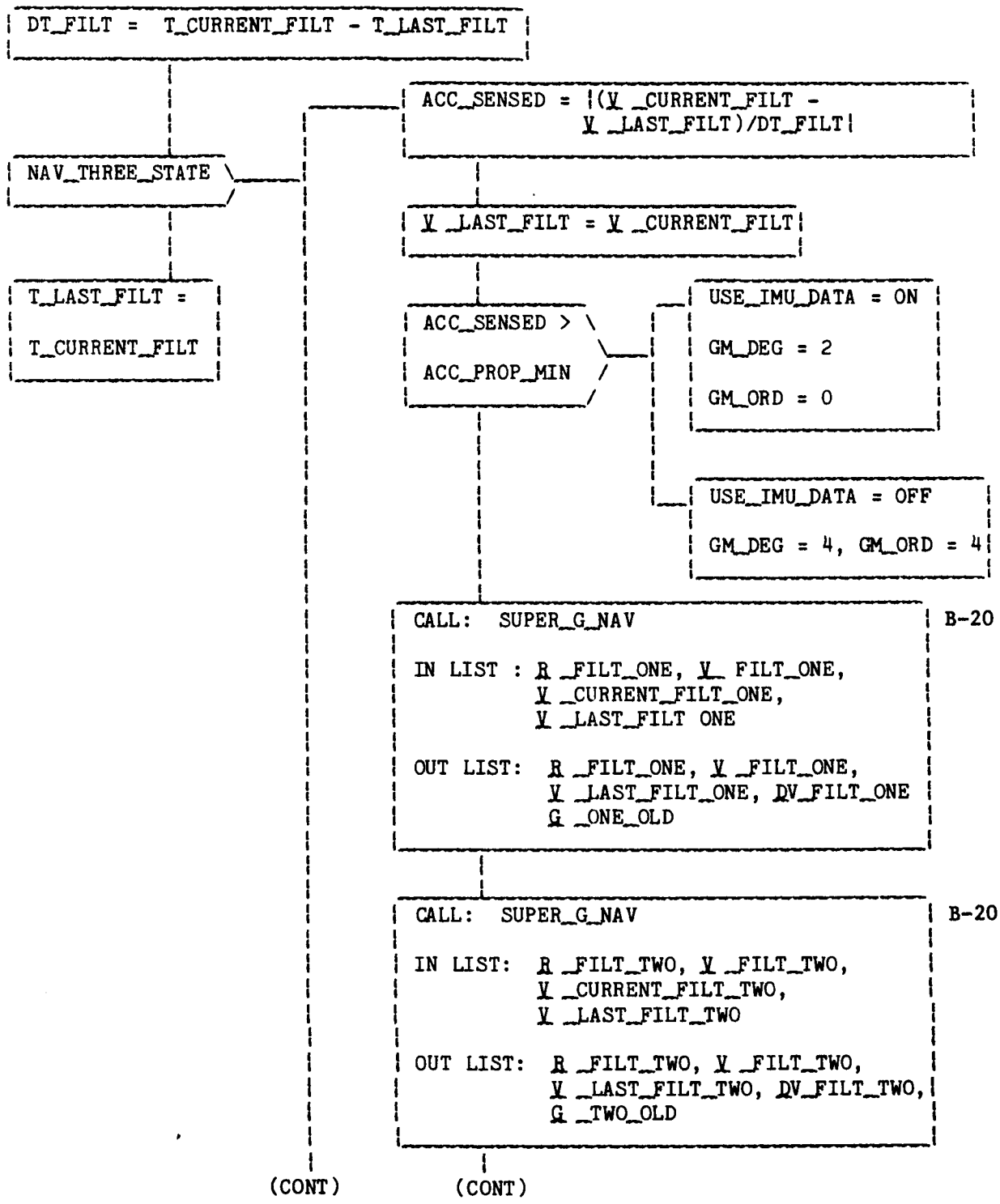
C-54

```
R_FILT_ONE = R_FINAL
R_FILT_TWO = R_FINAL
R_FILT_THREE = R_FINAL
V_FILT_ONE = V_FINAL
V_FILT_TWO = V_FINAL
V_FILT_THREE = V_FINAL
G_ONE_OLD = G_FINAL
G_TWO_OLD = G_FINAL
G_THREE_OLD = G_FINAL
V_LAST_FILT = V_CURRENT_FILT
T_LAST_FILT = T_CURRENT_FILT
```

```
CALL:  COVINIT
IN_LIST:  SIG_DIAG_UPDATE_M50,
          CORR_COEFF_UPDATE_M50,
          R_FILT_ONE, V_FILT_ONE
OUT LIST:  E
```

B-12

NAV_STATE_PROP



NAV_STATE_PROP (CONT)

```
CALL: SUPER_G_NAV                                   B-20

IN LIST:  R_FILT_THREE, V_FILT_THREE,
          V_CURRENT_FILT_THREE,
          V_LAST_FILT_THREE

OUT LIST:  R_FILT_THREE, V_FILT_THREE,
           V_LAST_FILT_THREE,
           DV_FILT_THREE, G_THREE_OLD
```

```
CALL: SUPER_G_NAV                                   B-20

IN LIST:  R_FILT, V_FILT, V_CURRENT_FILT,
          V_LAST_FILT

OUT LIST:  R_FILT, V_FILT, V_LAST_FILT,
           DV_FILT, G_OLD
```

SUPER_G_NAV

IN LIST: R, V, V_CURRENT, V_LAST

OUT LIST: R, V, V_LAST, DV, G_TWO

```
USE_IMU_ \
          \
DATA      /
          /
```

```
DV = V_CURRENT - V_LAST
```

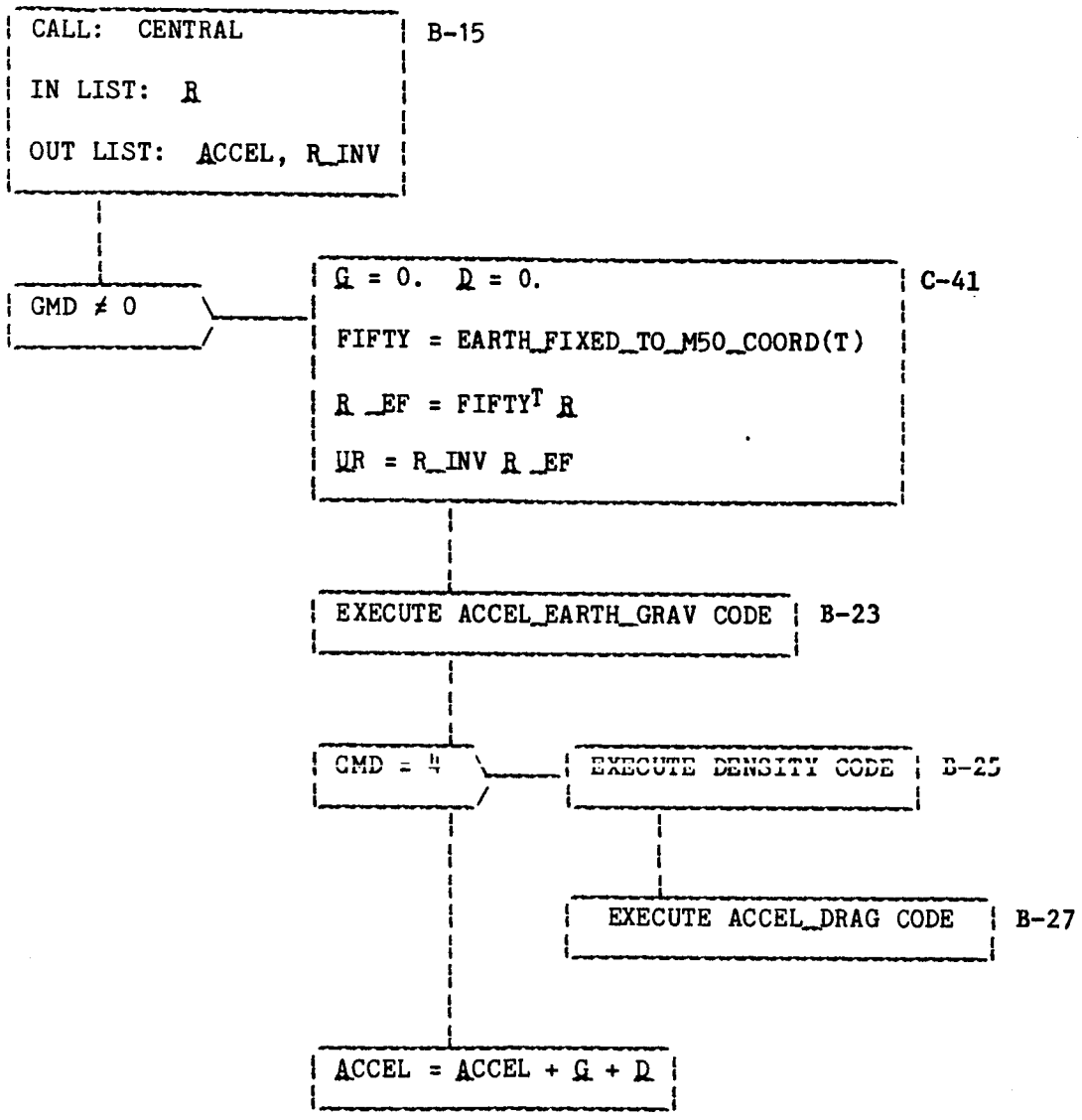
```
DV = 0
```

```
V_LAST = V_CURRENT
```

```
G_ONE = ACCEL(GM_DEG, GM_ORD, R, V, T_LAST_FILT)                B-21

R = R + DT_FILT (V + .5 (DV + DT_FILT G_ONE))

G_TWO = ACCEL(GM_DEG, GM_ORD, R, V, T_CURRENT_FILT)             B-21

V = V + DV + .5 DT_FILT (G_ONE + G_TWO)

R = R + 1./6. (G_TWO - G_ONE) DT_FILT^2
```

ACCEL (FUNCTION)

IN LIST: GMD, GMO, R, V, T



CENTRAL

IN LIST: R

OUT LIST: ACCEL, R_INV

```
R_INV = 1./|R|

ACCEL = -EARTH_MU R_INV^3 R
```

ACCEL_EARTH_GRAV CODE

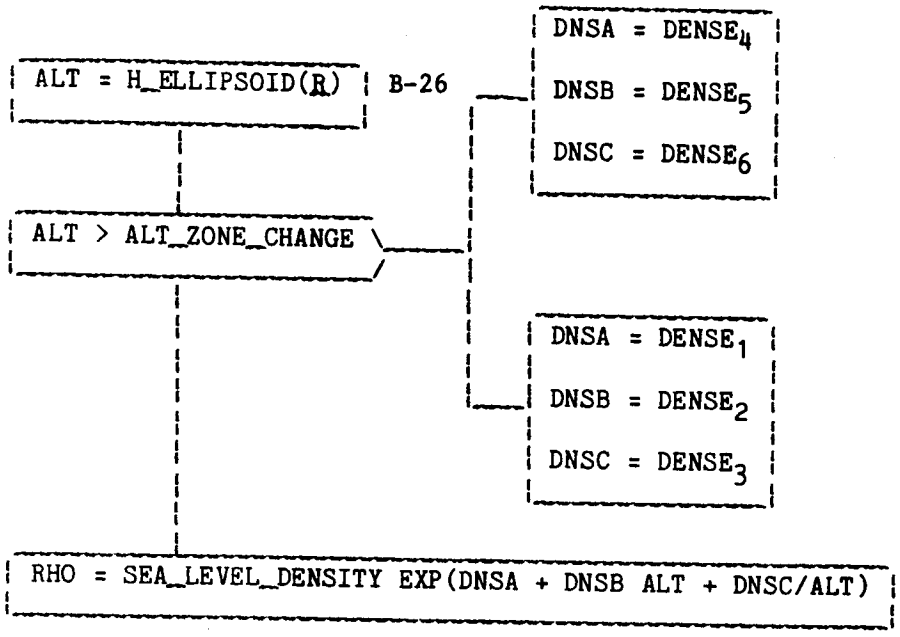
```
RO_ZERO = EARTH_RADIUS_GRAV R_INV
RO_N = RO_ZERO EARTH_MU R_INV^2
A(1, 2) = 3. UR(3)
A(2, 2) = 3.
L = 1
AUXILIARY = 0.
ZETA_REAL(1) = 1.
ZETA_IMAG(1) = 0.

DO FOR I = 1 TO GMO
    ZETA_REAL(I + 1) = UR(1) ZETA_REAL(I) - UR(2) ZETA_IMAG(I)
    ZETA_IMAG(I + 1) = UR(1) ZETA_IMAG(I) + UR(2) ZETA_REAL(I)

DC FOR N = 2 TO GMD
    A(N + 1, 1) = 0.
    A(N + 1, 2) = (2. N + 1.) A(N, 2)
    A(N, 1) = A(N, 2)
    A(N, 2) = UR(3) A(N + 1, 2)
    K = 2

    DO FOR J = 2 TO N
        A(N - J + 1, 1) = A(N - J + 1, 2)
        A(N - J + 1, 2) = (UR(3) A(N - J + 2, 2)
                          - A(N - J + 2, 1))/K
        K = K + 1

G = G AUXILIARY UR
G = FIFTY G
```

(CONT)

ACCEL_EARTH_GRAV CODE

```
F1 = 0.
F2 = 0
F3 = -A1, 1 ZONALN
F4 = -A1, 2 ZONALN

N ≤ GMO \___ DO FOR N1 = 1 \___
        /   TO N           /

F1 = F1 + N1 AN1, 1 (CL ZETA_REALN1 +
                     SL ZETA_IMAGN1)
F2 = F2 + N1 AN1, 1 (SL ZETA_REALN1
                    -CL ZETA_IMAGN1)
DNM = CL ZETA_REALN1 + 1 + SL ZETA_IMAGN1 + 1
F3 = F3 + DNM AN1 + 1, 1
F4 = F4 + DNM AN1 + 1, 2
L = L + 1

RO_N = RO_N RO_ZERO
G1 = G1 + RO_N F1
G2 = G2 + RO_N F2
G3 = G3 + RO_N F3
AUXILIARY = AUXILIARY + RO_N F4
```

DENSITY_CODE



H_ELLIPSOID (FUNCTION)

$$\text{H\_ELLIPSOID}(\underline{R}) = |\underline{R}| - (1 - \text{ELLIPT})\ \text{EARTH\_RADIUS\_EQUATOR} / \sqrt{1 + ((1 - \text{ELLIPT})^2 - 1)(1 - (\underline{U}\text{NIT}(\underline{R}) \cdot \underline{E}\text{ARTH\_POLE})^2)}$$

ACCEL_DRAG CODE

$\underline{V}\_R = \underline{V}\_REL\ (\underline{V}, \underline{R})$ B-28

$SA = [SIN\ (ALPHA)]^2$

$SB = |SIN\ (BETA)|$

$S2B = 2.\ SB\ SQRT(1. - SB^2)$

$CD = [CDF + CDN\ SA^{EXP\ SHAPE\ FACTOR}](1. - SB) + CDS\ SB + CDA\ S2B\ SA$

$\underline{D} = -\ CD\ RHO\ DRAG\_CONST\ |\underline{V}\_R|\ \underline{V}\_R$

V_REL (FUNCTION)

```
V_REL(V, R) = V - EARTH_RATE (EARTH_POLE X R)
```

COVEXTRAP_PF

NAV_THREE_STATE

CALL: VECTOR_SELECTION B-9

IN LIST: R_FILT_ONE, R_FILT_TWO, R_FILT_THREE

OUT LIST: R_FILT

GRAV_GRAD_OLD = GRAVITY_GRADIENT(R_COV_LAST) B-31

GRAV_GRAD_NEW = GRAVITY_GRADIENT(R_FILT) B-31

$PHI_{1 \text{ TO } 3,\ 1 \text{ TO } 3}$ = ID_MATRIX_3X3 + (DT_FILT^2/2) GRAV_GRAD_OLD

$PHI_{1 \text{ TO } 3,\ 4 \text{ TO } 6}$ = (DT_FILT) ID_MATRIX_3X3

$PHI_{4 \text{ TO } 6,\ 1 \text{ TO } 3}$ = (DT_FILT/2)(GRAV_GRAD_OLD + GRAV_GRAD_NEW

$PHI_{4 \text{ TO } 6,\ 4 \text{ TO } 6}$ = ID_MATRIX_3X3 + (DT_FILT^2/2)(GRAV_GRAD_NEW)

E = PHI E PHI^T

USE_IMU_DATA = OFF

VAR_UNMOD_ACC_DT = VAR_UNMOD_ACC_DT_COAST

VAR_ACC_QUANT = VAR_ACC_QUANT_COAST

VAR_ACC_ACC_DT = VAR_UNMOD_ACC_DT_IMU

VAR_ACC_QUANT = VAR_ACC_QUANT_IMU

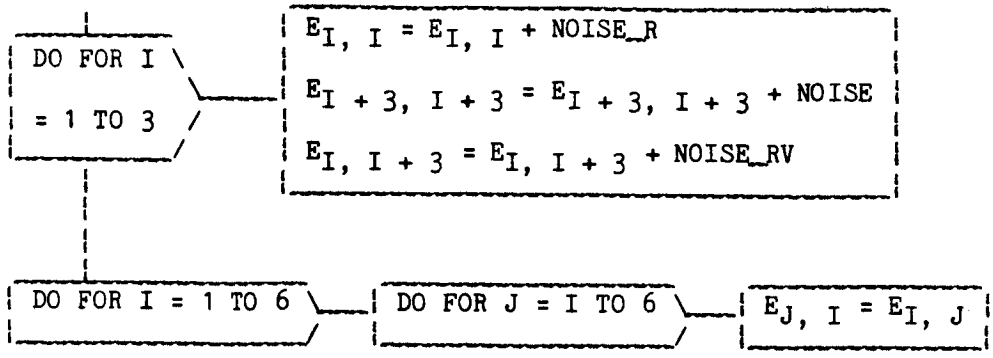
NOISE = VAR_ACC_QUANT + (VAR_UNMOD_ACC_DT) DT_FILT

NOISE_R = NOISE (DT_FILT^2) .25

NOISE_RV = NOISE (DT_FILT) .5

(CONT)

COVEXTRAP_PF (CONCLUDED)



GRAVITY_GRADIENT (FUNCTION)

$$\text{GRAVITY\_GRADIENT}(\underline{R}) = (\text{EARTH\_MU}/|\underline{R}|^5)(3\ \underline{R}\ \underline{R}^T - |\underline{R}|^2\ \text{ID\_MATRIX\_3X3})$$

OPS_3_DELTA_UPDATE

```
NAV_THREE_ \
           \
STATE = ON  /
```

```
CALL:  VECTOR_SELECTION                                          B-9

IN LIST:  V _FILT_ONE, V _FILT_TWO, V _FILT_THREE

OUT LIST:  V _FILT
```

```
M_TEMP = EARTH_FIXED_TO_M50_COORD(T_LAST_FILT) M_EFTORW^T        C-41

DR = M_TEMP DR_RW

R _FILT = R _FILT + DR

V _FILT = V _FILT + M_TEMP DV_RW + EARTH_RATE (EARTH_POLE X DR)
```

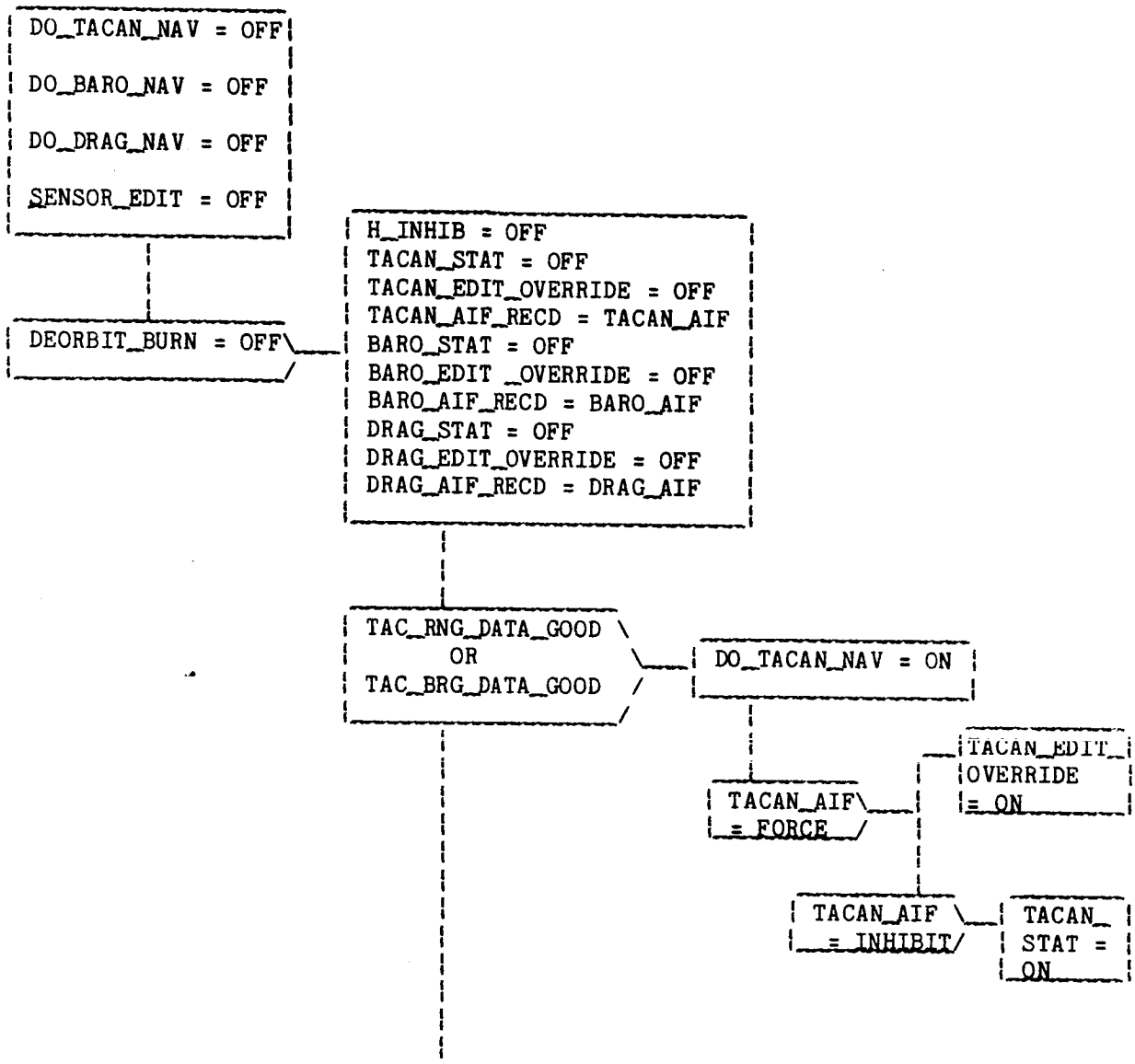
```
CALL:  COVINIT                                                   B-12

IN LIST:  SIG_DIAG_UPDATE, CORR_COEFF_UPDATE, R _FILT, V _FILT

OUT LIST:  E
```

```
NAV_THREE_STATE = ON \
                     /
```

```
R _FILT_ONE = R _FILT
R _FILT_TWO = R _FILT
R _FILT_THREE = R _FILT
V _FILT_ONE = V _FILT
V _FILT_TWO = V _FILT
V _FILT_THREE = V _FILT
```

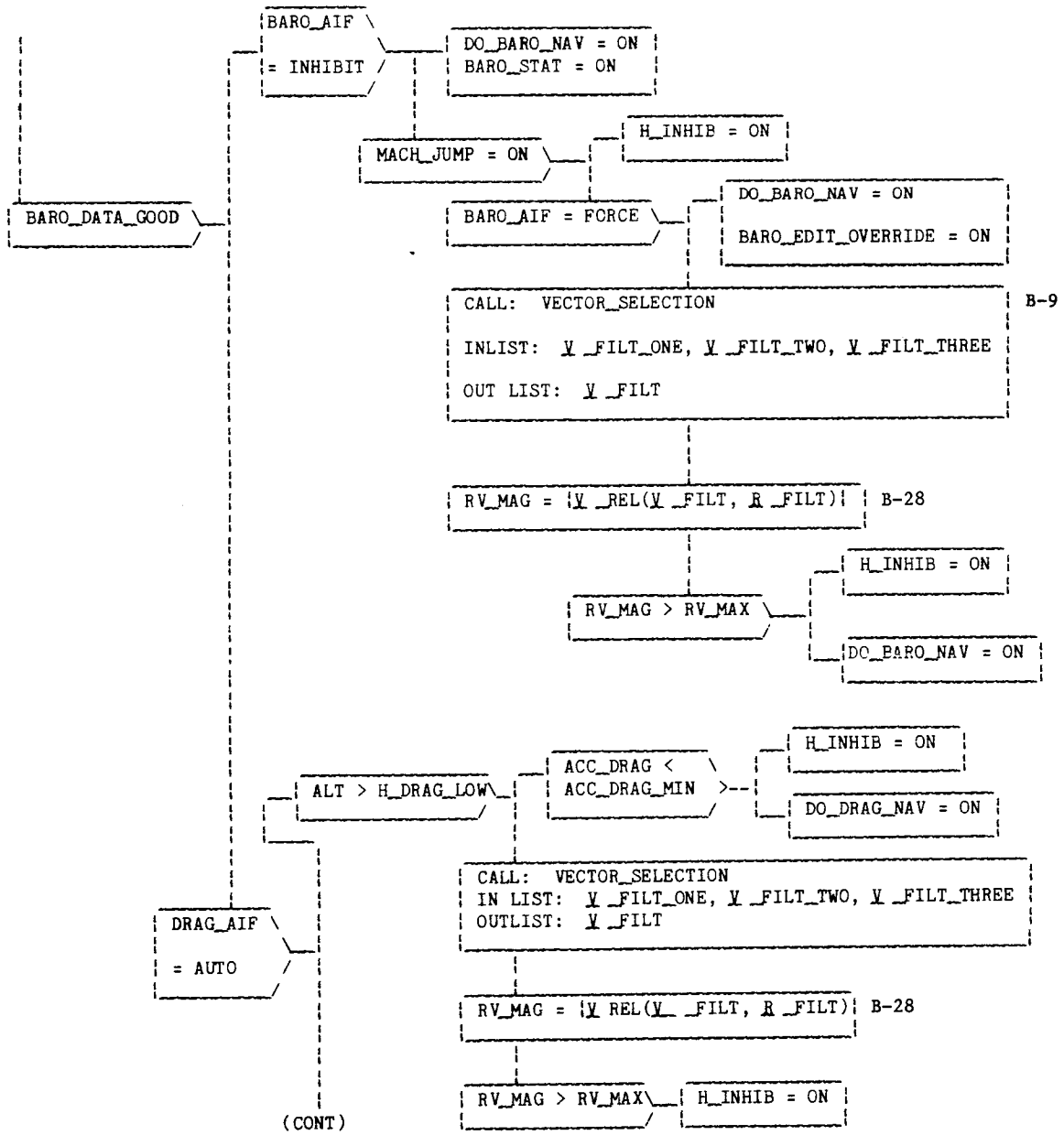
```
DR_RW = 0

DV_RW = 0

DO_DELTA_UPDATE = OFF
```

ENTRY_SENSOR_SELECT CODE

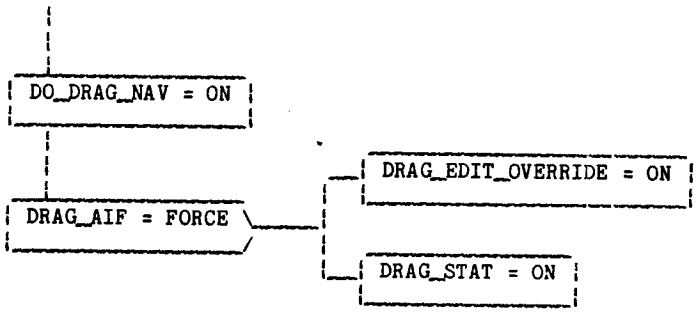


(CONT)

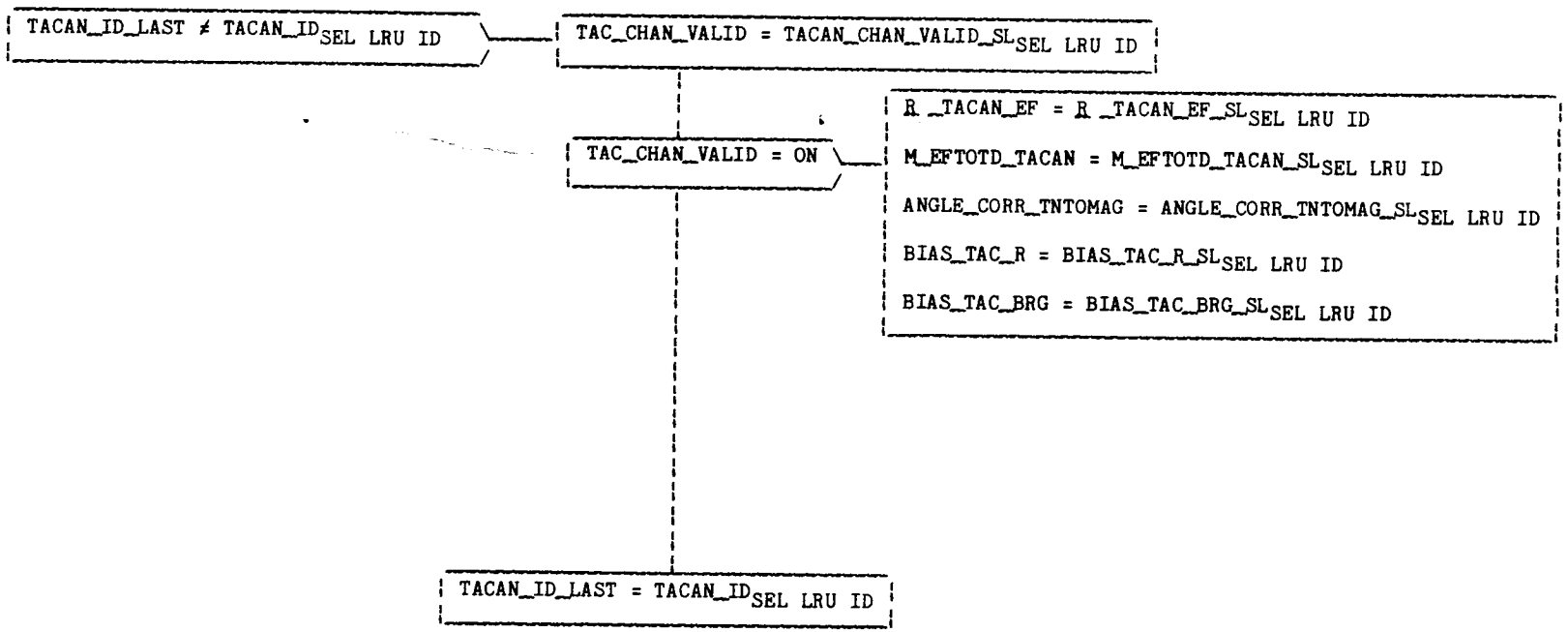
ENTRY_SESOR_SELECT CODE (CONTINUED)



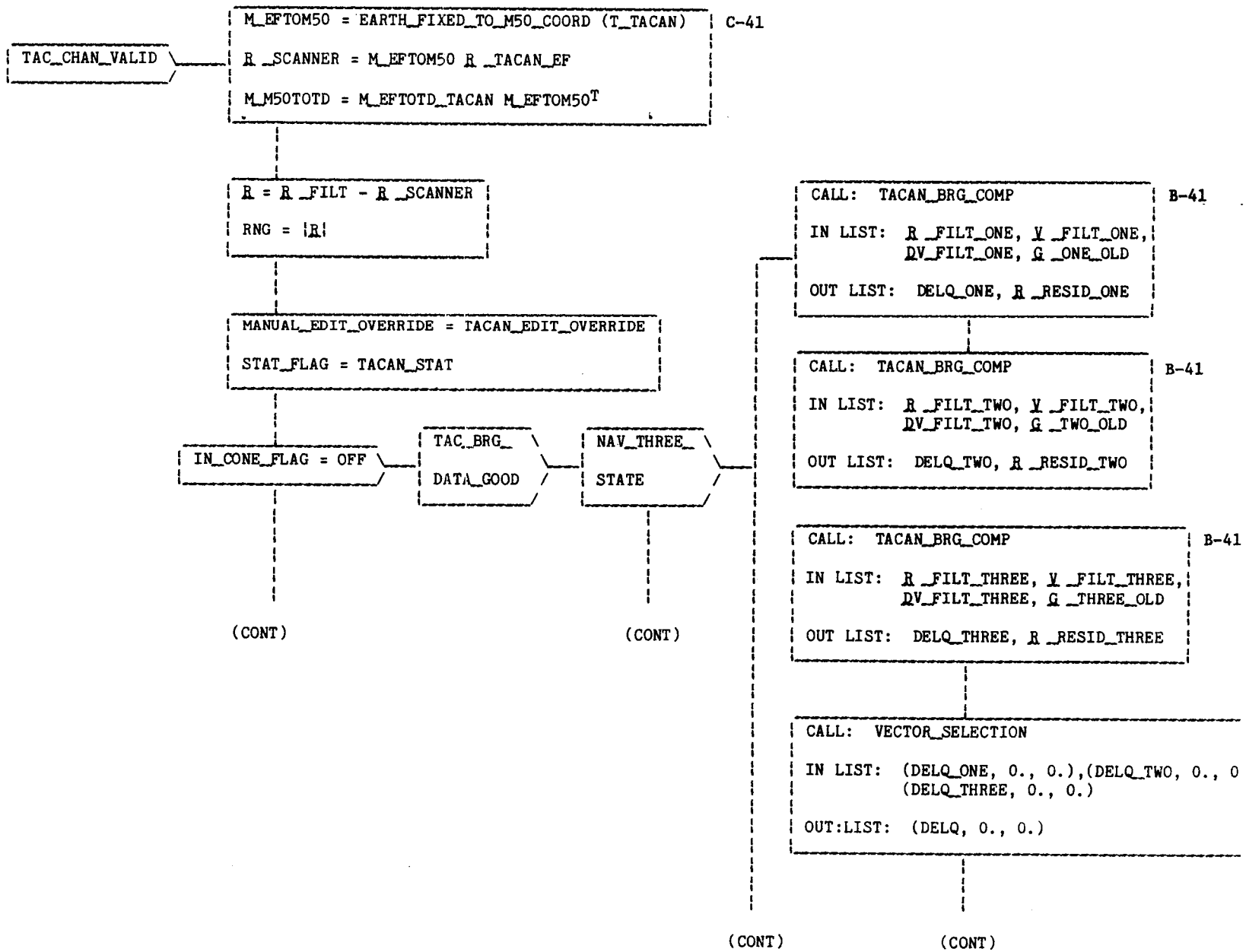
ENTRY_SENSOR_SELECT CODE (CONCLUDED)



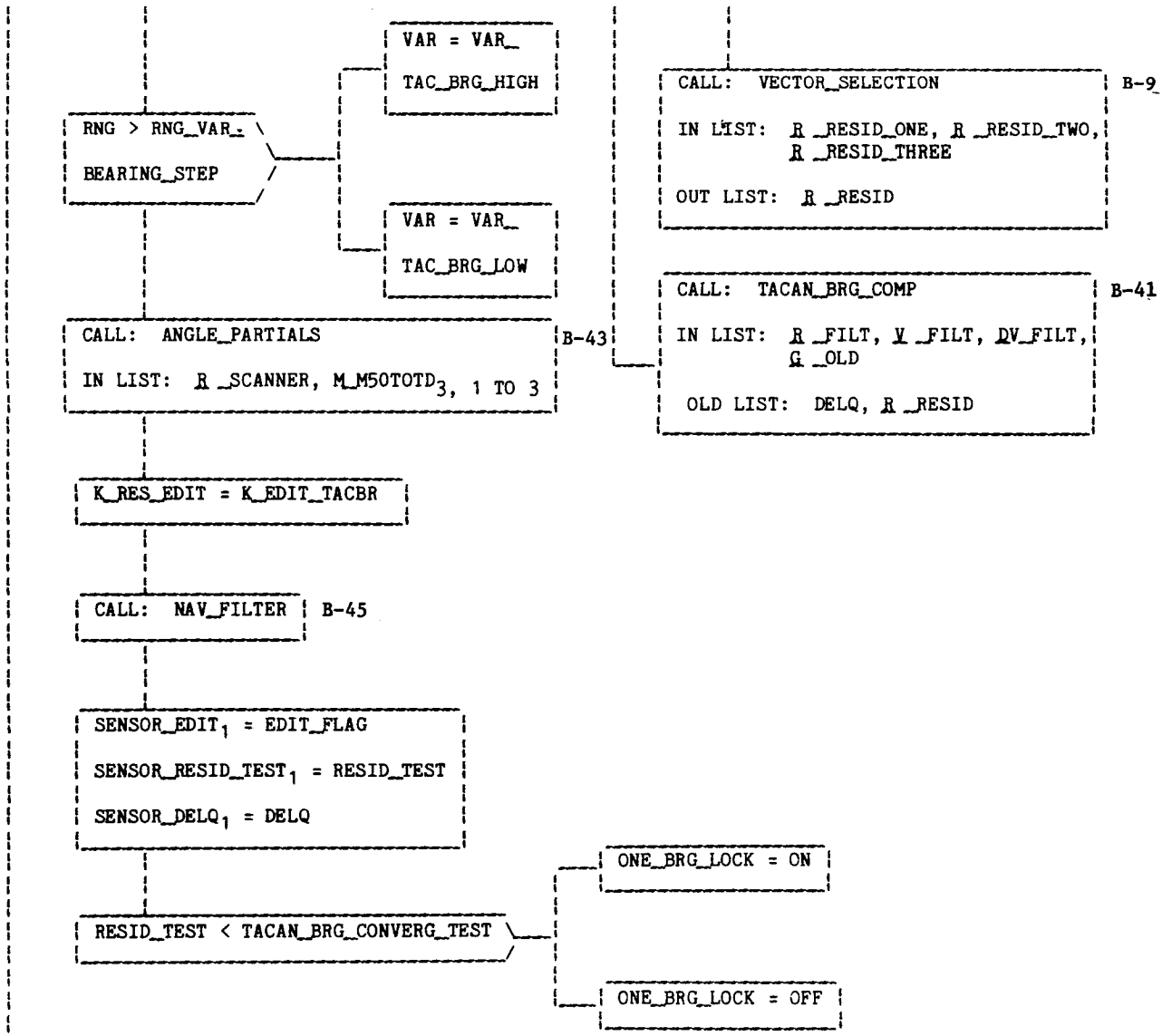
NAV_SENSOR_INIT



TACAN_NAV

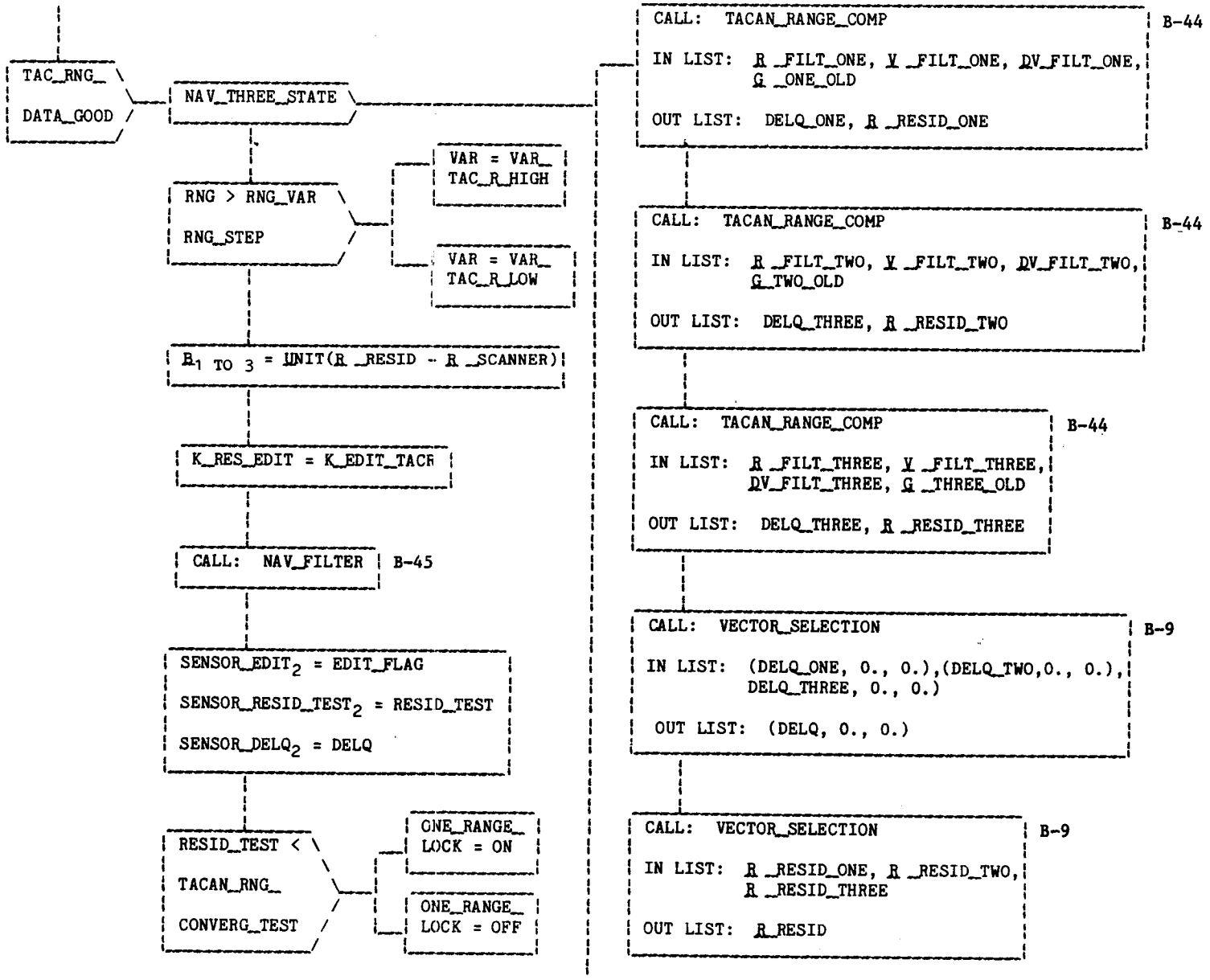

TAC_CHAN_VALID
M_EFTOM50 = EARTH_FIXED_TO_M50_COORD (T_TACAN)
C-41
R _SCANNER = M_EFTOM50 R _TACAN_EF
M_M50TOTD = M_EFTOTD_TACAN M_EFTOM50T
R = R _FILT - R _SCANNER
RNG = |R|
MANUAL_EDIT_OVERRIDE = TACAN_EDIT_OVERRIDE
STAT_FLAG = TACAN_STAT
IN_CONE_FLAG = OFF
TAC_BRG_
DATA_GOOD
NAV_THREE_
STATE
(CONT)
(CONT)
CALL: TACAN_BRG_COMP
B-41
IN LIST: R _FILT_ONE, V _FILT_ONE,
DV_FILT_ONE, G _ONE_OLD
OUT LIST: DELQ_ONE, R _RESID_ONE
CALL: TACAN_BRG_COMP
B-41
IN LIST: R _FILT_TWO, V _FILT_TWO,
DV_FILT_TWO, G _TWO_OLD
OUT LIST: DELQ_TWO, R _RESID_TWO
CALL: TACAN_BRG_COMP
B-41
IN LIST: R _FILT_THREE, V _FILT_THREE,
DV_FILT_THREE, G _THREE_OLD
OUT LIST: DELQ_THREE, R _RESID_THREE
CALL: VECTOR_SELECTION
IN LIST: (DELQ_ONE, 0., 0.),(DELQ_TWO, 0., 0
(DELQ_THREE, 0., 0.)
OUT:LIST: (DELQ, 0., 0.)
(CONT)
(CONT)

NAV (CONTINUED)



(CONT)

TACAN_NAV (CONTINUED)



(CONT)

TACAN_NAV (CONCLUDED)

```
CALL:  TACAN_RANGE_COMP                    B-44

IN LIST:  R_FILT, V_FILT, DV_FILT,
          G_GOLD

OUT LIST:  DELQ, R_RESID
```

TACAN_BRG_COMP

IN LIST: R, V, DV, G

OUT LIST: DQ, R_RESID_TACAN

CALL: SV_INTERP

IN LIST: T_TACAN, R, V, DV, G

B-42

REL_R = M_M50TOTD (R_RESID -R_SCANNER)

Q = ARCTAN2 (REL_R_2, REL_R_1) + BIAS_TAC_BRG - ANGLE_CORR_TNTOMAG + PI

DQ = Q_TAC_BRG - Q, R_RESID_TACAN = R_RESID

|DQ| > PI

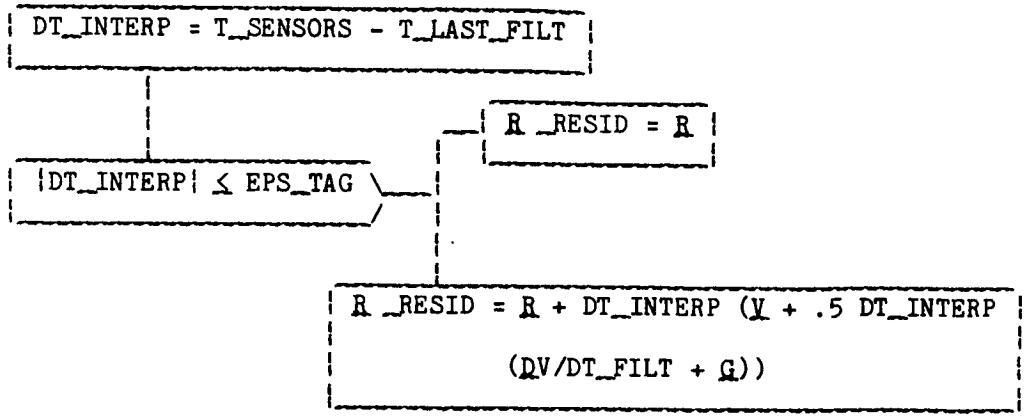
DQ > 0

DQ = DQ - 2PI

DQ = DQ + 2PI

SV_INTERP

IN LIST: T_SENSORS, R, V, DV, G



ANGLE_PARTIALS

IN LIST: R_SENSOR, I_Z

```
REL_R = R_RESID - R_SENSOR

IZ_CROSS_RELR = I_Z X REL_R

B1 TO 3 = IZ_CROSS_RELR/|IZ_CROSS_RELR|2
```

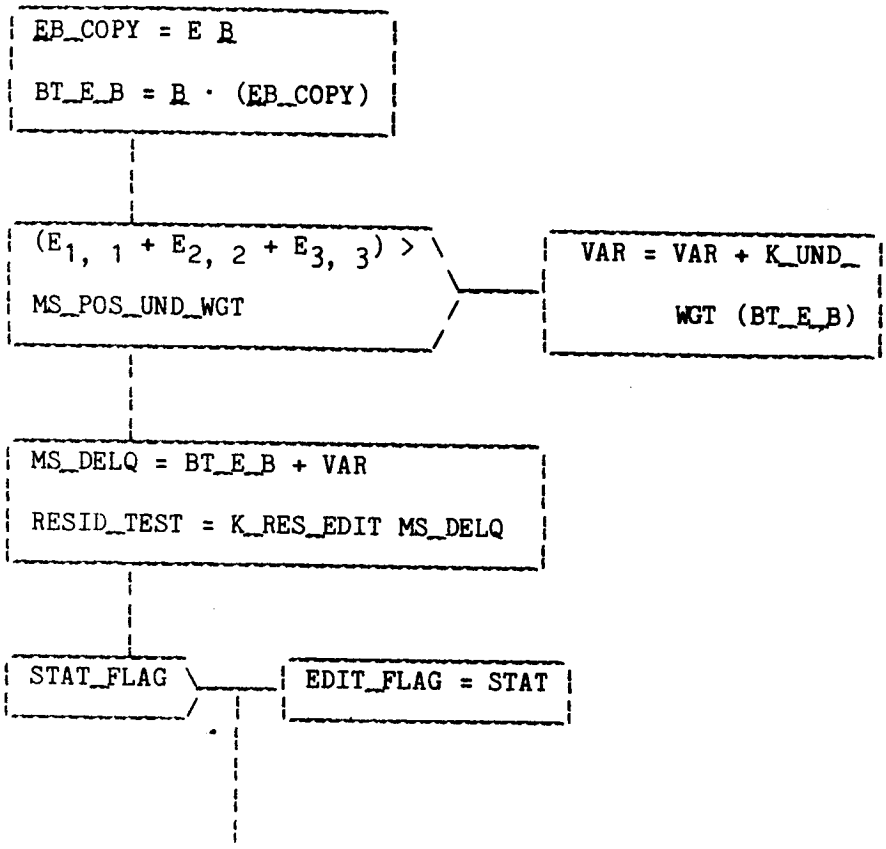
TACAN_RANGE_COMP

IN LIST: R, V, DV, G

OUT LIST: DQ, R_RESID_TACAN

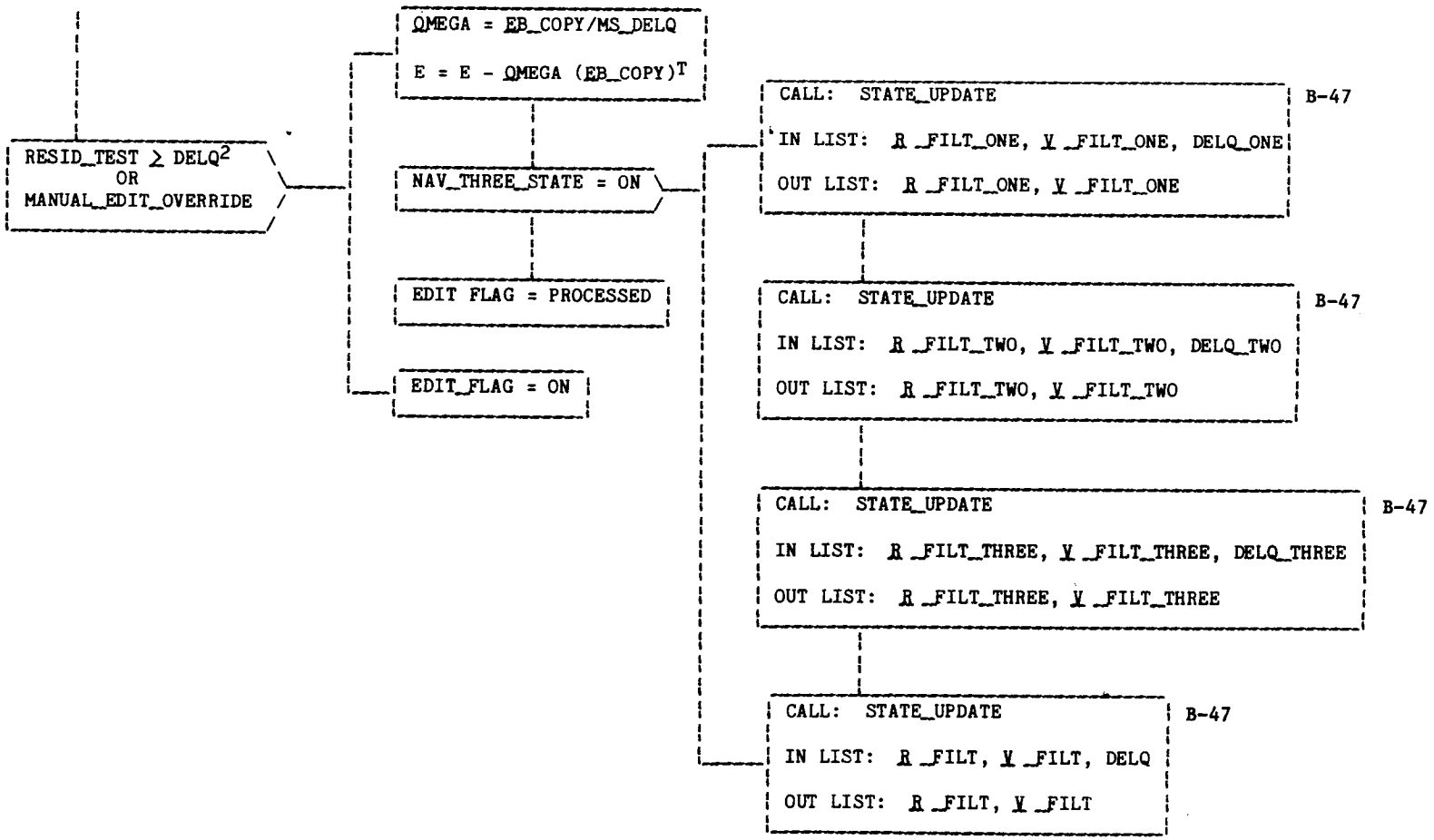
```
┌──────────────────────────────────┐
│ CALL:  SV_INTERP                 │  B-42
│                                  │
│ IN LIST:  T_TACAN, R, V, DV, G   │
└──────────────────────────────────┘
                 │
                 │
┌──────────────────────────────────────────────┐
│ Q = |R_RESID - R_SCANNER| + BIAS_TAC_R       │
│                                              │
│ DQ = Q_TAC_R - Q                             │
│                                              │
│ R_RESID_TACAN = R_RESID                      │
└──────────────────────────────────────────────┘
```

NAV_FILTER



(CONT)

NAV_FILTER (CONCLUDED)



STATE_UPDATE

IN LIST: $\underline{R}$, $\underline{V}$, DQ

OUT LIST: $\underline{R}$, $\underline{V}$

$$\underline{R} = \underline{R} + \underline{\Omega}\mathrm{MEGA}_{1 \text{ TO } 3}\ \mathrm{DQ}$$

$$\underline{V} = \underline{V} + \underline{\Omega}\mathrm{MEGA}_{4 \text{ TO } 6}\ \mathrm{DQ}$$

DRAG_NAV CODE

```
CALL:  VECTOR_SELECTION                                   B-9
IN LIST:  R_FILT_ONE, R_FILT_TWO, R_FILT_THREE
OUT LIST:  R_FILT

B1 TO 3 = UNIT(R_FILT)
VAR = VAR_DRAG

CALL:  SBODY_TO_M50                                       C-48
IN LIST:  Q_M50_BODY
OUT LIST:  M_SBODYM50

CALL:  DRAG_COMP                                          B-50
IN LIST:  R_FILT_ONE, V_FILT_ONE, DV_FILT_ONE
OUT LIST:  DELQ_ONE

CALL:  DRAG_COMP                                          B-50
IN LIST:  R_FILT_TWO, V_FILT_TWO, DV_FILT_TWO
OUT LIST:  DELQ_TWO

CALL:  DRAG_COMP                                          B-50
IN LIST:  R_FILT_THREE, V_FILT_THREE, DV_FILT_THREE
OUT LIST:  DELQ_THREE
```

(CONT)

DRAG_NAV CODE (CONCLUDED)

```
CALL:  VECTOR_SELECTION                                  B-9

IN LIST:  (DELQ_ONE, 0., 0.)(DELQ_TWO, 0., 0.),
          (DELQ_THREE, 0., 0.)

OUT LIST:  (DELQ, 0., 0.)
```

```
MANUAL_EDIT_OVERRIDE = DRAG_EDIT_OVERRIDE

STAT_FLAG = DRAG_STAT
```

```
K_RES_EDIT = K_EDIT_DRAG
```

```
CALL:  NAV_FILTER   B-45
```

```
SENSOR_EDIT4 = EDIT_FLAG                                 B-39

SENSOR_RESID_TEST4 = RESID_TEST

SENSOR_DELQ4 = DELQ
```

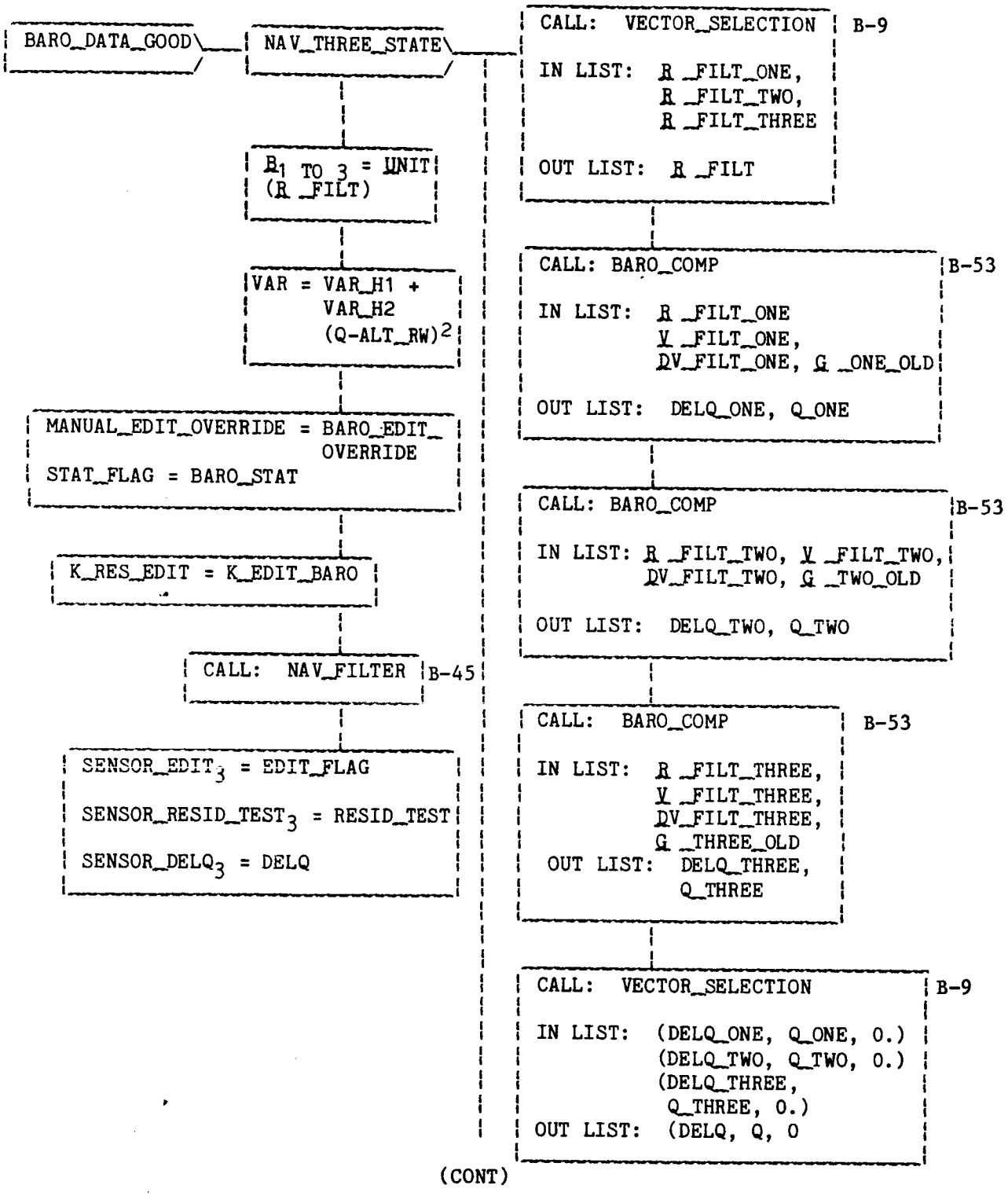
DRAG_COMP

IN LIST: R, V, DV

OUT LIST: DQ

```
V_RHO = V_REL(V, R), I V_RHO = UNIT(V_RHO)                          B-28
V_RHO_BODY = M_SBODYM50^T V_RHO
ALPHAR = |ARCTAN(V_RHO_BODY_3/V_RHO_BODY_1)|
C_DRAG = C_DRAG_ZERO + ALPHAR (C_DRAG_ONE + ALPHAR C_DRAG_TWO)
        |
Q = H_ELLIPSOID(R)   B-26
        |
DO FOR I = 1, 4 \___ Q > DENSITY_LIMIT_I \___ LAYER = I
        |
H_S = SCALE_HT_LAYER, RHO_ZERO = BASE_DEN_LAYER, BIAS_DRAG = BIAS_DRAG_LAYER_LAYER
        |
Q_DRAG = H_S ln(C_DRAG DRAG_CONST RHO_ZERO DT_FILT
                (V_RHO · V_RHO)/|(I V_RHO · DV)|)
DQ = Q_DRAG - Q - BIAS_DRAG
```

BARO_NAV



(CONT)

BARO_NAV (CONCLUDED)

```
CALL:  BARO_COMP                  B-53

IN LIST:  R _FILT, V _FILT,
          DV_FILT, G _OLD
OUT LIST:  DELQ, Q
```

BARO_COMP

IN LIST: R, V, DV, G

OUT LIST: DQ, Q

```
CALL:  SV_INTERP                          B-42

IN LIST:  T_BARO, R, V, DV, G
```

```
Q = H_ELLIPSOID (R _RESID) + BIAS_BARO    B-26

     -DELH_MSL_ELLIPSOID_RW

DQ = Q_BARO-Q
```

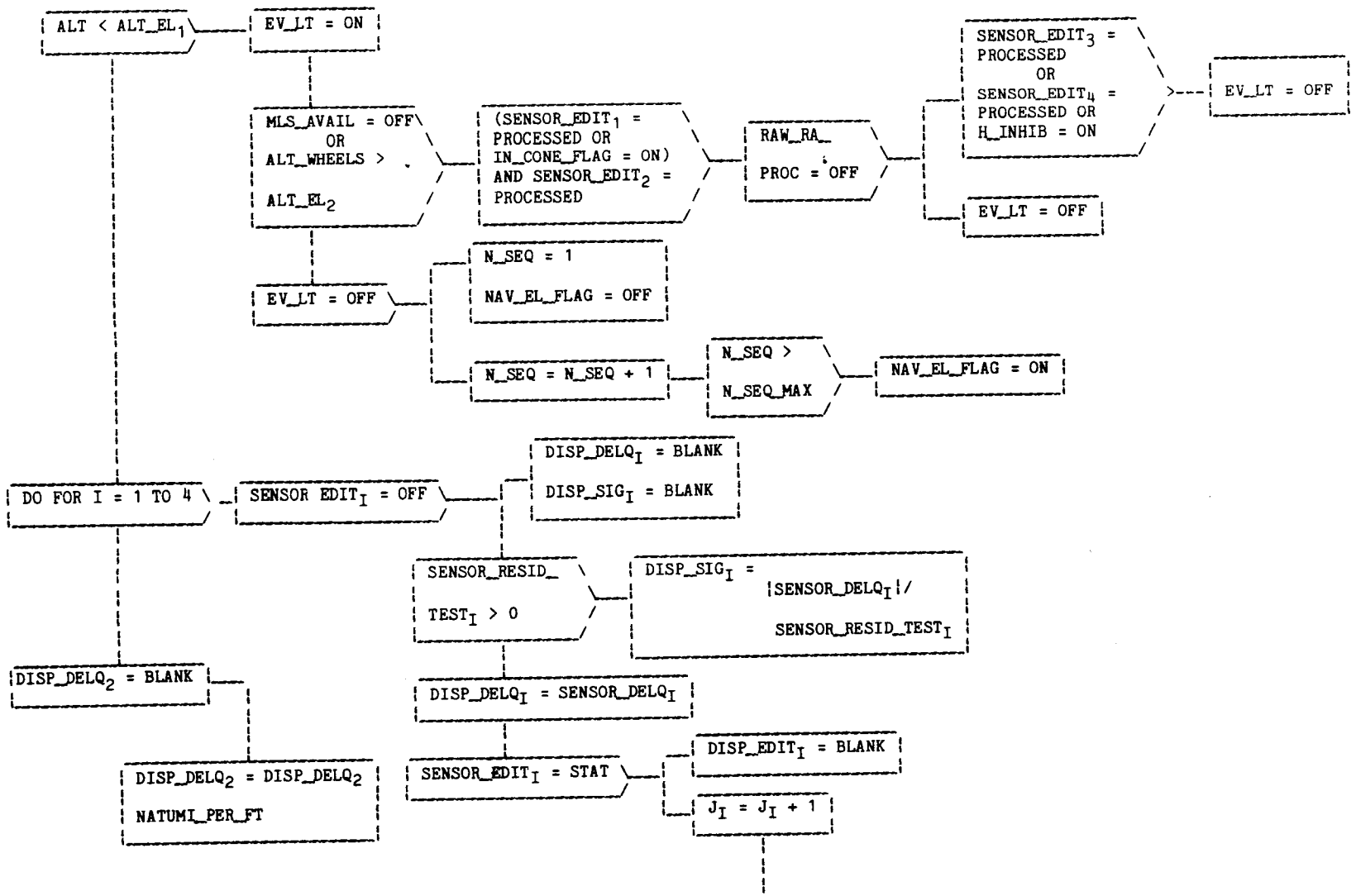
THREE_STATE_TO_ONE_STATE CODE

```
CALL:  VECTOR_SELECTION                                    B-9

IN LIST:  R_FILT_ONE, R_ _FILT_TWO, R_FILT_THREE

OUT LIST:  R_FILT

CALL:  VECTOR_SELECTION                                    B-9

IN LIST:  V_FILT_ONE, V_FILT_TWO, V_FILT_THREE

OUT LIST:  V_FILT

CALL:  VECTOR_SELECTION                                    B-9

IN LIST:  G_ONE_OLD, G_TWO_OLD, G_THREE_OLD

OUT LIST:  G_OLD
```

UPP_STATE_RESET

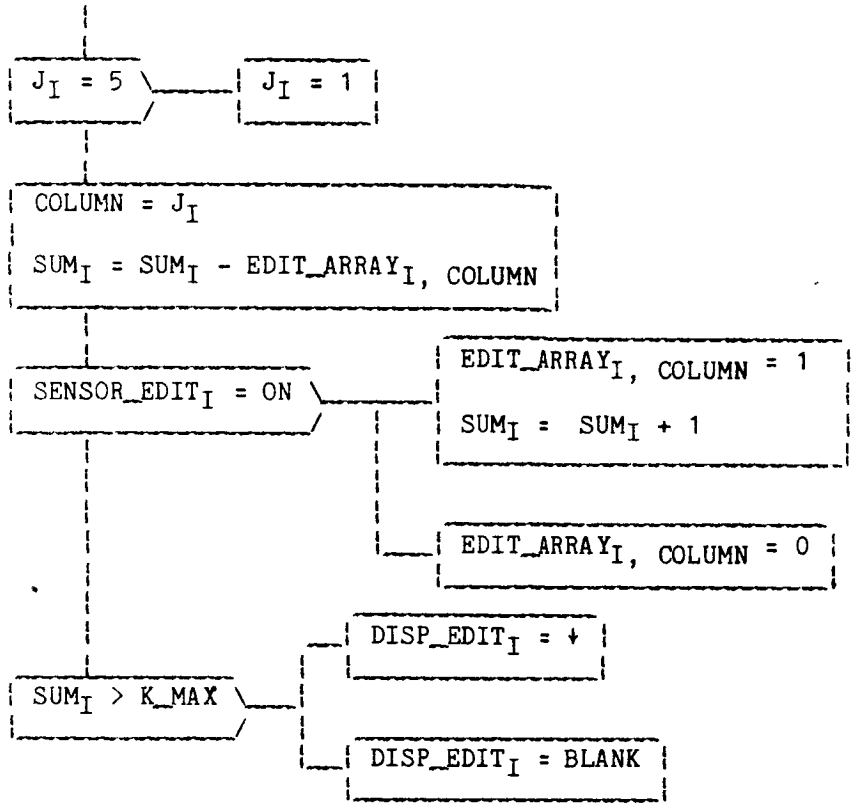
```
R_RESET = R_FILT
V_RESET = V_FILT
V_IMU_RESET = V_LAST_FILT
R_COV_LAST = R_FILT
G_RESET = G_OLD
T_RESET = T_LAST_FILT
FILT_UPDATE = ON
```

MEAS_PROCESSING_STATISTICS_ENTRY CODE



(CONT)

MEAS_PROCESSING_STATISTICS_ENTRY CODE (CONCLUDED)



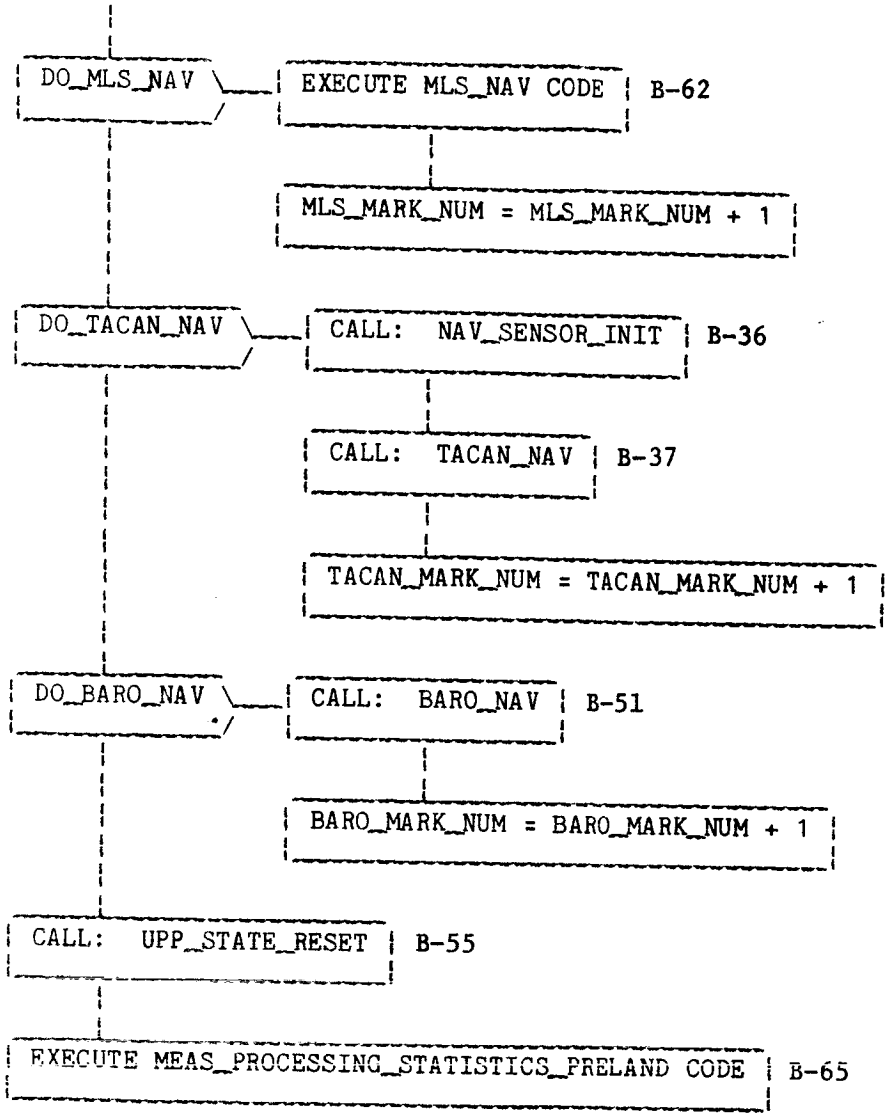
NOTE: THE CORRESONDENCE BETWEEN THE INDEX I AND THE MEASUREMENT TYPE IS AS FOLLOWS: 1~TACAN BEARING, 2~TACAN RANGE, 3~BARO ALTITUDE, AND 4~DRAG ALTITUDE.

FOR FURTHER INFORMATION SEE NOTE ON FLOW CHART FOR MEAS_PROCESSING_STATISTICS_PRELAND

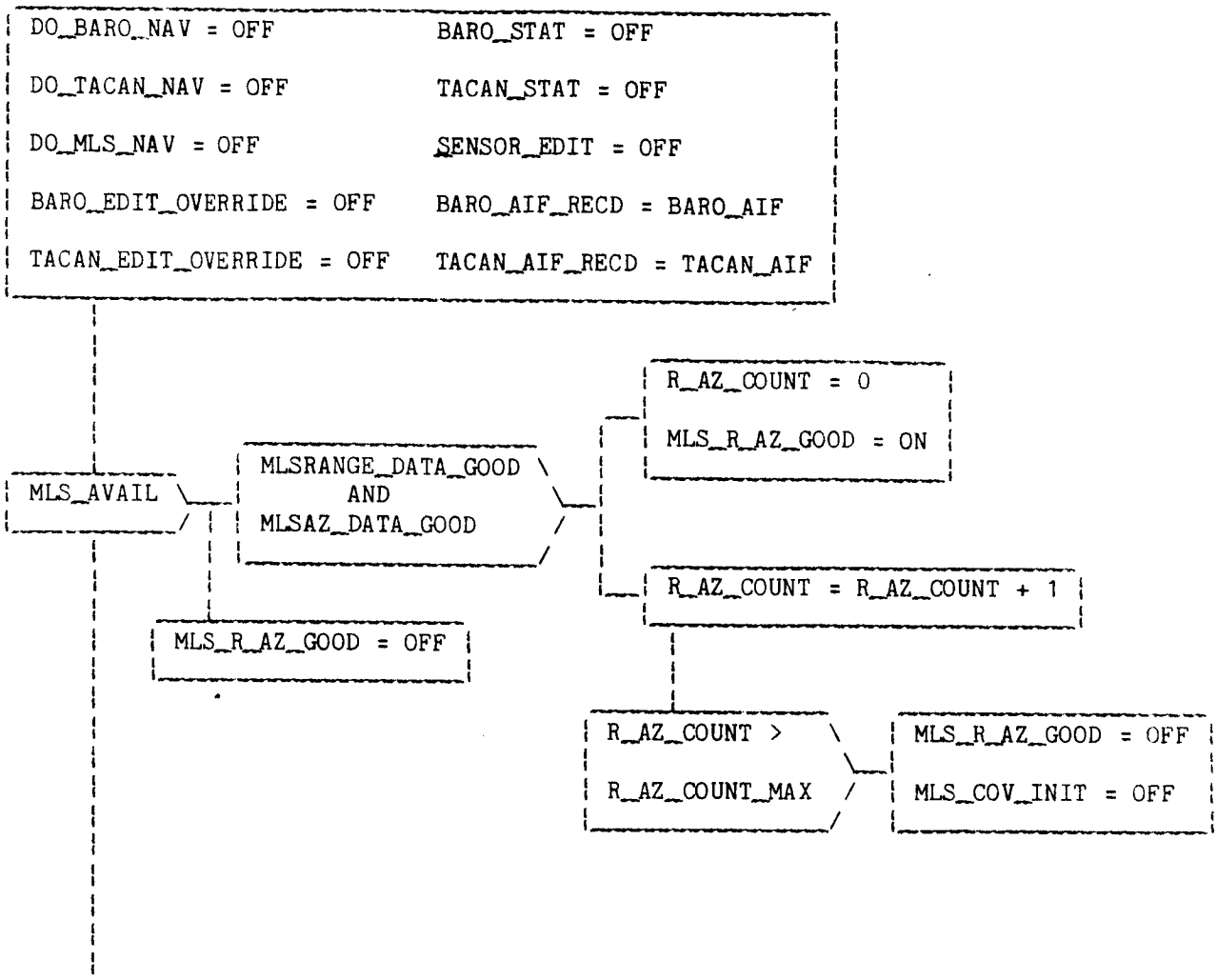
NAV_PRELAND

```
SNAP IMU (V_CURRENT_FILT, T_CURRENT_FILT)

SNAP BARO ALTIMETER (Q_BARO, MACH_JUMP, BARO_DATA_GOOD, T_BARO)
SNAP TACAN (Q_TAC_BRG, Q_TAC_R, TAC_RNG_DATA_GOOD, TAC_BRG_DATA GOOD,
            T_TACAN, SEL_LRU_ID)
T_BARO = T_BARO - TIME_BIAS_BARO
T_TACAN = T_TACAN - TIME_BIAS_TACAN

SNAP MSBLS (Q_RANGE, Q_AZMLS, Q_ELMLS, MLSRANGE_DATA_GOOD,
            MLSAZ_DATA_GOOD, MLSEL_DATA_GOOD, T_EF_RMLS,
            T_EF_AZMLS, T_EF_ELMLS)
PITCH_M = THETA RAD_PER_DEG
T_EF_RMLS =  T_EF_RMLS - TIME_BIAS_MLS
T_EF_AZMLS = T_EF_AZMLS - TIME_BIAS_MLS
T_EF_ELMLS =  T_EF_ELMLS - TIME_BIAS_MLS

CALL:  NAV_STATE_PROP        B-18

CALL:  COVEXTRAP_PF          B-29

EXECUTE PRELAND_SENSOR_SELECT CODE        B-60

DO_DELTA_UPDATE \___ CALL:  OPS_3_DELTA_UPDATE        B-32
                /

(CONT)
```

NAV_PRELAND (CONCLUDED)

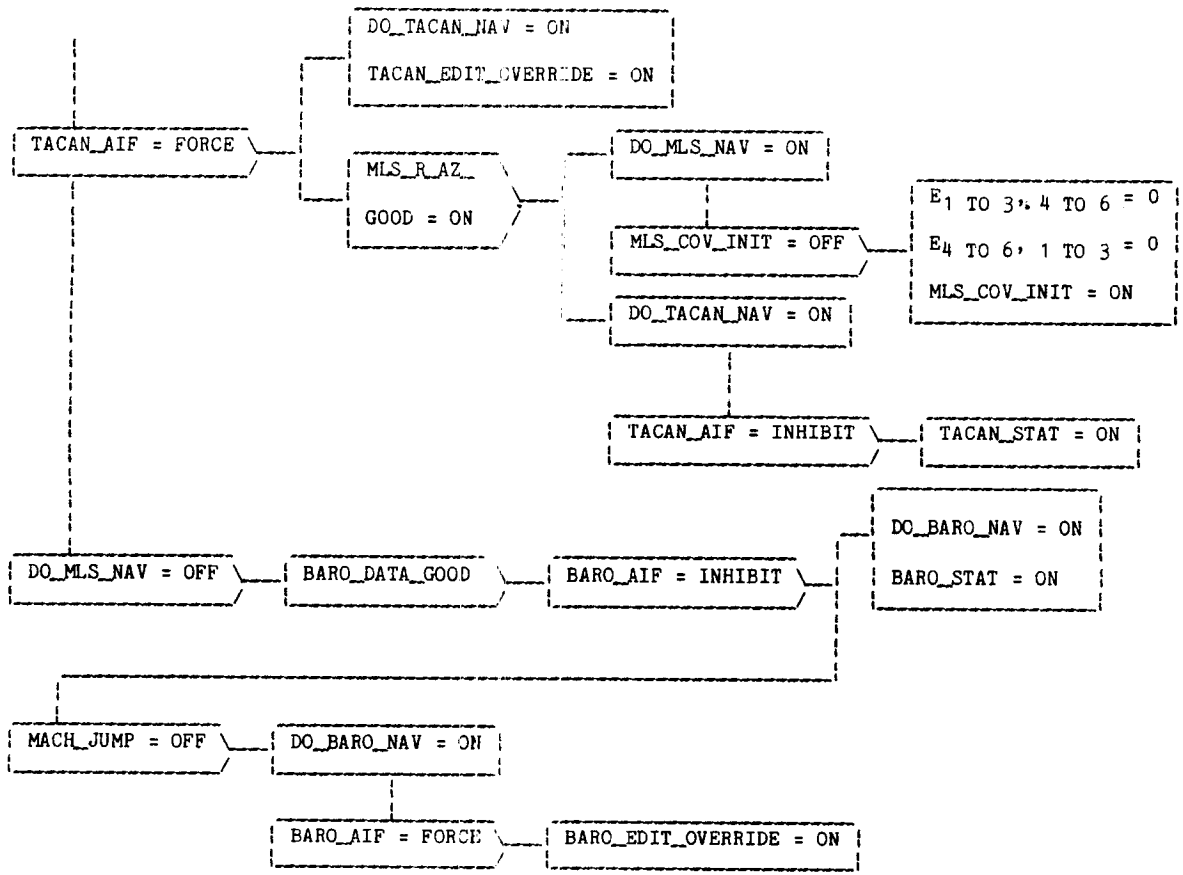


PRELAND_SENSOR_SELECT CODE



(CONT)

PRELAND_SENSOR_SELECT CODE (CONCLUDED)



MLS_NAV CODE

```
MANUAL_EDIT_OVERRIDE = OFF
STAT_FLAG = OFF
        |
MLSRANGE_DATA_GOOD \___ EXECUTE MLS_RANGE_NAV CODE  B-63
                   /
        |
MLSAZ_DATA_GOOD \___ EXECUTE MLS_AZ_NAV CODE  B-67
                /
        |
MLSEL_DATA_GOOD \___ EXECUTE MLS_EL_NAV CODE  B-64
                /
```

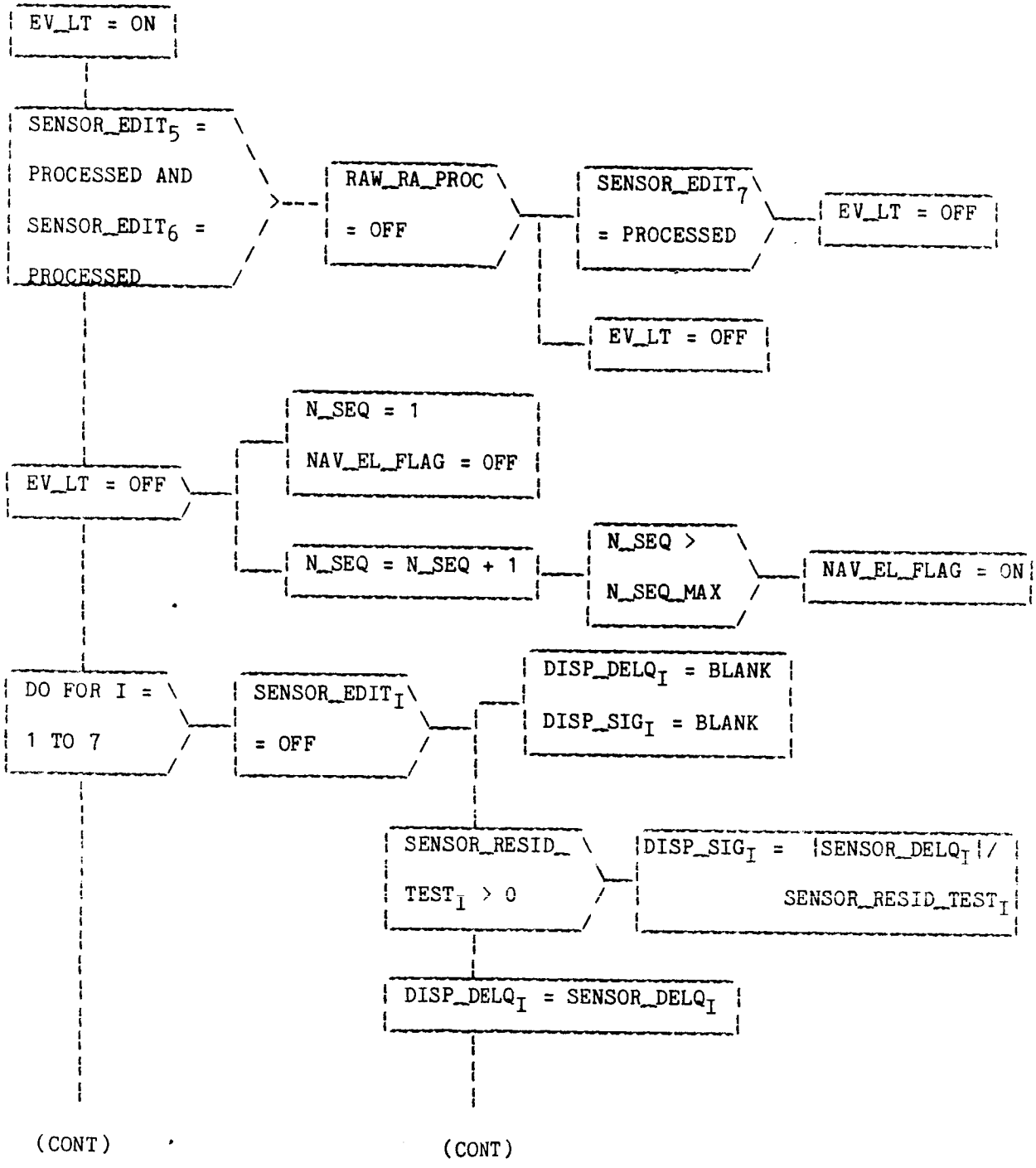
MLS_RANGE_NAV CODE

```
CALL:  SV_INTERP                                                    B-42
IN LIST:  T_EF_RMLS, R_FILT, V_FILT, DV_FILT, G_OLD
        |
VAR = VAR_RMLS
        |
R_SCANNER = EARTH_FIXED_TO_M50_COORD(T_EF_RMLS) R_RMLS_EF           C-41
        |
Q = |R_RESID - R_SCANNER| + BIAS_RMLS
DELQ = Q_RANGE - Q
        |
B1 TO 3 = UNIT(R_RESID - R_SCANNER)
        |
K_RES_EDIT = K_EDIT_MLSR
        |
CALL:  NAV_FILTER                                                   B-45
        |
SENSOR_EDIT6 = EDIT_FLAG
SENSOR_RESID_TEST6 = RESID_TEST
SENSOR_DELQ6 = DELQ
```

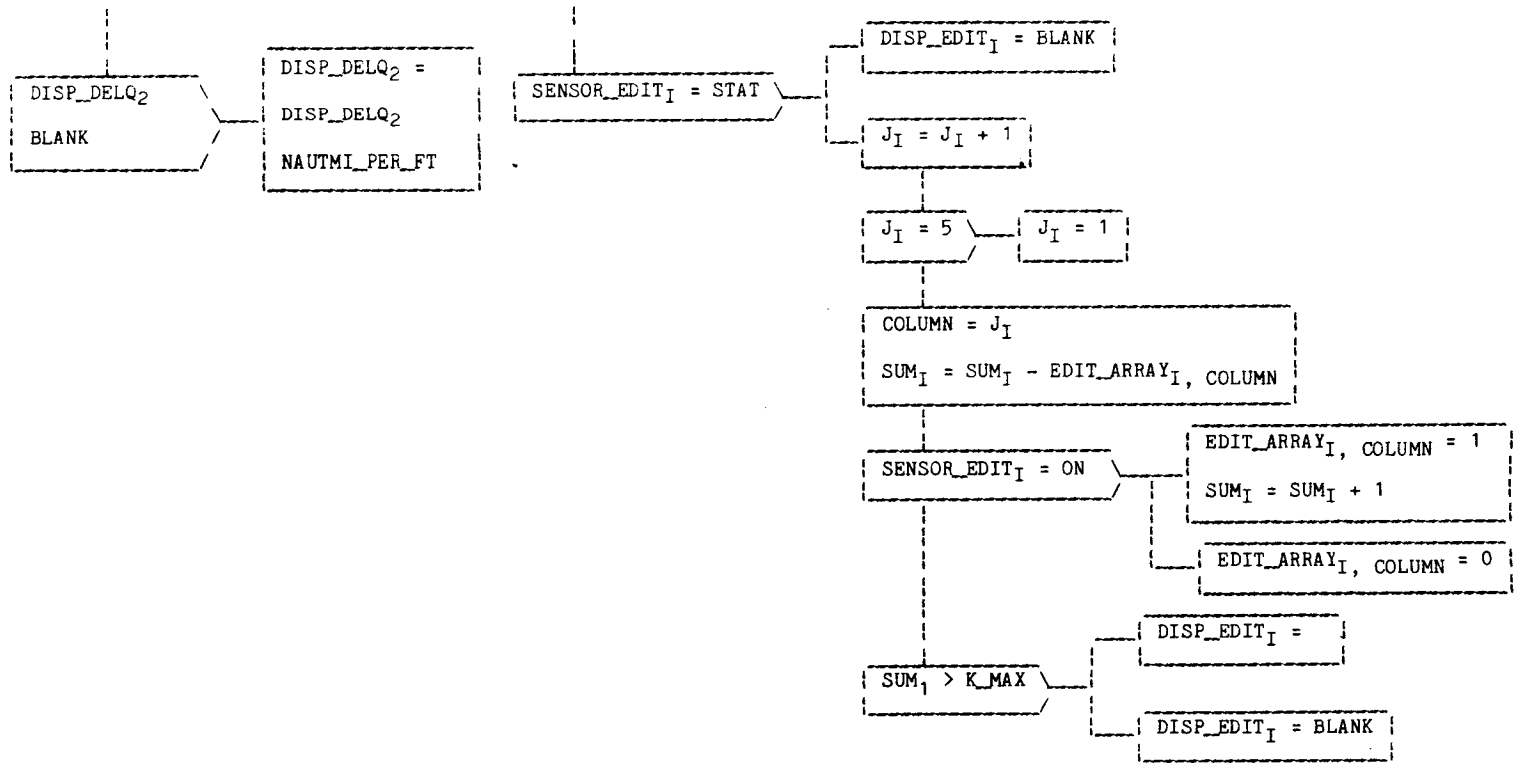
MLS_EL_NAV CODE

```
CALL:  SV_INTERP                                                    B-42
IN LIST:  T_EF_ELMLS, R_FILT, V_FILT, DV_FILT, G_OLD

M_EFTOM50 = EARTH_FIXED_TO M50_COORD(T_EF_ELMLS)                    C-41
R_ELMLS = M_EFTOM50 R_ELMLS_EF
VAR = VAR_ELMLS
M_M50_TO_SCANNER = M_EFTORAD_EL M_EFTOM50^T
R = M_M50_TO_SCANNER(R_RESID - R_ELMLS)
R_RHO = |R|
Q = ARCTAN(R3/R1) + BIAS_ELMLS
Q = Q + MLSANT_NB_DIST SIN(Q + PITCH_M - MLSANT_ANG)/R_RHO
DELQ = Q_ELMLS - Q

CALL:  ANGLE_PARTIALS                                               B-43
IN LIST:  R_ELMLS, -M_M50_TO_SCANNER2, 1 TO 3

K_RES_EDIT = K_EDIT_MLSEL

CALL:  NAV_FILTER                                                   B-45

SENSOR_EDIT7 = EDIT_FLAG
SENSOR_RESID_TEST7 = RESID_TEST
SENSOR_DELQ7' = DELQ
```

MEAS_PROCESSING_STATISTICS_PRELAND CODE



MEAS_PROCESSING_STATISTICS_PRELAND CODE (CONCLUDED)



NOTE: THE VECTORS DISP_EDIT, DISP_DELQ, AND DISP_SIG ARE OUTPUT TO COMPOOL FOR SUBSEQUENT USE BY DISPLAYS.

THE CORRESPONDENCE BETWEEN THE INDEX I AND THE MEASUREMENT TYPE IS AS FOLLOWS: 1~TACAN BEARING, 2~TACAN RANGE, 3~BARO ALTITUDE, 4~DRAG ALTITUDE 5~MLS AZIMUTH, 6~MLS RANGE, AND 7~MLS ELEVATION. THE ARRAYS SENSOR_DELQ AND SENSOR_RESID_TEST ARE FOUR DIMENSIONAL, WHILE THE ARRAY SENSOR_EDIT IS SEVEN DIMENSIONAL.

MLS AZ NAV CODE

```
CALL:  SV_INTERP
IN LIST:  T_EF_AZMLS, R _FILT, V _FILT, DV_FILT, G _OLD
```

```
M_EFTOM50 = EARTH_FIXED_TO_M50_COORD (T_EF_AZMLS)
R _AZMLS = M_EFTOM50 R _AZMLS_EF
VAR = VAR AZMLS
M_M50_TO_SCANNER = M_EFTORAD_R_AZ M_EFTOM50^T
R = M_M50_TO_SCANNER (R _RESID - R _AZMLS)
Q = ARCTAN (R2/R1) + BIAS_AZMLS
DELQ_ = Q_AZMLS - Q
```

```
CALL:  ANGLE_PARTIALS
IN LIST:  R _AZMLS, M_M50_TO_SCANNER3, 1 TO 3
```

```
K_RES_EDIT = K_EDIT_MLSAZ
```

```
CALL:  NAV_FILTER
```

```
SENSOR_EDIT5 = EDIT_FLAG
SENSOR_RESID_TEST5 = RESID_TEST
SENSOR_DELQ5 = DELQ
```

APPENDIX C

GENERAL REQUIREMENT PRINCIPAL FUNCTIONS AND COORDINATE TRANSFORMATIONS FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS

This page intentionally left blank.

CONTENTS

Subject | Page

Coordinate System Definitions

Aries Mean of 1950, Cartesian C-7
Earth Fixed - Greenwich True of Date C-8
Aries True of Date, Cartesian C-9
Geodetic Parameters C-10
Runway C-12
Topodetic C-13
MSBLS Scanner C-14
Structural Body C-15
Stable Member (IMU) C-16
NWU Geographic C-18
Body Axis C-19
UVW C-20

Entry Operations Computer Load General Requirements

Variable List and Flow Charts C-21

Variable List C-23
Flow Charts C-39

Coordinate System Flow Charts

EARTH_FIXED_TO_M50_COORD C-41
EF_TO_TOPDET C-42
EF_TO_RUNWAY C-43
EF_TO_SCANNER C-44
EF_TO_GEODETIC C-45
GEODETIC_TO_EF C-46
UVW_TO_M50 . . . . . C-47
SBODY_TO_M50 . . . . . C-48
QUAT_TO_MAT C-49

Site Lookup Flow Charts

ENTRY_RUNWAY_SITE_LOOKUP C-50
ENTRY_TACAN_SITE_LOOKUP C-53
ENTRY_RUNWAY_SITE_LOOKUP_INIT C-57
ENTRY_TACAN_SITE_LOOKUP_INIT C-56

Precision State Prediction

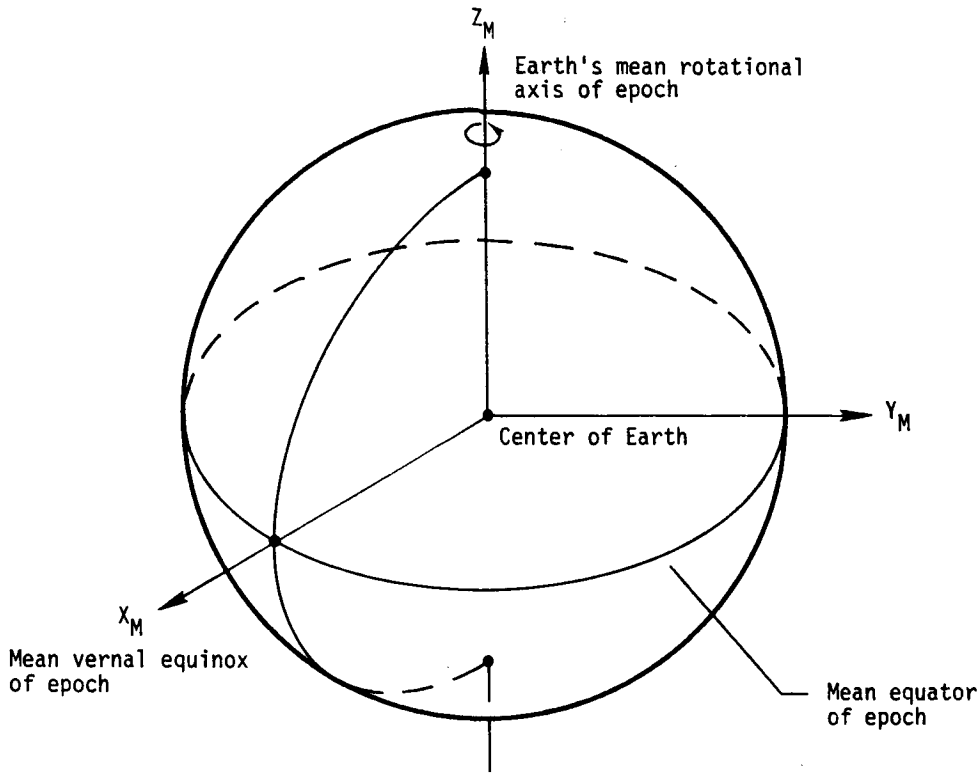
ENTRY_PRECISE_PREDICTOR C-54

AUTO TACAN SELECTION

ENTRY_AUTO_TACAN_SELECTION C-58
ENTRY_AUTO_TACAN_SELECTION_INIT C-60

COORDINATE SYSTEM DEFINITIONS

This page intentionally left blank



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.

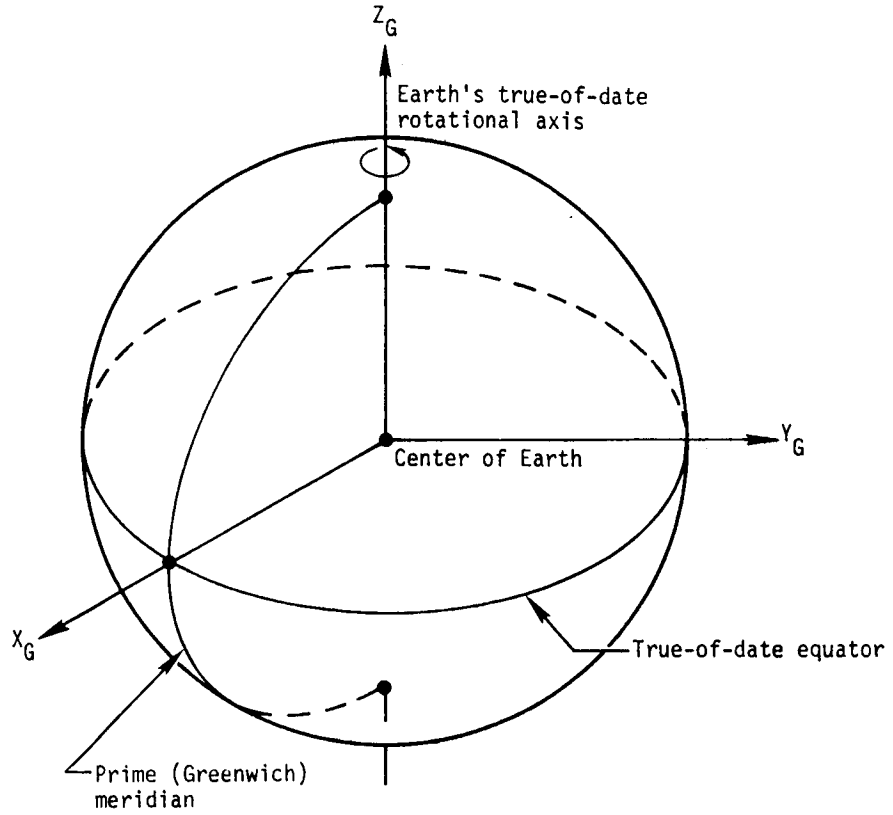
The X_M axis is directed toward the mean vernal equinox of epoch.

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

ARIES MEAN OF 1950, CARTESIAN



NAME: Earth fixed (Greenwich true of date) coordinate system

ORIGIN: The center of the earth

ORIENTATION: The X_G-Y_G plane is the earth's true of date equator.

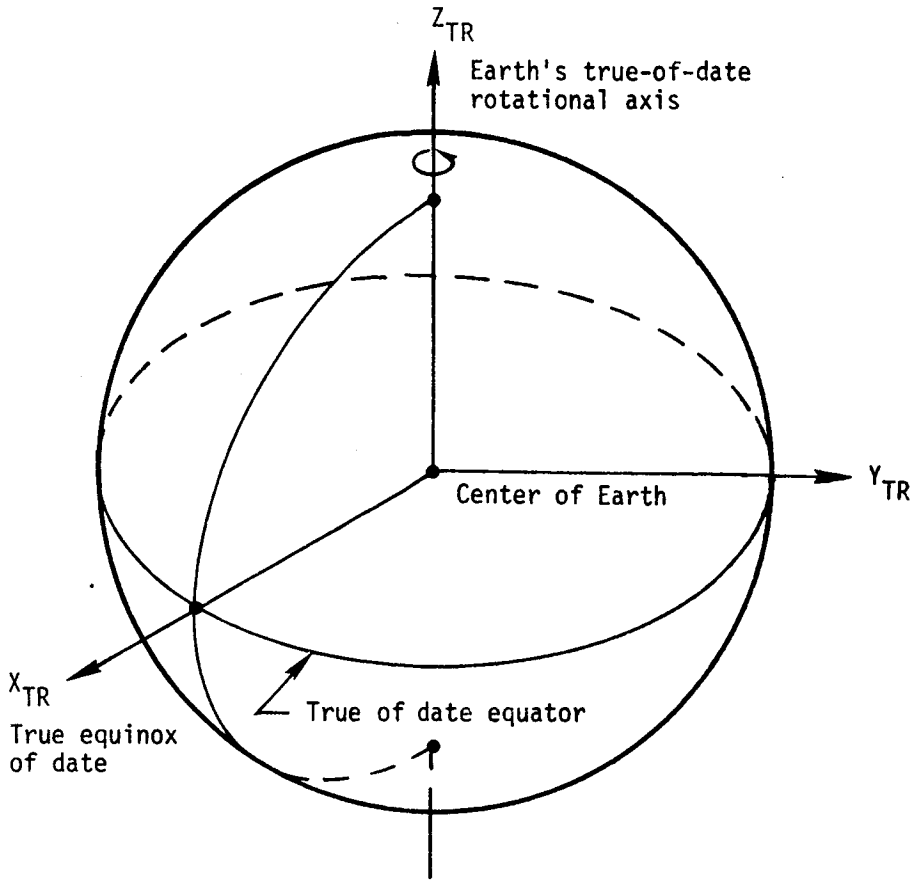
The Z_G axis is directed along the earth's true of date rotational axis and is positive north.

The $+X_G$ axis is directed toward the prime meridian.

The Y_G axis completes a right-handed system.

CHARACTERISTICS: Rotating, right-handed Cartesian. Velocity vectors expressed in this system are relative to a rotating reference frame fixed to the earth, whose rotation rates are expressed relative to the Aries mean of 1950 system.

EARTH FIXED GREENWICH TRUE OF DATE



NAME: Aries true of date, Cartesian, coordinate system

ORIGIN: The center of the earth

ORIENTATION: The epoch is the current time of interest.

The X_{TR}-Y_{TR} plane is the earth's true equator of epoch.

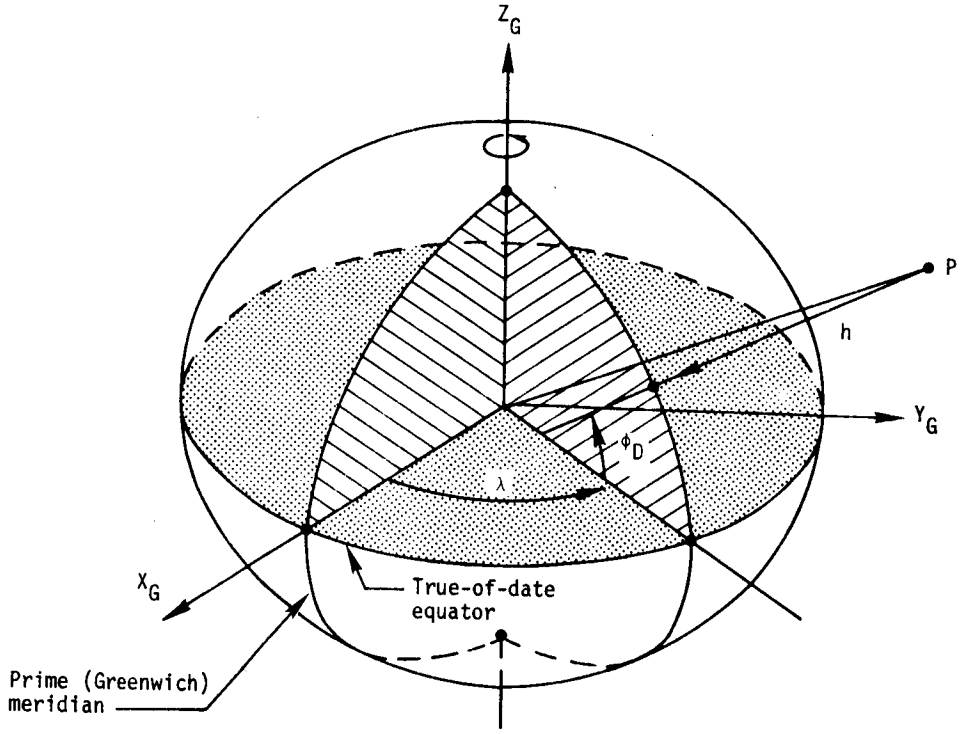
The X_{TR} axis is directed toward the true vernal equinox of epoch.

The Z_{TR} axis is directed along the earth's true rotational axis of epoch and is positive north.

The Y_{TR} axis completes the right-handed system.

CHARACTERISTICS: Quasi-inertial, right-handed Cartesian

ARIES TRUE OF DATE, CARTESIAN



NAME: Geodetic parameters

ORIGIN: This system consists of a set of parameters rather than a coordinate system; therefore, no origin is specified.

ORIENTATION: This system of parameters is based on an ellipsoidal model of the earth (e.g., the Fisher ellipse of 1960). For any point of interest we define a line known as the geodetic local vertical which is perpendicular to the ellipsoid and which contains the point of interest.

h, geodetic altitude, is the distance from the point of interest to the reference ellipsoid, measured along the geodetic local vertical, and is positive for points outside the ellipsoid.

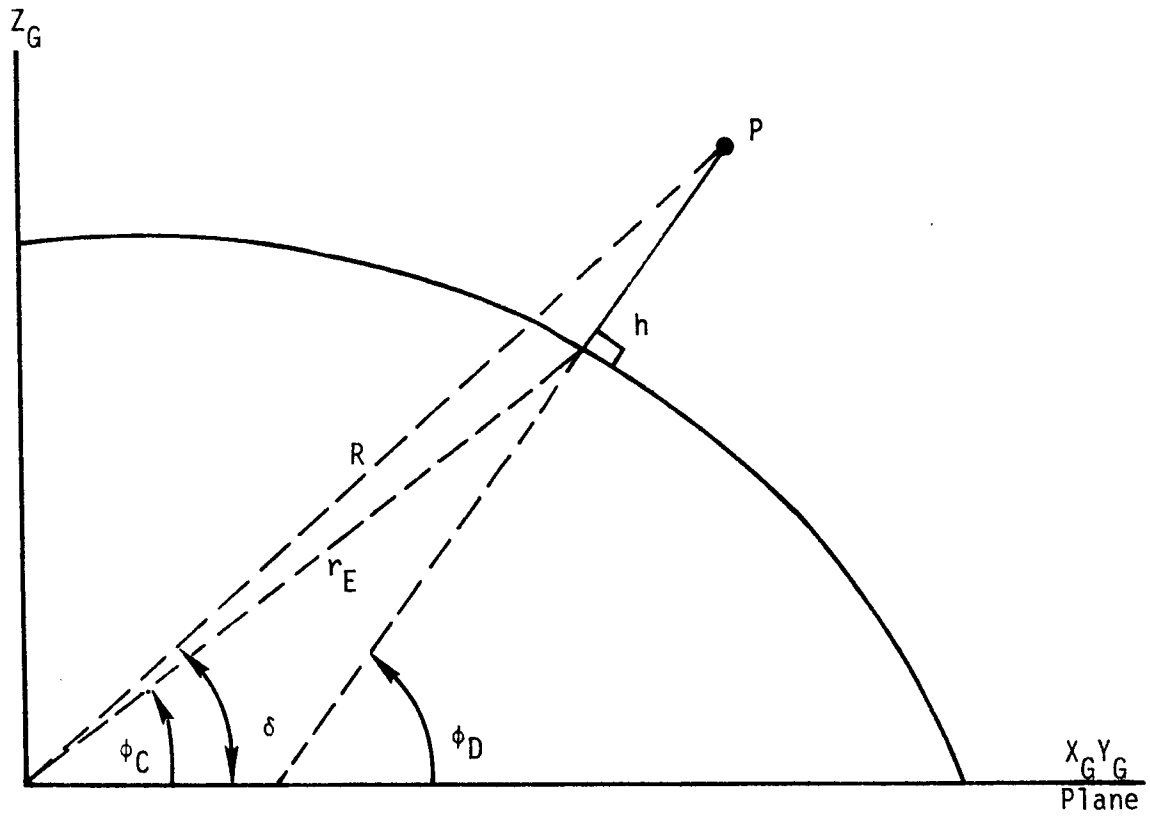
λ is the longitude measured in the plane of the earth's true equator from the Prime (Greenwich) Meridian to the local meridian, measured positive eastward.

ϕ_D is the geodetic latitude, measured in the plane of the local meridian from the earth's true equator to the geodetic local vertical, measured positive north from the equator.

NOTE: A detailed explanation of declination, geodetic latitude, and geocentric latitude is provided in Part B of this figure.

CHARACTERISTICS: Rotating polar coordinate parameters. Only position vectors are expressed in this coordinate system. Velocity vectors should be expressed in the Aries mean of 1950 or the Aries true of data polar for inertial or quasi-inertial representations, respectively.

(A) BASIC DEFINITIONS - GEODETIC PARAMETERS



NAME: Geodetic parameters

DEFINITIONS: h is the altitude of point P. Measured perpendicular from the surface of the referenced ellipsoid.

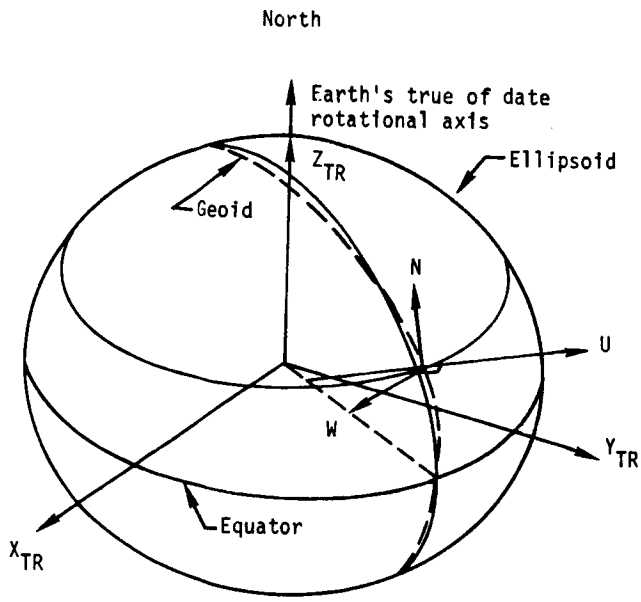
ϕ_D is the geodetic latitude of point P.

ϕ_C is the geocentric latitude of point P.

δ is the angle between radius vector and equatorial plane (declination).

λ is the longitude of point P. Angle (+ east) between plane of the figure and the plane formed by the Greenwich meridian.

(B) DETAILED EXPLANATION - GEODETIC PARAMETERS



NAME: Topodetic coordinate system

ORIGIN: Orbiter center of mass*

ORIENTATION: Z_{TD} is normal to a geodetic local tangent plane and is positive toward the earth's center.

X_{TD} is perpendicular to Z_{TD} axis and is positive northward along the meridian plane containing the orbiter.

Y_{TD} completes the right-handed orthogonal system

CHARACTERISTICS: Rotating, right-handed Cartesian system. Velocity vectors are expressible in this system for the orbiter, given relative velocity V_{TD} in this system.

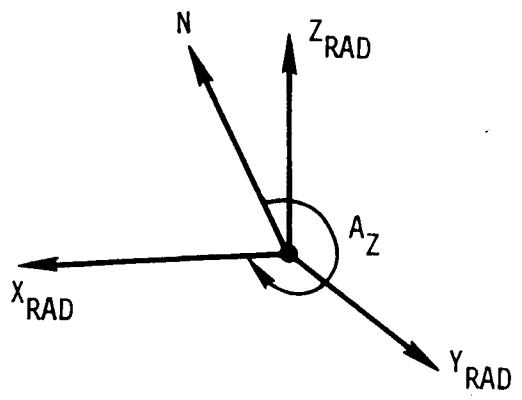
$$\gamma_{TD} = \sin^{-1} \frac{-\dot{Z}_{TD}}{V_{TD}}$$

$$\psi_{TD} = \tan^{-1} \frac{\dot{Y}_{TD}}{\dot{X}_{TD}}$$

ϕ_D = geodetic latitude

*A similar system may be defined for any point of interest

TOPODETIC COORDINATE SYSTEM



NAME: MSBLS radar coordinate system

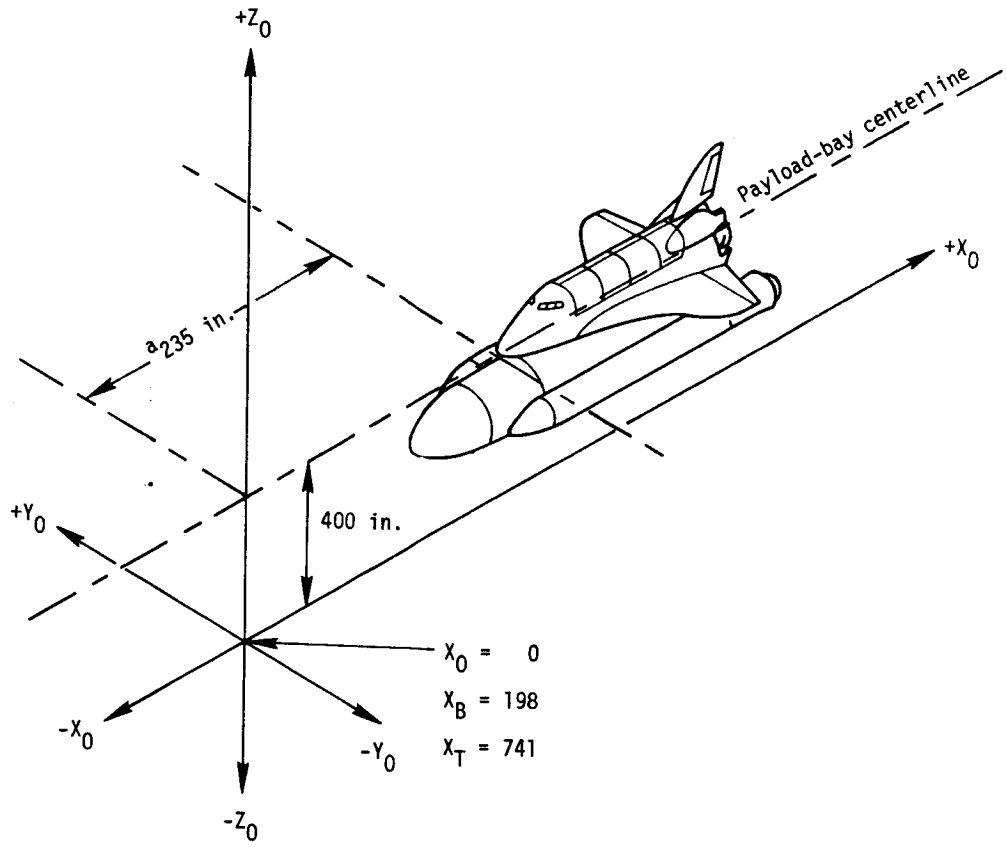
ORIGIN: MSBLS radar position

ORIENTATION AND DEFINITIONS: Z_{RAD} is normal to the ellipsoidal model, positive away from the center of the earth

X_{RAD} is the local horizontal plane of the radar in the boresight direction of the radar antenna. The angle A_Z is measured positively clockwise from true north to X_{RAD}

CHARACTERISTICS: Rotating, earth-referenced

MSBLS RADAR COORDINATE SYSTEM



NAME: Body coordinate system (structural)

ORIGIN: In the orbiter plane of symmetry, 400 inches below the centerline of the payload bay and at orbiter X-station = 0

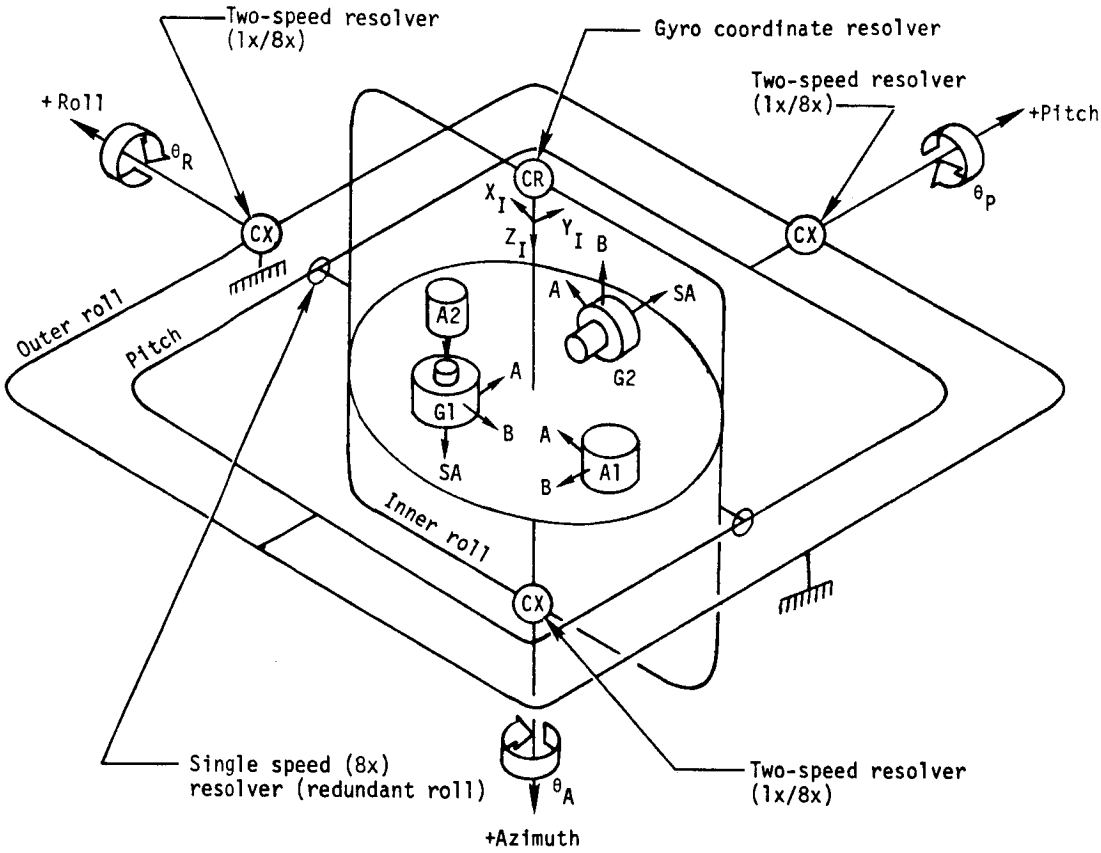
ORIENTATION: The X_0 axis is in the vehicle plane of symmetry, parallel to and 400 inches below the payload bay centerline. Positive sense is from the nose of the vehicle toward the tail.

The Z_0 axis is in the vehicle plane of symmetry, perpendicular to the X_0 axis. Positive upward in landing attitude.

The Y_0 axis completes a right-handed system.

CHARACTERISTICS: Rotating, right-handed Cartesian

BODY COORDINATE SYSTEM (STRUCTURAL)



NAME: Stable member (IMU)

ORIGIN: The intersection of the innermost gimbal axis and the measurement plane of the XY two axis accelerometer

ORIENTATION: The Z_I axis is coincident with the innermost gimbal axis.

The X_I axis is determined by the projection of the X accelerometer input axis (IA) onto a plane orthogonal to Z_I. Y_I completes a right-handed triad.

In a perfect IMU, with all misalignments zero, these relationships hold:

The X accelerometer and X gyro IAs are parallel to the X_I axis.

The Y accelerometer and Y gyro IAs are parallel to the Y_I axis.

The Z accelerometer and Z gyro IAs are parallel to the Z_I axis.

STABLE MEMBER (IMU)

CHARACTERISTICS: Nonrotating, right-handed, Cartesian system.

The reference alignment for the gimbal case shall be defined with the four gimbal angles at zero and with the vehicle in a horizontal position. In a perfect IMU, with all misalignments zero and with all gimbal angles at zero, the following relationships hold.

The outer roll axis and the X_I-axis will be parallel to X_{NB}. Positive X_I will be in the forward direction. Positive roll gimbal angles will be in the sense of a right-handed rotation of the gimbal case relative to the platform about the plus outer roll axis.

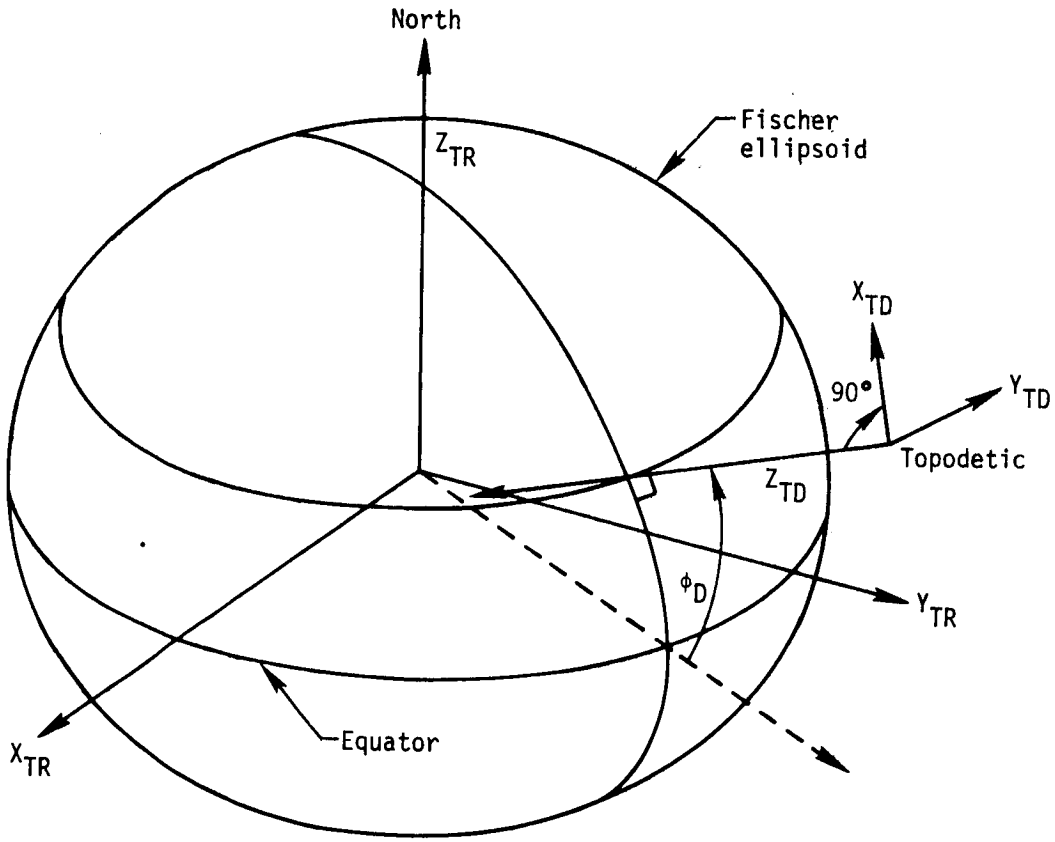
The pitch axis and Y_I will be parallel to Y_{NB}. Positive Y_I will be to the right of an observer looking forward in the vehicle. Positive pitch gimbal angles will be in the sense of a right-handed rotation of the gimbal case relative to the platform about the plus pitch axis.

The inner roll axis will be parallel to the outer roll axis, with the sense of rotation the same as for the outer roll axis.

The azimuth axis and Z_I will be parallel to Z_{NB}. Positive Z_I will be down relative to an observer standing in the vehicle. Positive azimuth gimbal angles will be in the sense of a right-handed rotation of the gimbal case relative to the platform about the plus azimuth axis.

X_{NB}, Y_{NB}, Z_{NB} are Cartesian components of the navigation base coordinate system.

STABLE MEMBER (IMU)



NAME: NWU geographic coordinate system

ORIGIN: Point of interest

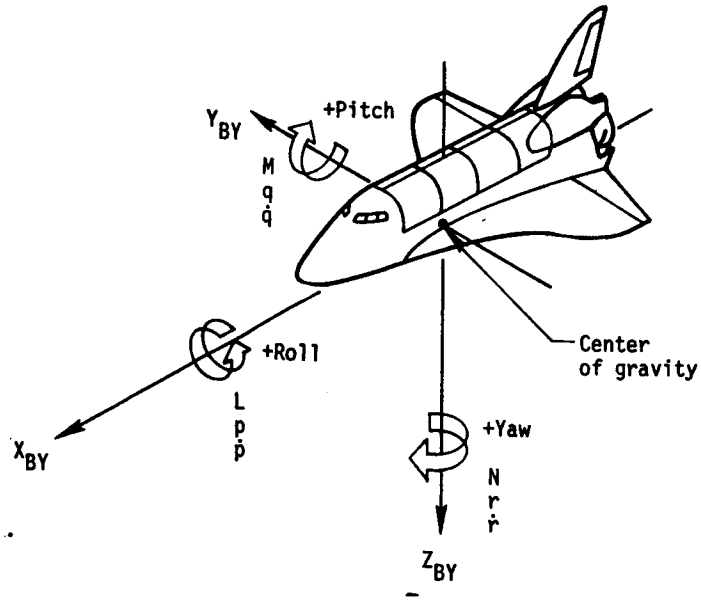
ORIENTATION: U is positive up along the earth's astronomic or plumb-bob vertical.

W is positive along the cross product of U and the Earth's spin axis.

N completes the right-handed orthogonal system. (N = W x U)

CHARACTERISTICS: Rotating, right-handed, earth referenced coordinate system

NWU GEOGRAPHIC 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

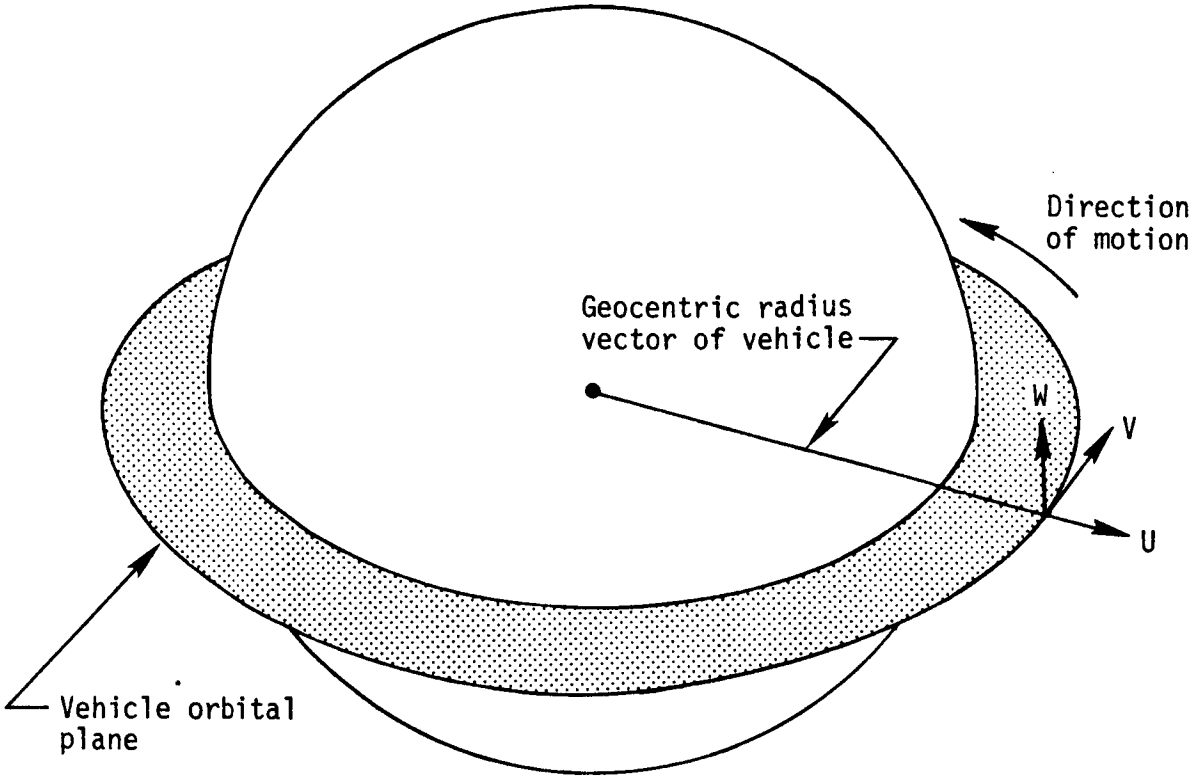
p, q, r: Body rates about X_{BY}, Y_{BY}, and Z_{BY} axes, respectively

$\dot{p}$, $\dot{q}$, $\dot{r}$: 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, roll sequence, where ψ = yaw, θ = pitch, and ϕ = roll or bank. This attitude sequence is yaw, pitch, and roll around the Z_{BY}, Y_{BY}, and X_{BY} axes, respectively.

(a) Basic definition.

BODY AXIS



NAME: UVW 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. (V = W x U).

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.

UVW COORDINATE SYSTEM

ENTRY OPERATIONS COMPUTER LOAD GENERAL REQUIREMENTS VARIABLE LIST AND FLOW CHARTS

This page intentionally left blank.

Variable List, Deorbit - Landing Computer Load

Variable name	Data type	Initial value	Coord frame	Variable description
A	M(3X3)	0		Transformation matrix from body to M50
ALPHA	S	0	--	Angle of attack used in state prediction (radians)
ALPHAIN	S	0	--	Snapped copy of angle of attack (degrees)
ALT	S	0	--	Current Orbiter altitude above reference ellipsoid
ALT_ABOVE_ELLIPSOID	V(10)	I-load	--	Altitude of the TACAN station above the reference ellipse
ALT_MLSEL	S	0	--	Altitude above reference ellipsoid of MSBLS elevation scanner
ALT_MLSEL_PSL ALT_MLSEL_SSL	F F	I-load I-load	-- --	Geodetic altitude of the MSBLS elevation antenna location for the primary and secondary landing site choices
ALT_MLS_R_AZ	S	0	--	Altitude of MSBLS range/azimuth scanner above reference ellipsoid
ALT_MLS_R_AZ_PSL ALT_MLS_R_AZ_SSL	F F	I-load I-load	-- --	Geodetic altitude of the MSBLS range/azimuth antenna location for the primary and secondary landing site choices
ALT_RW	S	0	--	Altitude above reference ellipsoid of runway reference point
ALT_TACAN_SL(I)	V(3)	0	--	Altitude of TACAN station (each LRU) output from site lookup, I=1, 3

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
ALT_WHEELS	S	0	--	Altitude of Orbiter cg (entry) or rear wheels (TAEM A/L) above runway altitude
ANGLE_CORR_TNTOMAG_RW	S	Pad	TD	Angle of magnetic variation from true north at selected runway
ANGLE_CORR_TNTOMAG_SL(I)	V(3)	0	TD	Variation of magnetic north from true north at TACAN site (each LRU) output from site lookup, I=1, 3
A-O	S	0	--	Local parameter in EF_TO_GEODETIC
AUTO_CHANNEL_ID	Int	0	--	Channel/mode identifier for the automatically selected TACAN station
AUTO_ID_CHANGED	Bit	Off	--	Flag indicating (ON) that the value of AUTO_CHANNEL_ID has been changed
AZ	S	0	TD	Bearing from true north EF_TO_RUNWAY, EF_TO_SCANNER
AZIMUTH_RW	S	0	TD	Bearing from true north of runway coordinate system +X axis

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
BETA	S	0	--	Sideslip angle used in state prediction (radians)
BETAIN	S	0	--	Snapped copy of sideslip angle (degrees)
BIAS_AZMLS	S	I-load		Initial MLS azimuth antenna measurement bias
BIAS_AZMLS_PSL BIAS_AZMLS_SSL	F F	I-load I-load	-- --	MSBLS azimuth data bias for the primary and secondary landing site choices
BIAS_ELMLS	S	I-load		Initial MLS elevation antenna measurement bias
BIAS_ELMLS_PSL BIAS_ELMLS_SSL	F F	I-load I-load	-- --	MSBLS elevation data bias for the primary and secondary landing site choices
BIAS_MLSRANGE	S	I-load		Initial MLS range antenna measurement bias
BIAS_MLSRANGE_PSL BIAS_MLSRANGE_SSL	F F	I-load I-load	-- --	MSBLS range data bias for the primary and secondary landing site choices
BIAS_TAC_BRG	V(10)	I-load	--	Any known error (bias) in the bearing transmitted by a TACAN ground station (loaded premission)

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
BIAS_TAC_BRG_SL(I)	V(3)	0	--	TACAN station bearing bias (each LRU) output from site lookup, I=1, 3
BIAS_TAC_R	V(10)	I-load	--	Any known error (bias) in the range measurement obtained from a TACAN ground station (loaded premission)
BIAS_TAC_R_SL(I)	V(3)	0		TACAN station range bias (each LRU) output from site lookup, I=1, 3
CAZ	S	0		Cosine of AZ
CLAT	S	0		Cosine of LAT_GEOD EF_TO_ TOPDET, GEODETIC_TO_EF
CLON	S	0		Cosine of LON EF_TO_TOPDET
COS_P	S	0		Cosine of geocentric elevation angle
DEG_PER_RAD	S	I-load		Conversion factor from radians to degrees
DEL	S	0		Delta value for radius calculation
DEL_LAT	S	0		Correction angle for latitude
DELH_MSL_ELLIPSOID_ RW	S	0		Altitude of mean sea level above reference ellipsoid at runway
DH_TACAN_SL(I)	V(3)	0		Altitude of mean sea level above reference ellipsoid at TACAN station (each LRU) output from site lookup, I=1, 3
DT_MAX	S	10		Maximum allowable time-step size

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
DUM	S	0		Dummy variable (EF_TO_GEODETIC, GEODETIC_TO_EF)
DUMI	S	0		Dummy variable (GEODETIC_TO_EF)
EARTH_RADIUS_EQUATOR	S	I-load		Earth equatorial radius
EARTH_RATE	S	I-load	--	Earth rotation rate
ELLIPT	S	I-load	--	Earth ellipticity constant
EL_SCANNER_BEARING	S	I-load	--	Bearing from true north of MLS elevation scanner boresight axis
EL_SCANNER_BEARING_PSL	F	I-load	--	MSBLS elevation antenna boresight azimuth to true north for the primary and secondary landing site choices
EL_SCANNER_BEARING_SSL	F	I-load		
FLATCON				The eccentricity squared of the ellipsoid
G_FINAL	V(3)	0	M50	Predicted Shuttle gravity vector
G_PREVIOUS	V(3)	0	M50	Acceleration at start of each prediction integration step
GMO	D	I-load	--	General term indicating order of modeled acceleration
GMD	D	I-load		General term indicating degree of modeled acceleration
I	Int	1	--	Integer-subscript or iteration counter
ID_CHANGE_REQUEST	Bit	Off	--	Flag requesting (ON) that the value of AUTO_CHANNEL_ID be changed

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
ID_TACAN_AUTO	V(2)	0	--	Current channel/mode identifiers for the most preferred TACAN stations
INNER_RADIUS	S	Pad	--	Threshold range from runway used to determine current TACAN region
LAM	S	0	--	Earth rotation angle from epoch
LAT_GEOD	S	0	--	Geodetic latitude of a point (EF_TO_TOPDET, EF_TO_RUNWAY, EF_TO_SCANNER, EF_TO_GEODETIC, GEODETIC_TO_EF)
LATITUDE_GEODETIC	V(10)	I-load	--	Geodetic latitude of the TACAN station
LAT_MLSEL	S	0	--	Geodetic latitude of the MSBLS elevation antenna
LAT_MLSEL_PSL LAT_MLSEL_SSL	F F	I-load I-load	-- --	Geodetic latitude of the MSBLS elevation antenna location for the primary and secondary landing site choices
LAT_MLS_R_AZ	S	0	--	Latitude of MSBLS range/azimuth scanner site
LAT_MLS_R_AZ_PSL LAT_MLS_R_AZ_SSL	F F	I-load I-load	-- --	Geodetic latitude of range/azimuth MSBLS antenna location for the primary and secondary landing site choices
LAT_TACAN_SL(I)	V(3)	0	--	Geodetic latitude of TACAN site (each LRU) output from site lookup, I=1, 3
LON	S	0	--	Geodetic longitude of a point (EF_TO_TOPDET, EF_TO_RUNWAY, EF_TO_SCANNER, EF_TO_GEODETIC, GEODETIC_TO_EF)

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
LONGITUDE_EAST	V(10)	I-load	--	Longitude of the TACAN station
LONG_MLSEL	S	0	--	Geodetic longitude of the MSBLS elevation antenna
LONG_MLSEL_PSL LONG_MLSEL_SSL	F F	I-load I-load	-- --	Longitude of the MSBLS elevation antenna location for the primary and secondary landing site choices
LONG_MLS_R_AZ	S	0	--	Longitude of MSBLS range/azimuth scanner site
LONG_MLS_R_AZ_PSL LONG_MLS_R_AZ_SSL	F F	I-load I-load	-- --	Longitude of range/azimuth MSBLS antenna location for the primary and secondary landing site choices
LONG_TACAN_SL(I)	V(3)	0	--	Longitude of TACAN site (each LRU) output from site lookup, I=1, 3
LRU_ID	Int	0	--	Index (1 to 3) input to TACAN site lookup when LRU is tuned to a ground station. Identifies which of three sets of output parameters is to be changed.
M, MATRIX, MAT	M(3)	0	--	General transformation matrices
MAGNETIC_VARIATION	V(10)	I-load		Angle between true north and magnetic north at the TACAN station
M_EFTORAD_EL	M(3)	I-load		Transformation matrix from Earth-fixed to MSBLS elevation radar coordinates
M_EFTORAD_R_AZ	M(3)	I-load		Transformation matrix from Earth-fixed to AZ/range MSLBS radar coordinate frame

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
M_EFTORW	M(3)	I-load		Earth-fixed to prime RW transformation matrix
M_EFTORW_SEC	M(3)	I-load		Transformation matrix from Earth-fixed to secondary runway
M_EFTOSCANNER	M	I-load		Transformation matrix from Earth-fixed to scanner coordinates
M_EFTOTD_TACAN_SL(I)	M	0		Transformation matrix from Earth-fixed to topedetic coordinates at TACAN site (each LRU) output from site lookup, I=1, 3
M_M50TOEF_AT_EPOCH	M(3)	I-load		Transformation matrix from M50 to Earth-fixed at T-epoch
MLS_AVAIL	Bit	Off	--	Flag indicating (ON) the availability of MSBLS at currently selected runway
MSL_ABOVE_ELLIPSOID	V(10)	I-load	--	The difference in an altitude above the reference ellipse and that altitude above mean sea level or geoid
NUM_TACANS	Int	I-load		Number of TACAN sites available for LRU tuning
NUMBER_STEPS	Int	0	--	Number of integration steps in the precise predictor
OLD_ID	V(2)	0	--	Previous value of ID_TACAN_AUTO
OUTER_RADIUS	S	Pad	--	Threshold range from runway used to determined current TACAN region

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
PHI	S	0		Geocentric elevation angle to the vehicle
PI	S	I-load		The constant PI
PRIME_RUNWAY_INDEX	I	1	--	Indicator of which landing site choice is desired as prime
P2,P3,P4,P5,P6	S	0	--	Local variables used in QUAT_TO_MAT
Q	V(4)	0	M50	General variable for Q_M50_BODY
Q_FIFTY_BODY	V(4)	0	M50	Quaternion representing the orientation of the Orbiter body with respect to M50 coordinates
Q_M50_BODY	V(4)	0	M50	Quaternion representing the orientation of the Orbiter body with respect to M50 coordinates
R	S	0		Radius magnitude of vehicle (geocentric)
RAD_P	S	0		Radius of Earth at geocentric elevation angle, ph:
RAD_PER_DEG	S	I-load	--	Radians per degree
RANGE_EF	V(2)	0	--	Range of vehicle from the most preferred TACAN stations
R_AZ_SCANNER_BEARING	S	0		Bearing from true north of MSBLS range azimuth scanner site

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
R_AZ_RADAR_BEARING_PSL	F	I-load	--	Boresight azimuth of the MSBLS range/azimuth antenna location for the primary and secondary landing site choices
R_AZ_RADAR_BEARING_SSL	F	I-load	--	
R_CC_LMAG_PRI	S	0	--	Magnitude of R _CC_L_PRI
R_CC_LMAG_SEC	S	0	--	Magnitude of R _CC_L_SEC
R _CC_L_PRI	V(3)	0	EF	Position vector of HAC center on the left side of the primary runway center line in EF coordinates
R _CC_L_SEC	V(3)	0	EF	Position vector of HAC center on the left side of the secondary runway centerline in EF coordinates
R_CC_RMAG_PRI	S	0	--	Magnitude of R _CC_R_PRI
R_CC_RMAG_SEC	S	0	--	Magnitude of R _CC_R_SEC
R _CC_R_PRI	V(3)	0	EF	Position vector of HAC center on the right side of the primary runway centerline in EF coordinates
R _CC_R_SEC	V(3)	0	EF	Position vector of HAC center on the right side of the secondary runway centerline in EF coordinates
RD_TAC	V(10)	0	--	Geodetic radius of mean sea level at the TACAN station
R_FINAL	V(3)	0	--	Position vector at end of prediction
RD_TAC_MSL_SL(I)	V(3)	0	--	Geodetic radius of mean sea level at TACAN site to which the I-th receiver is tuned

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
R_EF	V(3)	0	EF	Shuttle position vector in Earth-fixed coordinates
R_EF_EQUAT	S	0		Projection of vehicle position vector in equatorial plane
R_ELMLS_EF	V(3)	0	EF	Earth-fixed MLS elevation scanner position vector
R_GO_LS	S	0		Range of vehicle from runway threshold
R_INIT	V(3)	ASC NAV SEQ OR ORB/AND NAVSEQ		Initial value of the Orbiter position vector
R_LS_EF	V(3)	0	EF	Position vector of runway in Earth-fixed coordinates
R_LS_EF_SEC	V(3)	0	RW	Earth-fixed position vector of secondary runway threshold
R_M	V(3)		M50	Input position vector (UVW-to-M50)
R_RMLS_EF	V(3)	0	EF	Earth-fixed position vector of MLS range scanner
R_TAC	S	0		Magnitude of EF position vector from vehicle to TACAN site
R_TACAN_EF_SL(I)	V(3)	0	EF	Earth-fixed position vector of TACAN station (each LRU) output from site lookup, I=1, 3
R_XY	F	0		Radius squared to projection of vehicle's position vector in R_EF_1, R_EF_2 plane

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
RUNWAY_NAME_ASL RUNWAY_NAME_PSL RUNWAY_NAME_SSL	CHAR CHAR CHAR	I-load I-load I-load	-- -- --	Name of the a priori alternate, primary and secondary landing site choices
RUNWAY_ALT_ASL RUNWAY_ALT_PSL RUNWAY_ALT_SSL	F F F	I-load I-load I-load	-- -- --	Geodetic altitude of the alternate, primary and secondary landing site choices
RV_MAX	S	0	--	Maximum relative velocity magnitude for baro processing
RV_MAX_CONT	S	I-load	--	Maximum relative velocity magnitude for baro processing associated with the contingency landing site
RV_MAX_NOM	S	I-load	--	Maximum relative velocity magnitude for baro processing associated with the nominal landing site
RW_AZIMUTH_ASL RW_AZIMUTH_PSL RW_AZIMUTH_SSL	F F F	I-load I-load I-load	-- -- --	Azimuth to true north of the alternate, primary, and secondary landing site choices
RW_DELH_ASL RW_DELH_PSL RW_DELH_SSL	F F F	I-load I-load I-load	-- -- --	Delta height from ellipsoid to MSL for the alternate, primary, and secondary landing site choices
RW_LAT_ASL RW_LAT_PSL RW_LAT_SSL	F F F	I-load I-load I-load	-- -- --	Geodetic latitude of the alternate, primary, and secondary landing site choices
RW_LON_ASL RW_LON_PSL RW_LON_SSL	F F F	I-load I-load I-load	-- -- --	Longitude of the alternate, primary, and secondary landing site choices
RW_MAG_VAR_ASL RW_MAG_VAR_PSL RW_MAG_VAR_SSL	F F F	I-load I-load I-load	-- -- --	Magnetic variation for the alternate, primary and secondary landing site choices

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
RW_NAME	I	1	--	Current landing site designation for display symbol positioning
SAZ	S	0		Sine of AZ
SIN_P	S	0		Sine of geocentric elevation angle
SLAT	S	0		Sine of geodetic latitude
SLON	S	0		Sine of longitude
STEP_SIZE	S	0		Size of integration time steps for prediction
T	S	0		General time variable
TACAN_ID(I).	V(3)	0		ID of TACAN channel to which the I-th LRU is tuned, I=1, 3
TAC_ID	V(10)	I-load	--	A three-digit channel/mode designation, unique for each TACAN station
TAC_CHAN_VALID_SL(I)	Bit(3)	Off		Switch indicating (ON) a valid TACAN channel has been selected (site lookup output) for the I-th receiver, I=1,3
T_EPOCH	S	I-load		Time tag for M_M50TOEF_AT_EPOCH, Greenwich hour angle, and Earth-pole
TFINAL	S	0		Time at end of prediction
T_INIT	S	ASC NAV SEQ OR ORB/RAD NAV SEQ		Time at beginning of prediction

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
TIME	S	0		General time variable measured in seconds from the beginning of the year of date
U	V(3)	0	M50	Unit vector in the direction of the Orbiter's M50 position vector
V	V(3)	0	M50	Input velocity vector (UVW TO_M50)
VAR_H1	S	0	--	Additive variance term used in constructing the baro measurement variance
VAR_H1_CONT	S	I-load	--	Additive baro variance term associated with the contingency landing site
VAR_H1_NOM	S	I-load	--	Additive baro variance term associated with the nominal landing site
VAR_H2	S	0	--	Multiplicative variance term used in constructing the baro measurement variance
VAR_H2_CONT	S	I-load	--	Multiplicative baro variance term associated with the contingency landing site
VAR_H2_NOM	S	I-load	--	Mulitplicative baro variance term associated with the nominal landing site
V_FINAL	V(3)	0		Velocity vector at end of prediction
V_INIT	V(3)	ASC NAV SEQ OR ORB/RAD NAV SEQ		Initial value of the velocity vector

Variable List, Deorbit - Landing Computer Load (Cont)

Variable name	Data type	Initial value	Coord frame	Variable description
X_DMEAZ_RW	S	I-load	RW	X component of range/azimuth antenna in runway coordinates
X_DMEAZ_RW_PSL X_DMEAZ_RW_SSL	F F	I-load I-load	RW RW	X-component of MSBLS range/ azimuth antenna in runway coordinates for the primary and secondary landing site choices
X_EL_RW	S	I-load	RW	X component of elevation antenna - RW coordinates
X_EL_RW_PSL X_EL_RW_SSL	F F	I-load I-load	RW RW	X-component of MSBLS elevation antenna in runway coordinates for the primary and secondary landing site choices
Y_DMEAZ_RW	S	I-load	RW	Y component of range/azimuth antenna in runway coordinates
Y_DMEAZ_RW_PSL Y_DMEAZ_RW_SSL	F F	I-load I-load	RW RW	Y-component of MSBLS range/ azimuth antenna in runway coordinates for the primary and secondary landing site choices

This page intentionally left blank.

FLOW CHARTS

This page intentionally left blank.

EARTH_FIXED_TO_M50_COORD (FUNCTION)

$$\text{EARTH\_FIXED\_TO\_M50\_COORD(TIME)} = \text{M\_M50TOEF\_AT\_EPOCH}^T\ \text{M}$$

Where: M_M50TOEF_AT_EPOCH is the transformation from mean 50 to EARTH fixed coordinates at time = T_EPOCH. This matrix, T_EPOCH, and EARTH_RATE, are pad loads for OFT.

M is computed within the function (EARTH_FIXED_TO_M50_COORD) as

LAM = EARTH_RATE(TIME - T_EPOCH)

$$M = \begin{pmatrix} \cos(LAM) & -\sin(LAM) & 0 \\ \sin(LAM) & \cos(LAM) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

EF_TO_TOPDET (FUNCTION)

```
EF_TO_TOPDET(LAT_GEOD, LON) = M
```

where: M is calculated within the function as

CLON = cos(LON), SLON = sin(LON)

CLAT = cos(LAT_GEOD), SLAT = sin(LAT_GEOD)

$$M = \begin{pmatrix} -SLAT\ CLON & -SLAT\ SLON & CLAT \\ -SLON & CLON & 0 \\ -CLAT\ CLON & -CLAT\ SLON & -SLAT \end{pmatrix}$$

EF_TO_RUNWAY (FUNCTION)

EF_TO_RUNWAY(LAT_GEOD, LON, AZ) = (M) EF_TO_TOPDET(LAT_GEOD, LON)	C-42

where: M is calculated within the function as

CAZ = COS(AZ), SAZ = SIN(AZ)

$$M = \begin{pmatrix} CAZ & SAZ & 0 \\ -SAZ & CAZ & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

EF_TO_SCANNER (FUNCTION)

EF_TO_SCANNER(LAT_GEOD, LON, AZ) = (M) EF_TO_RUNWAY(LAT_GEOD, LON, AZ)	C-43

where: M is calculated within the function as

$$M = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

EF_TO_GEODETIC

IN LIST = R_EF

OUT LIST: LAT_GEOD, LON, ALT

```
FLATCON = 1.0 - (1.0 - ELLIPT)^2

A_0 = 1.0 - FLATCON

R_XY = R_EF_1^2 + R_EF_2^2

R = (R_XY + R_EF_3^2)^1/2

SIN_P = R_EF_3/R

COS_P = (R_XY)^1/2/R

RAD_P = EARTH_RADIUS_EQUATOR/(1.0 + FLATCON SIN_P^2/A_0)^1/2

DEL = (FLATCON SIN_P COS_P)/(1.0 - FLATCON COS_P^2)

DEL_LAT = RAD_P DEL/R

PHI = ARCTAN(SIN_P/COS_P)

LAT_GEOD = PHI + DEL_LAT

LON = ARCTAN2(R_EF_2, R_EF_1)

ALT = (R-RAD_P) (1.0 - 0.50 DEL DEL_LAT)
```

GEODETIC_TO_EF (FUNCTION)

GEODETIC_TO_EF(LAT_GEOD, LON, ALT) = $\underline{R}$ _EF

where: $\underline{R}$ _EF is calculated within the FUNCTION as:

CLAT = COS(LAT_GEOD), SLAT = SIN(LAT_GEOD)

DUM = $(1 - \text{ELLIPT})^2$

DUM1 = EARTH_RADIUS_EQUATOR/ $(\text{CLAT}^2 + \text{SLAT}^2\ \text{DUM})^{1/2}$

R_EF_EQUAT = (DUM1 + ALT)CLAT

$\underline{R}$ _EF = (R_EF_EQUAT COS(LON), R_EF_EQUAT SIN(LON), (DUM DUM1 + ALT)SLAT)

UVW_TO_M50 (FUNCTION)

IN LIST: $\underline{R}$, $\underline{V}$

$\underline{U} = \underline{R}/|\underline{R}|$

$\underline{W} = (\underline{R} \times \underline{V})/|\underline{R} \times \underline{V}|$

$\underline{Z} = (\underline{W} \times \underline{U})$

$\text{UVW\_TO\_M50}_{1 \text{ TO } 3,\ 1} = \underline{U}$

$\text{UVW\_TO\_M50}_{1 \text{ TO } 3,\ 2} = \underline{Z}$

$\text{UVW\_TO\_M50}_{1 \text{ TO } 3,\ 3} = \underline{W}$

SBODY_TO_M50

IN LIST: Q_FIFTY_BODY

OUT LIST: MAT

MATRIX = QUAT_TO_MAT(Q_FIFTY_BODY)
$MAT_{1,1} = -MATRIX_{1,1}$
$MAT_{1,2} = MATRIX_{2,1}$
$MAT_{1,3} = -MATRIX_{3,1}$
$MAT_{2,1} = -MATRIX_{1,2}$
$MAT_{2,2} = MATRIX_{2,2}$
$MAT_{2,3} = -MATRIX_{3,2}$
$MAT_{3,1} = -MATRIX_{1,3}$
$MAT_{3,2} = MATRIX_{2,3}$
$MAT_{3,3} = -MATRIX_{3,3}$

QUAT_TO_MAT (FUNCTION)

```
QUAT_TO_MAT(Q) = A
```

WHERE A IS CALCULATED WITHIN THE FUNCTION AS:

$P2 = Q_2 + Q_2$

$P3 = Q_3 + Q_3$

$P4 = Q_4 + Q_4$

$P5 = P2\ Q_2$

$P6 = P4\ Q_4$

$TEMP = 1.0 - P3\ Q_3$

$A_{1,1} = TEMP - P6$

$A_{2,2} = 1.0 - P5 - P6$

$A_{3,3} = TEMP - P5$

$P5 = P2\ Q_3$

$P6 = P4\ Q_1$

$A_{1,2} = P5 - P6$

$A_{2,1} = P5 + P6$

$P5 = P2\ Q_4$

$P6 = P3\ Q_1$

$A_{1,3} = P5 + P6$

$A_{3,1} = P5 - P6$

$P5 = P3\ Q_4$

$P6 = P_2\ Q_1$

$A_{2,3} = P5 - P6$

$A_{3,2} = P5 + P6$

ENTRY_RUNWAY_SITE_LOOKUP

DO CASE
PRIME_RUNWAY_INDEX

= 1

RW_NAME = 1
ALT_RW = RUNWAY_ALT_PSL
AZIMUTH_RW = RW_AZIMUTH_PSL
DELH_MSL_ELLIPSOID_RW = RW_DELH_PSL
ANGLE_CORR_TNTOMAG_RW = RW_MAG_VAR_PSL
LAT = RW_LAT_PSL
LON = RW_LON_PSL
LAT_MLS_R_AZ = LAT_MLS_R_AZ_PSL
LONG_MLS_R_AZ = LONG_MLS_R_AZ_PSL
ALT_MLS_R_AZ = ALT_MLS_R_AZ_PSL
R_AZ_SCANNER_BEARING = R_AZ_RADAR_BEARING_PSL
LAT_MLSEL = LAT_MLSEL_PSL
LONG_MLSEL = LONG_MLSEL_PSL
ALT_MLSEL = ALT_MLSEL_PSL
EL_SCANNER_BEARING = EL_SCANNER_BEARING_PSL
X_DMEAZ_RW = X_DMEAZ_RW_PSL
X_EL_RW = X_EL_RW_PSL
Y_DMEAZ_RW = Y_DMEAZ_RW_PSL
MLS_AVAIL = MLS_AVAIL_PSL
BIAS_MLS_RANGE = BIAS_MLS_RANGE_PSL
BIAS_ELMLS = BIAS_ELMLS_PSL
BIAS_AZMLS = BIAS_AZMLS_PSL

(CONT) (CONT)

ENTRY_RUNWAY_SITE_LOOKUP (CONT)

```
=2  RW_NAME = 2
    ALT_RW = RUNWAY_ALT_SSL
    AZIMUTH_RW = RW_AZIMUTH_SSL
    DELH_MSL_ELLIPSOID_RW = RW_DELH_SSL
    ANGLE_CORR_TNTOMAG_RW = RW_MAG_VAR_SSL
    LAT = RW_LAT_SSL
    LON = RW_LON_SSL
    LAT_MLS_R_AZ = LAT_MLS_R_AZ_SSL
    LONG_MLS_R_AZ = LONG_MLS_R_AZ_SSL
    ALT_MLS_R_AZ = ALT_MLS_R_AZ_SSL
    R_AZ_SCANNER_BEARING = R_AZ_RADAR_BEARING_SSL
    LAT_MLSEL = LAT_MLSEL_SSL
    LONG_MLSEL = LONG_MLSEL_SSL
    ALT_MLSEL = ALT_MLSEL_SSL
    EL_SCANNER_BEARING = EL_SCANNER_BEARING_SSL
    BIAS_MLS_RANGE = BIAS_MLSRANGE_SSL
    BIAS_ELMLS = BIAS_ELMLS_SSL
    BIAS_AZMLS = BIAS_AZMLS_SSL
    X_DMEAZ_RW = X_DMEAZ_RW_SSL
    X_EL_RW = X_EL_RW_SSL
    Y_DMEAZ_RW = Y_DMEAZ_RW_SSL
    MSL_AVAIL = MLS_AVAIL_SSL
```

(CONT) (CONT)

ENTRY_RUNWAY_SITE_LOOKUP (CONT)

```
                                  RW_NAME = 3
                                  ALT_RW = RUNWAY_ALT_ASL
                                  AZIMUTH_RW = RW_AZIMUTH_ASL
                              =3  DELH_MSL_ELLIPSOID_RW = RW_DELH_ASL
                                  ANGLE_CORR_TNTOMAG_RW = RW_MAG_VAR_ASL
                                  LAT = RW_LAT_ASL
                                  LON = RW_LON_ASL
                                  MLS_AVAIL = OFF

M_EFTORW = EF_TO_RUNWAY (LAT, LON, AZIMUTH_RW)        C-43
R _LS_EF = GEODETIC_TO_EF (LAT, LON, ALT_RW)          C-46

R _CC_L_PRI = R _LS_EF + M_EFTORW^T R _HAC_RW_L
R _CC_R_PRI = R _LS_EF + M_EFTORW^T R _HAC_RW_R
R_CC_LMAG_PRI = |R _CC_L_PRI|
R_CC_RMAG_PRI = |R _CC_R_PRI|

MLS_AVAIL\
          M_EFTORAD_R_AZ = EF_TO_SCANNER(LAT_MLS_R_AZ,                C-44
                           LONG_MLS_R_AZ, R_AZ_SCANNER_BEARING)
          M_EFTORAD_EL = EF_TO_SCANNER(LAT_MLSEL, LONG_MLSEL,         C-44
                         EL_SCANNER_BEARING)
          R _RMLS_EF = GEODETIC_TO_EF(LAT_MLS_R_AZ, LONG_MLS_R_AZ,    C-46
                       ALT_MLS_R_AZ)
          R _AZMLS_EF = R _RMLS_EF
          R _ELMLS_EF = GEODETIC_TO_EF(LAT_MLSEL, LONG_MLSEL,         C-46
                        ALT_MLSEL)
```

ENTRY_TACAN_SITE_LOOKUP

```
TAC_CHAN_VALID_SL_LRU ID = OFF
TACAN_ID_LRU ID = NEW_STATION_ID

DO FOR I = 1 TO NUM_TACANS

TACAN_ID_LRU ID = TAC_ID_I

LAT_TACAN_SL_LRU ID = LATITUDE_GEODETIC_I
RD_TAC_MSL_SL_LRU ID = RD_TAC_I
LONG_TACAN_SL_LRU ID = LONGITUDE_EAST_I
ALT_TACAN_SL_LRU ID = ALT_ABOVE_ELLIPSOID_I
DH_TACAN_SL_LRU ID = MSL_ABOVE_ELLIPSOID_I
ANGLE_CORR_TNTOMAG_SL_LRU ID = MAGNETIC_VARIATION_I
BIAS_TAC_BRG_SL_LRU ID = BIAS_TAC_BRG_I
BIAS_TAC_R_SL_LRU ID = BIAS_TAC_R_I
R_TACAN_EF_SL_LRU ID = R_TAC_EF_I
TAC_CHAN_VALID_SL_LRU ID = ON
M_EFTOTD_TACAN_SL_LRU ID= EF_TO_TOPDET (LAT_TACAN_SL_LRU ID, LONG_TACA_SL_LRU ID)
```

C-42

ENTRY_PRECISE_PREDICTOR

```
NUMBER_STEPS = MAX (ROUND ( |T FINAL - T INIT| / DT MAX ) ,1)

STEP_SIZE = (T FINAL - T INIT) / NUMBER STEPS

R _FINAL = R _INIT

V _FINAL = V _INIT

T = T_INIT
```

```
GMD_PRED = 0
```

```
CALL:  CENTRAL                                  B-22

INLIST:  R _FINAL

OUTLIST:  G _PREVIOUS, R_INV
```

```
SNAP ATTITUDE (ALPHAIN, BETAIN)

ALPHA = ALPHAIN RAD_PER_DEG

BETA = BETAIN RAD_PER_DEG
```

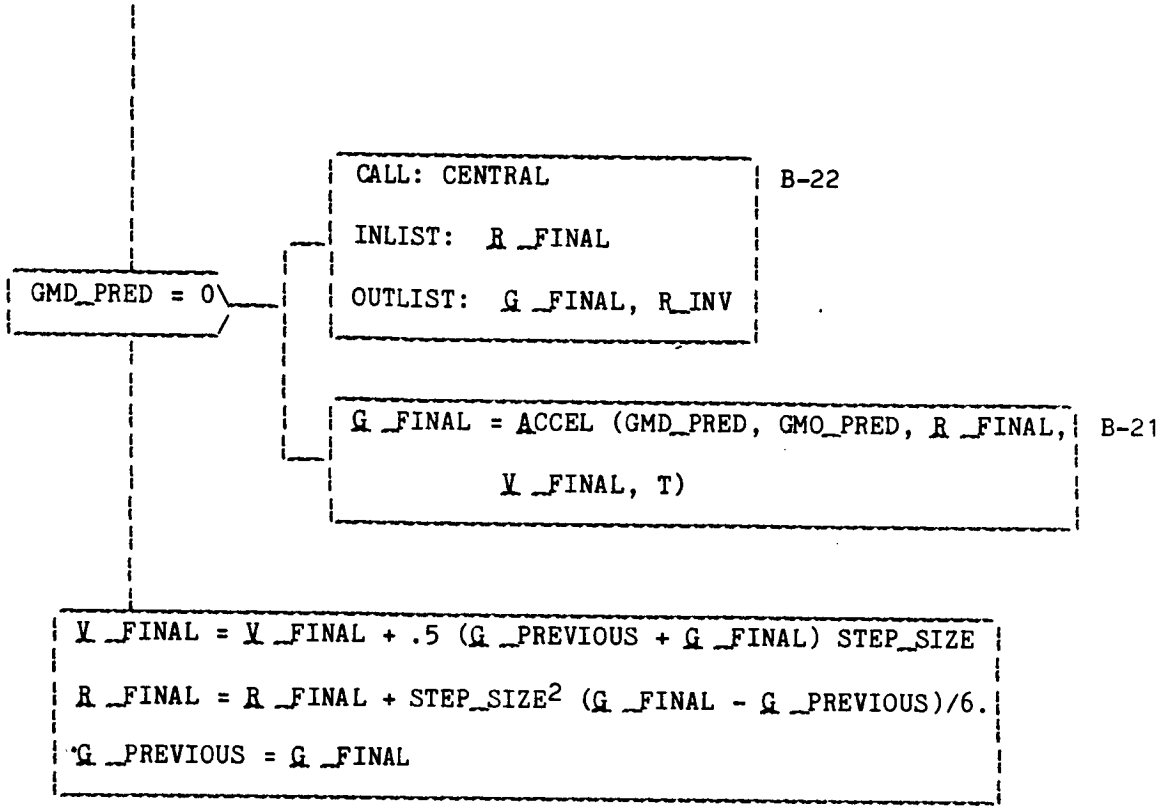
```
G _PREVIOUS = ACCEL(GMD_PRED, GMO_PRED, R _FINAL,   B-21
              V _FINAL, T)
```

```
DO FOR I = 1 TO
NUMBER_STEPS
```

```
T = T + STEP_SIZE

R _FINAL = R _FINAL + STEP_SIZE (V _FINAL + .5 STEP_SIZE
           G _PREVIOUS)
```

(CONT)

ENTRY_PRECISE_PREDICTOR (CONCLUDED)



ENTRY_TACAN_SITE_LOOKUP_INIT

DO FOR I = 1, NUM_TACANS

C-46

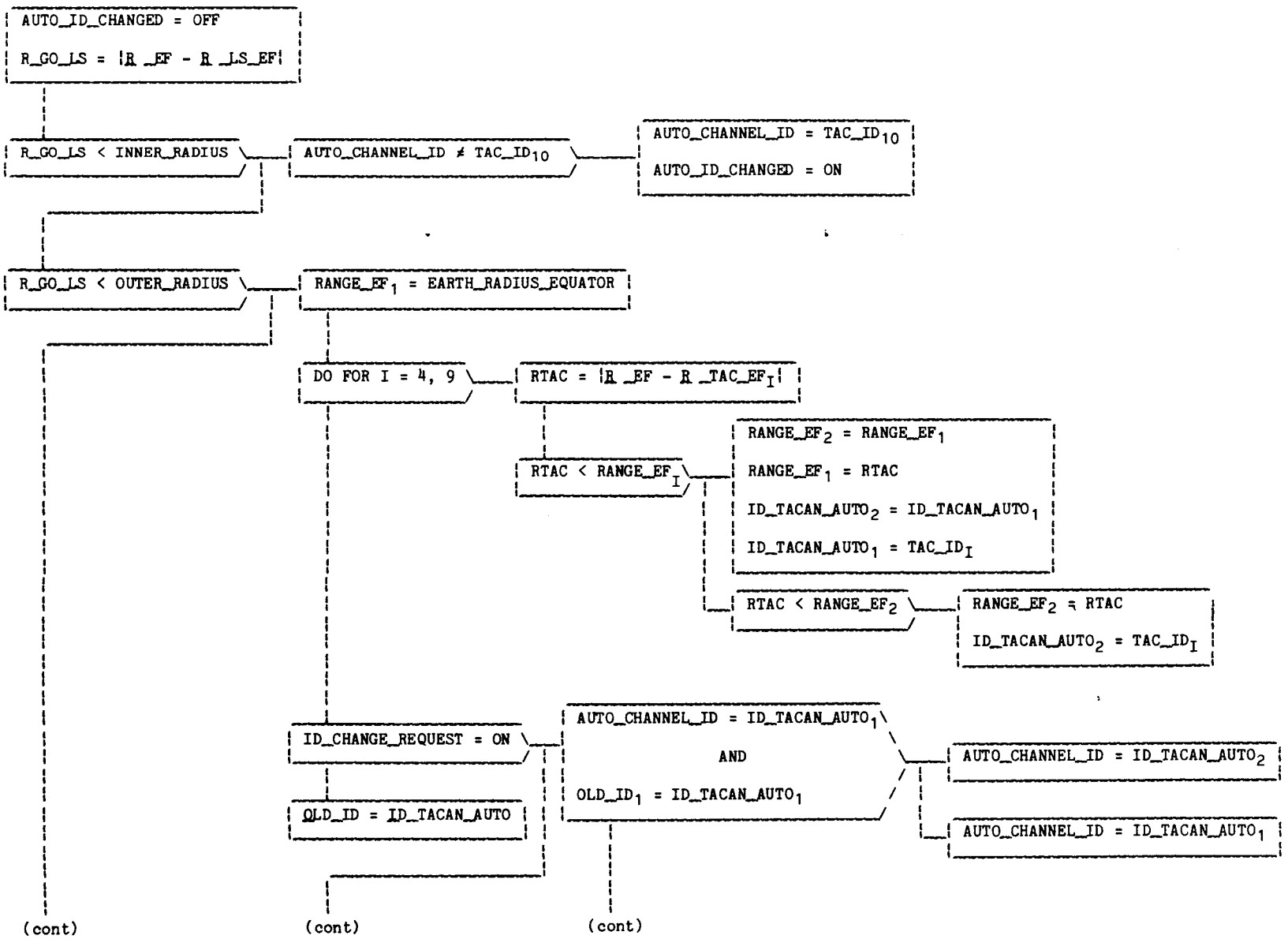
$R\_TAC\_EF_I$ = GEODETIC_TO_EF(LATITUDE_GEODETIC$_I$,
LONGITUDE_EAST$_I$, ALT_ABOVE_ELLIPSOID$_I$)

$RD\_TAC_I = (1.-ELLIPT)^2$ EARTH_RADIUS_EQUATOR/
$(1. + SIN^2$ (LATITUDE_GEODEDIC$_I$) ELLIPT (ELLIPT-2))$^{1/2}$
+ MSL_ABOVE_ELLIPSOID$_I$

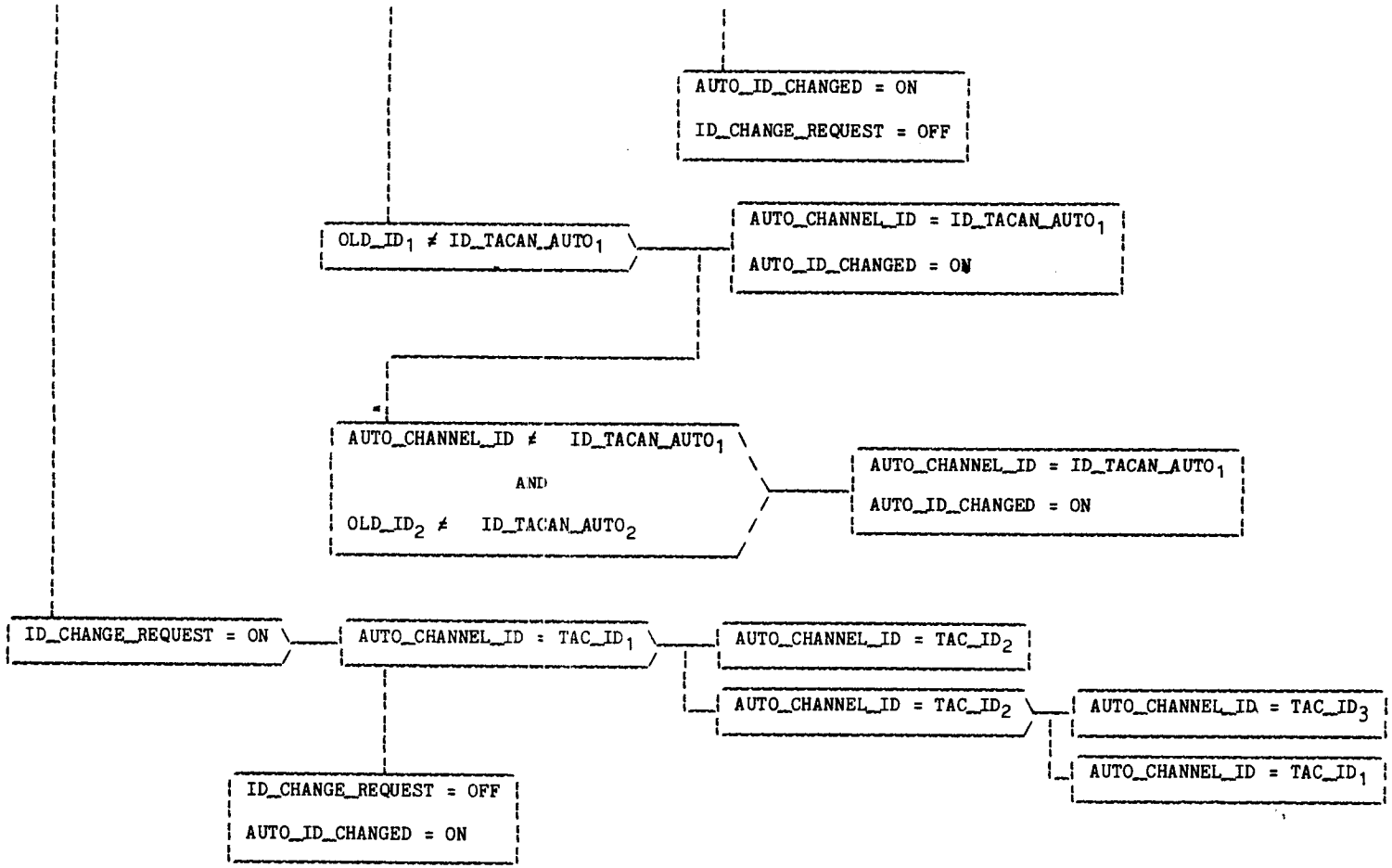
ENTRY_RUNWAY_SITE_LOOKUP_INIT

```
PRIME_RUNWAY_INDEX = 1

CALL:  ENTRY_RUNWAY_SITE_LOOKUP                                  C-36

M_EFTORW_SEC = EF_TO_RUNWAY(RW_LAT_SSL, RW_LON_SSL, RW_AZIMUTH_SSL)   C-43
R_LS_EF_SEC = GEODETIC_TO_EF(RW_LAT_SSL, RW_LON_SSL, RUNWAY_ALT_SSL)  C-46

AZIMUTH_RW_SEC = RW_AZIMUTH_SSL
ANGLE_CORR_TNTOMAG_RW_SEC = RW_MAG_VAR_SSL
R_CC_L_SEC = R_LS_EF_SEC + M_EFTORW_SEC^T R_HAC_RW_L
R_CC_R_SEC = R_LS_EF_SEC + M_EFTORW_SEC^T R_HAC_RW_R
R_CC_LMAG_SEC = |R_CC_L_SEC|
R_CC_RMAG_SEC = |R_CC_R_SEC|

                    RV_MAX = RV_MAX_NOM
                    VAR_H1 = VAR_H1_NOM
                    VAR_H2 = VAR_H2_NOM
MLS_AVAIL

                    RV_MAX = RV_MAX_CONT
                    VAR_H1 = VAR_H1_CONT
                    VAR_H2 = VAR_H2_CONT
```

ENTRY_AUTO_TACAN_SELECTION



ENTRY_AUTO_TACAN_SELECTION (concluded)



ENTRY_AUTO_TACAN_SELECTION_INIT

```
AUTO_CHANNEL_ID = TAC_ID1

AUTO_ID_CHANGED = ON
```

APPENDIX D

AREA NAVIGATION FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS

This page intentionally left blank.

APPENDIX D INDEX

Subject	Page
Variable List Definitions	D-4
Area Navigation Variable List	D-5
Area Navigation Principal Function Flow Charts	
HSI_SEQUENCER	D-20
NAV_STATE_TO_RW CODE	D-25
TAC_BARO_TO_RW CODE	D-26
TAC_BARO_TO_TOPODETIC CODE	D-27
MSBLS_TO_RW CODE	D-28
ENTRY_HSI_COMP CODE	D-29
LAND_HSI_COMP CODE	D-33
TAEM_HSI_COMP CODE	D-34
RANGE_BEAR_TO_HAC ENTRY	D-31

Note: Items followed by the word CODE (indented in the list) are not intended to be modules but represent a block of in-line code contained in the module above them.

VARIABLE LIST DEFINITIONS

- Code used for variable data type:

S:	scalar
V(n):	vector (dimension)
M(n):	square matrix (dimension)
INT:	integer
BIT:	bit
CHAR:	character
STR:	structure
ARR:	array

- Coordinate frame code and definition

BODY: (structural)	x:	parallel to the longitudinal axis (positive aft)
	y:	completes right-hand system
	z:	perpendicular to the x-axis, positive upward
M50:	Mean-of-50 reference coordinate system	
RW: (runway coordinates)	x:	down runway centerline in direction of landing
	y:	completes right-hand system
	z:	down, normal to ellipsoid
SCAN: (MLS scanner coordinates)	x:	scanner boresight axis
	y:	completes right-hand system
	z:	up, normal to ellipsoid
TD: (topodetic coordinates)	x:	north
	y:	east
	z:	down, normal to ellipsoid

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ALT_DG	BIT	Off	--	Barometric data-good flag
ALT_RW	S	0	--	Altitude above reference ellipsoid of runway reference point
ANGLE_CORR_TNTOMAG_RW	S	0	TD	Angle of magnetic variation from true north at selected runway
ANGLE_CORR_TNTOMAG_RW_SEC	S	0	TD	Angle of magnetic variation from true north at selected secondary runway
AZIMUTH_RW	S	0	--	Bearing from true north of runway coordinate system +X axis
AZIMUTH_RW_SEC	S	0	--	Azimuth of secondary runway measured from true north
BRG_FLAG_LEFT	BIT	Off	--	HSI data validity flag
BRG_FLAG_RIGHT	BIT	Off	--	HSI data validity flag
CDI_FLAG_LEFT	BIT	Off	--	HSI data validity flag
CDI_FLAG_RIGHT	BIT	Off	--	HSI data validity flag
CDI_LEFT	S	0	--	Course deviation from the extended runway center line
CDI_RIGHT	S	0	--	Course deviation from the extended runway center line
DEG_PER_RAD	S	Constant	--	Conversion factor from radians to degrees
DELH_MSL_ELLIPSOID_RW	S	0	--	Altitude of mean sea level above reference ellipsoid at runway

Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
GSI_FLAG_LEFT	BIT	Off	--	HSI data validity flag
GSI_FLAG_RIGHT	BIT	Off	--	HSI data validity flag
GSI_LEFT	S	0	--	Glide slope deviation for primary runway
GSI_RIGHT	S	0	--	Glide slope deviation for primary runway
HEADING_LEFT	S	0	--	Heading of relative velocity vector (entry) or of body X-axis (TAEM or A/L)
ALT_LAND	S	0		Altitude for automatic switch from TAEM display mode comps to autoland display mode comps
HEADING_RIGHT	S	0	--	Heading of relative velocity vector (entry) or of body X-axis (TAEM or A/L)
HPC	S	0	--	Barometric altitude obtained from the air data SOP
M_EFTORW	M(3)	0	--	Earth fixed to prime RW transformation matrix
M_EFTORW_SEC	M(3)	0	--	Transformation matrix from earth-fixed to secondary runway
MODE_LEFT	CHAR	--	--	Indicates setting of display mode switch (entry, TAEM or land) for left-side HSI
MODE_RIGHT	CHAR	--	--	Indicates setting of display mode switch (entry, TAEM or land) for right-side HSI

Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
MSBAZIMO(I)	S	0	--	MSBLS azimuth for the I-th receiver, I=1,3
MAZM_CMLK(I)	BIT	Off	--	MSBLS azimuth commfault/lock-on flag for I-th receiver, I=1,3
MSBELEVO(I)	S	0	--	MSBLS elevation for the I-th receiver, I=1,3
MELV_CMLK(I)	BIT	Off	--	MSBLS elevation comm-fault/lock on flag for I-th receiver, I=1,3
MSBRANGEO(I)	S	0	--	MSBLS range for the I-th receiver, I=1,3
MRNG_CMLK(I)	BIT	Off	--	MSBLS range commfault/lock-on flag for the I-th receiver, I=1,3
NAUTMI_PER_FT	S	Constant	--	Feet to nautical miles
POSITION_WRT_RUNWAY	V(3)	0	RW	Vehicle c.g. position vector WRT runway reference point (R _LS_EF)
PRIBEAR_LEFT	S	0	--	Primary bearing (to WP1-entry and TAEM, to WP2-land)
PRIBEAR_RIGHT	S	0	--	Primary bearing (to WP1-entry and TAEM, to WP2-land)
PRIRANGE_LEFT	S	0	--	Primary range to WP2 (via WP1-entry and TAEM, direct-land)
PRIRANGE_RIGHT	S	0	--	Primary range to WP2 (via WP1-entry and TAEM, direct-land)
MM_CODE_304	BIT	0		Major mode 304 flag

Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
RCVR_LEFT	INT	0	--	Indicates setting of string selection switch (when source-in MSBLS or TACAN) on left-side HSI
RCVR_RIGHT	INT	0	--	Indicates setting of string selection switch (when source-in MSBLS or TACAN) on right-side HSI
R_EF	V(3)	0	EF	Shuttle position vector in earth-fixed coordinates
R_LS_EF	V(3)	0	EF	Position vector of runway in earth-fixed coordinates
R_LS_EF_SEC	V(3)	0	RW	Earth-fixed position vector of secondary runway threshold
SECBEAR_LEFT	S	0	--	Bearing from Shuttle to WP1 for secondary runway entry; bearing from Shuttle to center of selected HAC for primary runway-TAEM
SECBEAR_RIGHT	S	0	--	Bearing from Shuttle to WP1 for secondary runway entry; bearing from Shuttle to center of selected HAC for primary runway-TAEM
SECRANGE_LEFT	S	0	--	Secondary range to WP2 via WP1-entry and direct-land; horizontal distance to center of selected HAC for primary runway-TAEM
SECRANGE_RIGHT	S	0	--	Secondary range to WP2 via WP1-entry and direct-land; horizontal distance to center of selected HAC for primary runway-TAEM

Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
SOURCE_LEFT	CHAR	--	--	Indicates which data source (MSBLS, TACAN, or NAV) switch is on for left-side HSI
SOURCE_RIGHT	CHAR	--	--	Indicates which data source (MSBLS, TACAN, or NAV) switch is on for right-side HSI
TACBEARO(I)	S	0	--	TACAN bearing data obtained from the SOP for each receiver, I=1,3
TBRG_CMLK(I)	BIT	Off	--	TACAN azimuth commfault/ lock-on flag for the I-th receiver, I=1,3
TRNG_CMLK(I)	BIT	Off	--	TACAN range commfault/lock-on flag for the I-th receiver, I=1,3
TACRANGEO(I)	S	0	--	TACAN range data obtained from the SOP for each receiver, I=1,3
X_DMEAZ_RW	S	0	RW	X-component of range/ azimuth antenna in runway coordinates
X_EL_RW	S	0	RW	X-component of elevation antenna, RW coordinates
Y_DMEAZ_RW	S	0	RW	Y-component of range/azimuth antenna in runway coordinates
P_SEC	S	-1	--	Sign of secondary runway Y-component of the Shuttle
RANGE_FT	S	0		Range to WP2 in feet
V _RHO_EF	V(3)	0	EF	Vehicle relative velocity vector in earth-fixed coordinates

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ALT_TACAN_SL(I)	V(3)	0	--	Altitude of TACAN station (each LRU) output from Site Lookup, I=1,3
ALT_WHEELS	S	0	--	Altitude of orbiter c.g. (entry) or rear wheels (TAEM & A/L) above runway altitude
ANGLE_CORR_TNTOMAG _SL(I)	V(3)	0	--	Variation of magnetic north from true north at TACAN site (each LRU) output from Site Lookup, I=1,3
DH_TACAN_SL(I)	V(3)	0	--	Altitude of mean sea level above reference ellipsoid at TACAN station (each LRU) output from Site Lookup, I=1,3
M_EFTOTD_TACAN_SL(I)	M	0	--	Transformation matrix from earth-fixed to topodetic coordinates at TACAN site (each LRU) output from Site Lookup, I=1,3
PSI_HSIMV	S	0	--	Angle between mag north and Shuttle X-axis
RD_TAC_SL(I)	S	0	--	Geodetic radius of mean sea level at TACAN site to which the I-th receiver is tuned
R _TACAN_EF_SL(I)	V(3)	0	EF	Earth-fixed position vector of TACAN station (each LRU) output from Site Lookup, I=1,3
TACAN_CHAN_VALID_ SL(I)	BIT	Off	--	Switch indicating (ON) a valid TACAN channel has been selected (Site Lookup output)

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
X_GSI	S	0	RW	Glide slope intercept point on extended runway center line
X_NEP	S	Design Dependent	RW	Runway X-component of the HAC center
X_WP2	S	Mission Dependent	RW	Runway X-component of way point two (WP2)

Variable List - continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
A	S	0	--	Angle at TACAN from true north to Shuttle
A	S	0	--	Coefficient in quadratic formula
A2	S	0	--	Angle defined by intersection of two great circle planes (one passing through the Shuttle position and HAC center, the other through the Shuttle position and WP1)
A3	S	0	--	Angle at HAC center from WP1 to entry point (ENT_RNG_BEAR)
ARC	S	0	--	Angle from NEP to WP1 measured WRT HAC center
B	S	0	--	Coefficient in quadratic formula
BEAR_CC	S	0	--	Bearing at HAC center WRT true north
BEARING	S	0	--	Bearing from Shuttle to WP1
BEAR_RW	S	0	--	Bearing to WP1 (entry/TAEM) or WP2 (A/L) measured with respect to RW
BEAR_VEH	S	0	--	Bearing from Shuttle to HAC center WRT true north
BEAR_VEH_WP1	S	0	--	Bearing to WP1 WRT true north
BRG_FLAG	BIT	Off	--	HSI data validity flag
C	S	0	--	Coefficient in quadratic formula

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
CDI	S	0	--	Course deviation from the extended runway center line
CDI_FLAG	BIT	Off	--	HSI data validity flag
COSB	S	0	--	Cosine of the angle at TACAN from earth-center to Shuttle
D	S	0	TD	Projection of slant range from TACAN to Shuttle onto X-Y plane
D	S	0	RW	X-component of vehicle position with respect to WP2
D_ARC	S	0	--	Arc length around the HAC from WP1 to EP
DIST_VEH_WP1	S	0	--	Surface range from Shuttle to WP1
DIST_WP2	S	0	--	Flat earth range from Shuttle to WP2
EL_MSBLS	S	0	--	MSBLS elevation angle
GSI	S	0	--	Glide slope deviation for primary runway
H_BARO	S	0	--	Barometric altitude obtained from selection filter
HEADING	S	0	TD	Heading angle from runway magnetic north (deg)
I	INT	--	--	Integer-subscript or iteration counter
LEFT_SIDE	BIT	Off	--	Indicates for which HSI the computations are being performed

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
MODE	CHAR	--	--	Indicates setting of display mode switch (entry, TAEM, or land)
N	INT	--	--	Index for Site Lookup parameters (TACAN) and raw data from SOP (TACAN or MSBLS)
P	S	-1	--	Sign of runway Y-component of the Shuttle
PHI	S	0	--	Angle from runway to HAC center measured WRT Shuttle
PRI_BEAR	S	0	--	Primary bearing (to WP1-entry and TAEM, to WP2-land)
PRI_RANGE	S	0	--	Primary range to WP2-(via WP1-entry and TAEM, direct-land)
RADIUS_EP	S	Mission Dependent	--	Radius of entry point heading alignment circle
RANGE	S	0	--	Range from Shuttle to WP2 via WP1
R_CC	S	0	--	Flat earth surface range from Shuttle to the HAC center
R_CC_EF	V(3)	0	EF	Position vector of HAC center in earth-fixed coordinates
R_CC_MAG	S	0	--	Earth radius at HAC center for primary runway
RCVR	INT	--	--	Indicates setting of string selection switch (when source is MSBLS or TACAN)

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R_TAC	S	0	--	Magnitude of TACAN position vector
R_VEH	S	0	--	Magnitude of Shuttle vector computed from HBARO and TACAN position
R_VEH_EF	V(3)	0	EF	Position vector of Shuttle in earth-fixed coordinates
R_VEH_MAG	S	0	--	Magnitude of R_VEH_EF
R_VEH_RW	V(3)	0	RW	Position vector of the Shuttle in runway coordinates
R_VEH_RW_SEC	V(3)	0	--	Shuttle position vector WRT secondary runway
R_VEH_TD_TAC	V(3)	0	--	Position vector of Shuttle in TACAN topodetic coordinates
SEC_BEAR	S	0	--	Bearing from Shuttle to WP1 for secondary runway-entry; bearing from Shuttle to center of selected HAC for primary runway-TAEM
SEC_RANGE	S	0	--	Secondary range to WP2 via WP1-entry and direct-land; horizontal distance to center of selected HAC for primary runway-TAEM
SIN_THET_VEH_CC	S	0	--	Sine of range angle from Shuttle to center of HAC
SOURCE	CHAR	--	--	Indicates which data source (MSBLS, TACAN, or NAV) switch is on
TAZ	S	0	--	Tangent of MSBLS azimuth angle

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
TEL	S	0	--	Tangent of MSBLS elevation angle
THETA	S	0	--	Angle which corrects Shuttle heading from the center of HAC to WP1
V_NORM	V(3)	0	EF	Vector normal to the great circle plane containing the Shuttle and the HAC center
X_CC	S	0	RW	X-component of vector from the Shuttle to HAC center in runway coordinates
X_EP	S	0	RW	Runway X-component of the HAC center
X_VEH_DMEAZ	S	0	RW	X-component of Shuttle position WRT MSBLS antenna
Y_CC	S	0	RW	Y-component of vector from the Shuttle to HAC center in runway coordinates
TEL2	S	0	--	Square of tangent of MSBLS elevation angle
HDG_FLAG	BIT	Off		General heading validity indicator
HDG_FLAG_LEFT	BIT	Off		Heading validity indicator for left HSI
HDG_FLAG_RIGHT	BIT	Off		Heading validity indicator for right HSI
C0(1,1),C1(1,1), C2(1,1),C3(1,1), C0(1,2),C1(1,2), C2(1,2),C3(1,2)	Arr	Mission Dependent		Coefficients used in analytical expressions for reference altitude versus range for nominal steep glide path angle

Variable List - Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
C0(2,1),C1(2,1), C2(2,1),C3(2,1), C0(2,2),C1(2,2), C2(2,2), C3(2,2)	Arr	Mission Dependent		Coefficients used in analytical expressions for reference altitude versus range for high mass steep glide path angle
CUBRC(I), I=1,2	Arr	Mission Dependent		Distance from the MEP to the transition point for two analytical expressions for reference altitude versus range
DELX_NEP	S	0		Distance from glide slope intercept point and the NEP
DELX_MEP	S	0		Distance from glide slope intercept point and the MEP
DR	S	0		Distance from vehicle ground position to the transition point for two analytical expressions for reference altitude versus range
H	S	0		Altitude above runway
HCO(1)	Arr	Mission Dependent		Reference altitude evaluated at the NEP for nominal steep glide path angle
HCO(2)	Arr	Mission Dependent		Reference altitude evaluated at the NEP for high mass steep glide path angle
HI_WINDS	BIT	Off		Flag denoting high or low winds at runway during landing
H_GSI_SHALLOW	S	Design Dependent		Altitude at which final flare begins and GSI_FLAG is set to OFF

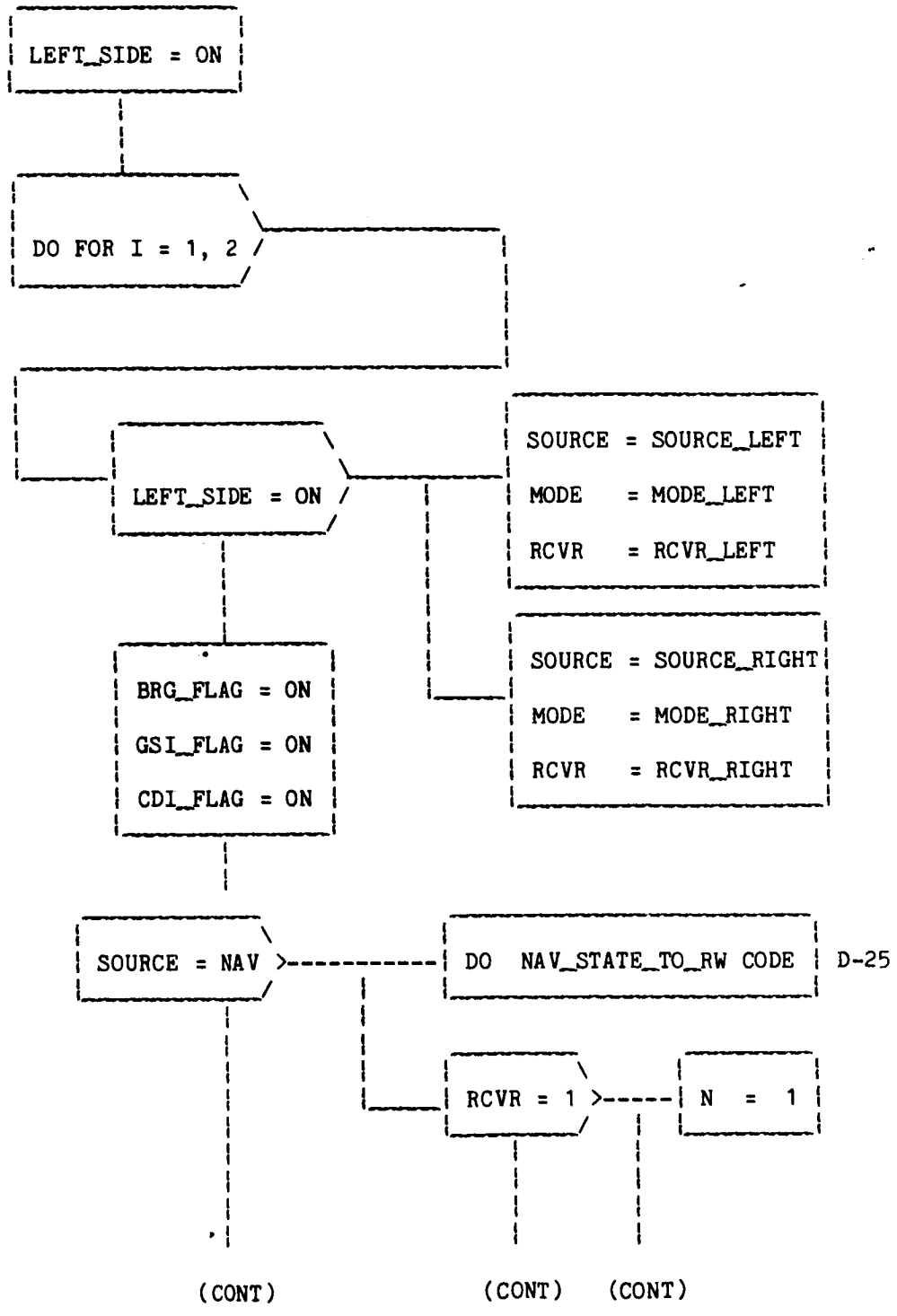
Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
HREF	S	0		Reference altitude used to compute the glide slope deviation
IGS	S	0		Glide slope index
M	S	0		Vehicle mass
MASS_FLAG	BIT	On		Flag denoting computation of quantities pertinent to the NEP and MEP
M_GSI	S	Mission Dependent		Boundary of high vehicle mass and low vehicle mass
NEP	BIT	Off		Flag denoting switch from NEP to MEP circle
R	S	0		Distance from the vehicle ground position to the MEP by way of the HAC
X_GSI_HI_WIND	S	Mission Dependent	RW	Glide slope intercept point on extended runway centerline for high wind condition
X_GSI_NOMINAL	S	Mission Dependent	RW	Glide slope intercept point on extended runway centerline for low wind condition
R _CC_L_PRI	V(3)	0	EF	Position vector of the HAC center on the left-side (-Y) of the runway centerline
R _CC_R_PRI	V(3)	0	EF	Position vector of the HAC center on the right-side (+Y) of the runway centerline
R_CC_LMAG_PRI	S	0	--	Magnitude of the vector R _CC_L_PRI

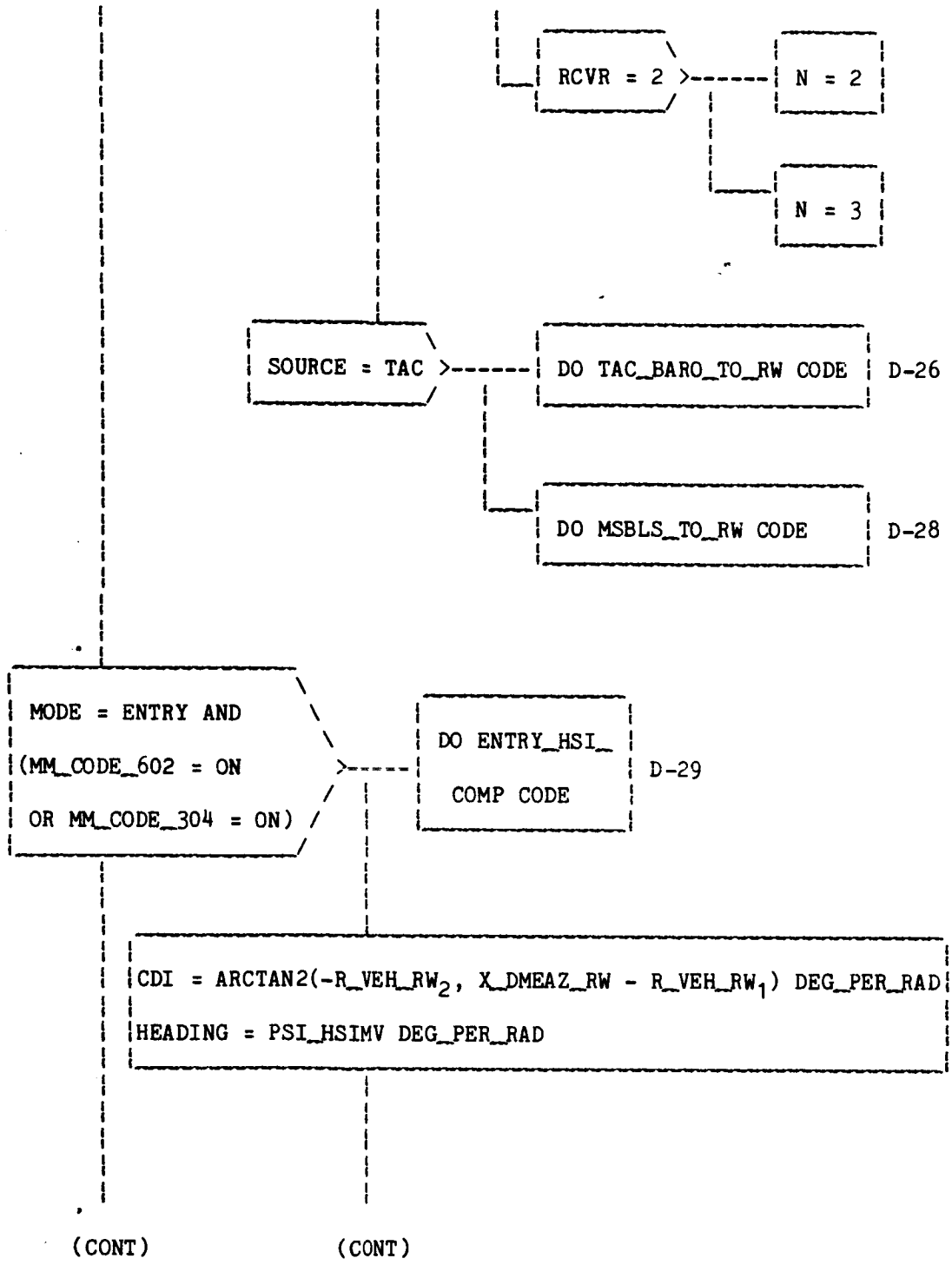
Variable List- Continued

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R_CC_RMAG_PRI	S	0	--	Magnitude of the vector R _CC_R_PRI
R _CC_L_SEC	V(3)	0	EF	Position vector of the HAC center on the left-side (-Y) of the secondary runway centerline
R _CC_R_SEC	V(3)	0	EF	Position vector of the HAC center on the right-side (+Y) of the secondary runway centerline
R_CC_LMAG_SEC	S	0	--	Magnitude of the vector R _CC_L_SEC
R_CC_RMAG_SEC	S	0	--	Magnitude of the vector R _CC_R_SEC

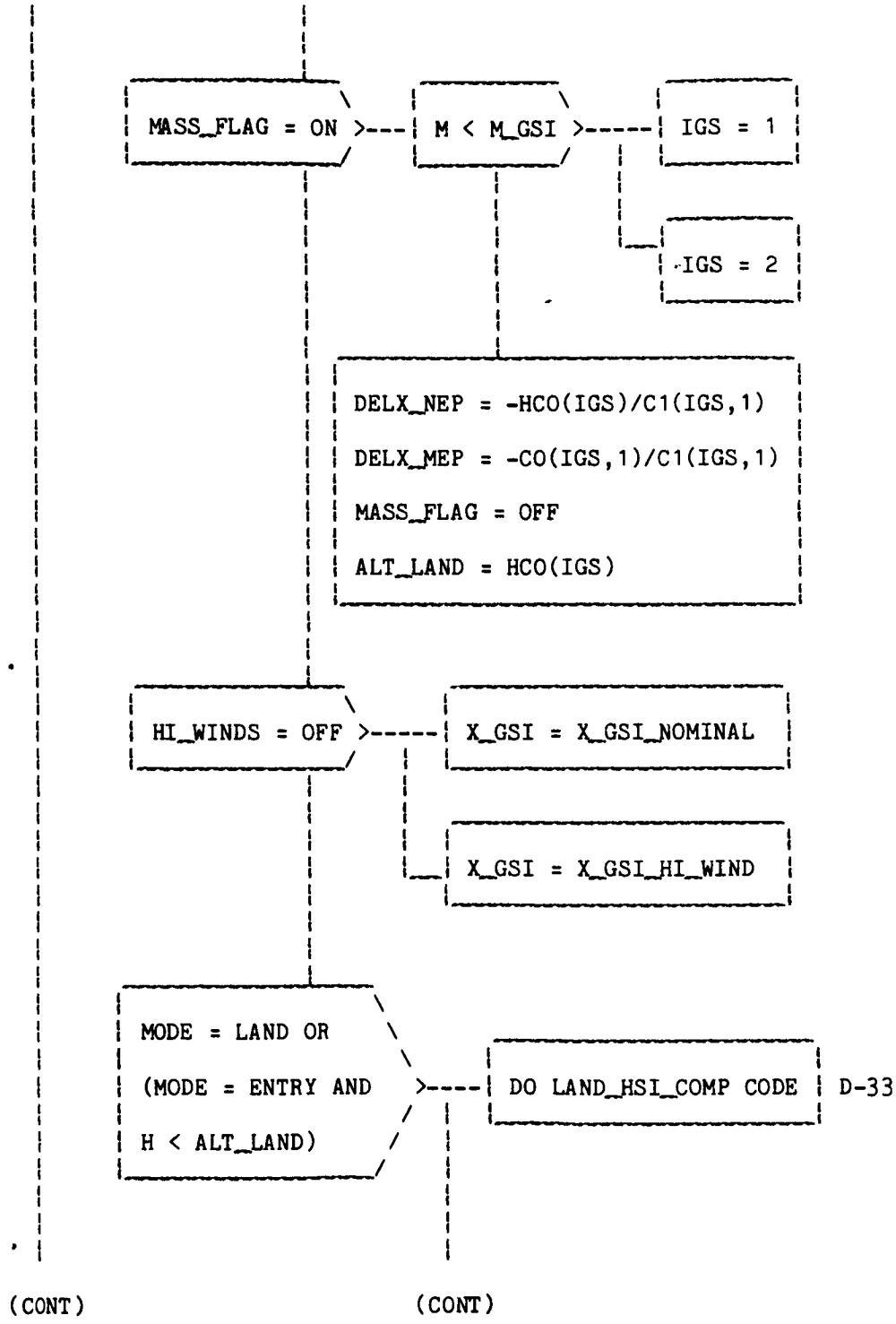
HSI_SEQUENCER



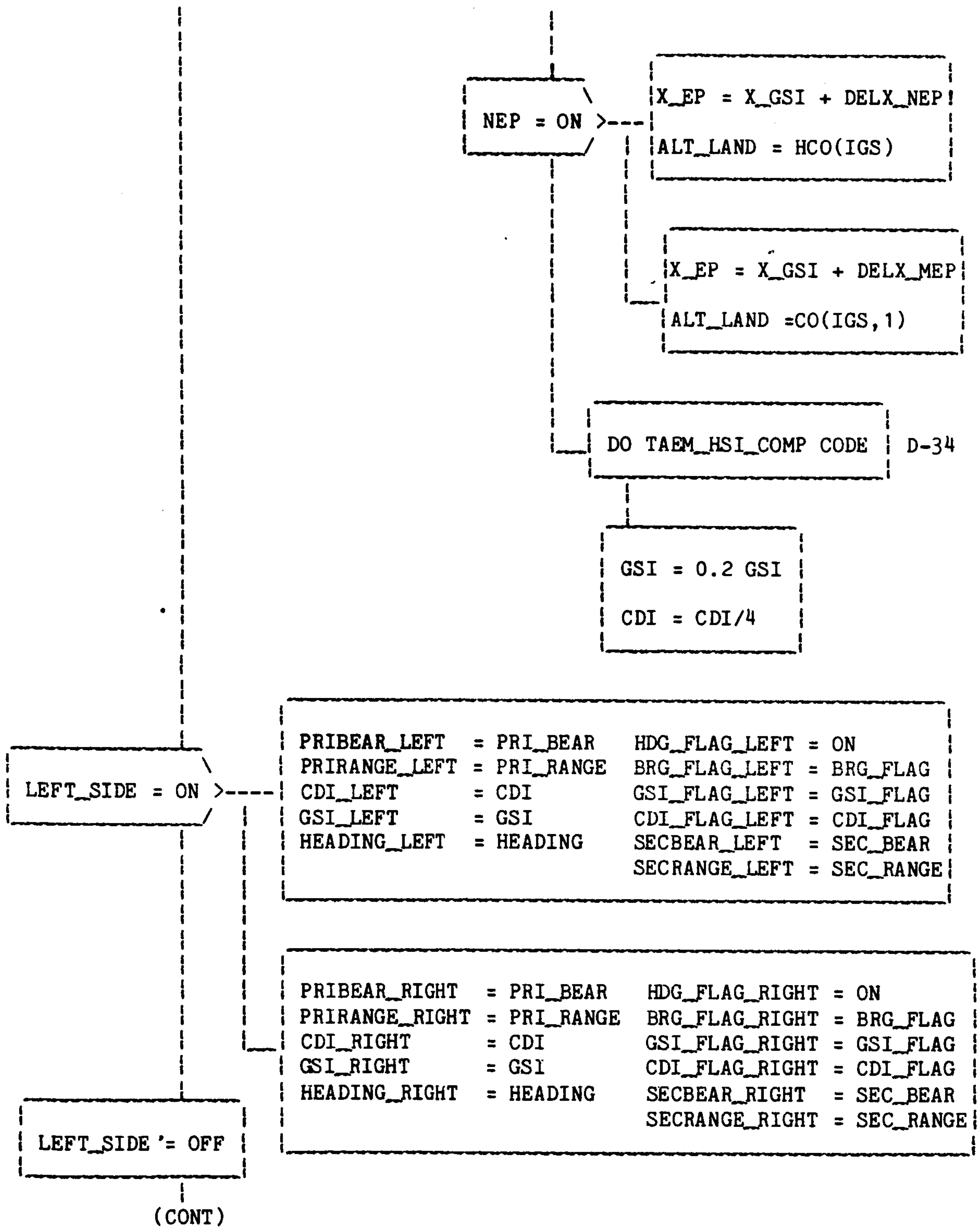
HSI_SEQUENCER (CONT)



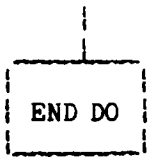
HSI_SEQUENCER (CONT)



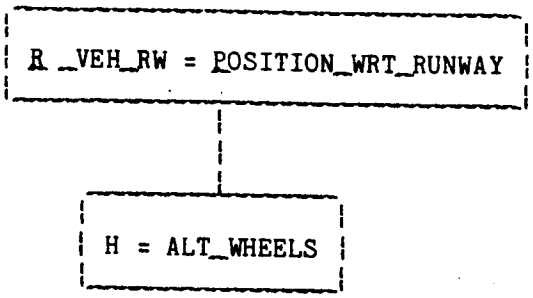
HSI_SEQUENCER (CONT)



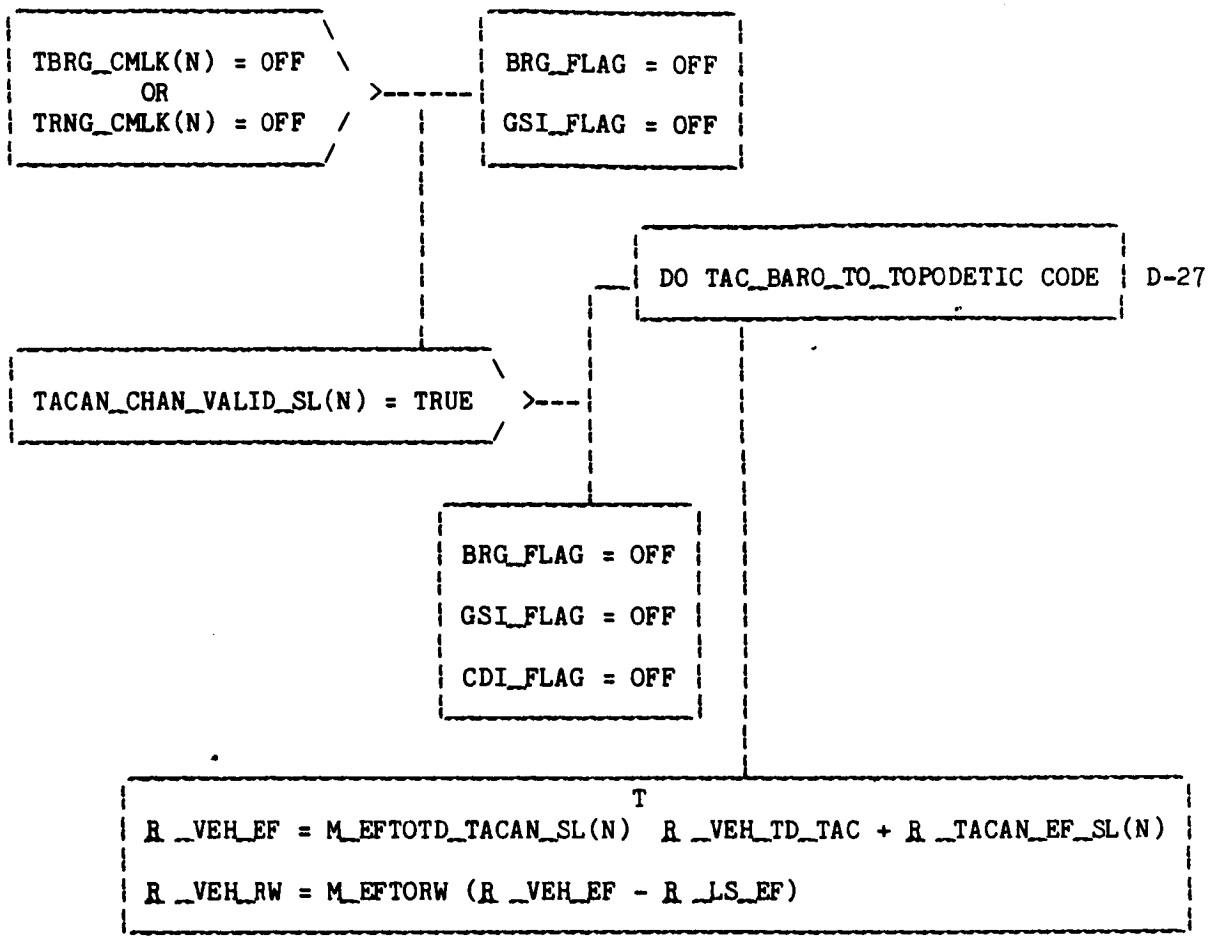
HSI SEQUENCER (CONT)



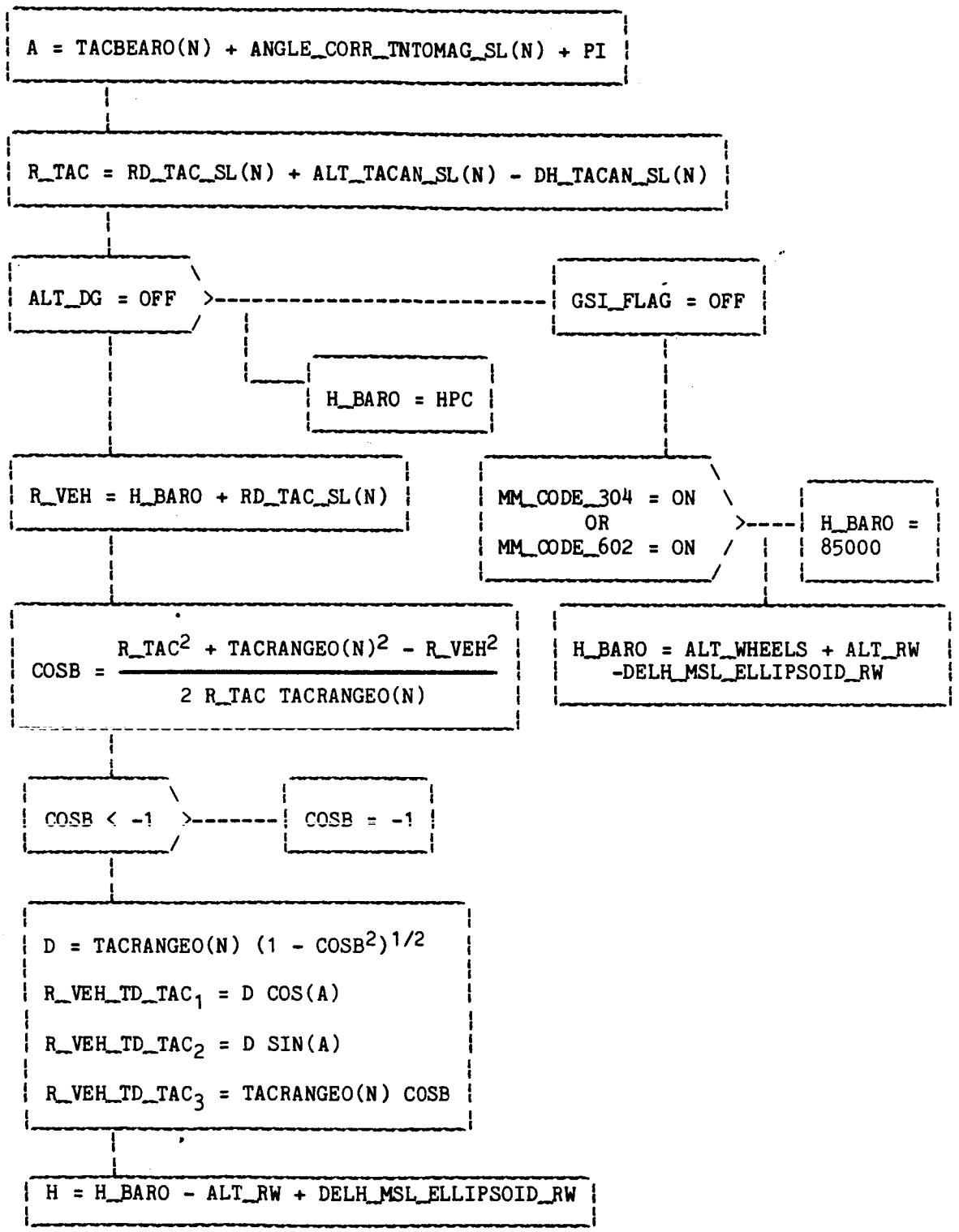
NAV_STATE_TO_RW_CODE



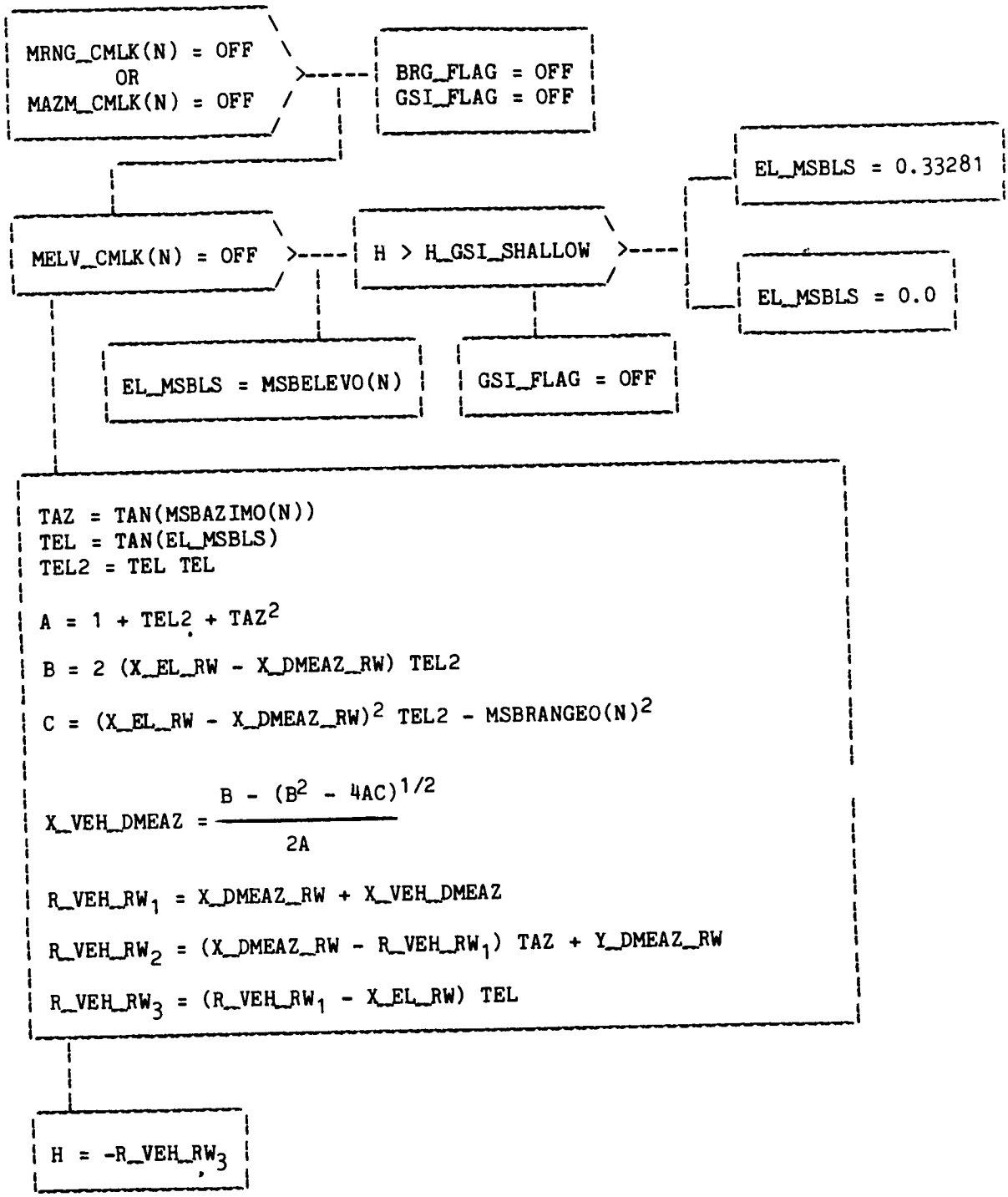
TAC_BARO_TO_RW CODE



TAC_BARO_TO_TOPODETIC CODE



MSBLS_TO_RW CODE



ENTRY_HSI_COMP CODE

```
SOURCE = NAV  >------ R_VEH_EF = R_EF

R_VEH_MAG = ABVAL(R_VEH_EF)

V_NORM = R_VEH_EF x V_RHO_EF

PSI = ARCTAN2(V_NORM3 R_VEH_MAG,(V_NORM1 R_VEH_EF2 -
                                 V_NORM2 R_VEH_EF1))

HEADING = (PSI - ANGLE_CORR_TNTOMAG_RW) DEG_PER_RAD

HEADING < 0  \------ HEADING = HEADING + 360

R_VEH_RW_SEC = M_EFTORW_SEC (R_VEH_EF - R_LS_EF_SEC)

P_SEC = SIGN(R_VEH_RW_SEC2)
P = SIGN(R_VEH_RW2)

P_SEC > 0 >------ CALL:  RANGE_BEAR_TO_HAC_ENTRY                D-31

                  INLIST:  R_CC_R_SEC, R_CC_RMAG_SEC,
                           P_SEC, AZIMUTH_RW_SEC,
                           ANGLE_CORR_TNTOMAG_RW_SEC

                  OUTLIST:  SEC_RANGE, SEC_BEAR

                  CALL:  RANGE_BEAR_TO_HAC_ENTRY                D-31

                  INLIST:  R_CC_L_SEC, R_CC_LMAG_SEC,
                           P_SEC, AZIMUTH_RW_SEC
                           ANGLE_CORR_TNTOMAG_RW_SEC

                  OUTLIST:  SEC_RANGE, SEC_BEAR

(CONT)
```

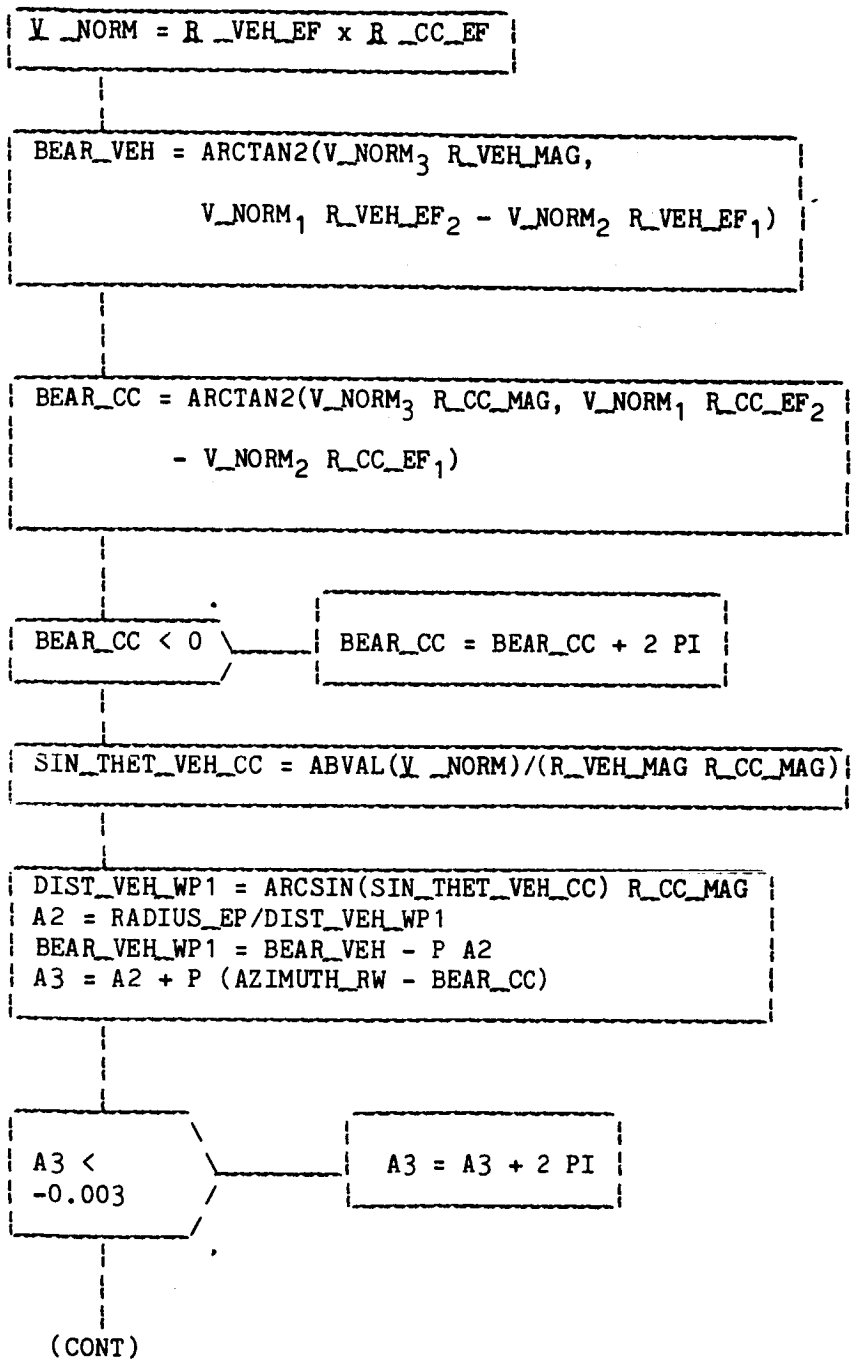
ENTRY_HSI_COMP CODE (CONT)

```
                                  CALL:  RANGE_BEAR_TO_HAC_ENTRY          D-31

                                  INLIST:  R _CC_R_PRI, R_CC_RMAG_PRI,
                                           P, AZIMUTH_RW,
                                           ANGLE_CORR_TNTOMAG_RW

                                  OUTLIST: PRI_RANGE, PRI_BEAR

                                  CALL:  RANGE_BEAR_TO_HAC_ENTRY          D-31

                                  INLIST:  R _CC_L_PRI, R_CC_LMAG_PRI,
                                           P, AZIMUTH_RW,
                                           ANGLE_CORR_TNTOMAG_RW

                                  OUTLIST:  PRI_RANGE, PRI_BEAR

GSI = 0
CDI = 0
GSI_FLAG = OFF
```

RANGE_BEAR_TO_HAC_ENTRY

INLIST: R _CC_EF, R_CC_MAG,P, AZIMUTH_RW,
ANGLE_CORR_TNTOMAG_RW

OUTLIST: RANGE, BEARING



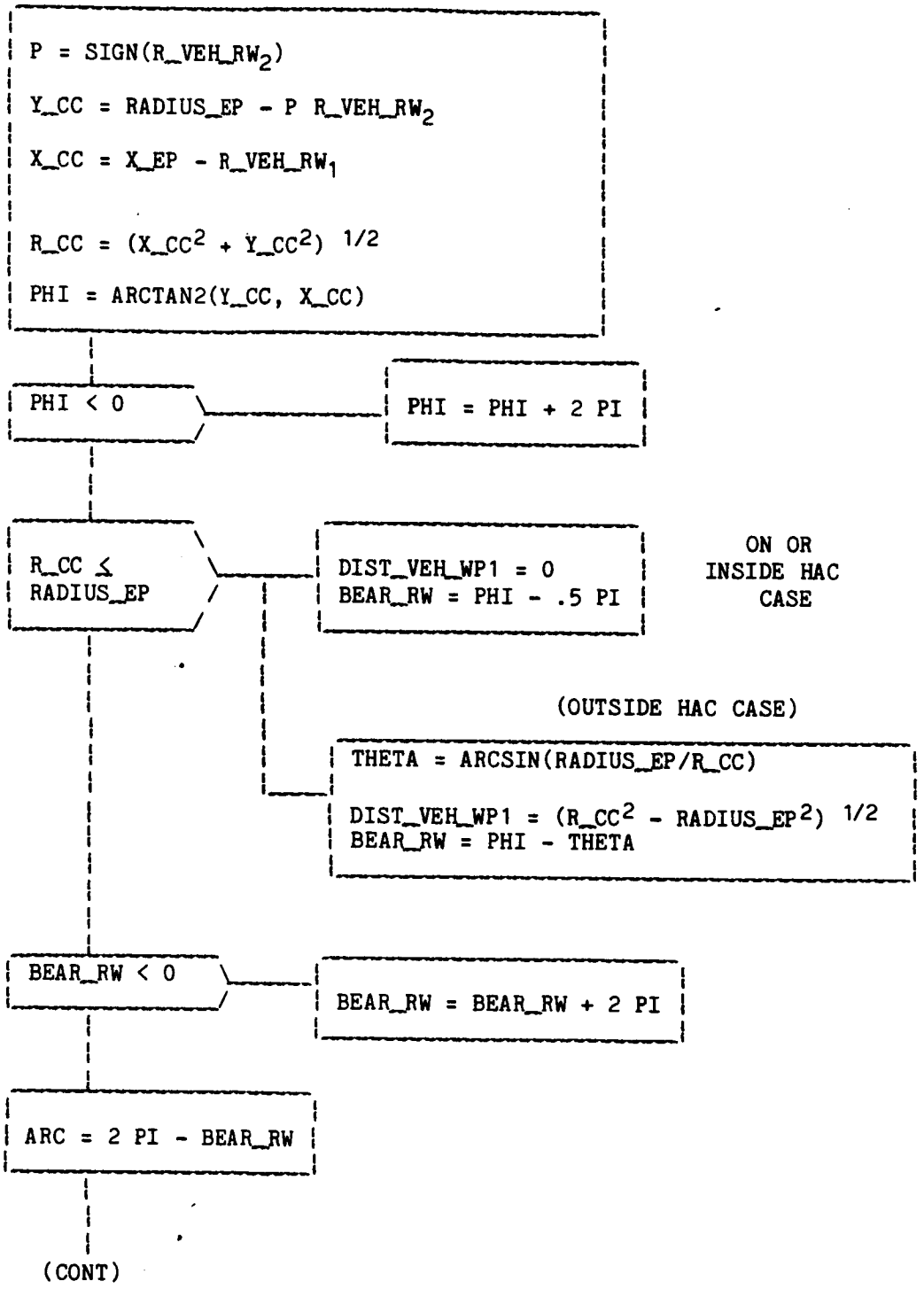
RANGE_BEAR_TO_HAC_ENTRY (CONT)

```
D_ARC = A3 RADIUS_EP

RANGE = (DIST_VEH_WP1 + D_ARC - X_NEP + X_WP2) NAUTMI_PER_FT
BEARING = (BEAR_VEH_WP1 - ANGLE_CORR_TNTOMAG_RW) DEG_PER_RAD

BEARING < 0 ---> BEARING = BEARING + 360
```

LAND_HSI_COMP CODE

```
D = X_WP2 - R_VEH_RW
                    1
PRI_BEAR = (ARCTAN2(-R_VEH_RW_2,D) + AZIMUTH_RW
              - ANGLE_CORR_TNTOMAG_RW) DEG_PER_RAD

PRI_BEAR < 0 \_____ PRI_BEAR = PRI_BEAR + 360
             /

IF PRI_BEAR > 360 \_____ PRI_BEAR = PRI_BEAR - 360
                  /

DIST_WP2 = (R_VEH_RW^2 + D^2)^1/2
PRI_RANGE = (DIST_WP2 NAUTMI_PER_FT) 10.
SEC_RANGE = PRI_RANGE
SEC_BEAR = PRI_BEAR

H>H_GSI_SHALLOW \_____ R = DIST_WP2 + X_GSI + DELX_MEP - X_WP2
                /      HREF = CO(IGS,1) + C1(IGS,1) R
                       GSI = H - HREF

                       GSI_FLAG = OFF
```

TAEM_HSI_COMP CODE

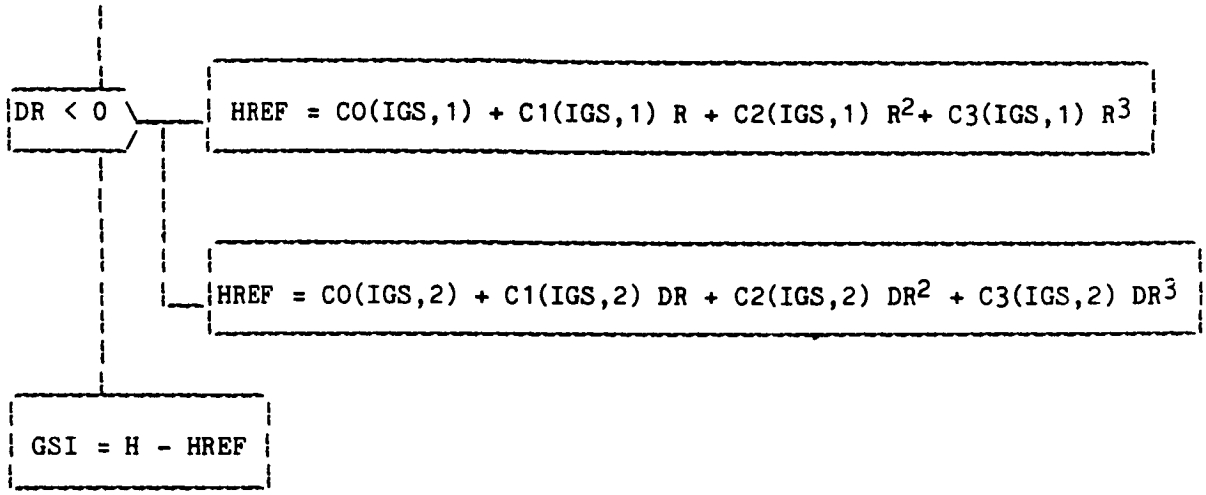


TAEM_HSI_COMP CODE (CONT)

```
D_ARC =
ARC RADIUS_EP

P < 0 \_____ BEAR_RW = 2 PI
          - BEAR_RW
          PHI = 2 PI - PHI

RANGE_FT = DIST_VEH_WP1 + D_ARC - X_EP + X_WP2
PRI_RANGE = (RANGE_FT NAUTMI_PER_FT) 10.
PRI_BEAR = (BEAR_RW + (AZIMUTH_RW - ANGLE_CORR_TNTOMAG_RW)) DEG_PER_RAD

PRI_BEAR > 360 \_____ PRI_BEAR = PRI_BEAR - 360

SEC_BEAR = (PHI + (AZIMUTH_RW - ANGLE_CORR_TNTOMAG_RW)) DEG_PER_RAD
SEC_RANGE = 10. R_CC NAUTMI_PER_FT

SEC_BEAR > 360 \_____ SEC_BEAR = SEC_BEAR - 360

R = RANGE_FT + X_GSI + DELX_MEP - X_WP2
DR = R - CUBRC(IGS)
```

(CONT)

TAEM_HSI_COMP CODE (CONT)



APPENDIX E

SPECIALIST FUNCTIONS NAVIGATION SUPPORT FORMULATIONS FLOW CHARTS AND VARIABLE NAMES DESCRIPTIONS

This page intentionally left blank.

APPENDIX E CONTENTS

Subject	Page
Variable list	E-5
Flow charts	E-7
RUNWAY_REDESIGNATE	E-7
DEORBIT_LANDING_SITE_UPLINK	E-8
DEORBIT_TACAN_SITE_UPLINK	E-9

This page intentionally left blank.

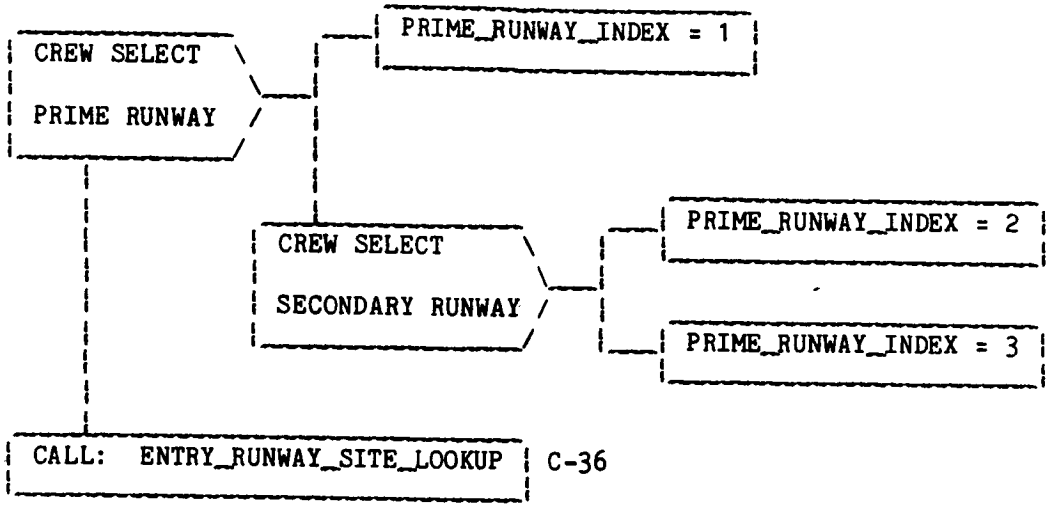
Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ALT_ABOVE_ ELLIPSOID	V(10)	I-load	-	Altitude of the TACAN station above reference ellipse
BIAS_TAC_BRG	V(10)	I-load	-	Any known error (bias) in the bearing transmitted by a TACAN ground station (loaded permission)
BIAS_TAC_R	V(10)	I-load	-	Any known error (bias) in the range measurement obtained from a TACAN ground station (loaded premission)
LANDING_SITE_ TABLE_SLOT	Binary	0	-	Uplink index for DEORBIT_ LANDING_SITE_UPLINK
LATITUDE_ GEODETIC	V(10)	I-load	-	Geodetic latitude of TACAN station
LONGITUDE_EAST	V(10)	I-load	-	Longitude of the TACAN station
MAGNETIC_ VARIATION	V(10)	I-load	-	Angle between true north and magnetic north at the TACAN station
MLS_AVAIL_ASL MLS_AVAIL_PSL MLS_AVAIL_SSL	BIT BIT BIT	I-load I-load I-load	- - -	Flag indicating (ON) the availability of MSBLS at alternate, primary, or secondary runway
OP_CODE	BIT(7)	0		Bit string indicating which command uplink has occured
PRIME_RUNWAY_ INDEX	I	1		Current prime landing site selection
RUNWAY_ALT_ASL RUNWAY_ALT_PSL RUNWAY_ALT_SSL	F F F	I-load I-load I-load	- - -	Geodetic altitude of the alternate, primary, and secondary landing site choices
RUNWAY_NAME_ASL RUNWAY_NAME_PSL RUNWAY_NAME_SSL	CHAR CHAR CHAR	I-load I-load I-load	- - -	Name of the *a priori* alternate, primary and secondary landing site choices

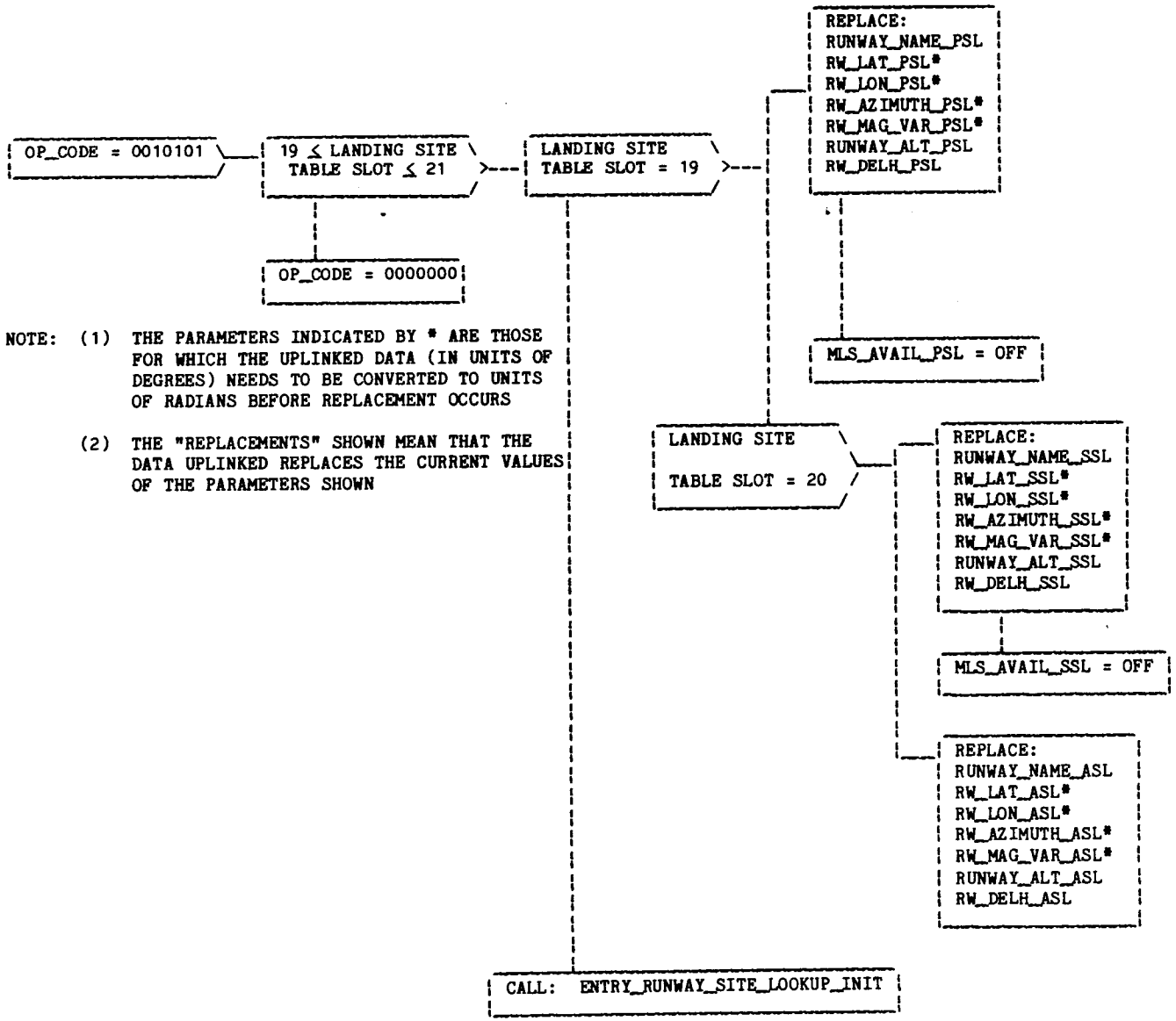
Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
RW_AZIMUTH_ASL RW_AZIMUTH_PSL RW_AZIMUTH_SSL	F F F	I-load I-load I-load	- - -	Azimuth to true north of the alternate, primary, and secondary landing site choices
RW_DELH_ASL RW_DELH_PSL RW_DELH_SSL	F F F	I-load I-load I-load	- - -	Delta height from ellipsoid to MSL for the alternate, primary and secondary landing site choice
RW_LAT_ASL RW_LAT_PSL RW_LAT_SSL	F F F	I-load I-load I-load	- - -	Geodetic latitude of the alternate, primary, and secondary landing site chocies
RW_LON_ASL RW_LON_PSL RW_LON_SSL	F F F	I-load I-load I-load	- - -	Longitude of the alternate, primary, and secondary landing site choices
RW_MAG_VAR_ASL RW_MAG_VAR_PSL RW_MAG_VAR_SSL	F F F	I-load I-load I-load	- - -	Magnetic variation for the alternate, primary, and secondary landing site choices
TAC_ID	V(10)	I-load	-	A three-digit channel/mode designation, unique for each TACAN station
TACAN_TABLE_SLOT_ID	BINARY	-	-	Uplink index for DEORBIT_TACAN_SITE_UPLINK

RUNWAY_REDESIGNATE



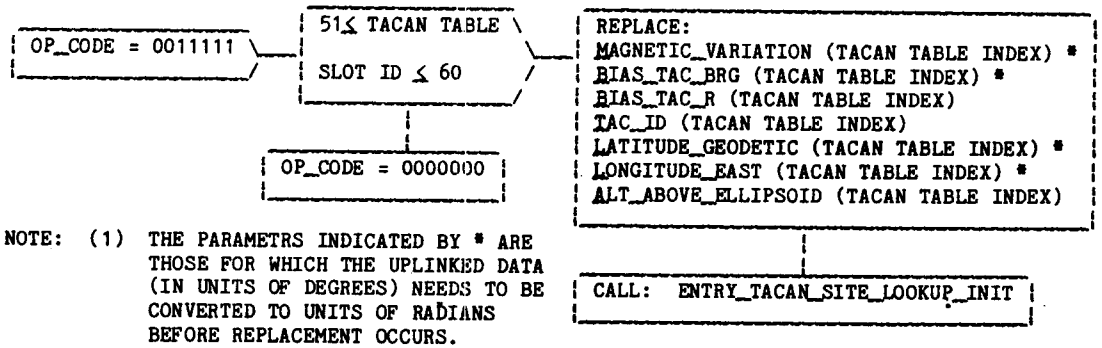
DEORBIT_LANDING_SITE_UPLINK



NOTE: (1) THE PARAMETERS INDICATED BY * ARE THOSE FOR WHICH THE UPLINKED DATA (IN UNITS OF DEGREES) NEEDS TO BE CONVERTED TO UNITS OF RADIANS BEFORE REPLACEMENT OCCURS

(2) THE "REPLACEMENTS" SHOWN MEAN THAT THE DATA UPLINKED REPLACES THE CURRENT VALUES OF THE PARAMETERS SHOWN

DEORBIT_TACAN_SITE_UPLINK



NOTE: (1) THE PARAMETRS INDICATED BY * ARE THOSE FOR WHICH THE UPLINKED DATA (IN UNITS OF DEGREES) NEEDS TO BE CONVERTED TO UNITS OF RADIANS BEFORE REPLACEMENT OCCURS.

(2) THE "REPLACEMENTS" SHOWN MEAN THAT THE DATA UPLINKED REPLACES THE CURRENT VALUES OF THE PARAMETERS SHOWN.

(3) TAC_ID IS THE CHANNEL/MODE IDENTIFIER FOR THE TACAN SITE.

(4) TACAN TABLE INDEX = TACAN TABLE SLOT ID-50, FOR COMPATIBILITY WITH OPS 2 SOFTWARE.

APPENDIX F

USER PARAMETER FLOW CHARTS, VARIABLE NAMES, AND DESCRIPTIONS

This page intentionally left blank.

APPENDIX F CONTENTS

Subject	Page
Variable List Definitions	F-4
Entry Operations Computer Load User Parameter Variable List and Flow Diagrams	
Variable List	F-5
Flow Diagrams	F-17
Deorbit/Landing User Parameter Processing Sequencer Principal Function	
DEORB_LAND_UPP_SEQ	F-17
Entry User Parameter Processing Principal Function	
USER_PARAM_PROPAGATOR	F-19
H_HDOT_ACCVERT	F-21
GUIDECOMP	F-23
ENTRY_MID_TARGET	F-26
ENT_RNG_BEAR	F-27
TACAN_DISP_COMPS	F-29
EARTH_FIXED_COMPS	F-20
TAEM User Parameter Processing Principal Function	
USER_PARAM_PROPAGATOR	F-19
H_HDOT_ACCVERT	F-21
GUIDECOMP	F-23
TACAN_DISP_COMPS	F-29
Autoland User Parameter Processing Principal Function	
USER_PARAM_PROPAGATOR	F-19
GUIDECOMP	F-23
TACAN_DISP_COMPS	F-29

APPENDIX F

VARIABLE LIST DEFINITIONS

- Code Used for Variable "Data Type":

S:	scalar
V(n):	vector (dimension)
M(n):	square matrix (dimension)
INT:	integer
BIT:	bit
CHAR:	character
STR:	structure
ARR:	array

- Coordinate Frame Code and Definition:

BODY: (structural)	x:	parallel to the longitudinal axis (positive aft)
	y:	completes right-hand system
	z:	perpendicular to the x-axis, positive upward
M50:	Mean-of-50 reference coordinate system	
RW: (runway coordinates)	x:	down runway centerline in direction of landing
	y:	completes right-hand system
	z:	down, normal to ellipsoid
SCAN: (MLS scanner coordinates)	x:	scanner boresight axis
	y:	completes right-hand system
	z:	up, normal to ellipsoid
TD: (topodetic coordinates)	x:	north
	y:	east
	z:	down, normal to ellipsoid

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
ACC_DRAG	S	0		Vehicle cg drag acceleration
ACC_LIFT	S	0		Vehicle cg lift acceleration
ACC_VERT	S	0		Vertical component of vehicle cg acceleration WRT earth rotating frame
ALT	S	0		Current orbiter altitude above reference ellipsoid
ALT_WHEELS	S	0		Altitude of orbiter cg (entry) or rear wheels (TAEM A/L) above runway altitude
AZIMUTH_RW	S	0		Bearing from true north of runway coordinate system +X axis
COURSE_WRT_RW	S	0		Vehicle velocity direction WRT runway centerline
DELAZ	S	0		Azimuth error (heading of relative velocity vector minus bearing to WP1)
DT_IMU	S	0		State vector AVERAGE_G integration time step
DV_S	V(3)	0	M50	IMU-sensed velocity change
EVENT_E3	Bit	Off		Mode transition from 301 to 302 event flag
EVENT_E16	Bit	Off		Mode transition from 303 to 304 event flag
EVENT_E16B	Bit	Off		Mode transition from 303 to 301 event flag
EVENT_E21	Bit	Off		Mode transition from 304 to 305 event flag
FLT_PATH_ANG	S	0		Angle between navigation base relative velocity vector and ellipsoid horizontal

Variable List (continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
EVENT_E11	Bit	Off		Guidance initiate flag
DELAZ_SEC	S	0		Azimuth error WRT secondary HAC tangent point (WP1)
OPS_3_INITIALIZE_ COMPLETE	Bit	Off		Signal indicating initial-ization of state parameters by nav sequencer
A2	S	0		Angle at HAC center from Shuttle to WP1
A3	S	0		Angle at HAC center from WP1 to entry point
BEAR_CC	S	0		Bearing at HAC center WRT true north
BEAR_VEH	S	0		Bearing from Shuttle to HAC center WRT true north
BEAR_VEH_WP1	S	0		Bearing to WP1 WRT true north
COS_THET_VEH_CC	S	0		Cosine of range angle from Shuttle to HAC center
COS_THET_VEH_WP1	S	0		Cosine of range angle from Shuttle to WP1
D_ARC	S	0		Arc length around the HAC from WP1 to EP
DIST_VEH_WP1	S	0		Surface range from Shuttle to WP1
P	S	0		Sign of runway Y-component of the Shuttle
Q_B_I	Arr	0		M50 to body quaternion
M_TEMP_TXPOS	M(3)	0		Transpose of earth-fixed to M50 transformation matrix
AZIMUTH_RW_SEC	S	0		Azimuth of secondary runway measured from true north

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
M_EFTORW_SEC	M(3)	0		Transformation matrix from earth-fixed to secondary runway
R _LS_EF_SEC	V(3)	0		Earth-fixed position vector of the secondary runway threshold
A3_TOL	S	Design Dependent		Tolerance for correcting the range of the angle A3
ALT_RW	S	0		Altitude above reference ellipsoid of runway reference point
FILT_UPDATE	Bit	Off		Switch indicating (ON) that the current navigation cycle is complete
G _RESET	V(3)	0	M50	Gravity acceleration vector for user parameter state integration
H_DOT_LAST	S	0		Previous value of H_DOT_ ELLIPSOID
NAUTMI_PER_FT	S	Constant		Feet to nautical miles
PI	S	Constant		The constant PI
COSTH	S	0		Cosine of Shuttle's pitch Euler angle (body to TD)
SINTH	S	0		Sine of Shuttle's pitch Euler angle (body to TD)
RW_ID_UPP	S	0		Current primary landing site selection symbol
RW_NAME	S	0		Current primary landing site selection symbol
G _OLD	V(3)	0	M50	Copy of G _RESET for use by user parameter propagator

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
P_SEC	S	0		Sign of secondary runway Y-component of the Shuttle
H_DOT_ELLIPSOID	S	0		Estimated topodetic altitude rate
LOAD_TOTAL	S	0		Total load factor
LOD	S	0		Vehicle lift over drag ratio
M_EFTORW	M(3)	0		Earth-fixed to prime RW transformation matrix
POSITION_WRT_RUNWAY	V(3)	0	RW	Vehicle cg position vector WRT runway reference point (R_LS_EF)
R_AVGG	V(3)	0	M50	Current Shuttle position vector
R_EF	V(3)	0	EF	Shuttle position vector in earth-fixed coordinates
REL_VEL_MAG	S	0		Magnitude of vehicle relative velocity
R_LS_EF	V(3)	0	EF	Position vector of runway in earth-fixed coordinates
RNG_TO_RW_THRESH	S	0		Surface range from Shuttle to RW threshold
THETA	S	0		Euler angle from TD to body frame (pitch)
T_STATE	S	0		Time tag for current user parameter state vector
V_AVGG	V(3)	0	M50	Current Shuttle velocity vector
V_RHO_EF	V(3)	0	EF	Earth relative velocity in earth-fixed coordinates
RNG_TO_RW_THRESH_SEC	S	0		Surface range to secondary runway threshold via WP1

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
RADIUS_NEP	S	Mission Dependent		Radius of nominal HAC
R_GO_RAMP	S	Design Dependent	RW	Preset value of horizontal distance of vehicle from RW reference point below which radar altimeter measurements will be made available to navigation filter
R_HAC_RW	V(3)	0	RW	Position vector of HAC center in runway coordinates
R_RESET	V(3)	0	M50	Vehicle position vector after all navigation updates reserved for reset of user parameter integrator position vector R_AVGG
TIME_BIAS_RADALT	S	Design Dependent		Pad loaded bias used to correct radar altimeter time tag
T_IMU	S	0		Time associated with currently read IMU velocity counts from the IMU detection filter (RM)
T_RADALT	S	0		Time at which radar altimeter measurement was read
T_RESET	S	0		Time associated with reserved reset state
T_STATE_LAST	S	0		Value of T_STATE at previous pass through user parameter processing
USE_IMU_DATA	Bit	0		Flag indicating usage of IMU data in propagation
V_IMU_CURRENT	V(3)	0	M50	Current selected accumulated IMU velocity

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
MID_TARGET	Bit	On		Flag which indicates (ON) whether averaging of primary and secondary targeting parameters is to be performed
MID_TARGET_RECD	Bit	Off		Copy of MID_TARGET for feedback
VEL_TGT_SWITCH	S	Design Dependent		Relative velocity value below which the flag MID_ TARGET is to be set OFF
VELOCITY_WRT_RUNWAY	V(3)	0	RW	Vehicle velocity vector WRT runway reference point (R_ LS_EF)
V _IMU_OLD	V(3)	0	M50	Current accumulated IMU velocity
V_GROUNDSPEED	S	0		Vehicle cg groundspeed WRT runway (A/L), reference ellipsoid (TAEM, entry)
V_MAG	S	0		Vehicle inertial speed
X_NB_CG	S	Mission Dependent		X_STRUCT_BODY distance from navigation base to cg
X_NEP	S	0	RW	Runway X-component of the HAC center
Z_NB_CG	S	Mission Dependent		Z_STRUCT_BODY distance from cg to navigation base
Z_NB_WH	S	Hard Code		Z_STRUCT_BODY distance from rear wheels to navigation base
X_NB_WH	S	Hard Code		X_STRUCT_BODY distance from navigation base to rear wheels
NAV_EL_FLAG	Bit	Off		Nav validity flag for event lamp processing

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
PSI	S	0		Earth relative velocity heading
R_CC_EF	V(3)	0	EF	Position vector of HAC in earth-fixed coordinates
R_CC_MAG	S	0		Earth radius at HAC center for primary runway
R_VEH_MAG	S	0		Magnitude of R_VEH_EF
SIN_B	S	0		Sine of earth-centered angle subtended by the radius of the HAC
SIN_BEAR_CORR	S	0		Sine of the angle which corrects the Shuttle heading from the center of HAC to WP1
SIN_THET_VEH_CC	S	0		Sine of range from Shuttle to center of HAC
TCG	V(3)	0	M50	Total acceleration of Shuttle
V_NORM	V(3)	0	EF	Vector normal to the great circle plane containing the Shuttle and the HAC center
V_RHO	V(3)	0	M50	Vehicle relative velocity vector
X_BD_UNIT	V(3)	0	M50	Second column of matrix M_BODYM50 expressing a unit vector in direction of +Y body axis
UPP_UPDATE	Bit	Off		Flag indicating UPP state has been updated by navigation filter
V_IMU_RESET	V(3)	0	M50	Copy of V_CURRENT_FILT reserved as velocity count at start of extrapolation interval when user parameter integrator is reset

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
V_RESET	V(3)	0	M50	Vehicle velocity vector after all navigation updates reserved for reset of user parameter integrator velocity vector V_AVGG
WBR	V(3)	0	Body	IMU-derived body rate in degrees/second
RAW_RA_PROC	Bit	Off		Radar altimeter processing flag
DG_RADALT	Bit	Off		Radar altimiter data-good flag
Q_RADALT	S	0		Radar altitude measurement
BIAS_RADALT	S	Design Dependent		Radar altimeter bias
RADALT_ANG	S	Hard Code		Radar altimeter antenna angle with body X-axis
RADALT_NB_DIST	S	Hard Code		Navigation base to RA antenna distance
EVENT_LAMP_FIVE	Bit	Off		Event lamp five indicator flag
RA_FLAG	Bit	Off		Radar altimeter validity indicator for event lamp processing
ALT_EL	V(3)	Design Dependent		Altitude regions for nav event lamp processing
N_SEQ_RA	I	1		Sequential counter for radar altimeter validity indicator
N_SEQ_MAX	I	Design Despendent		Number of sequential failures of the nav event lamp test criteria allowed before activating the nav event lamp (EVENT_LAMP_FIVE)

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
A_O	S	0		One minus earth eccentricity squared
EARTH_POLE	V(3)	Constant	M50	Unit vector in direction of earth's axis of rotation
EARTH_RADIUS_EQUATOR	S	Constant		Earth equatorial radius
FLATCON	S	0		Earth eccentricity squared
RAD_P	S	0		Radius of the earth at the geocentric angle of the Shuttle position vector
UK	S	0		Vector dot product of VNOR and EARTH_POLE
UX	V(3)	0	M50	X-vector component of the +Z topodetic unit vector in topocentric coordinates
VNOR	V(3)	0	M50	Unit vector colinear with the Shuttle position vector and directed in the opposite sense
IMU_SFC	V(3)	0,0,0		IMU selection filter control vector
IMU_SFC_PREV	V(3)	1,1,1		Previous value of IMU selection filter control vector
ELLIPT	S	Constant		Earth ellipticity constant
$TACBEARO_I$	S	0		TACAN bearing data obtained from the SOP for each receiver, I = 1,3
$TACRANGEO_I$	S	0		TACAN range data obtained from the SOP for each receiver, I = 1,3
$ANGLE\_CORR\_TNTOMAG\_SL_I$	V(3)	0		Magnetic variation at TACAN site (each LRU) output from Site Lookup, I = 1,3

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
M_EFTOTD_TACAN_SL$_I$	M	0		Transformation matrix from earth-tixed to topodetic coordinates at TACAN site (each LRU) output from Site Lookup, I = 1,3
R _TACAN_EF_SL$_I$	V(3)	0	EF	Earth-fixed position vector to TACAN station (each LRU) output from Site Lookup, I = 1,3
TACAN_CHAN_VALID_SL$_I$	Bit	Off		Switch indicating (ON) a valid TACAN channel has been selected (Site Lookup output)
TAC_MODE	Bit	On		Switch indicating "ON" when ABS_MODE is selected for HSD DISP and "OFF" when DELTA_MODE is selected.
TAC_AZ$_I$	S	0		TACAN azimuth for display in the ABS_MODE or delta azimuth in the DELTA_MODE
TAC_RNG$_I$	S	0		TACAN range for display in the ABS_MODE or delta range when in the DELTA_MODE
DEG_PER_RAD	S	Constant		Conversion factor from radians to degrees
TAC_MODE_DISP	Bit	On		Switch for the HSD display indicating "ON" when ABS_MODE is selected and "OFF" when DELTA_MODE is selected
R _EST	V(3)	0	EF	Difference between Shuttle position and TACAN site location in earth-fixed coordinates (TACAN range in earth-fixed coordinates)
R _TEMP	V(3)	0	TD	Position vector to the Shuttle from the selected TACAN in topodetic coordinates at TACAN site

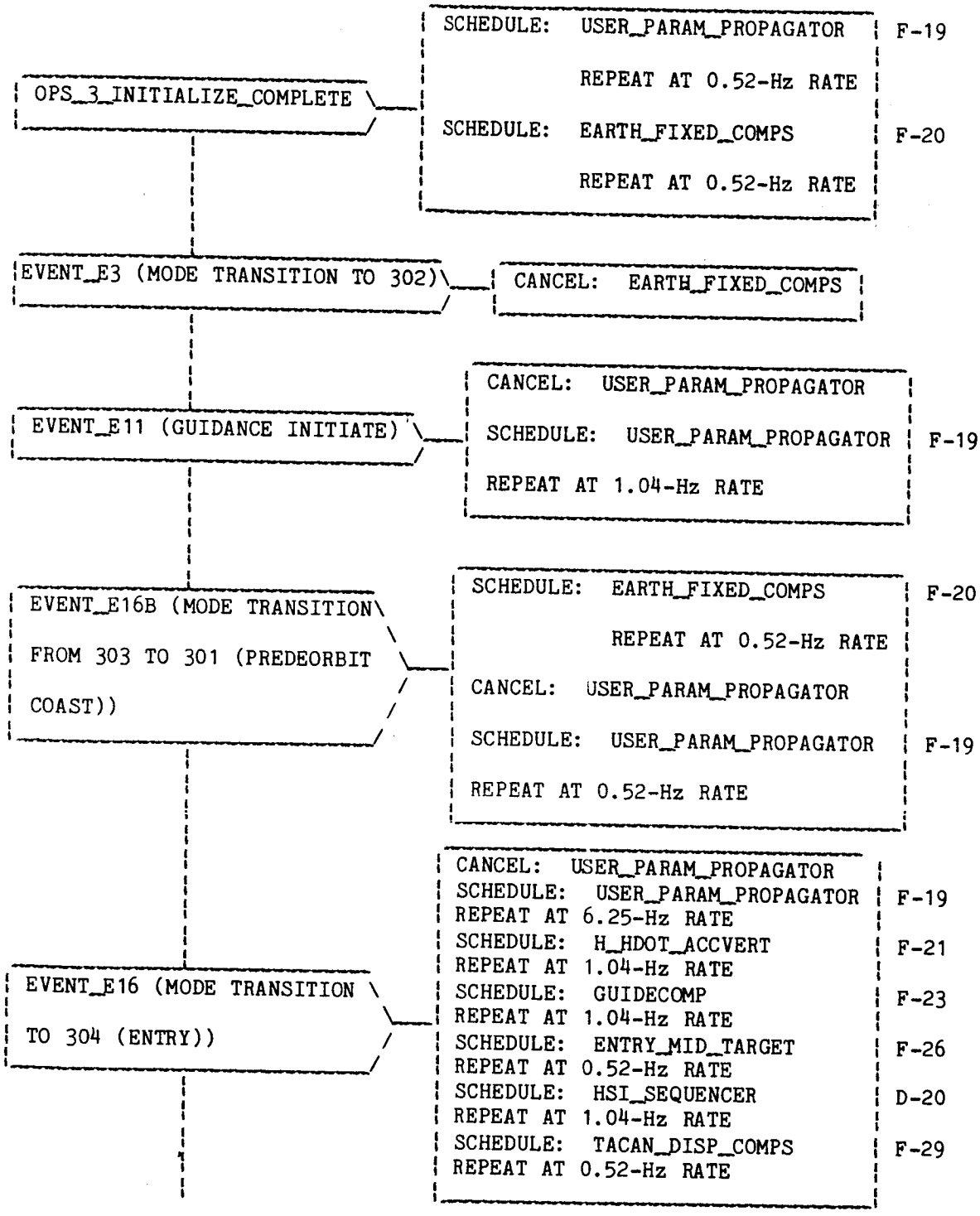
Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
TEMP	S	0		Internal variable used in computation of topodetic unit vector (H_HDOT_ACCVERT); Azimuth difference for each TACAN (TACAN_DISP_COMPS)
MM_CODE_305	Bit	Off		Major mode 305 flag
RAD_PER_DEG	S	Constant		Number of radians per degree
DELTA_T	S	0		Time difference associated with the calculation of DELTA_ACC_VERT
DELTA_ACC_VERT	S	0		Difference between the two most recent values of ACC_VERT excluding any navigation filter update value
ACC_VERT_OLD	S	0		Previous value of ACC_VERT
T_STATE_OLD	S	0		Previous value of T_STATE for case when UPP has not been updated by nav
TG_END	Bit	Off		TAEM guidance termination flag
V_IMU_PREV	V	0		Previous value of IMU-measured velocities
T_STATE_PREV	S	0		Previous value of T_STATE, corresponding to time tag for V_IMU_PREV
Y_VEH_RW_SEC	S	0		Y-component of the Shuttle position vector in runway coordinates
T_SEC_GMT	S	0		Time tag associated with earth-fixed state vectors
VNTDR_VEL_THRSH	S	Design Dependent		Threshold value of the relative velocity below which the VNT_DR_SEQ_INIT flag is set ON

Variable List (Continued)

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
VNT_DR_SEQ_INIT	Bit	Off		Flag which instructs MSC to initiate the VENT DOOR CNTL SEQ principal function
LDGR_VEL_THRSH	S	Design Dependent		Threshold value of the relative velocity below which the flag LD_GR_HYDR is set ON
LD_GR_HYDR	Bit	Off		Flag which instructs MSC to initiate the LND GEAR VLV CNTL principal function
TEST_VNT_DR	Bit	On		Internal single pass flag
TEST_LD_GR	Bit	On		Internal single pass flag

DEORB_LAND_UPP_SEQ



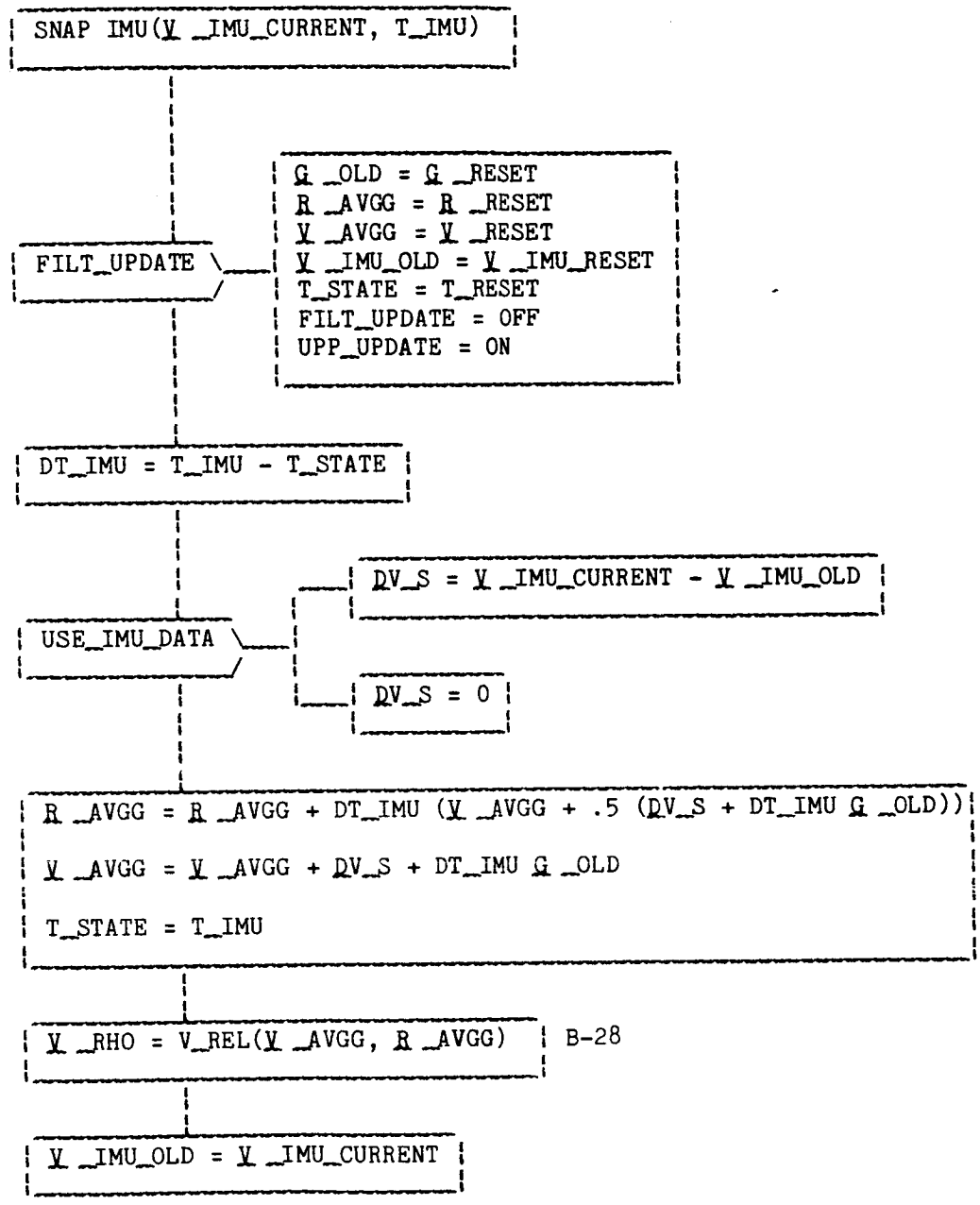
(CONT)

DEORB_LAND_UPP_SEQ (CONCLUDED)

```
EVENT_E21 (MODE TRANSITION TO 305 (TAEM))

TG_END = ON (TAEM GUIDANCE TERMINATION)

CANCEL:  ENTRY_MID_TARGET

CANCEL:  H_HDOT_ACCVERT

CANCEL:  GUIDECOMP

SCHEDULE:  GUIDECOMP

 REPEAT AT 6.25-Hz RATE
```

F-23

USER_PARAM_PROPAGATOR



EARTH_FIXED_COMPS

M_TEMP_TXPOS = EARTH_FIXED_TO_M50_COORD(T_STATE)^T	C-41
$\underline{R}$ _EF = M_TEMP_TXPOS $\underline{R}$ _AVGG	
$\underline{V}$ _RHO_EF = M_TEMP_TXPOS $\underline{V}$ _RHO	
T_SEC_GMT = T_STATE	

H_HDOT_ACCVERT

```
R_VEH_MAG = ABVAL (R _AVGG)
A_O = (1.0 - ELLIPT)^2
FLATCON = 1.0 - A_O
VNOR = - R _AVGG/R_VEH_MAG
UK = VNOR · EARTH_POLE
TEMP = (A_O + FLATCON UK^2)
RAD_P = EARTH_RADIUS_EQUATOR (A_O/TEMP)^1/2

UPP_UPDATE = ON
    UX = (EARTH_POLE - UK VNOR)
         (FLATCON UK RAD_P)/(TEMP R_VEH_MAG)

H_DOT_ELLIPSOID = -V _RHO · (UX + VNOR)
ALT = R_VEH_MAG - RAD_P
ALT_WHEELS = ALT - ALT_RW

MM_CODE_305
    ALT_WHEELS = ALT_WHEELS - (X_NB_WH SINTH + Z_NB_WH COSTH)
    H_DOT_ELLIPSOID = H_DOT_ELLIPSOID - WBR_2 RAD_PER_DEG
                      (X_NB_CG COSTH - Z_NB_CG SINTH)

UPP_UPDATE = ON
    ACC_VERT_ = ACC_VERT_OLD + DELTA_ACC_VERT / DELTA_T
                (T_STATE - T_STATE_LAST)
    UPP_UPDATE = OFF
```

(CONT) (CONT)

H_HDOT_ACCVERT (CONTINUED)

```
ACC_VERT = (H_DOT_ELLIPSOID - H_DOT_LAST)/(T_
            STATE - T_STATE_LAST)
DELTA_ACC_VERT = ACC_VERT - ACC_VERT_OLD
DELTA_T = T_STATE - T_STATE_OLD
T_STATE_OLD = T_STATE
ACC_VERT_OLD = ACC_VERT
```

```
H_DOT_LAST = H_DOT_ELLIPSOID
T_STATE_LAST = T_STATE
```

GUIDECOMP

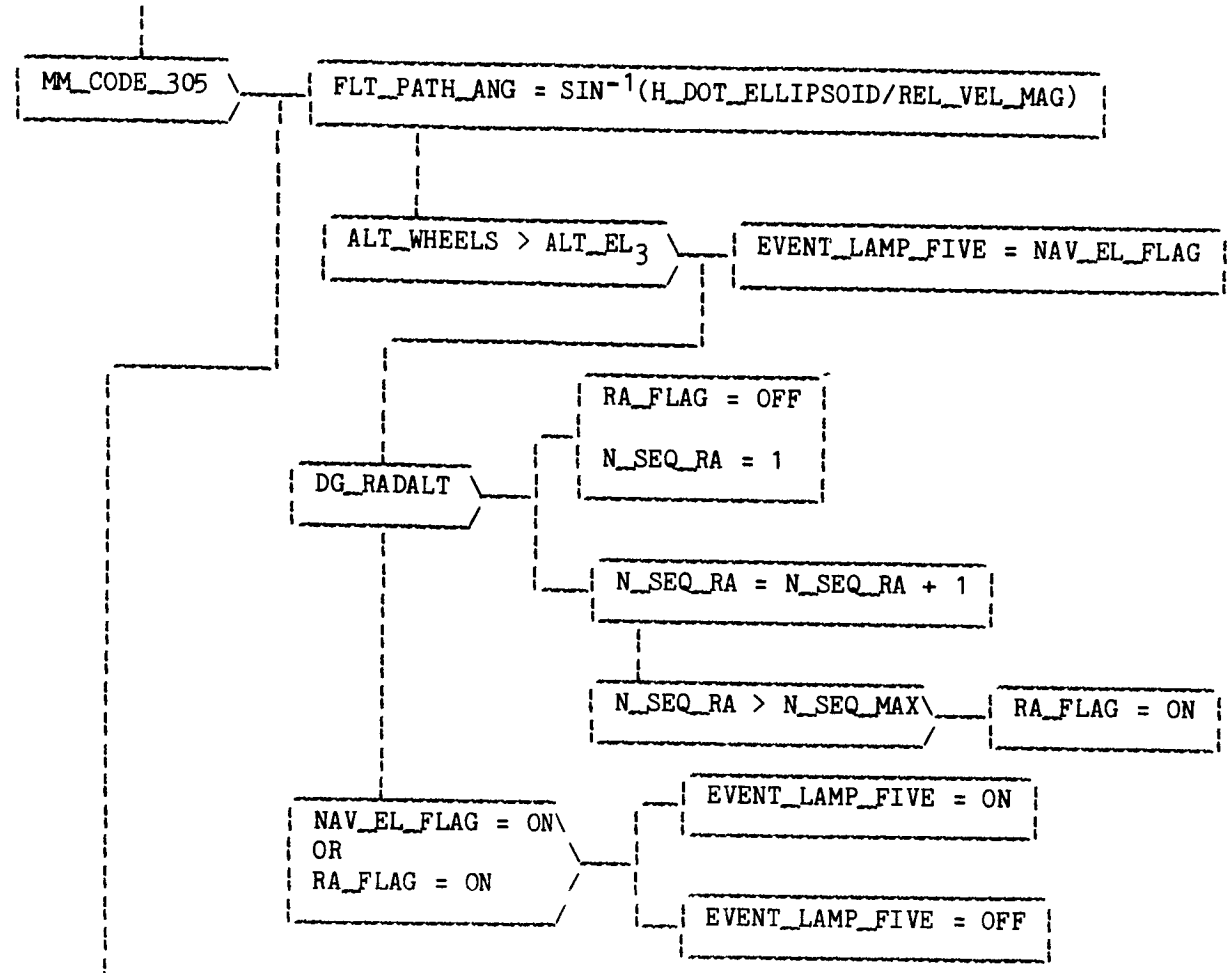
```
M_TEMP_TXPOS = EARTH_FIXED_TO_M50_COORD(T_STATE)^T   C-41

V_RHO_EF = M_TEMP_TXPOS V_RHO
REL_VEL_MAG = ABVAL(V_RHO)
R_EF = M_TEMP_TXPOS R_AVGG
POSITION_WRT_RUNWAY = M_EFTORW (R_EF - R_LS_EF)
VELOCITY_WRT_RUNWAY = M_EFTORW V_RHO_EF

TG_END = ON \__ SNAP RADAR ALTIMETER(Q_RADALT, T_RADALT, DG_RADALT)

RAW_RA_PROC \__ DG_RADALT \__ T_RADALT = T_RADALT - TIME_BIAS_RADALT
                                POSITION_WRT_RUNWAY3 = -Q_RADALT + BIAS_RADALT
                                + (T_STATE - T_RADALT) VELOCITY_WRT_RUNWAY3
                                - SIN(RADALT_ANG - THETA RAD_PER_DEG) RADALT_NB_DIST

                    (POSITION_WRT_RUNWAY1^2 \
                                            \   RAW_RA_PROC = ON
                    + POSITION_WRT_RUNWAY2^2) >--
                    < R_GO_RAMP^2            /

ALT_WHEELS = - POSITION_WRT_RUNWAY3 -(X_NB_WH SINTH
             + Z_NB_WH COSTH)
ALT = ALT_WHEELS + ALT_RW
H_DOT_ELLIPSOID = - VELOCITY_WRT_RUNWAY3 - WBR2 RAD_PER_DEG
                  (X_NB_CG COSTH - Z_NB_CG SINTH)
ACC_VERT = (H_DOT_ELLIPSOID - H_DOT_LAST)/(T_STATE - T_STATE_LAST)
H_DOT_LAST = H_DOT_ELLIPSOID
T_STATE_LAST = T_STATE

(CONT)   (CONT)
```

GUIDECOMP (CONTINUED)

```
TEST_LD_GR = ON \___ REL_VEL_MAG          \___ LD_GR_HYDR = ON
                    < LDGR_VEL_THRSH      /    TEST_LD_GR = OFF

TEST_VNT_DR = ON \___ REL_VEL_MAG          \___ VNT_DR_SEQ_INIT = ON
                    < VNTDR_VEL_THRSH     /    TEST_VNT_DR = OFF

COURSE_WRT_RW = ARCTAN2(VELOCITY_WRT_RUNWAY2, VELOCITY_WRT_RUNWAY1)

COURSE_WRT_RW < 0 \___ COURSE_WRT_RW = COURSE_WRT_RW + 2 PI

COURSE_WRT_RW = COURSE_WRT_RW DEG_PER_RAD

RW_ID_UPP = RW_NAME

V_GROUNDSPEED = (REL_VEL_MAG^2 - H_DOT_ELLIPSOID^2)^1/2

IMU_SFC = IMU_SFC_PREV \___ TCG = (V_IMU_OLD - V_IMU_PREV)/(T_STATE -
                            T_STATE_PREV)

ACC_DRAG = -(TCG · V_RHO)/REL_VEL_MAG
T_STATE_PREV = T_STATE
V_IMU_PREV = V_IMU_OLD
IMU_SFC_PREV = IMU_SFC
```

(CONT)

GUIDECOMP (CONTINUED)



$Y\_BD\_UNIT_1 = Q\_B\_I_3\ (Q\_B\_I_2 + Q\_B\_I_2) + Q\_B\_I_1\ (Q\_B\_I_4 + Q\_B\_I_4)$

$Y\_BD\_UNIT_2 = 1 - Q\_B\_I_2\ (Q\_B\_I_2 + Q\_B\_I_2) - Q\_B\_I_4\ (Q\_B\_I_4 + Q\_B\_I_4)$

$Y\_BD\_UNIT_3 = Q\_B\_I_4\ (Q\_B\_I_3 + Q\_B\_I_3) - Q\_B\_I_1\ (Q\_B\_I_2 + Q\_B\_I_2)$

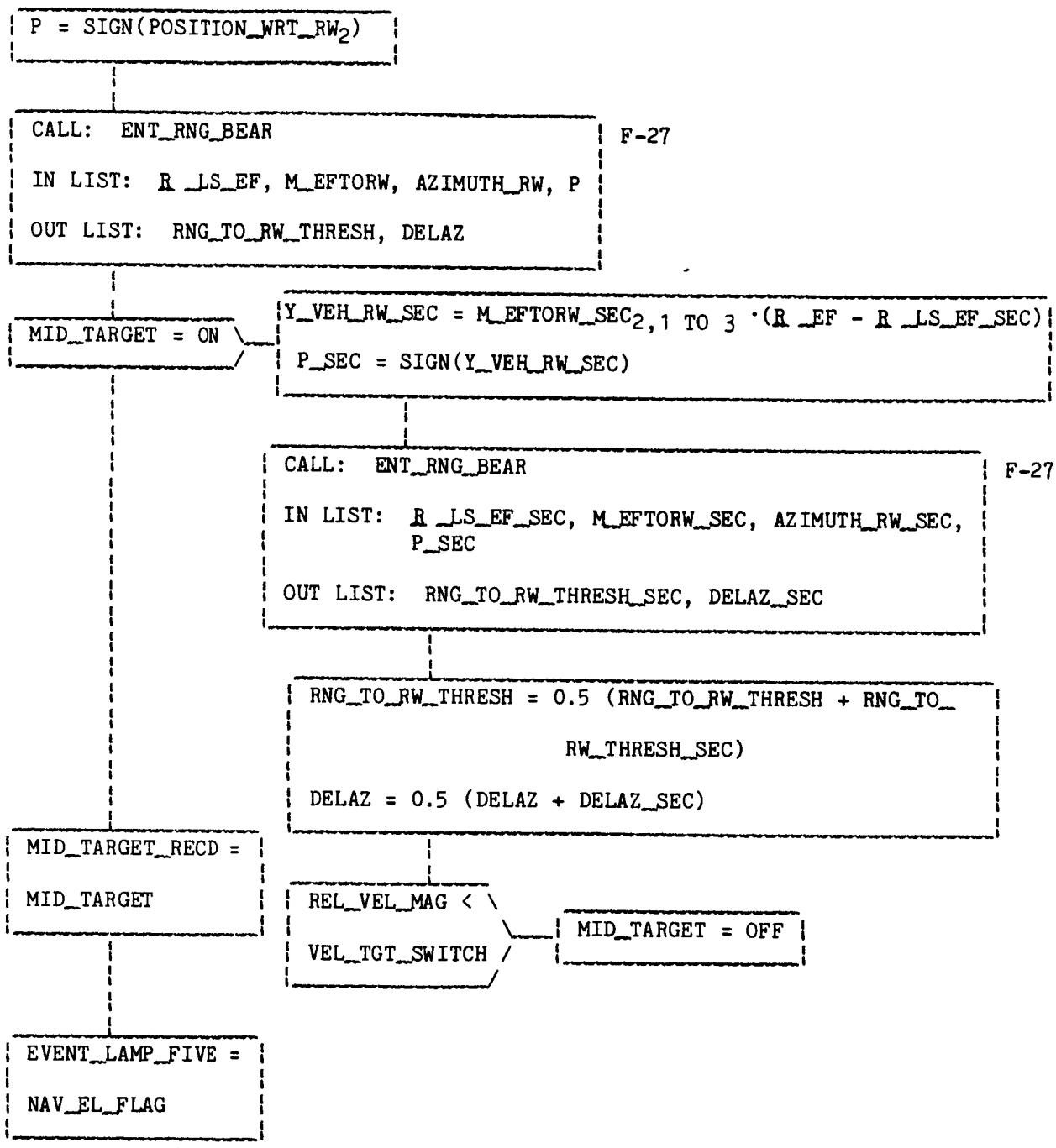
ACC_LIFT = $\underline{T}$CG · (($\underline{Y}$ _BD_UNIT x $\underline{V}$ _RHO)/ABVAL($\underline{Y}$ _BD_UNIT x $\underline{V}$ _RHO))

LOD = ACC_LIFT/ACC_DRAG

LOAD_TOTAL = ABVAL($\underline{T}$CG)

V_MAG = ABVAL($\underline{V}$ _AVGG)

ENTRY_MID_TARGET



ENT_RNG_BEAR

IN LIST: R_LS_EF, M_EFTORW, AZIMUTH_RW, P

OUT LIST: RNG_TO_RW_THRESH, DELAZ

$R\_HAC\_RW_2$ = P RADIUS_NEP

R_CC_EF = R_LS_EF + M_EFTORW^T R_HAC_RW

V_NORM = R_EF x R_CC_EF

R_CC_MAG = |R_CC_EF|

SIN_B = RADIUS_NEP/R_CC_MAG

BEAR_VEH = ARCTAN2(V_NORM_3 R_VEH_MAG, V_NORM_1 R_EF_2 - V_NORM_2 R_EF_1)

BEAR_CC = ARCTAN2(V_NORM_3 R_CC_MAG, V_NORM_1 $R\_CC\_EF_2$ - V_NORM_2 $R\_CC\_EF_1$)

BEAR_CC < 0 → BEAR_CC = BEAR_CC + 2 PI

COS_THET_VEH_CC = R_EF · R_CC_EF/(R_VEH_MAG R_CC_MAG)

SIN_THET_VEH_CC = $(1 - COS\_THET\_VEH\_CC^2)^{1/2}$

COS_THET_VEH_WP1 = COS_THET_VEH_CC + 0.5 SIN_B SIN_B COS_THET_VEH_CC

SIN_BEAR_CORR = SIN_B/SIN_THET_VEH_CC

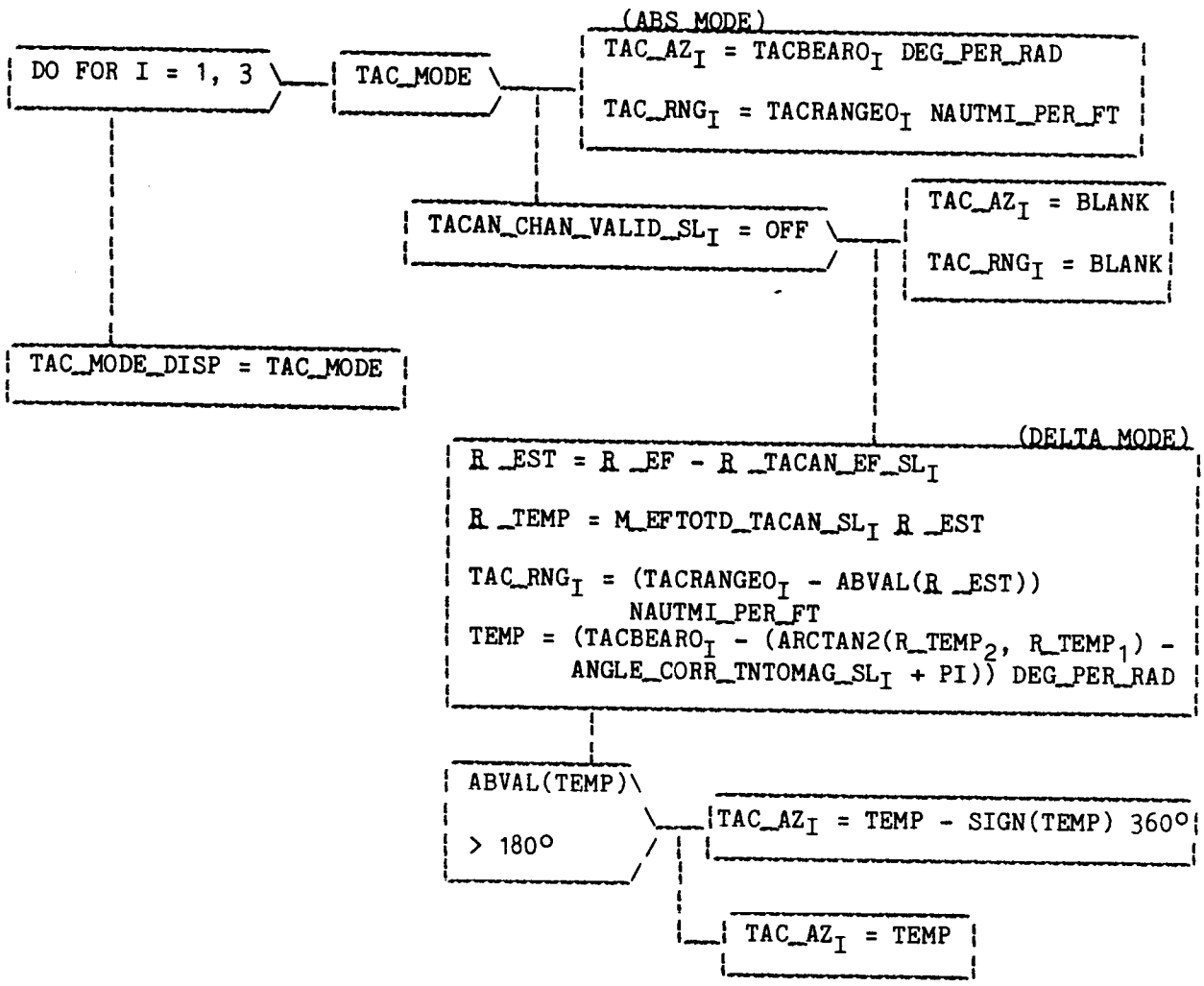
A2 = ARCCOS(COS_THET_VEH_WP1 SIN_BEAR_CORR)

(CONT)

ENT_RNG_BEAR (CONTINUED)

```
DIST_VEH_WP1 = ARCCOS(COS_THET_VEH_WP1) R_CC_MAG

BEAR_VEH_WP1 = BEAR_VEH - P ARCSIN(SIN_BEAR_CORR)

A3 = .5PI - A2 + P (AZIMUTH_RW - BEAR_CC)

A3 < A3_TOL \___ A3 = A3 + 2 PI
            /

D_ARC = A3 RADIUS_NEP

RNG_TO_RW_THRESH = (DIST_VEH_WP1 + D_ARC - X_NEP) NAUTMI_PER_FT

V_NORM = R_EF x V_RHO_EF

PSI = ARCTAN2(V_NORM3 R_VEH_MAG, (V_NORM1 R_EF2 - V_NORM2 R_EF1))

DELAZ = PSI - BEAR_VEH_WP1

ABVAL(DELAZ) > PI \___ DELAZ = DELAZ - 2 PI SIGN(DELAZ)
                  /
```

TACAN_DISP_COMPS



APPENDIX G

PRINCIPAL FUNCTION INTERFACE REQUIREMENTS

CONTENTS

Section | Page

PRINCIPAL FUNCTION OUTPUTS

ENTRY UPP (4.23) G-5
TAEM UPP (4.24) G-8
AUTOLAND UPP (4.25) G-11
DEORBIT/LANDING NAV SEQUENCER (4.123) G-13
ENTRY SITE LOOKUP (4.124) G-19
ENTRY NAVIGATION (4.127) G-30
PRELAND NAVIGATION (4.144) G-36
ENTRY AREA NAVIGATION (4.220) G-40
ENTRY PRECISE PREDICTOR (4.223) G-41
ENTRY AUTO TACAN SELECTION (4.239) G-42

PRINCIPAL FUNCTION INPUTS

ENTRY UPP (4.23) G-43
TAEM UPP (4.24) G-49
AUTOLAND UPP (4.25) G-54
DEORBIT/LANDING NAV SEQUENCER (4.123) G-59
ENTRY SITE LOOKUP (4.124) G-63
ENTRY NAVIGATION (4.127) G-69
PRELAND NAVIGATION (4.144) G-79
DEORBIT/LANDING UPP SEQUENCER (4.214) G-88
ENTRY AREA NAVIGATION (4.220) G-89
ENTRY PRECISE PREDICTOR (4.223) G-97
ENTRY AUTO TACAN SELECT (4.239) G-99

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP,4.23)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95L0150C	G46575	V_MAG	VEHICLE INERTIAL SPEED	ENT GUID, ENT DIP		FT/SEC
V95L0151CC	G03902	REL_VEL_MAG	GND REL VEL MAGNITUDE IN M50 SYS	ADTA SOP, ENT GUID, ENT DIP, NAVDAD SOP, VENT CNTL SEQ, LDG GEAR VLV CNTL, TLM	0,27K	FT/SEC
V95H0155CA	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	ENT AREA NAV, ENT AUTO TAC SEL, TACAN RM, GN&C/SM-PL IF		FT
V95H0156CA	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	ENT AREA NAV, ENT AUTO TAC SEL, TACAN RM, GN&C/SM-PL IF		FT
V95H0157CA	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	ENT AREA NAV, ENT AUTO TAC SEL, TACAN RM, GN&C/SM-PL IF		FT
V95A0160CB	G04205	ACC_DRAG	DRAG DECEL	ENT GUID, ENT DIP, NAVDAD SOP, AMI PROC, ENT NAV, TLM		FT/SEC^2
V95U0163CA	G04812	LOAD_TOTAL	TOTAL LOAD FACTOR	ENT GUID, E/L EV LT PROC, TLM		FT/SEC^2
V95H0165CB	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	ENT GUID, ENT AREA NAV, TACAN RM ENT DIP, 5.7, E/L EV LT PROC, TLM		FT
V95L0265CD	G04206	H_DOT_ELLIPSOID	EST ALTITUDE RATE	ENT GUID, ADTA SOP, ENT DIP, TLM		FT/SEC
V95A0170CB	G04801	ACC_VERT	VERTICAL ACCEL IN TOPODETIC COORD	AVVI PROC		FT/SEC^2
V95H0172C	G04803	DELAZ	HEADING ERR WRT HAC TANGENT POINT	ENT GUID, ENT DIP, TLM		RAD
V95H0175CC	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	AEROJET DAP, ADTA SOP, ENT NAV, PRELAND NAV, NAVDAD SOP, TLM	-10, +10000K	FT
V95H0176CA	G04809	RNG_TO_RW_THRESH	RANGE TO RUNWAY THRESHOLD VIA WP1	ENT GUID, ENT DIP, 5.7, TLM		NM
V95L0178CB	G04208	V_GROUNDSPEED	GROUNDSPEED	5.7, TACAN RM		FT/SEC
V95U0180C	G04802	LOD	LIFT/DRAG	ENT GUID, ENT DIP, TLM		
V95H0185CC	G02701	R_AVGG(1)	X-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT
V95H0186CC	G02702	R_AVGG(2)	Y-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP,4.23)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95H0187CC	G02703	R_AVGG(3)	Z-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT
V95L0190CC	G02704	V_AVGG(1)	X-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT/SEC
V95L0191CC	G02705	V_AVGG(2)	Y-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT/SEC
V95L0192CC	G02706	V_AVGG(3)	Z-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, DEORB GUID, DEORB MNVR DIP, STAR TRCK SOP, TLM		FT/SEC
V95W0200CE	G02707	T_STATE	TIME TAG ASSOC WITH CURRENT STATE	DEORB GUID, DEORB MNVR DIP, TLM		SEC
V95L0210CC	G02712	V_IMU_OLD(1)	X-COMP OF CURRENT ACCUM IMU VEL	DEORB GUID		FT/SEC
V95L0211CC	G02713	V_IMU_OLD(2)	Y-COMP OF CURRENT ACCUM IMU VEL	DEORB GUID		FT/SEC
V95L0212CC	G02714	V_IMU_OLD(3)	Z-COMP OF CURRENT ACCUM IMU VEL	DEORB GUID		FT/SEC
V95L0215CB	G47784	V_RHO(1)	X-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0216CB	G47785	V_RHO(2)	Y-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0217CB	G47786	V_RHO(3)	Z-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95H0220CB	G04210	POSITION_WRT_RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	ENT AREA NAV, 5.7, TLM		FT
V95H0221CB	G04211	POSITION_WRT_RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	ENT AREA NAV, 5.7, TLM		FT
V95H0225CA	G04201	COURSE_WRT_RW	COURSE WRT RW CENTER LINE	5.7, TLM		DEG
V95X0305XD	G48215	EVENT_LAMP_FIVE	NAV EVENT LAMP INDICATOR FLAG	E/L EV LT PROC, TLM	0,1	
V95L3884CA	G22804	V_RHO_EF(1)	X VELOCITY VECTOR EF(TOD)	ENT AREA NAV, GN&C/SM-PL IF		FT/SEC
V95L3885CA	G22805	V_RHO_EF(2)	Y VELOCITY VECTOR EF(TOD)	ENT AREA NAV, GN&C/SM-PL IF		FT/SEC
V95L3886CA	G22806	V_RHO_EF(3)	Z VELOCITY VECTOR EF(TOD)	ENT AREA NAV, GN&C/SM-PL IF		FT/SEC
V90U1916CC	G47429	RW_NAME	CURRENT LANDING SITE SELECTED	TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP,4.23)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95H0300CD	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	ENT AREA NAV		FT
V95L0255CD	G04212	VELOCITY_WRT_ RUNWAY(1)	DOWNRANGE VEL WRT RW	TLM		FT/SEC
V95L0256CD	G04213	VELOCITY_WRT_ RUNWAY(2)	CROSSRANGE VEL WRT RW	TLM		FT/SEC
V95U0205CC	G47151	RW_ID_UPP	INDEX OF CURRENT RW USED FOR UPP	TLM	1,3	
V93X5085XB		MID_TARGET_RECD	FLG IND AVG PRI & SEC TGT PARMS	6.21		
V95H0201CA	G81395	TAC_RNG(1)	TACAN 1 RANGE	6.21		NM
V95H0202CA	G81396	TAC_RNG(2)	TACAN 2 RANGE	6.21		NM
V95H0203CA	G81397	TAC_RNG(3)	TACAN 3 RANGE	6.21		NM
V95H0207CA	G81398	TAC_AZ(1)	TACAN 1 AZIMUTH	6.21		DEG
V95H0208CA	G81399	TAC_AZ(2)	TACAN 2 AZIMUTH	6.21		DEG
V95H0209CA	G81400	TAC_AZ(3)	TACAN 3 AZIMUTH	6.21		DEG
V95X0227XA	G81407	TAC_MODE_DISP	TACAN AES/DELTA DATA IND	6.21	0,1	
V95W3890CA	G22810	T_SEC_GMT	TIME TAG IF STATE(TOD)	GN&C/SM-PL IF		SEC
V95X0235XE	G47658	VNT_DR_SEQ_INIT	VENT DOOR SEQ INIT	MSC	0,1	
V95X0238X	G47659	LD_GR_HYDR	INIT LNDGF HYDR CONDITIONING FLAG	MSC	0,1	

OUTPUT FUNCTIONAL PARAMETERS FROM THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP,4.24)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95H0220CC	G04210	POSITION_WRT_ RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	TAEM GUID, ENT AREA NAV, 5.7, TLM		FT
V95H0221CC	G04211	POSITION_WRT_ RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	TAEM GUID, ENT AREA NAV, 5.7, TLM		FT
V95L0255CA	G04212	VELOCITY_WRT_ RUNWAY(1)	DOWNRANGE VEL WRT RW	TAEM GUID, TLM		FT/SEC
V95L0256CB	G04213	VELOCITY_WRT_ RUNWAY(2)	CROSSRANGE VEL WRT RW	TAEM GUID, TLM		FT/SEC
V95H0225CB	G04201	COURSE_WRT_RW	COURSE WRT RW CENTER LINE	TAEM GUID, 5.7, TLM, MSBLS SOP		DEG
V95L0151CD	G03902	REL_VEL_MAG	GND REL VEL MAGNITUDE IN M50 SYS	TAEM GUID, ADTA SOP, NAVDAD SOP, VENT CNTL SEQ, TLM, VERT SIT DIP	0,27K	FT/SEC
V95H0261CA	G04209	FLT_PATH_ANG	GROUND-REL FLT PATH ANGLE	TAEM GUID, TLM		DEG
V95L0265CB	G04206	H_DOT_ELLIPSOID	EST ALTITUDE RATE	TAEM GUID, VERT SIT DIP, ADTA SOP, TLM		FT/SEC
V95L0178CC	G04208	V_GROUNDSPEED	GROUNDSPEED	TAEM GUID, VERT SIT DIP, 5.7, TACAN RM, HSI PROC		FT/SEC
V95H0165CC	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	TAEM GUID, TACAN RM ENT AREA NAV, 5.7, VERT SIT DIP, E/L EV LT PROC, PRELAND NAV, TLM		FT
V95A0170CD	G04801	ACC_VERT	VERTICAL ACCEL IN TOPODETIC COORD	AVVI PROC, TLM		FT/SEC^2
V95H0175CD	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	PRELAND NAV, ENT NAV, ADTA SOP, NAVDAD SOP, TLM	-10, +10000K	FT
V95U0205CB	G47151	RW_ID_UPP	INDEX OF CURRENT RW USED FOR UPP	TAEM GUID		
V95A0160CC	G04205	ACC_DRAG	DRAG DECEL	NAVDAD SOP, ENT NAV		FT/SEC^2
V95H0185CD	G02701	R_AVGG(1)	X-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95H0186CD	G02702	R_AVGG(2)	Y-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95H0187CD	G02703	R_AVGG(3)	Z-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95L0190CD	G02704	V_AVGG(1)	X-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP,4.24)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95L0191CD	G02705	V_AVGG(2)	Y-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC
V95L0192CD	G02706	V_AVGG(3)	Z-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC
V95H0300CB	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	ENT AREA NAV		FT
V95X0305XA	G48215	EVENT_LAMP_FIVE	NAV EVENT LAMP INDICATOR FLAG	E/L EV LT PROC, TLM		
V95X0200CA	G02707	T_STATE	TIME TAG ASSOC WITH CURRENT STATE	TLM		SEC
V95L0215CC	G47784	V_RHO(1)	X-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0216CC	G47785	V_RHO(2)	Y-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0217CC	G47786	V_RHO(3)	Z-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95X0235XA	G47658	VNT_DR_SEQ_INIT	VENT DOCR SEQ INIT	MSC		
V95L3884CC	G22804	V_RHO_EF(1)	X VELOCITY VECTOR EF(TOD)	ENT AREA NAV		FT/SEC
V95L3885CC	G22805	V_RHO_EF(2)	Y VELOCITY VECTOR EF(TOD)	ENT AREA NAV		FT/SEC
V95L3886CC	G22806	V_RHO_EF(3)	Z VELOCITY VECTOR EF(TOD)	ENT AREA NAV		FT/SEC
V95H0155CC	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V95H0156CC	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V95H0157CC	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V95H0201CB	G81395	TAC_RNG(1)	TACAN 1 RANGE	6.21		NM
V95H0202CB	G81396	TAC_RNG(2)	TACAN 2 RANGE	6.21		NM
V95H0203CB	G81397	TAC_RNG(3)	TACAN 3 RANGE	6.21		NM
V95H0207CB	G81398	TAC_AZ(1)	TACAN 1 AZIMUTH	6.21		DEG
V95H0208CB	G81399	TAC_AZ(2)	TACAN 2 AZIMUTH	6.21		DEG
V95H0209CB	G81400	TAC_AZ(3)	TACAN 3 AZIMUTH	6.21		DEG

OUTPUT FUNCTIONAL PARAMETERS FROM THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP,4.24)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95X0227XB	G81407	TAC_MODE_DISP	TACAN ABS/DELTA DATA IND	6.21	0,1	
V90U1916CD	G47429	RW_NAME	CURRENT LANDING SITE SELECTED	TLM		
V90X8865XB	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	PRELAND NAV, TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP,4.25)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95L0178CD	G04208	V_GROUNDSPEED	GROUNDSPEED	A/L GUID, VERT SIT DIP, HSI PROC, TACAN RM, 5.7		FT/SEC
V95H0220CD	G04210	POSITION_WRT_RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	A/L GUID, ENT AREA NAV, 5.7, TLM		FT
V95H0221CD	G04211	POSITION_WRT_RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	A/L GUID, ENT AREA NAV, 5.7, TLM		FT
V95L0255CC	G04212	VELOCITY_WRT_RUNWAY(1)	DOWNRANGE VEL WRT RW	TLM		FT/SEC
V95L0256CA	G04213	VELOCITY_WRT_RUNWAY(2)	CROSSRANGE VEL WRT RW	A/L GUID, TLM		FT/SEC
V95L0151CB	G03902	REL_VEL_MAG	GND REL VEL MAGNITUDE IN M50 SYS	A/L GUID, ADTA SOP, NAVDAD SOP, VERT SIT DIP, TLM	0,27K	FT/SEC
V95H0261CB	G04209	FLT_PATH_ANG	GROUND-REL FLT PATH ANGLE	A/L GUID, TLM		DEG
V95H0225CC	G04201	COURSE_WRT_RW	COURSE WRT RW CENTER LINE	A/L GUID, 5.7, TLM, MSBLS SOP		DEG
V95L0265CC	G04206	H_DOT_ELLIPSOID	EST ALTITUDE RATE	A/L GUID, VERT SIT DIP, ADTA SOP, TLM		FT/SEC
V95H0165CD	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	A/L GUID, TACAN RM, ENT AREA NAV, 5.7, SF, E/L EV LT PROC, PRELAND NAV, VERT SIT DIP, TLM		FT
V95A0170CC	G04801	ACC_VERT	VERTICAL ACCEL IN TOPODETIC COORD	AVVI PROC		FT/SEC^2
V95H0185CE	G02701	R_AVGG(1)	X-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95H0186CE	G02702	R_AVGG(2)	Y-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95H0187CE	G02703	R_AVGG(3)	Z-COMP OF CURRENT SHUTTLE POS VCTR	A/E ATT PROC, TLM		FT
V95L0190CE	G02704	V_AVGG(1)	X-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC
V95L0191CE	G02705	V_AVGG(2)	Y-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC
V95L0192CE	G02706	V_AVGG(3)	Z-COMP OF CURRENT SHUTTLE VEL VCTR	A/E ATT PROC, TLM		FT/SEC
V95H0175CE	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	PRELAND NAV, NAVDAD SOP, ADTA SOP, ENT NAV, TLM	-10, +10000K	FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP,4.25)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V95H0300CC	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	ENT AREA NAV		FT
V95L0215CD	G47784	V_RHO(1)	X-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0216CD	G47785	V_RHO(2)	Y-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95L0217CD	G47786	V_RHO(3)	Z-COMP OF RELATIVE VEL IN M50	A/E ATT PROC		FT/SEC
V95A0160CD	G04205	ACC_DRAG	DRAG DECEL	ENT NAV, TLM		FT/SEC^2
V95W0200CB	G02707	T_STATE	TIME TAG ASSOC WITH CURRENT STATE	TLM		SEC
V95H0155CD	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V95H0156CD	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V95H0157CD	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	TACAN RM, ENT AREA NAV, ENT AUTO TAC SEL		FT
V90U1916CE	G47429	RW_NAME	CURRENT LANDING SITE SELECTED	TLM		
V95H0201CC	G81395	TAC_RNG(1)	TACAN 1 RANGE	6.21		NM
V95H0202CC	G81396	TAC_RNG(2)	TACAN 2 RANGE	6.21		NM
V95H0203CC	G81397	TAC_RNG(3)	TACAN 3 RANGE	6.21		NM
V95H0207CC	G81398	TAC_AZ(1)	TACAN 1 AZIMUTH	6.21		DEG
V95H0208CC	G81399	TAC_AZ(2)	TACAN 2 AZIMUTH	6.21		DEG
V95H0209CC	G81400	TAC_AZ(3)	TACAN 3 AZIMUTH	6.21		DEG
V95X0227XC	G81407	TAC_MODE_DISP	TACAN ABS/DELTA DATA IND	6.21	0,1	
V90X8865XC	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	PRELAND NAV, TLM	0,1	
V95X0305XB	G48215	EVENT_LAMP_FIVE	NAV EVENT LAMP INDICATOR FLAG	E/L EVLT PROC, TLM	0,1	

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U8500CD	G47405	DT_MAX	MAX ALLOW TIME STEP SIZE	ENT PREC PRED		SEC
V90X0535X	G46498	DEORBIT_BURN	FLAG INDICATING THRUSTING FLIGHT	ENT NAV		
V90X0539X	G46499	OPS_3_INITIALIZE _COMPLETE	FLAG TO ENABLE CYCLIC EXEC OF UPSP	MSC, D/L UPP SEQ		
V90H0587CA	G25502	R_FILT_ONE(1)	X-COMP OF FILTER CURR POS STATE 1	ENT NAV, TLM		FT
V90H0588CA	G25503	R_FILT_ONE(2)	Y-COMP OF FILTER CURR POS STATE 1	ENT NAV, TLM		FT
V90H0589CA	G25504	R_FILT_ONE(3)	Z-COMP OF FILTER CURR POS STATE 1	ENT NAV, TLM		FT
V90H0590CA	G46510	R_FILT_TWO(1)	X-COMP OF FILTER CURR POS STATE 2	ENT NAV, TLM		FT
V90H0592CA	G46511	R_FILT_TWO(2)	Y-COMP OF FILTER CURR POS STATE 2	ENT NAV, TLM		FT
V90H0592CA	G46512	R_FILT_TWO(3)	Z-COMP OF FILTER CURR POS STATE 2	ENT NAV, TLM		FT
V90H0593CA	G46519	R_FILT_THREE(1)	X-COMP OF FILTER CURR POS STATE 3	ENT NAV, TLM		FT
V90H0594CA	G46520	R_FILT_THREE(2)	Y-COMP OF FILTER CURR POS STATE 3	ENT NAV, TLM		FT
V90H0595CA	G46521	R_FILT_THREE(3)	Z-COMP OF FILTER CURR POS STATE 3	ENT NAV, TLM		FT
V90L0639CA	G25505	V_FILT_ONE(1)	X-COMP OF FILTER CURR VEL STATE 1	ENT NAV, TLM		FT/SEC
V90L0640CA	G25506	V_FILT_ONE(2)	Y-COMP OF FILTER CURR VEL STATE 1	ENT NAV, TLM		FT/SEC
V90L0641CA	G25507	V_FILT_ONE(3)	Z-COMP OF FILTER CURR VEL STATE 1	ENT NAV, TLM		FT/SEC
V90L0642CA	G46513	V_FILT_TWO(1)	X-COMP OF FILTER CURR VEL STATE 2	ENT NAV, TLM		FT/SEC
V90L0643CA	G46514	V_FILT_TWO(2)	Y-COMP OF FILTER CURR VEL STATE 2	ENT NAV, TLM		FT/SEC
V90L0644CA	G46515	V_FILT_TWO(3)	Z-COMP OF FILTER CURR VEL STATE 2	ENT NAV, TLM		FT/SEC
V90L0645CA	G46522	V_FILT_THREE(1)	X-COMP OF FILTER CURR VEL STATE 3	ENT NAV, TLM		FT/SEC
V90L0646CA	G46523	V_FILT_THREE(2)	Y-COMP OF FILTER CURR VEL STATE 3	ENT NAV, TLM		FT/SEC
V90L0647CA	G46524	V_FILT_THREE(3)	Z-COMP OF FILTER CURR VEL STATE 3	ENT NAV, TLM		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90L0630CA	G25509	V_LAST_FILT_ ONE(1)	X-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC
V90L0631CA	G25510	V_LAST_FILT_ ONE(2)	Y-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC
V90L0632CA	G25511	V_LAST_FILT_ ONE(3)	Z-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC
V90L0633CA	G46516	V_LAST_FILT_ TWO(1)	X-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0634CA	G46517	V_LAST_FILT_ TWO(2)	Y-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0635CA	G46518	V_LAST_FILT_ TWO(3)	Z-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0636CA	G46525	V_LAST_FILT_ THREE(1)	X-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90L0637CA	G46526	V_LAST_FILT_ THREE(2)	Y-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90L0638CA	G46527	V_LAST_FILT_ THREE(3)	Z-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90W0534CD	G25508	T_LAST_FILT	TIME OF FILTR STATE VECTOR	ENT NAV		SEC
V90H0581CA	G25512	R_COV_LAST(1)	X-COMP OF POS VCT W CURR MTRX	ENT NAV		FT
V90H0582CA	G25513	R_COV_LAST(2)	Y-COMP OF POS VCT W CURR MTRX	ENT NAV		FT
V90H0583CA	G25514	R_COV_LAST(3)	Z-COMP OF POS VCT W CURR MTRX	ENT NAV		FT
V90X0224XD	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT UPP		
V90A0243CD	G28207	G_RESET(1)	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TLM		FT/SEC^2
V90A0244CD	G28208	G_RESET(2)	SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TLM		FT/SEC^2
V90A0245CD	G28209	G_RESET(3)	SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TLM		FT/SEC^2
V90X0537X	G25587	NAV_THREE_STATE	THREE-STATE FLAG ON/OFF	ENT NAV, PRELAND NAV, MSC, TLM		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H0235CD	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90H0236CD	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90H0237CD	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90L0239CD	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90L0240CD	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90L0241CD	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90U8502CD	G47407	GMO_PRED	GRAVITY MODEL ORDER	ENT PREC PRED, TLM		
V90U8501CD	G47406	GMD_PRED	GRAVITY MODEL DEGREE	ENT PREC PRED, TLM		
		DRAG_CONST	DRAG ACC MODEL CONST	ENT NAV		FT^2/SLUGS
V90W0225CD	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT UPP, TLM		SEC
V90L0247CD	G28210	V_IMU_RESET(1)	SEL X-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90L0248CD	G28211	V_IMU_RESET(2)	SEL Y-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90L0249CD	G28212	V_IMU_RESET(3)	SEL Z-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90U0650CA	G25551	E(1,1)	COVARIANCE MATRIX ELEMENT 1-1	ENT NAV, TLM		
V90U0651CA	G25552	E(1,2)	COVARIANCE MATRIX ELEMENT 1-2	ENT NAV		
V90U0652CA	G25553	E(1,3)	COVARIANCE MATRIX ELEMENT 1-3	ENT NAV		
V90U0653CA	G25554	E(1,4)	COVARIANCE MATRIX ELEMENT 1-4	ENT NAV		
V90U0654CA	G25555	E(1,5)	COVARIANCE MATRIX ELEMENT 1-5	ENT NAV		
V90U0655CA	G25556	E(1,6)	COVARIANCE MATRIX ELEMENT 1-6	ENT NAV		
V90U0656CA	G25557	E(2,1)	COVARIANCE MATRIX ELEMENT 2-1	ENT NAV		
V90U0657CA	G25558	E(2,2)	COVARIANCE MATRIX ELEMENT 2-2	ENT NAV, TLM		
V90U0658CA	G25559	E(2,3)	COVARIANCE MATRIX ELEMENT 2-3	ENT NAV		
V90U0659CA	G25560	E(2,4)	COVARIANCE MATRIX ELEMENT 2-4	ENT NAV		
V90U0660CA	G25561	E(2,5)	COVARIANCE MATRIX ELEMENT 2-5	ENT NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.	Nomenclature	Destination	Range	Units
V90U0661CA	G25562 E(2,6)	COVARIANCE MATRIX ELEMENT 2-6	ENT NAV		
V90U0662CA	G25563 E(3,1)	COVARIANCE MATRIX ELEMENT 3-1	ENT NAV		
V90U0663CA	G25564 E(3,2)	COVARIANCE MATRIX ELEMENT 3-2	ENT NAV		
V90U0664CA	G25565 E(3,3)	COVARIANCE MATRIX ELEMENT 3-3	ENT NAV, TLM		
V90U0665CA	G25566 E(3,4)	COVARIANCE MATRIX ELEMENT 3-4	ENT NAV		
V90U0666CA	G25567 E(3,5)	COVARIANCE MATRIX ELEMENT 3-5	ENT NAV		
V90U0667CA	G25568 E(3,6)	COVARIANCE MATRIX ELEMENT 3-6	ENT NAV		
V90U0668CA	G25569 E(4,1)	COVARIANCE MATRIX ELEMENT 4-1	ENT NAV		
V90U0669CA	G25570 E(4,2)	COVARIANCE MATRIX ELEMENT 4-2	ENT NAV		
V90U0670CA	G25571 E(4,3)	COVARIANCE MATRIX ELEMENT 4-3	ENT NAV		
V90U0671CA	G25572 E(4,4)	COVARIANCE MATRIX ELEMENT 4-4	ENT NAV, TLM		
V90U0672CA	G25573 E(4,5)	COVARIANCE MATRIX ELEMENT 4-5	ENT NAV		
V90U0673CA	G25574 E(4,6)	COVARIANCE MATRIX ELEMENT 4-6	ENT NAV		
V90U0674CA	G25575 E(5,1)	COVARIANCE MATRIX ELEMENT 5-1	ENT NAV		
V90U0675CA	G25576 E(5,2)	COVARIANCE MATRIX ELEMENT 5-2	ENT NAV		
V90U0676CA	G25577 E(5,3)	COVARIANCE MATRIX ELEMENT 5-3	ENT NAV		
V90U0677CA	G25578 E(5,4)	COVARIANCE MATRIX ELEMENT 5-4	ENT NAV		
V90U0678CA	G25579 E(5,5)	COVARIANCE MATRIX ELEMENT 5-5	ENT NAV, TLM		
V90U0679CA	G25580 E(5,6)	COVARIANCE MATRIX ELEMENT 5-6	ENT NAV		
V90U0680CA	G25581 E(6,1)	COVARIANCE MATRIX ELEMENT 6-1	ENT NAV		
V90U0681CA	G25582 E(6,2)	COVARIANCE MATRIX ELEMENT 6-2	ENT NAV		
V90U0682CA	G25583 E(6,3)	COVARIANCE MATRIX ELEMENT 6-3	ENT NAV		
V90U0683CA	G25584 E(6,4)	COVARIANCE MATRIX ELEMENT 6-4	ENT NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U0684CA	G25585	E(6,5)	COVARIANCE MATRIX ELEMENT 6-5	ENT NAV		
V90U0685CA	G25586	E(6,6)	COVARIANCE MATRIX ELEMENT 6-6	ENT NAV, TLM		
V90L0621CC	G27908	V_LAST_FILT(1)	X-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90L0622CC	G27909	V_LAST_FILT(2)	Y-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90L0623CC	G27910	V_LAST_FILT(3)	Z-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90W1287CA	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ORB UPP SEQ		SEC
V90H1276CA	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1277CA	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1278CA	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90L1279CA	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1280CA	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1281CA	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90Q0555CA		MM_CODE	SNAP-MAJOR MODE CODE	TLM		
V97U5512CB	G50269	SIG_DIAG_UVW_INIT(1)	SQRT COV MTRX DIAG ELE 1 NEXT OPS	ORB UPP SEQ		FT
V97U5513CB	G50270	SIG_DIAG_UVW_INIT(2)	SQRT COV MTRX DIAG ELE 2 NEXT OPS	ORB UPP SEQ		FT
V97U5514CB	G50271	SIG_DIAG_UVW_INIT(3)	SQRT COV MTRX DIAG ELE 3 NEXT OPS	ORB UPP SEQ		FT
V97U5515CB	G50272	SIG_DIAG_UVW_INIT(4)	SQRT COV MTRX DIAG ELE 4 NEXT OPS	ORB UPP SEQ		FT/SEC
V97U5516CB	G50273	SIG_DIAG_UVW_INIT(5)	SQRT COV MTRX DIAG ELE 5 NEXT OPS	ORB UPP SEQ		FT/SEC
V97U5517CB	G50274	SIG_DIAG_UVW_INIT(6)	SQRT COV MTRX DIAG ELE 6 NEXT OPS	ORB UPP SEQ		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V97U5285CB	G50275	CORR_COEFF_INIT(1)	CORR COEFF FOR NEXT OPS ELE 1	ORB UPP SEQ		
V97U5286CB	G50276	CORR_COEFF_INIT(2)	CORR COEFF FOR NEXT OPS ELE 2	ORB UPP SEQ		
V97U5287CB	G50277	CORR_COEFF_INIT(3)	CORR COEFF FOR NEXT OPS ELE 3	ORB UPP SEQ		
V97U5288CB	G50278	CORR_COEFF_INIT(4)	CORR COEFF FOR NEXT OPS ELE 4	ORB UPP SEQ		
V97U5289CB	G50279	CORR_COEFF_INIT(5)	CORR COEFF FOR NEXT OPS ELE 5	ORB UPP SEQ		
V97U5290CB	G50280	CORR_COEFF_INIT(6)	CORR COEFF FOR NEXT OPS ELE 6	ORB UPP SEQ		
V97U5291CB	G50281	CORR_COEFF_INIT(7)	CORR COEFF FOR NEXT OPS ELE 7	ORB UPP SEQ		
V90H8508CD	G47408	R_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ENT PREC PRED		FT
V90H8509CD	G47409	R_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ENT PREC PRED		FT
V90H8510CD	G47410	R_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ENT PREC PRED		FT
V90L8513CD	G47411	V_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ENT PREC PRED		FT/SEC
V90L8514CD	G47412	V_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ENT PREC PRED		FT/SEC
V90L8515CD	G47413	V_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ENT PREC PRED		FT/SEC
V90W8512CD	G47414	T_INIT	TIME OF INIT VECTOR	ENT PREC PRED		SEC
V90W8506CD	G47415	T_FINAL	TIME OF FINAL VECTOR	ENT PREC PRED		SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H1815CA	G25801	X_DMEAZ_RW	X-COMP RNG/AZ ANTENNA IN RW COORD	ENT AREA NAV		FT
V90H1816CA	G25802	Y_DMEAZ_RW	Y-COMP RNG/AZ ANTENNA IN RW COORD	ENT AREA NAV		FT
V90H1817CA	G25847	AZIMUTH_RW	AZIMUTH OF RW FROM TRUE NORTH	ENT AREA NAV, ENT UPP, HSI PROC		RAD
V90H1818CA	G25846	ALT_RW	ALTITUDE OF RW WRT REF ELLIPSOID	ENT UPP, TAEM UPP, ENT AREA NAV A/L UPP, AVVI PROC		FT
V90H1819CA	G25848	DELH_MSL_ ELLIPSOID_RW	ALT OF MSL ABOVE REF ELLIP AT RW	ENT AREA NAV, PRELAND NAV AVVI PROC		FT
V90H1820CA	G25849	ANGLE_CORR_ TNTOMAG_RW	MAGNETIC VARIATION OF RW	A/E ATT PROC, ENT AREA NAV, HSI PROC, TLM	0,6.28	RAD
V90H1825CA	G25804	R_ELMLS_EF	X COMP EF POS VCT MLS ELEV ANT	PRELAND NAV		FT
V90H1826CA	G25805		Y-COMP EF POS VCT MLS ELEV ANT	PRELAND NAV		FT
V90H1827CA	G25806		Z-COMP EF POS VCT MLS ELEV ANT	PRELAND NAV		FT
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV, ENT UPP		
V90H1828CA	G25931	R_AZMLS_EF	X-COMP EF POS VCT OF MLS AZ ANT	PRELAND NAV		FT
V90H1829CA	G25932		Y-COMP EF POS VCT OF MLS AZ ANT	PRELAND NAV		FT
V90H1830CA	G25933		Z-COMP EF POS VCT OF MLS AZ ANT	PRELAND NAV		FT
V90H1831CA	G25934	R_RMLS_EF	X-COMP EF POS VCT OF MLS RNG ANT	PRELAND NAV		FT
V90H1832CA	G25935		Y-COMP EF POS VCT OF MLS RNG ANT	PRELAND NAV		FT
V90H1833CA	G25936		Z-COMP EF POS VCT OF MLS RNG ANT	PRELAND NAV		FT
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, TACAN RM, ENT NAV, PRELAND NAV		FT
V90H1843CA	G25916	ANGLE_CORR_ TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		RAD
V90H1844CA	G25922	ANGLE_CORR_ TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		RAD
V90H1845CA	G25927	ANGLE_CORR_ TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		RAD
V90H1846CA	G25917	ALT_TACAN_SL(1)	ALTITUDE OF TACAN 1 STATION	ENT AREA NAV		FT
V90H1847CA	G25923	ALT_TACAN_SL(2)	ALTITUDE OF TACAN 2 STATION	ENT AREA NAV		FT
V90H1848CA	G25928	ALT_TACAN_SL(3)	ALTITUDE OF TACAN 3 STATION	ENT AREA NAV		FT
V90H1849CA	G25919	DH_TACAN_SL(1)	ALT OF MSL ABV RLF ELLIP AT TAC 1	ENT AREA NAV		FT
V90H1850CA	G25924	DH_TACAN_SL(2)	ALT OF MSL ABV RLF ELLIP AT TAC 2	ENT AREA NAV		FT
V90H1851CA	G25930	DH_TACAN_SL(3)	ALT OF MSL ABV RLF ELLIP AT TAC 3	ENT AREA NAV		FT
V90U1865CA	G25807	M_EFTORAD_R_AZ	EF TO RNG/AZ MSBLS RDR COORD/1-1	PRELAND NAV		
V90U1866CA	G25808		EF TO RNG/AZ MSBLS RDR COORD/1-2	PRELAND NAV		
V90U1867CA	G25809		EF TO RNG/AZ MSBLS RDR COORD/1-3	PRELAND NAV		
V90U1868CA	G25810		EF TO RNG/AZ MSBLS RDR COORD/2-1	PRELAND NAV		
V90U1869CA	G25811		EF TO RNG/AZ MSBLS RDR COORD/2-2	PRELAND NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U1870CA	G25812		EF TO RNG/AZ MSBLS RDR COORD/2-3	PRELAND NAV		
V90U1871CA	G25813		EF TO RNG/AZ MSBLS RDR COORD/3-1	PRELAND NAV		
V90U1872CA	G25814		EF TO RNG/AZ MSBLS RDR COORD/3-2	PRELAND NAV		
V90U1873CA	G25815		EF TO RNG/AZ MSBLS RDR COORD/3-3	PRELAND NAV		
V90U1875CA	G25816	M_EFTORAD_EL	EF TO MSBLS EL COORD ELE 1-1	PRELAND NAV		
V90U1876CA	G25817		EF TO MSBLS EL COORD ELE 1-2	PRELAND NAV		
V90U1877CA	G25818		EF TO MSBLS EL COORD ELE 1-3	PRELAND NAV		
V90U1878CA	G25819		EF TO MSBLS EL COORD ELE 2-1	PRELAND NAV		
V90U1879CA	G25820		EF TO MSBLS EL COORD ELE 2-2	PRELAND NAV		
V90U1880CA	G25821		EF TO MSBLS EL COORD ELE 2-3	PRELAND NAV		
V90U1881CA	G25822		EF TO MSBLS EL COORD ELE 3-1	PRELAND NAV		
V90U1882CA	G25823		EF TO MSBLS EL COORD ELE 3-2	PRELAND NAV		
V90U1883CA	G25824		EF TO MSBLS EL COORD ELE 3-3	PRELAND NAV		
V90U1890CA	G25852	M_EFTORW_SEC	EARTH FIXED TO SEC RUNWAY ELE 1-1	ENT UPP, ENT AREA NAV		
V90U1891CA	G25853		EARTH FIXED TO SEC RUNWAY ELE 1-2	ENT UPP, ENT AREA NAV		
V90U1892CA	G25854		EARTH FIXED TO SEC RUNWAY ELE 1-3	ENT UPP, ENT AREA NAV		
V90U1893CA	G25855		EARTH FIXED TO SEC RUNWAY ELE 2-1	ENT UPP, ENT AREA NAV		
V90U1894CA	G25856		EARTH FIXED TO SEC RUNWAY ELE 2-2	ENT UPP, ENT AREA NAV		
V90U1895CA	G25857		EARTH FIXED TO SEC RUNWAY ELE 2-3	ENT UPP, ENT AREA NAV		
V90U1896CA	G25858		EARTH FIXED TO SEC RUNWAY ELE 3-1	ENT UPP, ENT AREA NAV		
V90U1897CA	G25859		EARTH FIXED TO SEC RUNWAY ELE 3-2	ENT UPP, ENT AREA NAV		
V90U1898CA	G25860		EARTH FIXED TO SEC RUNWAY ELE 3-3	ENT UPP, ENT AREA NAV		
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, DEORB MNVR DIP, ENT AUTO TAC SEL		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, DEORB MNVR DIP, ENT AUTO TAC SEL		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, DEORB MNVR DIP, ENT AUTO TAC SEL		FT
V90H1885CA	G25825	BIAS_RMLS	MSBLS RANGE MEASUREMENT BIAS	PRELAND NAV		FT
V90H1886CA	G25826	BIAS_AZMLS	MSBLS AZIMUTH MEASUREMENT BIAS	PRELAND NAV		RAD
V90H1887CA	G25827	BIAS_ELMLS	MSBLS ELEVATION MEASUREMENT BIAS	PRELAND NAV		RAD
V90H1910CA	G46535	X_EL_RW	X-COMP CF ELEV ANTENNA IN RW COORD	ENT AREA NAV		FT
V90H1911CA	G25869	AZIMUTH_RW_SEC	AZ OF SEC RW FROM TRUE NORTH	ENT UPP, ENT AREA NAV		RAD
V90H1913CA	G25868	ANGLE_CORR_ TNTOMAG_RW_SEC	MAGNETIC VARIATION OF SEC RW	ENT AREA NAV		RAD
V90H1852CA	G25870	BIAS_TAC_R_SL(1)	TACAN RANGE STATION BIAS (TAC 1)	ENT NAV, PRELAND NAV		FT
V90H1853CA	G47929	BIAS_TAC_R_SL(2)	TACAN RANGE STATION BIAS (TAC 2)	ENT NAV, PRELAND NAV		FT
V90H1854CA	G47930	BIAS_TAC_R_SL(3)	TACAN RANGE STATION BIAS (TAC 3)	ENT NAV, PRELAND NAV		FT
V90H1855CA	G25871	BIAS_TAC_BRG_ SL(1)	TACAN BEARING STATION BIAS (TAC 1)	PRELAND NAV, ENT NAV		RAD
V90H1856CA	G47931	BIAS_TAC_BRG_ SL(2)	TACAN BEARING STATION BIAS (TAC 2)	PRELAND NAV, ENT NAV		RAD
V90H1857CA	G47932	BIAS_TAC_BRG_ SL(3)	TACAN BEARING STATION BIAS (TAC 3)	PRELAND NAV, ENT NAV		RAD
V90H1903CA	G25861	R_LS_EF_SEC	X-COMP SEC LDG SITE POS VCT IN EF	ENT UPP, ENT AREA NAV		FT
V90H1904CA	G25862		Y-COMP SEC LDG SITE POS VCT IN EF	ENT UPP, ENT AREA NAV		FT
V90H1905CA	G25863		Z-COMP SEC LDG SITE POS VCT IN EF	ENT UPP, ENT AREA NAV		FT
V90X1858XA	G25872	TACAN_CHAN_ VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG (TAC 1)	ENT UPP, TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV	0,1	

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90X1859XA	G47933	TACAN_CHAN_ VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG (TAC 2)	ENT UPP, TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV	0,1	
V90X1860XA	G47934	TACAN_CHAN_ VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG (TAC 3)	ENT UPP, TAEM UPP, A/L UPP, ENT NAV, PRELAND NAV, ENT AREA NAV	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_ SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U1784CA	G46537	M_EFTOTD_TACAN_SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1793CA	G46546	M_EFTOTD_TACAN_SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT UPP, TAEM UPP, A/L UPP, ENT AREA NAV, ENT NAV, PRELAND NAV		
V90H1861CA	G46532	RD_TAC_SL(1)	GEODETIC RADIUS AT TACAN SITE 1	ENT AREA NAV		FT
V90H1862CA	G46533	RD_TAC_SL(2)	GEODETIC RADIUS AT TACAN SITE 2	ENT AREA NAV		FT
V90H1863CA	G46534	RD_TAC_SL(3)	GEODETIC RADIUS AT TACAN SITE 3	ENT AREA NAV		FT
V90U1914CA	G47820	RUNWAY_NAME_PSL	NAME OF PRIME RW FOR DISPLAY	6.21		
V90U1915CA	G47862	RUNWAY_NAME_ASL	NAME OF ALTERNATE RW FOR DISPLAY	6.21		
V90H1917CA	G47842	RUNWAY_AZIMUTH_PSL	AZIMUTH OF PRIME RW FOR DISPLAY	6.21		
V90H1918CA	G47843	RUNWAY_AZIMUTH_SSL	AZIMUTH OF SECONDARY RW FOR DISPLAY	6.21		
V90H1919CA	G47864	RUNWAY_AZIMUTH_ASL	AZIMUTH OF ALTERNATE RW FOR DISPLAY	6.21		
V90U1916CA	G47429	RW_NAME	CURRNT LANDING SITE SELECTED	6.21, ENT UPP, TAEM UPP		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H1925CA		R_CC_L_PRI	X-COMP POS VCT HAC LFT SIDE RW	ENT AREA NAV		FT
V90H1926CA			Y-COMP POS VCT HAC LFT SIDE RW	ENT AREA NAV		FT
V90H1927CA			Z-COMP POS VCT HAC LFT SIDE RW	ENT AREA NAV		FT
V90H1928CA		R_CC_R_PRI	X-COMP POS VCT HAC RHT SIDE RW	ENT AREA NAV		FT
V90H1929CA			Y-COMP POS VCT HAC RHT SIDE RW	ENT AREA NAV		FT
V90H1930CA			Z-COMP POS VCT HAC RHT SIDE RW	ENT AREA NAV		FT
V90H1931CA		R_CC_LMAG_PRI	MAG OF POS VCT HAC LFT SIDE RW	ENT AREA NAV		FT
V90H1932CA		R_CC_RMAG_PRI	MAG OF POS VCT HAC RHT SIDE RW	ENT AREA NAV		FT
V90H1933CA		R_CC_L_SEC	X-COMP POS VCT HAC LS SEC RW	ENT AREA NAV		FT
V90H1934CA			Y-COMP POS VCT HAC LS SEC RW	ENT AREA NAV		FT
V90H1935CA			Z-COMP POS VCT HAC LS SEC RW	ENT AREA NAV		FT
V90H1936CA		R_CC_R_SEC	X-COMP POS VCT HAC RS SEC RW	ENT AREA NAV		FT
V90H1937CA			Y-COMP POS VCT HAC RS SEC RW	ENT AREA NAV		FT
V90H1938CA			Z-COMP POS VCT HAC RS SEC RW	ENT AREA NAV		FT
V90H1939CA		R_CC_LMAG_SEC	MAG OF POS VCT HAC LS SEC RW	ENT AREA NAV		FT
V90H1940CA		R_CC_RMAG_SEC	MAG OF POS VCT HAC RS SEC RW	ENT AREA NAV		FT
V90U1822CA	G47841	RUNWAY_NAME_SSL	NAME OF SEC RW FOR DISPLAY	6.21		
V90U1802CA	G46528	TACAN_ID(1)	TACAN 1 GND STA CHAN	ENT NAV, PRELAND NAV, 6.21, TLM		
V90U1803CA	G46529	TACAN_ID(2)	TACAN 2 GND STA CHAN	ENT NAV, PRELAND NAV, 6.21, TLM		
V90U1804CA	G46530	TACAN_ID(3)	TACAN 3 GND STA CHAN	ENT NAV, PRELAND NAV, 6.21, TLM		
V90X3720XA	G50308	MLS_AVAIL	MSBLS AVAILABILITY FLAG	PRELAND NAV, D/L NAV SEQ		
V90H3721CA	G50325	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE1	ENT AUTO TAC SEL		FT
V90H3722CA	G50326	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE1	ENT AUTO TAC SEL		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H3723CA	G50327	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE1	ENT AUTO TAC SEL		FT
V90H3724CA	G50328	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE2	ENT AUTO TAC SEL		FT
V90H3725CA	G50329	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE2	ENT AUTO TAC SEL		FT
V90H3726CA	G50330	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE2	ENT AUTO TAC SEL		FT
V90H3727CA	G50331	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE3	ENT AUTO TAC SEL		FT
V90H3728CA	G50332	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE3	ENT AUTO TAC SEL		FT
V90H3729CA	G50333	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE3	ENT AUTO TAC SEL		FT
V90H3730CA	G50334	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE4	ENT AUTO TAC SEL		FT
V90H3731CA	G50335	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE4	ENT AUTO TAC SEL		FT
V90H3732CA	G50336	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE4	ENT AUTO TAC SEL		FT
V90H3733CA	G50337	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE5	ENT AUTO TAC SEL		FT
V90H3734CA	G50338	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE5	ENT AUTO TAC SEL		FT
V90H3735CA	G50339	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE5	ENT AUTO TAC SEL		FT
V90H3736CA	G50340	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE6	ENT AUTO TAC SEL		FT
V90H3737CA	G50341	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE6	ENT AUTO TAC SEL		FT
V90H3738CA	G50342	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE6	ENT AUTO TAC SEL		FT
V90H3739CA	G50343	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE7	ENT AUTO TAC SEL		FT
V90H3740CA	G50344	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE7	ENT AUTO TAC SEL		FT
V90H3741CA	G50345	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE7	ENT AUTO TAC SEL		FT
V90H3742CA	G50346	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE8	ENT AUTO TAC SEL		FT
V90H3743CA	G50347	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE8	ENT AUTO TAC SEL		FT
V90H3744CA	G50348	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE8	ENT AUTO TAC SEL		FT
V90H3745CA	G50349	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE9	ENT AUTO TAC SEL		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H3746CA	G50350	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE9	ENT AUTO TAC SEL		FT
V90H3747CA	G50351	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE9	ENT AUTO TAC SEL		FT
V90H3748CA	G50352	R_TAC_EF(1)	X-COMP EF POS VECTOR OF TAC SITE10	ENT AUTO TAC SEL		FT
V90H3749CA	G50353	R_TAC_EF(2)	Y-COMP EF POS VECTOR OF TAC SITE10	ENT AUTO TAC SEL		FT
V90H3750CA	G50354	R_TAC_EF(3)	Z-COMP EF POS VECTOR OF TAC SITE10	ENT AUTO TAC SEL		FT
TBD		RV_MAX	MAXIMUM RELATIVE VELOCITY MAGNITUDE FOR AUTO SELECTION OF BARO DATA	ENTRY NAV		FT/SEC
TBD		VAR_H1	ADDITIVE BARO VARIANCE TERM	ENTRY NAV, PRELAND NAV		FT^2
TBD		VAR_H2	MULTIPLICATIVE BARO VARIANCE TERM	ENTRY NAV, PRELAND NAV		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90U0216CC	G28224	DISP_SIG(1)	TAC AZ RESID RATIO	6.21, TLM		
V90U0217CC	G28225	DISP_SIG(2)	TAC AZ RESID RATIO	6.21, TLM		
V90X0224XE	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT UPP, TAEM UPP, A/L UPP		
V90H0212CC	G28220	DISP_DELQ(1)	TAC AZ MEAS-RESIDUAL	6.21, TLM		RAD
V90H0214CC	G28221	DISP_DELQ(2)	TAC R MEAS RESIDUAL	6.21, TLM		NM
V90H6587CB	G25502	R_FILT_ONE	X-COMP OF FILTER CURR POS STATE 1	TLM		FT
V90H6588CB	G25503		Y-COMP OF FILTER CURR POS STATE 1	TLM		FT
V90H6589CB	G25504		Z-COMP OF FILTER CURR POS STATE 1	TLM		FT
V90H6590CB	G46510	R_FILT_TWO	X-COMP OF FILTER CURR POS STATE 2	TLM		FT
V90H6591CB	G46511		Y-COMP OF FILTER CURR POS STATE 2	TLM		FT
V90H6592CB	G46512		Z-COMP OF FILTER CURR POS STATE 2	TLM		FT
V90H6593CB	G46519	R_FILT_THREE	X-COMP OF FILTER CURR POS STATE 3	TLM		FT
V90H6594CB	G46520		Y-COMP OF FILTER CURR POS STATE 3	TLM		FT
V90H6595CB	G46521		Z-COMP OF FILTER CURR POS STATE 3	TLM		FT
V90L0639CB	G25505	V_FILT_ONE	X-COMP OF FILTER CURR POS STATE 1	TLM		FT/SEC
V90L0640CB	G25506		Y-COMP OF FILTER CURR POS STATE 1	TLM		FT/SEC
V90L0641CB	G25507		Z-COMP OF FILTER CURR POS STATE 1	TLM		FT/SEC
V90L0642CB	G46513	V_FILT_TWO	X-COMP OF FILTER CURR POS STATE 2	TLM		FT/SEC
V90L0643CB	G46514		Y-COMP OF FILTER CURR POS STATE 2	TLM		FT/SEC
V90L0644CB	G46515		Z-COMP OF FILTER CURR POS STATE 2	TLM		FT/SEC
V90L0645CB	G46522	V_FILT_THREE	X-COMP OF FILTER CURR POS STATE 3	TLM		FT/SEC
V90L0646CB	G46523		Y-COMP OF FILTER CURR POS STATE 3	TLM		FT/SEC
V90L0647CB	G46524		Z-COMP OF FILTER CURR POS STATE 3	TLM		FT/SEC
V90L0630CB	G25509	V_LAST_FILT_ONE	X-COMP OF ACCUM SENSED VEL STATE 1	TLM		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90L0631CB	G25510		Y-COMP OF ACCUM SENSED VEL STATE 1	TLM		FT/SEC
V90L0632CB	G25511		Z-COMP OF ACCUM SENSED VEL STATE 1	TLM		FT/SEC
V90L0633CB	G46516	V_LAST_FILT_TWO	X-COMP OF ACCUM SENSED VEL STATE 2	TLM		FT/SEC
V90L0634CB	G46517		Y-COMP OF ACCUM SENSED VEL STATE 2	TLM		FT/SEC
V90L0635CB	G46518		Z-COMP OF ACCUM SENSED VEL STATE 2	TLM		FT/SEC
V90L0636CB	G46525	V_LAST_FILT_ THREE	X-COMP OF ACCUM SENSED VEL STATE 3	TLM		FT/SEC
V90L0637CB	G46526		Y-COMP OF ACCUM SENSED VEL STATE 3	TLM		FT/SEC
V90L0638CB	G46527		Z-COMP OF ACCUM SENSED VEL STATE 3	TLM		FT/SEC
V90A0781C	G26705	G_ONE_OLD	X-COMP GRAV ACCEL VECTOR STATE 1	TLM		FT/SEC^2
V90A0782C	G26706		Y-COMP GRAV ACCEL VECTOR STATE 1	TLM		FT/SEC^2
V90A0783C	G26707		Z-COMP GRAV ACCEL VECTOR STATE 1	TLM		FT/SEC^2
V90A0784C	G46483	G_TWO_OLD	X-COMP GRAV ACCEL VECTOR STATE 2	TLM		FT/SEC^2
V90A0785C	G46484		Y-COMP GRAV ACCEL VECTOR STATE 2	TLM		FT/SEC^2
V90A0786C	G46485		Z-COMP GRAV ACCEL VECTOR STATE 2	TLM		FT/SEC^2
V90A0787C	G46495	G_THREE_OLD	X-COMP GRAV ACCEL VECTOR STATE 3	TLM		FT/SEC^2
V90A0788C	G46496		Y-COMP GRAV ACCEL VECTOR STATE 3	TLM		FT/SEC^2
V90A0789C	G46497		Z-COMP GRAV ACCEL VECTOR STATE 3	TLM		FT/SEC^2
V90A0243CE	G28207	G_RESET	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC^2
V90A0244CE	G28208		SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC^2
V90A0245CE	G28209		SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC^2
V90X0213XC	G28223	DISP_EDIT(1)	TAC AZ EDIT HIST IND	GAX, 6.21, TLM		
V90X0215XC	G28222	DISP_EDIT(2)	TAC R EDIT HIST IND	GAX, 6.21, TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H0235CE	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT
V90H0236CE	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT
V90H0237CE	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT
V90L0239CE	G28204	V_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC
V90L0240CE	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC
V90L0241CE	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		FT/SEC
V90W0225CE	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT UPP, TAEM UPP, A/L UPP, TLM		SEC
V90L0247CE	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	ENT UPP, TAEM UPP, A/L UPP		FT/SEC
V90L0248CE	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	ENT UPP, TAEM UPP, A/L UPP		FT/SEC
V90L0249CE	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	ENT UPP, TAEM UPP, A/L UPP		FT/SEC
V90J0226CB	G28226	TAC_AIF_RECD	TACAN AUT/INH/FOR FLAG FDBK	6.21		
V90H0584CE	G27911	R_FILT(1)	X-COMP OF FLTR'S CURR POS VECTOR	D/L NAV SEQ, PRELAND NAV		FT
V90H0585CE	G27912	R_FILT(2)	Y-COMP OF FLTR'S CURR POS VECTOR	D/L NAV SEQ, PRELAND NAV		FT
V90H0586CE	G27913	R_FILT(3)	Z-COMP OF FLTR'S CURR POS VECTOR	D/L NAV SEQ, PRELAND NAV		FT
V90L0624CE	G27904	V_FILT(1)	X-COMP OF FLTR'S CURR VEL VECTOR	D/L NAV SEQ, PRELAND NAV		FT/SEC
V90L0625CE	G27905	V_FILT(2)	Y-COMP OF FLTR'S CURR VEL VECTOR	D/L NAV SEQ, PRELAND NAV		FT/SEC
V90L0626CE	G27906	V_FILT(3)	Z-COMP OF FLTR'S CURR VEL VECTOR	D/L NAV SEQ, PRELAND NAV		FT/SEC
V90W0534CE	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	D/L NAV SEQ, PRELAND NAV		SEC
V90A0711CA	G50732	DISP_DELQ(4)	DRAG ALT MEAS RESIDUAL	6.21 TLM		
V90X0712XA	G50734	DISP_EDIT(4)	DRAG ALT EDIT HIST IND	GAX, 6.21, TLM		
V90U0713CA	G50733	DISP_SIG(4)	DRAG ALT RESID RATIO	6.21, TLM		
V90J0714CA	G50317	DRAG_AIF_RECD	DRAG H A/I/F EDIT IND	6.21, TLM	0,2	
V90X0538XD	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	ENT UPP, TAEM UPP, A/L UPP, TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90X715XA	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	ENT UPP, TAEM UPP, A/L UPP		
V90W0716CA		T_TACAN	TIME OF TACAN READ	TLM		
V90N8867CB		Q_TAC_R	DATA SNAP-SELECTED TACAN RANGE	TLM		FT
V90N8868CB	G07814	Q_TAC_BRG	DATA SNAP-SELECTED TACAN BEARING	TLM		RAD
V90X0717XA		TAC_RNG_DATA_GOOD	DATA GOOD FLAG-TACAN RANGE	TLM		
V90X0718XA		TAC_BRG_DATA_GOOD	DATA GOOD FLAG-TACAN BEARING	TLM		
TBD		DELTA_T	TIME INCREMENT TO ADD TO STATE VECTOR TIME-TAG	6.21		SEC
V90U8864CB		SEL_LRU_ID	DATA SNAP-TACAN LRU NUMBER	TLM		
V90U8847CB	G48528	DO_DRAG_NAV	FLAG IND DRAG ACT BEING PROCESSED	TLM		
V90U8846CB	G48529	DO_TACAN_NAV	FLG IND TACAN DATA BEING PRODESSED	TLM		
V90U8848CB	G48527	Q_DRAG	DRAG MEASUREMENT	TLM		FT
V90J8842CB	G48531	TACAN_MARK_NUM	COUNTER-TACAN MEAS BEING PROCESSED	TLM		
V90J8844CB	G48533	DRAG_MARK_NUM	COUNTER-DRAG MEAS BEING PROCESSED	TLM		
V90X0768XA		ONE_RANGE_LOCK	TACAN RM 1 LRU RNG LOCKON RQMT FLG	TACAN RM	0,1	
V90X0769XA		ONE_BRG_LOCK	TACAN RM 1 LRU BRG LOCKON RQMT FLG	TACAN RM	0,1	
V93X5030X	G46572	DO_DELTA_UPDATE	FLG INDICATING IF UPD IS TO BE PERF	6.21		
V93H5010CB	G71815	DR_RW	NAV UPDATE DELTA X POSIT	6.21		FT
V93H5011CB	G71816		NAV UPDATE DELTA Y POSIT	6.21		FT
V93H5012CB	G71817		NAV UPDATE DELTA Z POSIT	6.21		FT
V93L5020CB	G71818	DV_RW	NAV UPDATE DELTA X VEL	6.21		FT/SEC
V93L5021CB	G71819		NAV UPDATE DELTA Y VEL	6.21		FT/SEC
V93L5022CB	G71820		NAV UPDATE DELTA Z VEL	6.21		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90X0276XA		NAV_THREE_STATE	SNAPPED THREE-STATE FLAG ON/OFF	TLM		
TBD		DO_DELTA_T_ UPDATE	FLAG TO PERFORM DELTA_T UPDATE	6.21	ON/OFF	
V90X8861XB		BARO_DATA_GOOD	DATA SNAP-ADTA DATA GOOD FLAG	TLM		
V90X0259XC	G50933	DO_BARO_NAV	FLAG IND BARO ALT BEING PROCESSED	TLM		
V90J8343CC	G48532	BARO_MARK_NUM	COUNTER-BARO MEAS BEING PROCESSED	TLM		
V90P8871CB		Q_BARO	DATA SNAP-ADS CORR PRESSURE ALT	TLM		FT
V95W3400C	G47948	T_BARO	TIME OF BARO READ	TLM		SEC
V90J0227CC	G50315	BARO_AIF_RECD	BARO AUT/INH/FOR FLAG FDBK	TLM		
V90X0277XA		IMU_STATUS	SNAP-IMU SELECT FILTER CMD IMU 1	TLM		
V90X0278XA		IMU_STATUS	SNAP-IMU SELECT FILTER CMD IMU 2	TLM		
V90X0279XA		IMU_STATUS	SNAP-IMU SELECT FILTER CMD IMU 3	TLM		
V90U8841CA	G50735	SENSOR_EDIT(1)	TAC AZ FILTER FLAG	TLM		
V90U8880CA	G50736	SENSOR_EDIT(2)	TAC R FILTER FLAG	TLM		
V90U8881CA	G50737	SENSOR_EDIT(3)	BARO ALT FILTER FLAG	TLM		
V90U8882CA	G50738	SENSOR_EDIT(4)	DRAG ALT FILTER FLAG	TLM		
V90U0222CC	G28217	DISP_SIG(3)	BARO ALT RESID RATIO	TLM, 6.21		
V90H0221CC	G28216	DISP_DELQ(3)	BARO ALT MEAS RESIDUAL	TLM, 6.21		FT
V90X0223XC	G28219	DISP_EDIT(3)	BARO ALT EDIT HIST IND	TLM, 6.21, GAX		
V90W8512CD	G47414	T_INIT	TIME AT BEGINNING OF PRED	ENT PREC PRED		SEC
V90U8500CC		DT_MAX	MAX ALLOWABLE STEP SIZE	ENT PREC PRED		SEC
V90U8502CC		GMO_PRED	GRAVITY MODEL ORDER	ENT PREC PRED		
V90U8501CC		GMD_PRED	GRAVITY MODEL DEGREE	ENT PREC PRED		
V90H8508CD		R_INIT	X-COMP SHUTTLE POS VECTOR AT T_INIT	ENT PREC PRED		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.	Nomenclature	Destination	Range	Units
V90H8509CD		Y-COMP SHUTTLE POS VECTOR AT T_INIT	ENT PREC PRED		FT
V90H9510CD		Z-COMP SHUTTLE POS VECTOR AT T_INIT	ENT PREC PRED		FT
V90L8513CD	V_INIT	X-COMP SHUTTLE VEL VECTOR AT T_INIT	ENT PREC PRED		FT/SEC
V90L8514CD	V_INIT	Y-COMP SHUTTLE VEL VECTOR AT T_INIT	ENT PREC PRED		FT/SEC
V90L8515CD	V_INIT	Z-COMP SHUTTLE VEL VECTOR AT T_INIT	ENT PREC PRED		FT/SEC
V90W8506CD	T_FINAL	TIME AT WHICH STATE IS DESIRED	ENT PREC PRED		SEC
V90L0621CC	V_LAST_FILT(1)	X-COMP VEL W COV MTRX & FLTR UPDATE	PRELAND NAV		FT/SEC
V90L0622CC	V_LAST_FILT(2)	Y-COMP VEL W COV MTRX & FLTR UPDATE	PRELAND NAV		FT/SEC
V90L0623CC	V_LAST_FILT(3)	Z-COMP VEL W COV MTRX & FLTR UPDATE	PRELAND NAV		FT/SEC
V90H0581CA	R_COV_LAST(1)	X-COMP POS VCT W CURR COV MTRX	PRELAND NAV		FT
V90H0582CA	R_COV_LAST(2)	Y-COMP POS VCT W CURR COV MTRX	PRELAND NAV		FT
V90H0583CA	R_COV_LAST(3)	Z-COMP POS VCT W CURR COV MTRX	PRELAND NAV		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H0212CB	G28220	DISP_DELQ(1)	TAC AZ MEAS RESIDUAL	6.21, TLM		RAD
V90X0213XB	G28223	DISP_EDIT(1)	TAC AZ EDIT HIST IND	6.21, GAX, TLM		
V90H0214CB	G28221	DISP_DELQ(2)	TAC R MEAS RESIDUAL	6.21, TLM		NM
V90X0215XB	G28222	DISP_EDIT(2)	TAC R EDIT HIST IND	6.21, GAX, TLM		
V90U0216CB	G28224	DISP_SIG(1)	TAC AZ RESID RATIO	6.21, TLM		
V90U0217CB	G28225	DISP_SIG(2)	TAC R RESID RATIO	6.21, TLM		
V90X0218XA	G28213	DISP_EDIT(5)	MSBLS AZ EDIT HIST IND	GAX, TLM		
V90X0219XA	G28214	DISP_EDIT(6)	MSBLS R EDIT HIST IND	GAX, TLM		
V90X0220XA	G28215	DISP_EDIT(7)	MSBLS EL EDIT HIST IND	GAX, TLM		
V90H0221CB	G28216	DISP_DELQ(3)	BARO ALT MEAS RESIDUAL	6.21, TLM		FT
V90U222CB	G28217	DISP_SIG(3)	BARO ALT RESID RATIO	6.21, TLM		
V90X0223XB	G28219	DISP_EDIT(3)	BARO ALT EDIT HIST IND	6.21, GAX, TLM		
V90H0235CC	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	A/L UPP, TAEM UPP		FT
V90H0236CC	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	A/L UPP, TAEM UPP		FT
V90H0237CC	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	A/L UPP, TAEM UPP		FT
V90L0239CC	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	A/L UPP, TAEM UPP		FT/SEC
V90L0240CC	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	A/L UPP, TAEM UPP		FT/SEC
V90L0241CC	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	A/L UPP, TAEM UPP		FT/SEC
V90A0243CC	G28207	G_RESET(1)	SEL X-COMP OF GRAV ACCEL VCT RST	A/L UPP, TAEM UPP		FT/SEC^2
V90A0244CC	G28208	G_RESET(2)	SEL Y-COMP OF GRAV ACCEL VCT RST	A/L UPP, TAEM UPP		FT/SEC^2
V90A0245CC	G28209	G_RESET(3)	SEL Z-COMP OF GRAV ACCEL VCT RST	A/L UPP, TAEM UPP		FT/SEC^2
V90X0224XC	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	A/L UPP, TAEM UPP		
V90L0247CC	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	A/L UPP, TAEM UPP		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90L0248CC	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	A/L UPP, TAEM UPP		FT/SEC
V90L0249CC	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	A/L UPP, TAEM UPP		FT/SEC
V90W0225CC	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	A/L UPP, TLM		SEC
V90J0226CC	G28226	TAC_AIF_RCVD	TACAN AUT/INH/FOR FLAG FDBK	6.21, TLM		
V90J0227CB	G50315	BARO_AIF_RCVD	BARO AUT/INH/FOR FLAG FDBK	6.21, TLM		
V90U0231CA	G47979	DISP_DELQ(5)	MSBLS AZ MEAS RESIDUAL	TLM		RAD
V90U0232CA	G47980	DISP_DELQ(6)	MSBLS R MEAS RESIDUAL	TLM		FT
V90U0233CA	G47981	DISP_DELQ(7)	MSBLS EL MEAS RESIDUAL	TLM		RAD
V90U0253CA	G47982	DISP_SIG(5)	MSBLS AZ RESID RATIO	TLM		
V90U0254CA	G47983	DISP_SIG(6)	MSBLS R RESID RATIO	TLM		
V90U0255CA	G47984	DISP_SIG(7)	MSBLS EL RESID RATIO	TLM		
V90U0719CB		TACAN_AIF	TACAN AUTO/INHIBIT/FORCE SWITCH	TLM		
V90U0257C		BARO_AIF	BARO AUTO/INHIBIT/FORCE SWITCH	TLM		
V90X0234XA	G50934	DO_MLS_NAV	FLAG IND MLS BEING PROC	TLM		
V90U8846CC	G48529	DO_TACAN_NAV	FLG IND TACAN DATA BEING PROCESSED	TLM		
V90X0259XA	G50933	DO_BARO_NAV	FLAG IND BARO ALT BEING PROCESSED	TLM		
V90J0242CA	G50937	MLS_MARK_NUM	COUNTER-MLS MEAS BEING PROCESSED	TLM		
V90J8842CC	G48531	TACAN_MARK_NUM	COUNTER-TACAN MEAS BEING PROCESSED	TLM		
V90J8843CB	G48532	BARO_MARK_NUM	COUNTER-BARO MEAS BEING PROCESSED	TLM		
V90X0768XB		ONE_RANGE_LOCK	TACAN RM 1 LRU RNG LOCKON RQMT FLG	TACAN RM	0,1	
V90X0769XB		ONE_BRG_LOCK	TACAN RM 1 LRU BRG LOCKON RQMT FLG	TACAN RM	0,1	
V93H5010CC	G71815	DR_RW	NAV UPDATE DELTA X POSIT	6.21		FT
V93H5011CC	G71816		NAV UPDATE DELTA Y POSIT	6.21		FT

OUTPUT FUNCTIONAL PARAMETERS FROM THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V93H5012CC	G71817		NAV UPDATE DELTA Z POSIT	6.21		FT
V93L5020CC	G71818	DV_RW	NAV UPDATE DELTA X VEL	6.21		FT/SEC
V93L5021CC	G71819		NAV UPDATE DELTA Y VEL	6.21		FT/SEC
V93L5022CC	G71820		NAV UPDATE DELTA Z VEL	6.21		FT/SEC
V90X0715XB	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	TAEM UPP, A/L UPP		
V90X0538XB	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	TAEM UPP, A/L UPP		
V90P8871CD		Q_BARO	DATA SNAP-ADS CORR PRESSURE ALT	TLM		
V90W8870CB		T_BARO	DATA SNAP-ADS CORR P ALT TIME TAG	TLM		
V90X8861XC		BARO_DATA_GOOD	DATA SNAP-ADTA DATA GOOD FLAG	TLM		
V90N8867CC		Q_TAC_R	DATA SNAP-SELECTED TACAN RANGE	TLM		
V90U8868CC	G07814	Q_TAC_BRG	DATA SNAP-SELECTED TACAN BEARING	TLM		
V90X0716CB		T_TACAN	TIME OF TACAN READ	TLM		
V90X0717XB		TAC_RNG_DATA_ GOOD	DATA GOOD FLAG-TACAN RANGE	TLM		
V90X0718XB		TAC_BRG_DATA_ GOOD	DATA GOOD FLAG-TACAN BEARING	TLM		
V90U8850CB		TACAN_ID	DATA SNAP-SEL TAC CHANNEL W/MODE	TLM		
V90J8864CC		SEL_LRU_ID	DATA SNAP-TACAN LRU NUMBER	TLM		
V90H0264CA		Q_RANGE	SNAPPED SELECTED MLS RANGE	TLM		
V90H0265CA		Q_AZMLS	SNAPPED SELECTED MLS AZIMUTH	TLM		
V90H0266CA		Q_ELMLS	SNAPPED SELECTED MLS ELEVATION	TLM		
V90W0267CA		T_EF_RMLS	SNAPPED MLS RANGE MEAS TIME	TLM		
V90W0268CA		T_EF_AZMLS	SNAPPED MLS AZIMUTH MEAS TIME	TLM		
V90W0269CA		T_EF_ELMLS	SNAPPED MLS ELEVATION MEAS TIME	TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90X0273XA		MLSRANGE_DATA_GOOD	SNAPPED MLS RANGE DATA GOOD	TLM		
V90X0274XA		MLSEL_DATA_GOOD	SNAPPED MLS ELEVATION DATA GOOD	TLM		
V90X0275XA		MLSAZ_DATA_GOOD	SNAPPED MLS AZIMUTH DATA GOOD	TLM		
V90U8841CB	G50735	SENSOR_EDIT(1)	TAC AZ FILTER FLAG	TLM		
V90U8880CB	G50736	SENSOR_EDIT(2)	TAC R FILTER FLAG	TLM		
V90U8881CB	G50737	SENSOR_EDIT(3)	BARO ALT FILTER FLAG	TLM		
V90U8883CA	G50739	SENSOR_EDIT(5)	MSBLS AZ FILTR FLAG	TLM		
V90U8884CA	G50740	SENSOR_EDIT(6)	MSBLS R FILTER FLAG	TLM		
V90U8885CA	G50741	SENSOR_EDIT(7)	MSBLS EL FILTER FLAG	TLM		
V90X8935XD	G46572	DO_DELTA_UPDATE	FLAG INDICATING (ON) TO DO DELTA STATE UPDATE	6.21, TLM		
V90X0276XD		NAV_THREE_STATE	FLAG INDICATING ONE OR THREE STATE OPERATION	TLM		

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV,4.220)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H0878CA	G46597	HEADING_LEFT	LH MAG HEADING OF REL VEL VECTOR	HSI PROC		DEG
V90H0953CA	G47819	HEADING_RIGHT	RH MAG HEADING OF REL VEL VECTOR	HSI PROC		DEG
V90X0966XA	G46595	CDI_FLAG_LEFT	LH COURSE DEVIATION - VALID FLAG	HSI PROC		
V90X0967XA	G46596	CDI_FLAG_RIGHT	RH COURSE DEVIATION - VALID FLAG	HSI PROC		
V90H0954CA	G21008	PRIBEAR_LEFT	LH PRIMARY BEARING	HSI PROC	0,360	DEG
V90H0955CA	G46593	PRIBEAR_RIGHT	RH PRIMARY BEARING	HSI PROC	0,360	DEG
V90H0956CA	G21001	PRIRANGE_LEFT	LH PRIMARY RANGE	HSI PROC		NM
V90H0957CA	G46587	PRIRANGE_RIGHT	RH PRIMARY RANGE	HSI PROC		NM
V90H0958CA	G21003	CDI_LEFT	LH COURSE DEVIATION	HSI PROC		DEG
V90H0959CA	G46589	CDI_RIGHT	RH COURSE DEVIATION	HSI PROC		DEG
V90H0960CA	G21004	GSI_LEFT	LH GLIDE SLOPE DEVIATION	HSI PROC		FT
V90H0961CA	G46590	GSI_RIGHT	RH GLIDE SLOPE DEVIATION	HSI PROC		FT
V90H0962CA	G21002	SECRANGE_LEFT	LH SECONDARY RANGE	HSI PROC		NM
V90H0963CA	G46588	SECRANGE_RIGHT	RH SECONDARY RANGE	HSI PROC		NM
V90X0968XA	G21005	HDG_FLAG_LEFT	LH HEADING DATA - VALID FLAG	HSI PROC		
V90X0969XA	G48066	HDG_FLAG_RIGHT	RH HEADING DATA - VALID FLAG	HSI PROC		
V90X0970XA	G21006	BRG_FLAG_LEFT	LH BEARING DATA - VALID FLAG	HSI PROC		
V90X0971XA	G46591	BRG_FLAG_RIGHT	RH BEARING DATA - VALID FLAG	HSI PROC		
V90X0972XA	G21007	GSI_FLAG_LEFT	LH GLIDE SLOPE DEV DATA VALID FLAG	HSI PROC		
V90X0973XA	G46592	GSI_FLAG_RIGHT	RH GLIDE SLOPE DEV DATA VALID FLAG	HSI PROC		
V90H0964CA	G21009	SECBEAR_LEFT	LH SECONDARY BEARING	HSI PROC		DEG
V90H0965CA	G46594	SECBEAR_RIGHT	RH SECONDARY BEARING	HSI PROC		DEG

OUTPUT FUNCTIONAL PARAMETERS FROM THE ENTRY PRECISE PREDICTOR MODULE (ENT PREC PRED 4.223)

M/S ID	Level B No.	Nomenclature	Destination	Range	Units
V90H0881CA	G47416 R_FINAL	X-COMP PREDICTED SHUTTLE POS VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT
V90H0882CA	G47417	Y-COMP PREDICTED SHUTTLE POS VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT
V90H0883CA	G47418	Z-COMP PREDICTED SHUTTLE POS VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT
V90L0885CA	G47419 V_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT/SEC
V90L0886CA	G47420	Y-COMP PREDICTED SHUTTLE VEL VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT/SEC
V90L0887CA	G47421	Z-COMP PREDICTED SHUTTLE VEL VECTR	D/L NAV SEQ, AOA/ATO TGT, ASC MNVR DIP, DEORB GUID, DEORB MNVR DIP, ENTRY NAV		FT/SEC
V90A0889C	G48105 G_FINAL	X-COMP PREDICTED SHUTTLE GRAV VCTR	D/L NAV SEQ, ENTRY NAV		FT/SEC^2
V90A0890C	G48106	Y-COMP PREDICTED SHUTTLE GRAV VCTR	D/L NAV SEQ, ENTRY NAV		FT/SEC^2
V90A0891C	G48107	Z-COMP PREDICTED SHUTTLE GRAV VCTR	D/L NAV SEQ, ENTRY NAV		FT/SEC^2

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90J0124CB	G50319	AUTO_CHANNEL_ID	TACAN CHANNEL SELECTION	TACAN SOP, TLM	±1,±126	
V90X0125XB	G50318	AUTO_ID_CHANGED	CHANGE IN CHANNEL ID	TACAN RM	0,1	
V90X0126XB	G50320	ID_CHANGE_ REQUEST	ID CHANGE REQUEST RESET	TACAN RM	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP,4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95W0002C	C92156	T_IMU	IMU INPUT TRANS TIME TAG	IMU INT PROC		SEC
V95H5102C	G07807	TACRANGEO(1)	TACAN NO 1 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5122C	G07811	TACBEARO(1)	TACAN NO 1 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5202C	G07808	TACRANGEO(2)	TACAN NO 2 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5222C	G07812	TACBEARO(2)	TACAN NO 2 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5302C	G07809	TACRANGEO(3)	TACAN NO 3 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5322C	G07813	TACBEARO(3)	TACAN NO 3 BEARING OUT	TACAN SOP	0,6.28	RAD
V90X2503X	G14723	IMU_SFC(1)	IMU SELECTION FILTER COMMAND IMU 1	IMU RM		
V90X2571X		IMU_SFC(2)	IMU SELECTION FILTER COMMAND IMU 2	IMU RM		
V90X2572X		IMU_SFC(3)	IMU SELECTION FILTER COMMAND IMU 3	IMU RM		
V90L2557C	G14702	V_IMU_CURRENT(1)	SEL TOTAL X VEL M50	IMU RM	+/-10M	FT/SEC
V90L2558C	G14703	V_IMU_CURRENT(2)	SEL TOTAL Y VEL M50	IMU RM	+/-10M	FT/SEC
V90L2559C	G14704	V_IMU_CURRENT(3)	SEL TOTAL Z VEL M50	IMU RM	+/-10M	FT/SEC
V90X0224XD	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	D/L NAV SEQ		
V90A0243CD	G28207	G_RESET(1)	SEL X-COMP OF GRAV ACCEL VCTR RST	D/L NAV SEQ		FT/SEC^2
V90A0244CD	G28208	G_RESET(2)	SEL Y-COMP OF GRAV ACCEL VCTR RST	D/L NAV SEQ		FT/SEC^2
V90A0245CD	G28209	G_RESET(3)	SEL Z-COMP OF GRAV ACCEL VCTR RST	D/L NAV SEQ		FT/SEC^2
V90H0235CD	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	D/L NAV SEQ		FT
V90H0236CD	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	D/L NAV SEQ		FT
V90H0237CD	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	D/L NAV SEQ		FT
V90L0239CD	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	D/L NAV SEQ		FT/SEC
V90L0240CD	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	D/L NAV SEQ		FT/SEC
V90L0241CD	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	D/L NAV SEQ		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP, 4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90W0225CD	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	D/L NAV SEQ		SEC
V90L0247CD	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	D/L NAV SEQ		FT/SEC
V90L0248CD	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	D/L NAV SEQ		FT/SEC
V90L0249CD	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	D/L NAV SEQ		FT/SEC
V90H1817CA	G25847	AZIMUTH_RW	AZIMUTH OF RW FROM TRUE NORTH	ENT SITE LOOKUP		RAD
V90H1818CA	G25846	ALT_RW	ALTITUDE OF RW WRT REF ELLIPSOID	ENT SITE LOOKUP		FT
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP, 4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR_TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR_TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR_TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90U1890CA	G25852	M_EFTORW_SEC	EARTH FIXED TO SEC RUNWAY, ELE 1-1	ENT SITE LOOKUP		
V90U1891CA	G25853		EARTH FIXED TO SEC RUNWAY, ELE 1-2	ENT SITE LOOKUP		
V90U1892CA	G25854		EARTH FIXED TO SEC RUNWAY, ELE 1-3	ENT SITE LOOKUP		
V90U1893CA	G25855		EARTH FIXED TO SEC RUNWAY, ELE 2-1	ENT SITE LOOKUP		
V90U1894CA	G25856		EARTH FIXED TO SEC RUNWAY, ELE 2-2	ENT SITE LOOKUP		
V90U1895CA	G25857		EARTH FIXED TO SEC RUNWAY, ELE 2-3	ENT SITE LOOKUP		
V90U1896CA	G25858		EARTH FIXED TO SEC RUNWAY, ELE 3-1	ENT SITE LOOKUP		
V90U1897CA	G25859		EARTH FIXED TO SEC RUNWAY, ELE 3-2	ENT SITE LOOKUP		
V90U1898CA	G25860		EARTH FIXED TO SEC RUNWAY, ELE 3-3	ENT SITE LOOKUP		
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1911CA	G25869	AZIMUTH_RW_SEC	AZ OF SEC RW FROM TRUE NORTH	ENT SITE LOOKUP		RAD
V90H1903CA	G25861	R_LS_EF_SEC	X-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT
V90H1904CA	G25862		Y-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT
V90H1905CA	G25863		Z-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT
V90X1858XA	G25872	TACAN_CHAN_VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP, 4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1859XA	G47933	TACAN_CHAN_ VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_ VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_ SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_ SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		
V90U1793CA	G46546	M_EFTOTD_TACAN_ SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP, 4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90U1916CA	G47429	RW_NAME	CURRENT LANDING SITE SELECTED	ENT SITE LOOKUP		
V90X0224XE	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT NAV		
V90A0243CE	G28207	G_RESET	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0244CE	G28208		SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0245CE	G28209		SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90H0235CE	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0236CE	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0237CE	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90L0239CE	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0240CE	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0241CE	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90W0225CE	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT NAV		SEC
V90L0247CE	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0248CE	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0249CE	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY USER PARAMETER PROCESSING MODULE (ENT UPP, 4.23)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X0538XD	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	ENT NAV		
V90X0715XA	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	ENT NAV		
V90U2240CA	G19849	Q_B_I	M50 TO BODY QUAT MEASURED ELEM 1	A/E ATT PROC	+/-1	
V90U2241CA	G19850		M50 TO BODY QUAT MEASURED ELEM 2	A/E ATT PROC	+/-1	
V90U2242CA	G19851		M50 TO BODY QUAT MEASURED ELEM 3	A/E ATT PROC	+/-1	
V90U2243CA	G19852		M50 TO BODY QUAT MEASURED ELEM 4	A/E ATT PROC	+/-1	
V93X5015X	G81378	TAC_MODE	TACAN ABSOLUTE/DELTA DATA CMD	6.21	0,1	
V93X5085XA		MID_TARGET	FLG IND AVG PRI & SEC TGT PARMS	6.21	0,1	
V90X8162X	G47671	MM_CODE_305	MAJOR MODE 305 FLAG	MSC	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP, 4.24)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1108XA	G47153	TG_END	TAEM GUIDANCE TERMINATION FLAG	TAEM GUID	0,1	
V95W0002C	C92156	T_IMU	IMU INPUT TRANS TIME TAG	IMU INT PROC		SEC
V95H5102C	G07807	TACRANGEO(1)	TACAN NO 1 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5122C	G07811	TACBEARO(1)	TACAN NO 1 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5202C	G07808	TACRANGEO(2)	TACAN NO 2 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5222C	G07812	TACBEARO(2)	TACAN NO 2 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5302C	G07809	TACRANGEO(3)	TACAN NO 3 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5322C	G07813	TACBEARO(3)	TACAN NO 3 BEARING OUT	TACAN SOP	0,6.28	RAD
V95W7000C	G08407	T_RADALT	RADAR ALTIMETER TIME	RA SOP		SEC
V90H4002C	G14407	Q_RADALT	SELECTED RALT HEIGHT-RAW	SF	0,5000	FT
V90X4003X	G14408	DG_RADALT	RALT HEIGHT DATA GOOD	SF	0,1	
V90R5321C	G14442	WBR2	SELECTED RGA PITCH RATE	SF	+/-20	DEG/SEC
V90X2503X	G14723	IMU_SFC(1)	IMU SELECTION FILTER COMMAND IMU 1	IMU RM		
V90X2571X		IMU_SFC(2)	IMU SELECTION FILTER COMMAND IMU 2	IMU RM		
V90X2572X		IMU_SFC(3)	IMU SELECTION FILTER COMMAND IMU 3	IMU RM		
V90L2557C	G14702	V_IMU_CURRENT(1)	SEL TOTAL X VEL M50	IMU RM	+/-10M	FT/SEC
V90L2558C	G14703	V_IMU_CURRENT(2)	SEL TOTAL Y VEL M50	IMU RM	+/-10M	FT/SEC
V90L2559C	G14704	V_IMU_CURRENT(3)	SEL TOTAL Z VEL M50	IMU RM	+/-10M	FT/SEC
V90H1818CA	G25846	ALT_RW	ALTITUDE OF RW WRT REF ELLIPSOID	ENT SITE LOOKUP		FT
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP, 4.24)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR_ TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR_ TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR_ TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90X1858XA	G25872	TACAN_CHAN_ VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP, 4.24)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1859XA	G47933	TACAN_CHAN_ VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_ VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_ SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_ SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		
V90U1793CA	G46546	M_EFTOTD_TACAN_ SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP, 4.24)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90U1916CA	G47429	RW_NAME	CURRENT LANDING SITE SELECTED	ENT SITE LOOKUP		
V90X0224XE	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT NAV		
V90A0243CE	G28207	G_RESET	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0244CE	G28208		SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0245CE	G28209		SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90H0235CE	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0236CE	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0237CE	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90L0239CE	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0240CE	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0241CE	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90W0225CE	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT NAV		SEC
V90L0247CE	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0248CE	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0249CE	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE TAEM USER PARAMETER PROCESSING MODULE (TAEM UPP, 4.24)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X0538XD	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	ENT NAV		
V90X0715XA	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	ENT NAV		
V90X0715XB	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	PRELAND NAV		
V90X0538XB	G46500	USE_IMU_DATA	FLAG TO USE-IMU ACCUM VEL OR NOT	PRELAND NAV		
V90H2215C	G19817	COSTH	EULER ANGLE PITCH COSINE	A/E ATT PROC	+/-1	
V90H2216C	G19816	SINTH	EULER ANGLE PITCH SINE	A/E ATT PROC	+/-1	
V90H2217C	G19801	THETA	BODY PITCH ATTITUDE EULER ANGLE	A/E ATT PROC	+/-90	DEG
V93X5015X	G81378	TAC_MODE	TACAN ABSOLUTE/DELTA DATA CMD	6.21	0,1	
V90X8162X	G47671	MM_CODE_305	MAJOR MODE 305 FLAG	MSC		
V90H0235CC	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90H0236CC	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90H0237CC	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90L0239CC	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90L0240CC	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90L0241CC	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90A0243CC	G28207	G_RESET(1)	SEL X-COMP GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90A0244CC	G28208	G_RESET(2)	SEL Y-COMP GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90A0245CC	G28209	G_RESET(3)	SEL Z-COMP GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90X0224XC	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	PRELAND NAV		
V90L0247CC	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90L0248CC	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90L0249CC	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90W0225CC	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	PRELAND NAV		SEC

INPUT FUNCTIONAL PARAMETERS FOR THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP, 4.25)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1108XA	G47153	TG_END	TAEM GUIDANCE TERMINATION FLAG	TAEM GUID	0,1	
V95W0002C	C92156	T_IMU	IMU INPUT TRANS TIME TAG	IMU INT PROC		SEC
V95H5102C	G07807	TACRANGEO(1)	TACAN NO 1 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5122C	G07811	TACBEARO(1)	TACAN NO 1 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5202C	G07808	TACRANGEO(2)	TACAN NO 2 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5222C	G07812	TACBEARO(2)	TACAN NO 2 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5302C	G07809	TACRANGEO(3)	TACAN NO 3 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5322C	G07813	TACBEARO(3)	TACAN NO 3 BEARING OUT	TACAN SOP	0,6.28	RAD
V95W7000C	G08407	T_RADALT	RADAR ALTIMETER TIME	RA SOP		SEC
V90H4002C	G14407	Q_RADALT	SELECTED RALT HEIGHT-RAW	SF	0,5000	FT
V90X4003X	G14408	DG_RADALT	RALT HEIGHT DATA GOOD	SF	0,1	
V90R5321C	G14442	WBR2	SELECTED RGA PITCH RATE	SF	+/-20	DEG/SEC
V90X2503XA	G14723	IMU_SFC(1)	IMU SELECTION FILTER COMMAND IMU 1	IMU RM		
V90X2571X		IMU_SFC(2)	IMU SELECTION FILTER COMMAND IMU 2	IMU RM		
V90X2572X		IMU_SFC(3)	IMU SELECTION FILTER COMMAND IMU 3	IMU RM		
V90L2557C	G14702	V_IMU_CURRENT(1)	SEL TOTAL X VEL M50	IMU RM	+/-10M	FT/SEC
V90L2558C	G14703	V_IMU_CURRENT(2)	SEL TOTAL Y VEL M50	IMU RM	+/-10M	FT/SEC
V90L2559C	G14704	V_IMU_CURRENT(3)	SEL TOTAL Z VEL M50	IMU RM	+/-10M	FT/SEC
V90H1818CA	G25846	ALT_RW	ALTITUDE OF RW WRT REF ELLIPSOID	ENT SITE LOOKUP		FT
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP, 4.25)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR_ TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR_ TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR_ TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90X1858XA	G25872	TACAN_CHAN_ VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP, 4.25)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1859XA	G47933	TACAN_CHAN_ VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_ VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_ SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_ SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP, 4.25)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1793CA	G46546	M_EFTOTD_TACAN_SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90X0224XE	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT NAV		
V90A0243CE	G28207	G_RESET	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0244CE	G28208		SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90A0245CE	G28209		SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT NAV		FT/SEC^2
V90H0235CE	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0236CE	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90H0237CE	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT NAV		FT
V90L0239CE	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0240CE	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90L0241CE	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT NAV		FT/SEC
V90W0225CE	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT NAV		SEC
V90L0247CE	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0248CE	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC
V90L0249CE	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	ENT NAV		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE AUTOLAND USER PARAMETER PROCESSING MODULE (A/L UPP, 4.25)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X0538XD	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	ENT NAV		
V90X0715XA	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	ENT NAV		
V90H0235CC	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90H0236CC	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90H0237CC	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	PRELAND NAV		FT
V90L0239CC	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90L0240CC	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90L0241CC	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	PRELAND NAV		FT/SEC
V90A0243CC	G28207	G_RESET(1)	SEL X-COMP OF GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90A0244CC	G28208	G_RESET(2)	SEL Y-COMP OF GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90A0245CC	G28209	G_RESET(3)	SEL Z-COMP OF GRAV ACCEL VCTR RST	PRELAND NAV		FT/SEC^2
V90X0224XC	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	PRELAND NAV		
V90L0247CC	G28210	V_IMU_RESET(1)	SEL X-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90L0248CC	G28211	V_IMU_RESET(2)	SEL Y-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90L0249CC	G28212	V_IMU_RESET(3)	SEL Z-COMP OF ACCUM SENSED VEL RST	PRELAND NAV		FT/SEC
V90W0225CC	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	PRELAND NAV		SEC
V90X0715XB	G49017	NAV_EL_FLAG	NAV VALID FLG SETTING EVENT LAMP	PRELAND NAV		
V90X0538XB	G46500	USE_IMU_DATA	FLAG TO USE IMU ACCUM VEL OR NOT	PRELAND NAV		
V90H2215C	G19817	COSTH	EULER ANGLE PITCH COSINE	A/E ATT PROC	+/-1	
V90H2216C	G19816	SINTH	EULER ANGLE PITCH SINE	A/E ATT PROC	+/-1	
V90H2217C	G19801	THETA	BODY PITCH ATTITUDE EULER ANGLE	A/E ATT PROC	+/-90	DEG
V93X5015X	G81378	TAC_MODE	TACAN ABSOLUTE/DELTA DATA CMD	6.21	0,1	
V90X8162X	G47671	MM_CODE_305	MAJOR MODE 305 FLAG	MSC	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X3003X	G14404	MLSAZ_DATA_GOOD	MSBLS AZIMUTH DATA GOOD	SF	0,1	
V90X3063X	G14406	MLSRANGE_DATA_ GOOD	MSBLS RANGE DATA GOOD	SF	0,1	
V97U5512CB	G50269	SIG_DIAG_UVW_ INIT(1)	SQRT COV MTRX DIAG ELE 1 NEXT OPS	ORB UPP SEQ		FT
V97U5513CB	G50270	SIG_DIAG_UVW_ INIT(2)	SQRT COV MTRX DIAG ELE 2 NEXT OPS	ORB UPP SEQ		FT
V97U5514CB	G50271	SIG_DIAG_UVW_ INIT(3)	SQRT COV MTRX DIAG ELE 3 NEXT OPS	ORB UPP SEQ		FT
V97U5515CB	G50272	SIG_DIAG_UVW_ INIT(4)	SQRT COV MTRX DIAG ELE 4 NEXT OPS	ORB UPP SEQ		FT/SEC
V97U5516CB	G50273	SIG_DIAG_UVW_ INIT(5)	SQRT COV MTRX DIAG ELE 5 NEXT OPS	ORB UPP SEQ		FT/SEC
V97U5517CB	G50274	SIG_DIAG_UVW_ INIT(6)	SQRT COV MTRX DIAG ELE 6 NEXT OPS	ORB UPP SEQ		FT/SEC
V97U5285CB	G50275	CORR_COEFF_INIT (1)	CORR COEFF FOR NEXT OPS ELE 1	ORB UPP SEQ		
V97U5286CB	G50276	CORR_COEFF_INIT (2)	CORR COEFF FOR NEXT OPS ELE 2	ORB UPP SEQ		
V97U5287CB	G50277	CORR_COEFF_INIT (3)	CORR COEFF FOR NEXT OPS ELE 3	ORB UPP SEQ		
V97U5288CB	G50278	CORR_COEFF_INIT (4)	CORR COEFF FOR NEXT OPS ELE 4	ORB UPP SEQ		
V97U5289CB	G50279	CORR_COEFF_INIT (5)	CORR COEFF FOR NEXT OPS ELE 5	ORB UPP SEQ		
V97U5290CB	G50280	CORR_COEFF_INIT (6)	CORR COEFF FOR NEXT OPS ELE 6	ORB UPP SEQ		
V97U5291CB	G50281	CORR_COEFF_INIT (7)	CORR COEFF FOR NEXT OPS ELE 7	ORB UPP SEQ		
V90L0630CB	G25509	V_LAST_FILT_ONE	X-COMP OF ACCUM SENSED VEL STATE 1	IMU RM		FT/SEC
V90L0631CB	G25510		Y-COMP OF ACCUM SENSED VEL STATE 1	IMU RM		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0632CB	G25511		Z-COMP OF ACCUM SENSED VEL STATE 1	IMU RM		FT/SEC
V90L0633CB	G46516	V_LAST_FILT_TWO	X-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0634CB	G46517		Y-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0635CB	G46518		Z-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0636CB	G46525	V_LAST_FILT_ THREE	X-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
V90L0637CB	G46526		Y-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
V90L0638CB	G46527		Z-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
	G50308	MLS_AVAIL	FLG INDICATING THE AVAIL OF MLS DATA AT RUNWAY SELECTED	SITE LOOKUP		
		EVENT E14A	OMS CUTOFF CONFIRMATION FLAG	MSC		
V90L0621CC	G27908	V_LAST_FILT(1)	X-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90L0622CC	G27909	V_LAST_FILT(2)	Y-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90L0623CC	G27910	V_LAST_FILT(3)	Z-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90H0584CE	G27911	R_FILT(1)	X-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0585CE	G27912	R_FILT(2)	Y-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0586CE	G27913	R_FILT(3)	Z-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90L0624CE	G27904	V_FILT(1)	X-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0625CE	G27905	V_FILT(2)	Y-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0626CE	G27906	V_FILT(3)	Z-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90W0534CE	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	IMU RM, ENT NAV		
V90W1287CB	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ASC NAV SEQ		SEC
V90H1276CB	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ASC NAV SEQ		FT
V90H1277CB	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ACS NAV SEQ		FT
V90H1278CB	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ACS NAV SEQ		FT

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L1279CB	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90L1280CB	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90L1281CB	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90H1276CC	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1277CC	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1278CC	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90L1279CC	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1280CC	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1281CC	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90W1287CC	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ORB UPP SEQ		SEC
V90H0881CA	G47416	R_FINAL	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0882CA	G47417		Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0883CA	G47418		Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90L0885CA	G47419	V_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0886CA	G47420		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0887CA	G47421		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90A0889C	G48105	G_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90A0890C	G48106		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90A0891C	G48107		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90Q8001C			MAJOR MODE CODE	MSC	1,5	
V90X8164X	G43204	EVENT_E1	MM 201 FROM MM 301 FLAG	MSC		
V90X8169X	G43205		OPS-1 TO OPS-3 TRNSITION EVENT FLG	MSC		
V90X8188X	G54409	INITIATE_PWR_ FLIGHT_NAVEVENT	INITIATE PF FLAG	MSC		

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U2023CC	G48797	VEH_MASS	CURRENT VEHICLE MASS	DEORB GUID		SLUGS
		EVENT 14A	OMS CUTOFF CONFIRMATION FLG	MSC	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95J5020C	G50321	NEW_STATION_ID	TACAN 1,2, OR 3 NEW STATION CHAN NO	TACAN SOP	+/-126	
V95J5021C	G46531	LRU_ID	TACAN LRU NUMBER	TACAN SOP	1,3	
V93J4467C	G75104	PRIME_RUNWAY_ INDEX	HORIZ SIT-RUNWAY SELECTED	6.21		
	G47820	RUNWAY_NAME_PSL	LANDING SITE SELECTION SYMBOL FOR DESIGNATED PRIME, LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		
	G47821	RUNWAY_ALT_PSL	ALTITUDE OF RUNWAY REFERENCE POINT ABOVE REFERENCE ELLIPSOID FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47822	RW_AZIMUTH_PSL	BEARING FROM TRUE NORTH OF RUNWAY COORDINATE SYSTEM +X AXIS AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47823	RW_DELH_PSL	ALTITUDE OF MEAN SEA LEVEL ABOVE REFERENCE ELLIPSOID AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47824	RW_MAG_VAR_PSL	VARIATION OF MAGNETIC NORTH FROM TRUE NORTH AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47825	RW_LAT_PSL	GEODETIC LATITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47826	RW_LON_PSL	LONGITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47827	LAT_MLS_R_AZ_PSL	LATITUDE OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47828	LONG_MLS_R_AZ_ PSL	LONGITUDE OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47829	ALT_MLS_R_AZ_ PSL	ALTITUDE OF MSBLS RANGE/AZIMUTH SCANNER ABOVE THE REFERENCE ELLIPSOID FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
	G47830	R_AZ_RADAR_ BEARING_PSL	BEARING FROM TRUE NORTH OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47831	LAT_MLSEL_PSL	LATITUDE OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47832	LONG_MLSEL_PSL	LONGITUDE OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED PRIME LANDING	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47833	ALT_MLSEL_PSL	ALTITUDE OF MSBLS ELEVATION SCANNER ABOVE THE REFERENCE ELLIPSOID FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47834	EL_SCANNER_ BEARING_PSL	BEARING FROM TRUE NORTH OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47835	BIAS_MLSRANGE_ PSL	INITIAL MSBLS RANGE ANTENNA MEASUREMENT BIAS FOR PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47836	BIAS_AZMLS_PSL	INITIAL MSBLS AZIMUTH ANTENNA MEASUREMENT BIAS FOR PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47837	BIAS_ELMLS_PSL	INITIAL MSBLS ELEVATION ANTENNA MEASUREMENT BIAS FOR PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47838	X_DMEAZ_RW_PSL	X-COMPONENT OF RANGE/AZIMUTH ANTENNA IN RW COORDINATES AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47839	X_EL_RW_PSL	X-COMPONENT OF ELEVATION ANTENNA IN RW COORDINATES AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47840	Y_DMEAZ_RW_PSL	Y-COMPONENT OF RANGE/AZIMUTH ANTENNA IN RW COORDINATES AT DESIGNATED PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47841	RUNWAY_NAME_SSL	LANDING SITE SELECTION SYMBOL FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
	G47842	RUNWAY_ALT_SSL	ALTITUDE OF RUNWAY REFERENCE POINT ABOVE REFRENCE ELLIPSOID FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47843	RW_AZIMUTH_SSL	BEARING FROM TRUE NORTH OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47844	RW_DELH_SSL	ALTITUDE OF MEAN SEA LEVEL ABOVE REFERENCE ELLIPSOID AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47845	RW_MAG_VAR_SSL	VARIATION OF MAGNETIC NORTH FROM TRUE NORTH AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47846	RW_LAT_SSL	GEODETIC LATITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47847	RW_LON_SSL	LONGITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47848	LAT_MLS_R_AZ_ SSL	LATITUDE OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47849	LONG_MLS_R_AZ SSL	LONGITUDE OF MSBLS RANGE/AZIMUTH SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47850	ALT_MLS_R_AZ_ SSL	ALTITUDE OF MSBLS RANGE/AZIMUTH SCANNER ABOVE THE REFERENCE ELLIPSOID FOR THE SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47851	R_AZ_RADAR_ BEARING_SSL	BEARING FROM TRUE NORTH OF MSBLS RANGE/ AZIMUTH SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47852	LAT_MLSEL_SSL	LATITUDE OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47853	LONG_MLSEL_SSL	LONGITUDE OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
	G47854	ALT_MLSEL_SSL	ALTITUDE OF MSBLS ELEVATION SCANNER ABOVE THE REFERENCE ELLIPSOID FOR THE SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47855	EL_SCANNER_ BEARING_SSL	BEARING FROM TRUE NORTH OF MSBLS ELEVATION SCANNER SITE FOR DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47856	BIAS_MLSRANGE_ SSL	INITIAL MSBLS RANGE ANTENNA MEASUREMENT BIAS FOR SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47857	BIAS_AZMLS_SSL	INITIAL MSBLS AZIMUTH ANTENNA MEASUREMENT BIAS FOR SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47858	BIAS_ELMLS_SSL	INITIAL MSBLS ELEVATION ANTENNA MEASUREMENT BIAS FOR SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G50312	MLS_AVAIL_PSL	MSBLS DATA AVAILABILITY FLAG FOR PRIME LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)	ON, OFF	
	G50313	MLS_AVAIL_SSL	MSBLS DATA AVAILABILITY FLAG FOR SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)	ON, OFF	
	G47859	X_DMEAZ_RW_SSL	X-COMPONENT OF RANGE/AZIMUTH ANTENNA IN RW COORDINATES AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47860	X_EL_RW_SSL	X-COMPONENT OF ELEVATION ANTENNA IN RW COORDINATES AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47861	Y_DMEAZ_RW_SSL	Y-COMPONENT OF RANGE/AZIMUTH ANTENNA IN RW COORDINATES AT DESIGNATED SECONDARY LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47862	RUNWAY_NAME_ASL	LANDING SITE SELECTION SYMBOL FOR DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		
	G47863	RUNWAY_ALT_ASL	ALTITUDE OF RUNWAY REFERENCE POINT ABOVE REFERENCE ELLIPSOID FOR DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
	G47864	RW_AZIMUTH_ASL	BEARING FROM TRUE NORTH OF RUNWAY COORDINATE SYSTEM +X AXIS AT DESIGNATED LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47865	RW_DELH_ASL	ALTITUDE OF MEAN SEA LEVEL ABOVE REFERENCE ELLIPSOID AT DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47866	RW_MAG_VAR_ASL	VARIATION OF MAGNETIC NORTH FROM TRUE NORTH AT DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47867	RW_LAT_ASL	GEODETIC LATITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47868	RW_LON_ASL	LONGITUDE OF RUNWAY REFERENCE POINT AT DESIGNATED ALTERNATE LANDING SITE	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47869*	TAC_ID	ARRAY OF TACAN STATION IDENTIFIERS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		
	G47871*	LATITUDE_ GEODETIC	GEODETIC LATITUDES OF THE TACAN STATIONS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47872*	RD_TAC	GEODETIC RADIUS AT THE TACAN SITES	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47873*	LONGITUDE_EAST	LONGITUDES OF THE TACAN STATIONS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47874*	ALT_ABOVE_ ELLIPSOID	THE DIFFERENCE IN AN ALTITUDE ABOVE THE REFERENCE ELLIPSOID	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47575*	MSL_ABOVE_ ELLIPSOID	THE DIFFERENCE IN AN ALTITUDE ABOVE THE REFERENCE ELLIPSOID AND THAT ALTITUDE ABOVE MEAN SEA LEVEL	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT
	G47876*	MAGNETIC_ VARIATION	ANGLE BETWEEN TRUE NORTH AND MAGNETIC NORTH AT THE TACAN STATIONS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD
	G47877*	BIAS_TAC_BRG	VECTOR OF BIASES IN THE BEARING TRANSMITTED BY THE TACAN GROUND STATIONS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		RAD

*Note: These numbers repeat at deltas of 10 to reach a total final value of G47928.

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.	Nomenclature	Source	Range	Units
	G47878* BIAS_TAC_R	VECTOR OF BIASES IN THE RANGE MEASUREMENTS OBTAINED FROM A TACAN GROUND STATIONS	LND SITE UPDATE (5.20) (VIA OPS-3 INITIALIZATION)		FT

*Note: These numbers repeat at deltas of 10 to reach a total final value of G47928.

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95A0160CB	G04205	ACC_DRAG	DRAG DECEL	ENT UPP		FT/SEC^2
V95H0175CC	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	ENT UPP	-10.+10000K	FT
V95H0175CD	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	TAEM UPP	-10.+10000K	FT
V95A0160CC	G04205	ACC_DRAG	DRAG DECEL	TAEM UPP		FT/SEC^2
V95H0175CE	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	A/L UPP	-10.+10000K	FT
V95A0160CD	G04205	ACC_DRAG	DRAG DECEL	A/L UPP		FT/SEC^2
V95W0002C	C92156	T_CURRENT_FILT	IMU INPUT TRANS TIME TAG	IMU INT PROC		SEC
V95L0065CA	C98001	V_CURRENT_FILT_ ONE	IMU 1 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L0066CA	C98004		IMU 1 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L0067CA	C98007		IMU 1 ACCUM SENSED CHANGE Z VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L1065CA	C98002	V_CURRENT_FILT_ TWO	IMU 2 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L1066CA	C98005		IMU 2 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L1067CA	C98008		IMU 2 ACCUM SENSED CHANGE Z VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2065CA	C98003	V_CURRENT_FILT_ THREE	IMU 3 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2066CA	C98006		IMU 3 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2067CA	C98009		IMU 3 ACCUM SENSED CHANGE Z VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95H3001C	G06621	Q_BARO	ADS CORRECTED PRESSURE ALTITUDE	ADTA SOP	0,100K	FT
V95W3400C	G47148	T_BARO	ADS CORRECTED PRESS ALT TIME TAG	ADTA SOP		SEC
V95X3111X	G14424	BARO_DATA_GOOD	PRESSURE ALTITUDE DATA GOOD FLAG	ADTA SOP	0,1	
V95X3112X		MACH_JUMP	ADS MACH JUMP FLAG SNAPPED	ADTA SOP	0,1	
		DRAG_CONST	DRAG ACC MODEL CONST	D/L NAV SEQ		$FT^2/SLUG$
V90X2601X	G14707	IMU_FAIL(1)	IMU 1 FAIL	IMU RM	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X2701X	G14708	IMU_FAIL(2)	IMU 2 FAIL	IMU RM	0,1	
V90X2801X	G14709	IMU_FAIL(3)	IMU 3 FAIL	IMU RM	0,1	
V90X2503X	G14723	IMU_SFC(1)	IMU SELECTION FILTER COMMAND IMU 1			
V90X2571X		IMU_SFC(2)	IMU SELECTION FILTER COMMAND IMU 2	IMU RM		
V90X2572X		IMU_SFC(3)	IMU SELECTION FILTER COMMAND IMU 3	IMU RM		
V90L25570	G14702	V_CURRENT_FILT	SEL TOTAL X VEL M50	IMU RM	+/-10M	FT/SEC
V90L2558C	G14703		SEL TOTAL Y VEL M50	IMU RM	+/-10M	FT/SEC
V90L2559C	G14704		SEL TOTAL Z VEL M50	IMU RM	+/-10M	FT/SEC
V90H3592C		Q_RAC_R	SELECTED RANGE DATA	TACAN RM		FT
V90H3590C		Q_TAC_BRG	SELECTED BEARING DATA	TACAN RM		RAD
V90X3591X	G50307	TAC_BRG_DATA_GOOD	BEARING DATA GOOD	TACAN RM	0,1	
		DELTA_T	TIME INCREMENT TO ADD TO STATE VECTOR TIME TAG	6.21		SEC
V90X3593X	G50306	TAC_RNG_DATA_GOOD	RANGE DATA GOOD	TACAN RM	0,1	
V90X3598X		IN_CONE_FLAG	INSIDE CONE FLAG	TACAN RM	0,1	
V90J3595C	G14426	SEL_LRU_ID	SELECTED LRU ID	TACAN RM	1,3	
V90W3596C		T_TACAN	TACAN TIME TAG	TACAN RM		SEC
V90X0535X	G46498	DEORBIT BURN	FLAG INDICATING THRUSTING FLIGHT	D/L NAV SEQ		
V90H0587CA	G25502	R_FILT_ONE(1)	X-COMP OF FILTER CURR POS STATE 1	D/L NAV SEQ		FT
V90H0588CA	G25503	R_FILT_ONE(2)	Y-COMP OF FILTER CURR POS STATE 1	D/L NAV SEQ		FT
V90H0589CA	G25504	R_FILT_ONE(3)	Z-COMP OF FILTER CURR POS STATE 1	D/L NAV SEQ		FT
V90H0590CA	G46510	R_FILT_TWO(1)	X-COMP OF FILTER CURR POS STATE 2	D/L NAV SEQ		FT
V90H0591CA	G46511	R_FILT_TWO(2)	Y-COMP OF FILTER CURR POS STATE 2	D/L NAV SEQ		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H0592CA	G46512	R_FILT_TWO(3)	Z-COMP OF FILTER CURR POS STATE 2	D/L NAV SEQ		FT
		DO_DELTA_T_UPDATE	FLG TO PERFORM DELTA_T UPDATE	6.21	ON/OFF	
V90H0593CA	G46519	R_FILT_THREE(1)	X-COMP OF FILTER CURR POS STATE 3	D/L NAV SEQ		FT
V90H0591CA	G46520	R_FILT_THREE(2)	Y-COMP OF FILTER CURR POS STATE 3	D/L NAV SEQ		FT
V90H0595CA	G46521	R_FILT_THREE(3)	Z-COMP OF FILTER CURR POS STATE 3	D/L NAV SEQ		FT
V90L0639CA	G25505	V_FILT_ONE(1)	X-COMP OF FILTER CURR VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0640CA	G25506	V_FILT_ONE(2)	Y-COMP OF FILTER CURR VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0641CA	G25507	V_FILT_ONE(3)	Z-COMP OF FILTER CURR VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0642CA	G46513	V_FILT_TWO(1)	X-COMP OF FILTER CURR VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0643CA	G46514	V_FILT_TWO(2)	Y-COMP OF FILTER CURR VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0644CA	G46515	V_FILT_TWO(3)	Z-COMP OF FILTER CURR VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0645CA	G46522	V_FILT_THREE(1)	X-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0646CA	G46523	V_FILT_THREE(2)	Y-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0647CA	G46524	V_FILT_THREE(3)	Z-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0630CA	G25509	V_LAST_FILT_ONE(1)	X-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0631CA	G25510	V_LAST_FILT_ONE(2)	Y-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0632CA	G25511	V_LAST_FILT_ONE(3)	Z-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0633CA	G46516	V_LAST_FILT_TWO(1)	X-COMP OF ACCUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0634CA	G46517	V_LAST_FILT_TWO(2)	Y-COMP OF ACCUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0635CA	G46518	V_LAST_FILT_TWO(3)	Z-COMP OF ACCUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0636CA	G46525	V_LAST_FILT_THREE(1)	X-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0637CA	G46526	V_LAST_FILT_THREE(2)	Y-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0638CA	G46527	V_LAST_FILT_THREE(3)	Z-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90W0534CD	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	D/L NAV SEQ		SEC
V90H0581CA	G25512	R_COV_LAST(1)	X-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90H0582CA	G25513	R_COV_LAST(2)	Y-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90H0583CA	G25514	R_COV_LAST(3)	Z-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90X0537X	G25587	NAV_THREE_STATE	THREE-STATE FLAG ON/OFF	D/L NAV SEQ		
V90U0650CA	G25551	E(1,1)	COVARIANCE MATRIX ELEMENT 1-1	D/L NAV SEQ		
V90U0651CA	G25552	E(1,2)	COVARIANCE MATRIX ELEMENT 1-2	D/L NAV SEQ		
V90U0652CA	G25553	E(1,3)	COVARIANCE MATRIX ELEMENT 1-3	D/L NAV SEQ		
V90U0653CA	G25554	E(1,4)	COVARIANCE MATRIX ELEMENT 1-4	D/L NAV SEQ		
V90U0654CA	G25555	E(1,5)	COVARIANCE MATRIX ELEMENT 1-5	D/L NAV SEQ		
V90U0655CA	G25556	E(1,6)	COVARIANCE MATRIX ELEMENT 1-6	D/L NAV SEQ		
V90U0656CA	G25557	E(2,1)	COVARIANCE MATRIX ELEMENT 2-1	D/L NAV SEQ		
V90U0657CA	G25558	E(2,2)	COVARIANCE MATRIX ELEMENT 2-2	D/L NAV SEQ		
V90U0658CA	G25559	E(2,3)	COVARIANCE MATRIX ELEMENT 2-3	D/L NAV SEQ		
V90U0659CA	G25560	E(2,4)	COVARIANCE MATRIX ELEMENT 2-4	D/L NAV SEQ		
V90U0660CA	G25561	E(2,5)	COVARIANCE MATRIX ELEMENT 2-5	D/L NAV SEQ		
V90U0661CA	G25562	E(2,6)	COVARIANCE MATRIX ELEMENT 2-6	D/L NAV SEQ		
V90U0662CA	G25563	E(3,1)	COVARIANCE MATRIX ELEMENT 3-1	D/L NAV SEQ		
V90U0663CA	G25564	E(3,2)	COVARIANCE MATRIX ELEMENT 3-2	D/L NAV SEQ		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U0664CA	G25565	E(3,3)	COVARIANCE MATRIX ELEMENT 3-3	D/L NAV SEQ		
V90U0665CA	G25566	E(3,4)	COVARIANCE MATRIX ELEMENT 3-4	D/L NAV SEQ		
V90U0666CA	G25567	E(3,5)	COVARIANCE MATRIX ELEMENT 3-5	D/L NAV SEQ		
V90U0667CA	G25568	E(3,6)	COVARIANCE MATRIX ELEMENT 3-6	D/L NAV SEQ		
V90U0668CA	G25569	E(4,1)	COVARIANCE MATRIX ELEMENT 4-1	D/L NAV SEQ		
V90U0669CA	G25570	E(4,2)	COVARIANCE MATRIX ELEMENT 4-2	D/L NAV SEQ		
V90U0670CA	G25571	E(4,3)	COVARIANCE MATRIX ELEMENT 4-3	D/L NAV SEQ		
V90U0671CA	G25572	E(4,4)	COVARIANCE MATRIX ELEMENT 4-4	D/L NAV SEQ		
V90U0672CA	G25573	E(4,5)	COVARIANCE MATRIX ELEMENT 4-5	D/L NAV SEQ		
V90U0673CA	G25574	E(4,6)	COVARIANCE MATRIX ELEMENT 4-6	D/L NAV SEQ		
V90U0674CA	G25575	E(5,1)	COVARIANCE MATRIX ELEMENT 5-1	D/L NAV SEQ		
V90U0675CA	G25576	E(5,2)	COVARIANCE MATRIX ELEMENT 5-2	D/L NAV SEQ		
V90U0676CA	G25577	E(5,3)	COVARIANCE MATRIX ELEMENT 5-3	D/L NAV SEQ		
V90U0677CA	G25578	E(5,4)	COVARIANCE MATRIX ELEMENT 5-4	D/L NAV SEQ		
V90U0678CA	G25579	E(5,5)	COVARIANCE MATRIX ELEMENT 5-5	D/L NAV SEQ		
V90U0679CA	G25580	E(5,6)	COVARIANCE MATRIX ELEMENT 5-6	D/L NAV SEQ		
V90U0680CA	G25581	E(6,1)	COVARIANCE MATRIX ELEMENT 6-1	D/L NAV SEQ		
V90U0681CA	G25582	E(6,2)	COVARIANCE MATRIX ELEMENT 6-2	D/L NAV SEQ		
V90U0682CA	G25583	E(6,3)	COVARIANCE MATRIX ELEMENT 6-3	D/L NAV SEQ		
V90U0683CA	G25584	E(6,4)	COVARIANCE MATRIX ELEMENT 6-4	D/L NAV SEQ		
V90U0684CA	G25585	E(6,5)	COVARIANCE MATRIX ELEMENT 6-5	D/L NAV SEQ		
V90U0685CA	G25586	E(6,6)	COVARIANCE MATRIX ELEMENT 6-6	D/L NAV SEQ		
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25835		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		
V90U1809CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25838		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		
V90U1813CA	G25850		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR_ TNTOMAG_S1	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR_ TNTOMAG_S2	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR_ TNTOMAG_S3	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90H1852CA	G25870	BIAS_TAC_R_SL(1)	TACAN RANGE STATION BIAS(TAC 1)	ENT SITE LOOKUP		FT
V90H1853CA	G47929	BIAS_TAC_R_SL(2)	TACAN RANGE STATION BIAS(TAC 2)	ENT SITE LOOKUP		FT
V90H1854CA	G25830	BIAS_TAC_R_SL(3)	TACAN RANGE STATION BIAS(TAC 3)	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1855CA	G25871	BIAS_TAC_BRG_SL(1)	TACAN BEARING STATION BIAS(TAC 1)	ENT SITE LOOKUP		RAD
V90H1856CA	G47931	BIAS_TAC_BRG_SL(2)	TACAN BEARING STATION BIAS(TAC 2)	ENT SITE LOOKUP		RAD
V90H1857CA	G47932	BIAS_TAC_BRG_SL(3)	TACAN BEARING STATION BIAS(TAC 3)	ENT SITE LOOKUP		RAD
V90X1858XA	G25872	TACAN_CHAN_VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	
V90X1859XA	G47933	TACAN_CHAN_VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		
V90U1793CA	G46546	M_EFTOTD_TACAN_SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90U1802CA	G46528	TACAN_ID(1)	TACAN 1 GND STA CHAN	ENT SITE LOOKUP		
V90U1803CA	G46529	TACAN_ID(2)	TACAN 2 GND STA CHAN	ENT SITE LOOKUP		
V90U1804CA	G46530	TACAN_ID(3)	TACAN 3 GND STA CHAN	ENT SITE LOOKUP		
V90U2240CA	G19849	Q_M50_BODY	M50 TO BODY QUAT MEASURED ELEM 1	A/E ATT PROC	+/-1	
V90U2241CA	G19850		M50 TO BODY QUAT MEASURED ELEM 2	A/E ATT PROC	+/-1	
V90U2242CA	G19851		M50 TO BODY QUAT MEASURED ELEM 3	A/E ATT PROC	+/-1	
V90U2243CA	G19852		M50 TO BODY QUAT MEASURED ELEM 4	A/E ATT PROC	+/-1	
V90H2246C	G46905	ALPHAIN	NAV DERIVED ANGLE OF ATTACK	A/E ATT PROC	0,45	DEG
V90H2249C	G47143	BETAIN	INERTIAL SIDESLIP ANGLE	A/E ATT PROC	+/-10	DEG
V93J4470C	G75101	TACAN_AIF	HORIZ SIT-TAC A/I/F EDIT CMD	6.21	0,2	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V93H5010CA	G71815	DR_RW	NAV UPDATE DELTA X POSIT	6.21		FT
V93H5011CA	G71816		NAV UPDATE DELTA Y POSIT	6.21		FT
V93H5012CA	G71817		NAV UPDATE DELTA Z POSIT	6.21		FT
V93H5020CA	G71818	DV_RW	NAV UPDATE DELTA X VEL	6.21		FT/SEC
V93H5021CA	G71819		NAV UPDATE DELTA Y VEL	6.21		FT/SEC
V93H5022CA	G71820		NAV UPDATE DELTA Z VEL	6.21		FT/SEC
V93X5030X	G46572	DO_DELTA_UPDATE	UPDATE DELTAS CMD	6.21		
V93J5013	G50316	DRAG_AIF	DRAG H A/I/F EDIT CMD	6.21	0,2	
V93H5010R	G71815	DR_RW	NAV UPDATE DELTA X POSIT	UL		FT
V93H5011R	G71816		NAV UPDATE DELTA Y POSIT	UL		FT
V93H5012R	G71817		NAV UPDATE DELTA Z POSIT	UL		FT
V93L5020R	G71818	DV_RW	NAV UPDATE DELTA X VEL	UL		FT/SEC
V93L5021R	G71819		NAV UPDATE DELTA Y VEL	UL		FT/SEC
V93L5022R	G71820		NAV UPDATE DELTA Z VEL	UL		FT/SEC
V96H1200C	G26137	R_GND	X-COMP UPLINK SHUTTLE POS VCTR	UL		FT
V96H1201C	G26138		Y-COMP UPLINK SHUTTLE POS VCTR	UL		FT
V96H1202C	G26139		Z-COMP UPLINK SHUTTLE POS VCTR	UL		FT
V96L1203C	G16140	V_GND	X-COMP UPLINK SHUTTLE VEL VCTR	UL		FT/SEC
V96L1204C	G16141	V_GND	Y-COMP UPLINK SHUTTLE VEL VCTR	UL		FT/SEC
V96L1205C	G16142	V_GND	Z-COMP UPLINK SHUTTLE VEL VCTR	UL		FT/SEC
V96W1206C	G26143	T_GND	TIME OF UPLINK STATE VCTR	UL		SEC
		VAR_H1	ADDITIVE VAR USED IN BARO, PROCESS	ENT SITE LOOKUP		FT^2
		VAR_H2	MULTIPLICATIVE VAR USED IN BARO PROCESS	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1818C	G25846	ALT_RW	ALTITUDE ABOVE REF ELLIPSOID OF RNWY	ENT SITE LOOKUP		FT
	G50314	BARO_AIF	HORIZ SIT_BARO A/I/F EDIT CMD	HORIZ SIT		
		RV_MAX	MAX RELATIVE VEL MAG FOR BARO PROC	ENT SITE LOOKUP		FT/SEC
	G27908	V _LAST_FILT	PREV SEL ACUML IMU VELOCITY	IMU RM		FT/SEC
	27910	OP_CODE	BIT STRING INDICATING WHOLE VECT UPD	UL		
V90H0881CA	G47416	R_FINAL	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0882CA	G47417		Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0883CA	G47418		Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90L0885CA	G47419	V_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0886CA	G47420		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0887CA	G47421		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90A0889C	G48105	G_FINAL	X-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90A0890C	G48106		Y-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90A0891C	G48107		Z-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90H1819CB	G25848	DELH_MSL_ ELLIPSOID_RW	ALT OF MSL ABOVE REF ELLIP AT RW	ENT SITE LOOKUP		FT
V95H0165CB	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE (ENTRY)	ENT UPP		FT
V95H0165CC	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE (ENTRY)	TAEM UPP		FT
V95H0165CD	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE (ENTRY)	A/L UPP		FT
V90X8865XB	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	TAEM UPP		
V90X8865XC	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	A/L UPP		
V90X3720XA	G50308	MLS_AVAIL	MLS AVAILABILITY	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95H0175CC	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	ENT UPP	-10.+10000K	FT
V95H0165CC	G04203	ALT_WHEELS	ALT TO REAR WHEELS NAV BASE(ENTRY)	TAEM UPP		FT
V95H0175CD	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	TAEM UPP	-10.+10000K	FT
V90X8865XB	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	TAEM UPP		
V95H0175CE	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	A/L UPP	-10.+10000K	FT
V90X8865XC	G49018	RAW_RA_PROC	RADAR ALTIMETER PROCESSING FLAG	A/L UPP		
V95H2001C	G06621	Q_BARO	ADS CORRECTED PRESSURE ALTITUDE	ADTA SOP	0,100K	FT
V95W3400C	G47148	T_BARO	ADS CORRECTED PRESS ALT TIME TAG	ADTA SOP		SEC
V95X3111X		BARO_DATA_GOOD	PRESSURE ALTITUDE DATA GOOD FLAG	ADTA SOP	0,1	
V95X3112X		MACH_JUMP	ADS MACH JUMP FLAG SNAPPED	ADTA SOP	0,1	
V95W6000C	G08122	T_EF_RMLS	MSBLS RANGE MEASUREMENT TIME	MSBLS SOP		SEC
V95X6010C	G08123	T_EF_AZMLS	MSBLS AZIMUTH MEASUREMENT TIME	MSBLS SOP		SEC
V95X6020C	G08124	T_EF_ELMLS	MSBLS ELEVATION MEASUREMENT TIME	MSBLS SOP		SEC
V90H3002C	G14401	Q_AZMLS	SELECTED MSBLS AZIMUTH-RAW	SF	+/-20	DEG
V90H3032C	G14402	Q_ELMLS	SELECTED MSBLS ELEVATION-RAW	SF	0.30	DEG
V90H3062C	G14403	Q_RANGE	SELECTED MSBLS RANGE-RAW	SF	0,100000	FT
V90X3003X	G14404	MLSAZ_DATA_GOOD	MSBLS AZIMUTH DATA GOOD	SF	0,1	
V90X3033X	G14405	MLSEL_DATA_GOOD	MSBLS ELEVATION DATA GOOD	SF	0,1	
V90X3063X	G14406	MLSRANGE_DATA_ GOOD	MSBLS RANGE DATA GOOD	SF	0,1	
V90L2557C	G14702	V_CURRENT_FILT	SEL TOTAL X VEL M50	IMU RM	+/-10M	FT/SEC
V9012558C	G14703		SEL TOTAL Y VEL M50	IMU RM	+/-10M	FT/SEC
V90L2559C	G14704		SEL TOTAL Z VEL M50	IMU RM	+/-10M	FT/SEC
V90H3592C		Q_TAC_R	SELECTED RANGE DATA	TACAN RM		FT

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H3590C		Q_TAC_BRG	SELECTED BEARING DATA	TACAN RM	0.2 PI	RAD
V90X3591C	G50307	TAC_BRG_DATA_GOOD	BEARING DATA GOOD	TACAN RM	0,1	
V90X3593X	G50306	TAC_RNG_DATA_GOOD	RANGE DATA GOOD	TACAN RM	0,1	FT
V90X3598X		IN_CONE_FLAG	INSIDE CONE FLAG	TACAN RM	0,1	
V90J3595C	G14426	SEL_LRU_ID	SELECTED LRU ID	TACAN RM	1,3	
V90W3596C		T_TACAN	TACAN TIME TAG	TACAN RM		SEC
V90X0537X	G25587	NAV_THREE_STATE	THREE_STATE FLAG ON/OFF	D/L NAV SEQ		
V90L0621CC	G27908	V_LAST_FILT(1)	X-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90L0622CC	G27909	V_LAST_FILT(2)	Y-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90L0623CC	G27910	V_LAST_FILT(3)	Z-COMP VEL W COV MTRX & FLTR UPDTE	ENT NAV		FT/SEC
V90H1819CA	G25848	DELH_MSL_ELLIPSOID_RW	ALT OF MSL ABOVE REF ELLIP AT RW	ENT SITE LOOKUP		FT
V90H1825CA	G25804	R_ELMLS_EF	X-COMP EF POS VCT MLS ELEV ANT	ENT SITE LOOKUP		FT
V90H1826CA	G25805		Y-COMP EF POS VCT MLS ELEV ANT	ENT SITE LOOKUP		FT
V90H1827CA	G25806		Z-COMP EF POS VCT MLS ELEV ANT	ENT SITE LOOKUP		FT
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1828CA	G25931	R_AZMLS_EF	X-COMP EF POS VCT OF MLS AZ ANT	ENT SITE LOOKUP		FT
V90H1829CA	G25932		Y-COMP EF POS VCT OF MLS AZ ANT	ENT SITE LOOKUP		FT
V90H1830CA	G25933		Z-COMP EF POS VCT OF MLS AZ ANT	ENT SITE LOOKUP		FT
V90H1831CA	G25934	R_RMLS_EF	X-COMP EF POS VCT OF MLS RNG ANT	ENT SITE LOOKUP		FT
V90H1832CA	G25935		Y-COMP EF POS VCT OF MLS RNG ANT	ENT SITE LOOKUP		FT
V90H1833CA	G25936		Z-COMP EF POS VCT OF MLS RNG ANT	ENT SITE LOOKUP		FT
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90U1865CA	G25807	M_EFTORAD_R_AZ	EF TO RNG/AZ MSBLS RDR COORD/1-1	ENT SITE LOOKUP		
V90U1866CA	G25808		EF TO RNG/AZ MSBLS RDR COORD/1-2	ENT SITE LOOKUP		
V90U1867CA	G25809		EF TO RNG/AZ MSBLS RDR COORD/1-3	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1868CA	G25810		EF TO RNG/AZ MSBLS RDR COORD/2-1	ENT SITE LOOKUP		
V90U1869CA	G25811		EF TO RNG/AZ MSBLS RDR COORD/2-2	ENT SITE LOOKUP		
V90U1870CA	G25812		EF TO RNG/AZ MSBLS RDR COORD/2-3	ENT SITE LOOKUP		
V90U1872CA	G25813		EF TO RNG/AZ MSBLS RDR COORD/3-1	ENT SITE LOOKUP		
V90U1873CA	G25814		EF TO RNG/AZ MSBLS RDR COORD/3-2	ENT SITE LOOKUP		
V90U1873CA	G25815		EF TO RNG/AZ MSBLS RDR COORD/3-3	ENT SITE LOOKUP		
V90U1875CA	G25816	M_EFTORAD_EL	EF TO MSBLS EL COORD, ELE 1-1	ENT SITE LOOKUP		
V90U1876CA	G25817		EF TO MSBLS EL COORD, ELE 1-2	ENT SITE LOOKUP		
V90U1877CA	G25818		EF TO MSBLS EL COORD, ELE 1-3	ENT SITE LOOKUP		
V90U1878CA	G25819		EF TO MSBLS EL COORD, ELE 2-1	ENT SITE LOOKUP		
V90U1879CA	G25820		EF TO MSBLS EL COORD, ELE 2-2	ENT SITE LOOKUP		
V90U1880CA	G25821		EF TO MSBLS EL COORD, ELE 2-3	ENT SITE LOOKUP		
V90U1881CA	G25822		EF TO MSBLS EL COORD, ELE 3-1	ENT SITE LOOKUP		
V90U1882CA	G25823		EF TO MSBLS EL COORD, ELE 3-2	ENT SITE LOOKUP		
V90U1883CA	G25824		EF TO MSBLS EL COORD, ELE 3-3	ENT SITE LOOKUP		
V90H1885CA	G25825	BIAS_RMLS	MSBLS RANGE MEASUREMENT BIAS	ENT SITE LOOKUP		FT
V90H1886CA	G25826	BIAZ_AZMLS	MSBLS AZIMUTH MEASUREMENT BIAS	ENT SITE LOOKUP		RAD
V90H1887CA	G25827	BIAZ_ELMLS	MSBLS ELEVATION MEASUREMENT BIAS	ENT SITE LOOKUP		RAD
V90H1852CA	G25870	BIAS_TAC_R_SL(1)	TACAN RANGE STATION BIAS(TAC 1)	ENT SITE LOOKUP		FT
V90H1853CA	G47929	BIAS_TAC_R_SL(2)	TACAN RANGE STATION BIAS(TAC 2)	ENT SITE LOOKUP		FT
V90H1854CA	G47930	BIAS_TAC_R_SL(3)	TACAN RANGE STATION BIAS(TAC 3)	ENT SITE LOOKUP		FT
V90H1855CA	G25871	BIAS_TAC_BRG_ SL(1)	TACAN BEARING STATION BIAS(TAC 1)	ENT SITE LOOKUP		RAD
V90H1856CA	G47931	BIAS_TAC_BRG_ SL(2)	TACAN BEARING STATION BIAS(TAC 2)	ENT SITE LOOKUP		RAD

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1857CA	G47932	BIAS_TAC_BRG_SL(3)	TACAN BEARING STATION BIAS(TAC 3)	ENT SITE LOOKUP		RAD
V90X1858XA	G25872	TACAN_CHAN_VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	
V90X1859XA	G47933	TACAN_CHAN_VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		
V90U1793CA	G46546	M_EFTOTD_TACAN_SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90U1802CA	G46528	TACAN_ID(1)	TACAN 1 GND STA CHAN	ENT SITE LOOKUP		
V90U1803CA	G46529	TACAN_ID(2)	TACAN 2 GND STA CHAN	ENT SITE LOOKUP		
V90U1804CA	G46530	TACAN_ID(3)	TACAN 3 GND STA CHAN	ENT SITE LOOKUP		
V90X3720XA	G50308	MLS_AVAIL	MLS AVAILABILITY INDICATOR	ENT SITE LOOKUP		
V90H0584CE	G27911	R_FILT(1)	X-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0585CE	G27912	R_FILT(2)	Y-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0586CE	G27913	R_FILT(3)	Z-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90L0624CE	G27904	V_FILT(1)	X-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0625CE	G27905	V_FILT(2)	Y-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0626CE	G27906	V_FILT(3)	Z-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90W0534CE	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	ENT NAV		SEC
V90H2217C	G19801	THETA	BODY PITCH ATTITUDE EULER ANGLE	A/E ATT PROC	+/-90	DEG

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V93J4470C	G75101	TACAN_AIF	HORIZ SIT-TAC A/I/F EDIT CMD	6.21	0,2	
V93J4473C	G50314	BARO_AIF	HORIZ SIT-BA A/I/F EDIT CMD	6.21	0,2	
V93H5010CA	G71815	DR_RW	NAV UPDATE DELTA X POSIT	6.21		FT
V93H5011CA	G71816		NAV UPDATE DELTA Y POSIT	6.21		FT
V93H5012CA	G71817		NAV UPDATE DELTA Z POSIT	6.21		FT
V93L5020CA	G71818	DV_RW	NAV UPDATE DELTA X VEL	6.21		FT/SEC
V93L5021CA	G71819		NAV UPDATE DELTA Y VEL	6.21		FT/SEC
V93L5022CA	G71820		NAV UPDATE DELTA Z VEL	6.21		FT/SEC
V93X5030X	G46572	DO_DELTA_UPDATE	UPDATE DELTA CMD	6.21, UL		
V93H5010R	G71815	DR_RW	NAV UPDATE DELTA X POSIT	UL		FT
V93H5011R	G71816		NAV UPDATE DELTA Y POSIT	UL		FT
V93H5012R	G71817		NAV UPDATE DELTA Z POSIT	UL		FT
V93L5020R	G71818	DV_RW	NAV UPDATE DELTA X VEL	UL		FT/SEC
V93L5021R	G71819		NAV UPDATE DELTA Y VEL	UL		FT/SEC
V93L5022R	G71820		NAV UPDATE DELTA Z VEL	UL		FT/SEC
V90U0650CA	G25551	E(1,1)	COVARIANCE MATRIX ELEMENT 1-1	ENT NAV		
V90U0651CA	G25552	E(1,2)	COVARIANCE MATRIX ELEMENT 1-2	ENT NAV		
V90U0652CA	G25553	E(1,3)	COVARIANCE MATRIX ELEMENT 1-3	ENT NAV		
V90U0653CA	G25554	E(1,4)	COVARIANCE MATRIX ELEMENT 1-4	ENT NAV		
V90U0654CA	G25555	E(1,5)	COVARIANCE MATRIX ELEMENT 1-5	ENT NAV		
V90U0655CA	G25556	E(1,6)	COVARIANCE MATRIX ELEMENT 1-6	ENT NAV		
V90U0656CA	G25557	E(2,1)	COVARIANCE MATRIX ELEMENT 2-1	ENT NAV		
V90U0657CA	G25558	E(2,2)	COVARIANCE MATRIX ELEMENT 2-2	ENT NAV		
V90U0658CA	G25559	E(2,3)	COVARIANCE MATRIX ELEMENT 2-3	ENT NAV		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U0659CA	G25560	E(2,4)	COVARIANCE MATRIX ELEMENT 2-4	ENT NAV		
V90U0660CA	G25561	E(2,5)	COVARIANCE MATRIX ELEMENT 2-5	ENT NAV		
V90U0661CA	G25562	E(2,6)	COVARIANCE MATRIX ELEMENT 2-6	ENT NAV		
V90U0662CA	G25563	E(3,1)	COVARIANCE MATRIX ELEMENT 3-1	ENT NAV		
V90U0663CA	G25564	E(3,2)	COVARIANCE MATRIX ELEMENT 3-2	ENT NAV		
V90U0664CA	G25565	E(3,3)	COVARIANCE MATRIX ELEMENT 3-3	ENT NAV		
V90U0665CA	G25566	E(3,4)	COVARIANCE MATRIX ELEMENT 3-4	ENT NAV		
V90U0666CA	G25567	E(3,5)	COVARIANCE MATRIX ELEMENT 3-5	ENT NAV		
V90U0667CA	G25568	E(3,6)	COVARIANCE MATRIX ELEMENT 3-6	ENT NAV		
V90U0668CA	G25569	E(4,1)	COVARIANCE MATRIX ELEMENT 4-1	ENT NAV		
V90U0669CA	G25570	E(4,2)	COVARIANCE MATRIX ELEMENT 4-2	ENT NAV		
V90U0670CA	G25571	E(4,3)	COVARIANCE MATRIX ELEMENT 4-3	ENT NAV		
V90U0671CA	G25572	E(4,4)	COVARIANCE MATRIX ELEMENT 4-4	ENT NAV		
V90U0672CA	G25573	E(4,5)	COVARIANCE MATRIX ELEMENT 4-5	ENT NAV		
V90U0673CA	G25574	E(4,6)	COVARIANCE MATRIX ELEMENT 4-6	ENT NAV		
V90U0674CA	G25575	E(5,1)	COVARIANCE MATRIX ELEMENT 5-1	ENT NAV		
V90U0675CA	G25576	E(5,2)	COVARIANCE MATRIX ELEMENT 5-2	ENT NAV		
V90U0676CA	G25577	E(5,3)	COVARIANCE MATRIX ELEMENT 5-3	ENT NAV		
V90U0677CA	G25578	E(5,4)	COVARIANCE MATRIX ELEMENT 5-4	ENT NAV		
V90U0678CA	G25579	E(5,5)	COVARIANCE MATRIX ELEMENT 5-5	ENT NAV		
V90U0679CA	G25580	E(5,6)	COVARIANCE MATRIX ELEMENT 5-6	ENT NAV		
V90U0680CA	G25581	E(6,1)	COVARIANCE MATRIX ELEMENT 6-2	ENT NAV		
V90U0681CA	G25582	E(6,2)	COVARIANCE MATRIX ELEMENT 6-3	ENT NAV		
V90U0682CA	G25583	E(6,3)	COVARIANCE MATRIX ELEMENT 6-3	ENT NAV		

INPUT FUNCTIONAL PARAMETERS FOR THE PRELAND NAVIGATION MODULE (PRELAND NAV 4.144)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U0683CA	G25584	E(6,4)	COVARIANCE MATRIX ELEMENT 6-4	ENT NAV		
V90U0684CA	G25585	E(6,5)	COVARIANCE MATRIX ELEMENT 6-5	ENT NAV		
V90U0685CA	G25586	E(6,6)	COVARIANCE MATRIX ELEMENT 6-6	ENT NAV		
V90H0581CA		R_COV_LAST(1)	X-COMP POS VCT W CURR COV MTRX	ENT NAV		FT
V90H0582CA		R_COV_LAST(2)	Y-COMP POS VCT W CURR COV MTRX	ENT NAV		FT
V90H0583CA		R_COV_LAST(3)	Z-COMP POS VCT W CURR COV MTRX	ENT NAV		FT

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING UPP SEQUENCER MODULE (D/L UPP SEQ, 4.214)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1108XA	G47153	TG_END	TAEM GUIDANCE TERMINATION FLAG	TAEM GUID	0,1	
V90X0539X	G46499	OPS_3_INIT_COMPLETE	SIG TO ENABLE CYCLIC EXEC OF UPSP	D/L NAV SEQ		
V90X8161X	G47559	MM_CODE_304	MAJOR MODE 304 FLAG	MSC	0,1	
V90X8162X	G47671	MM_CODE_305	MAJOR MODE 305 FLAG	MSC	0,1	
V90X8163X	G47937	EVENT_E11	GUIDANCE INITIATE FLAG	MSC		
V90X8624X	G78728	MM_CODE_302	MAJOR MODE 302 FLAG	MSC	0,1	
V90X8183X	G47783	EVENT_E16B	MAJOR MODE 301 FLAG	MSC	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95H0155CA	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	ENT UPP		FT
V95H0156CA	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	ENT UPP		FT
V95H0157CA	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	ENT UPP		FT
V95H0165CB	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	ENT UPP		FT
V95H0220CB	G04210	POSITION_WRT_ RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	ENT UPP		FT
V95H0221CB	G04211	POSITION_WRT_ RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	ENT UPP		FT
V95L3884CA	G22804	V_RHO_EF(1)	X VELOCITY VECTOR EF(TOD)	ENT UPP		FT/SEC
V95L3885CA	G22805	V_RHO_EF(2)	Y VELOCITY VECTOR EF(TOD)	ENT UPP		FT/SEC
V95L3886CA	G22806	V_RHO_EF(3)	Z VELOCITY VECTOR EF(TOD)	ENT UPP		FT/SEC
V95H0300CD	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	ENT UP		FT
V95H0220CC	G04210	POSITION_WRT_ RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	TAEM UPP		FT
V95H0221CC	G04211	POSITION_WRT_ RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	TAEM UPP		FT
V95H0165CC	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	TAEM UPP		FT
V95H0300CB	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	TAEM UPP		FT
V95L3884CC	G22804	V_RHO_EF(1)	X VELOCITY VECTOR EF(TOD)	TAEM UPP		FT/SEC
V95L3885CC	G22805	V_RHO_EF(2)	Y VELOCITY VECTOR EF(TOD)	TAEM UPP		FT/SEC
V95L3886CC	G22806	V_RHO_EF(3)	Z VELOCITY VECTOR EF(TOD)	TAEM UPP		FT/SEC
V95H0155CC	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	TAEM UPP		FT
V95H0156CC	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	TAEM UPP		FT
V95H0157CC	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	TAEM UPP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95H0220CD	G04210	POSITION_WRT_ RUNWAY(1)	DOWNRANGE DISTANCE WRT RW	A/L UPP		FT
V95H0221CD	G04211	POSITION_WRT_ RUNWAY(2)	CROSSRANGE DISTANCE WRT RW	A/L UPP		FT
V95H0165CD	G04203	ALT_WHEELS	ALT TO REAR WHEELS/NAV BASE(ENTRY)	A/L UPP		FT
V95H0300CC	G54410	POSITION_WRT_ RUNWAY(3)	VERTICAL DISTANCE WRT RW	A/L UPP		FT
V95H0155CD	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	A/L UPP		FT
V95H0156CD	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	A/L UPP		FT
V95H0157CD	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	A/L UPP		FT
V95H3001C	G06621	HPC	ADS CORRECTED PRESSURE ALTITUDE	ADTA SOP	0,100K	FT
V95X3111X		ALT_DG	PRESSURE ALTITUDE DATA GOOD FLAG	ADTA SOP	0,1	
V95H5102C	G07807	TACRANGEO(1)	TACAN NO 1 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5122C	G07811	TACBEARO(1)	TACAN NO 1 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5202C	G07808	TACRANGEO(2)	TACAN NO 2 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5222C	G07812	TACBEARO(2)	TACAN NO 2 BEARING OUT	TACAN SOP	0,6.28	RAD
V95H5302C	G07809	TACRANGEO(3)	TACAN NO 3 RANGE OUT	TACAN SOP	0,2432000	FT
V95H5322C	G07813	TACBEARO(3)	TACAN NO 3 BEARING OUT	TACAN SOP	0,6.28	RAD
V95X5140X	G51002	TRNG_CMLK(1)	TACAN 1 RANGE COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95X5240X	G51003	TRNG_CMLK(2)	TACAN 2 RANGE COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95X5340X	G51004	TRNG_CMLK(3)	TACAN 3 RANGE COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95X5141X	G50999	TBRG_CMLK(1)	TACAN 1 BEAR COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95X5241X	G51000	TBRG_CMLK(2)	TACAN 2 BEAR COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95X5341X	G51001	TBRG_CMLK(3)	TACAN 3 BEAR COMFAULT/LOCKON FLAG	TACAN SOP	0,1	
V95H6102C	G08119	MSBRANGEO(1)	MSBLS 1 RANGE OUT	MSBLS SOP	0,125000	FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95H6122C	G08113	MSBAZIMO(1)	MSBLS 1 AZIMUTH OUT	MSBLS SOP	+/-0.6	RAD
V95H6142C	G08116	MSBELEVO(1)	MSBLS 1 ELEVATION OUT	MSBLS SOP	0,0.6	RAD
V95H6202C	G08120	MSBRANGEO(2)	MSBLS 2 RANGE OUT	MSBLS SOP	0,125000	FT
V95H6222C	G08114	MSBAZIMO(2)	MSBLS 2 AZIMUTH OUT	MSBLS SOP	+/-0.6	RAD
V95H6242C	G08117	MSBELEVO(2)	MSBLS 2 ELEVATION OUT	MSBLS SOP	0,0.6	RAD
V95H6302C	G08121	MSBRANGEO(3)	MSBLS 3 RANGE OUT	MSBLS SOP	0,125000	FT
V95H6322C	G08115	MSBAZIMO(3)	MSBLS 3 AZIMUTH OUT	MSBLS SOP	+/-0.6	RAD
V95H6342C	G08118	MSBELEVO(3)	MSBLS 3 ELEVATION OUT	MSBLS SOP	0,0.6	RAD
V95X6056X	G50729	MRNG_CMLK(1)	MSBLS 1 RANGE COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6062X	G50730	MRNG_CMLK(2)	MSBLS 2 RANGE COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6067X	G50731	MRNG_CMLK(3)	MSBLS 3 RANGE COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6057X	G50723	MELV_CMLK(1)	MSBLS 1 EL COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6063X	G50724	MELV_CMLK(2)	MSBLS 2 EL COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6068X	G50725	MELV_CMLK(3)	MSBLS 3 EL COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6058X	G50726	MAZM_CMLK(1)	MSBLS 1 AZ COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6064X	G50727	MAZM_CMLK(2)	MSBLS 2 AZ COMFAULT/LOCKON FLAG	MSBLS SOP		
V95X6069X	G50728	MAZM_CMLK(3)	MSBLS 3 AZ COMFAULT/LOCKON FLAG	MSBLS SOP		
V90H1815CA	G25801	X_DMEAZ_RW	X-COMP RNG/AZ ANTENNA IN RW COORD	ENT SITE LOOKUP		FT
V90H1816CA	G25802	Y_DMEAZ_RW	Y-COMP RNG/AZ ANTENNA IN RW COORD	ENT SITE LOOKUP		FT
V90H1817CA	G25847	AZIMUTH_RW	AZIMUTH OF RW FROM TRUE NORTH	ENT SITE LOOKUP		RAD
V90H1818CA	G25846	ALT_RW	ALTITUDE OF RW WRT REF ELLIPSOID	ENT SITE LOOKUP		FT
V90H1819CA	G25848	DELH_MSL ELLIPSOID_RW	ALT OF MSL ABOVE REF ELLIP AT RW	ENT SITE LOOKUP		FT
V90H1820CA	G25849	ANGLE_CORR_ TNTOMAG_RW	MAGNETIC VARIATION OF RW	ENT SITE LOOKUP	0,6.28	RAD

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1805CA	G25832	M_EFTORW	EF TO PRIME RW XFORM MTRX ELE 1-1	ENT SITE LOOKUP		
V90U1806CA	G25833		EF TO PRIME RW XFORM MTRX ELE 1-2	ENT SITE LOOKUP		
V90U1807CA	G25834		EF TO PRIME RW XFORM MTRX ELE 1-3	ENT SITE LOOKUP		
V90U1808CA	G25836		EF TO PRIME RW XFORM MTRX ELE 2-1	ENT SITE LOOKUP		
V90U1809CA	G25837		EF TO PRIME RW XFORM MTRX ELE 2-2	ENT SITE LOOKUP		
V90U1810CA	G25838		EF TO PRIME RW XFORM MTRX ELE 2-3	ENT SITE LOOKUP		
V90U1811CA	G25839		EF TO PRIME RW XFORM MTRX ELE 3-1	ENT SITE LOOKUP		
V90U1812CA	G25840		EF TO PRIME RW XFORM MTRX ELE 3-2	ENT SITE LOOKUP		
V90U1813CA	G25841		EF TO PRIME RW XFORM MTRX ELE 3-3	ENT SITE LOOKUP		
V90H1834CA	G25904	R_TACAN_EF_SL(1)	X-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1835CA	G25905		Y-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1836CA	G25906		Z-COMP EF POS VECTOR OF TACAN 1	ENT SITE LOOKUP		FT
V90H1837CA	G25907	R_TACAN_EF_SL(2)	X-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1838CA	G25908		Y-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1839CA	G25909		Z-COMP EF POS VECTOR OF TACAN 2	ENT SITE LOOKUP		FT
V90H1840CA	G25910	R_TACAN_EF_SL(3)	X-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1841CA	G25911		Y-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1842CA	G25912		Z-COMP EF POS VECTOR OF TACAN 3	ENT SITE LOOKUP		FT
V90H1843CA	G25916	ANGLE_CORR_ TNTOMAG_SL(1)	MAGNETIC VARIATION AT TACAN 1 SITE	ENT SITE LOOKUP		RAD
V90H1844CA	G25922	ANGLE_CORR_ TNTOMAG_SL(2)	MAGNETIC VARIATION AT TACAN 2 SITE	ENT SITE LOOKUP		RAD
V90H1845CA	G25927	ANGLE_CORR_ TNTOMAG_SL(3)	MAGNETIC VARIATION AT TACAN 3 SITE	ENT SITE LOOKUP		RAD
V90H1846CA	G25917	ALT_TACAN_SL(1)	ALTITUDE OF TACAN 1 STATION	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1847CA	G25923	ALT_TACAN_SL(2)	ALTITUDE OF TACAN 2 STATION	ENT SITE LOOKUP		FT
V90H1848CA	G25928	ALT_TACAN_SL(3)	ALTITUDE OF TACAN 3 STATION	ENT SITE LOOKUP		FT
V90H1849CA	G25919	DH_TACAN_SL(1)	ALT OF MSL ABV REF ELLIP AT TAC 1	ENT SITE LOOKUP		FT
V90H1850CA	G25924	DH_TACAN_SL(2)	ALT OF MSL ABV REF ELLIP AT TAC 2	ENT SITE LOOKUP		FT
V90H1851CA	G25930	DH_TACAN_SL(3)	ALT OF MSL ABV REF ELLIP AT TAC 3	ENT SITE LOOKUP		FT
V90U1890CA	G25852	M_EFTORW_SEC	EARTH FIXED TO SEC RUNWAY, ELE 1-1	ENT SITE LOOKUP		
V90U1891CA	G25853		EARTH FIXED TO SEC RUNWAY, ELE 1-2	ENT SITE LOOKUP		
V90U1892CA	G25854		EARTH FIXED TO SEC RUNWAY, ELE 1-3	ENT SITE LOOKUP		
V90U1893CA	G25855		EARTH FIXED TO SEC RUNWAY, ELE 2-1	ENT SITE LOOKUP		
V90U1894CA	G25856		EARTH FIXED TO SEC RUNWAY, ELE 2-2	ENT SITE LOOKUP		
V90U1895CA	G25857		EARTH FIXED TO SEC RUNWAY, ELE 2-3	ENT SITE LOOKUP		
V90U1896CA	G25858		EARTH FIXED TO SEC RUNWAY, ELE 3-1	ENT SITE LOOKUP		
V90U1897CA	G25859		EARTH FIXED TO SEC RUNWAY, ELE 3-2	ENT SITE LOOKUP		
V90U1898CA	G25860		EARTH FIXED TO SEC RUNWAY, ELE 3-3	ENT SITE LOOKUP		
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1910CA	G46535	X_EL_RW	X-COMP OF ELEV ANTENNA IN RW COORD	ENT SITE LOOKUP		FT
V90H1911CA	G25869	AZIMUTH_RW_SEC	AZ OF SEC RW FROM TRUE NORTH	ENT SITE LOOKUP		RAD
V90H1913CA	G25868	ANGLE_CORR_ TNTOMAG_RW_SEC	MAGNETIC VARIATION OF SEC RW	ENT SITE LOOKUP		RAD
V90H1903CA	G25861	R_LS_EF_SEC	X-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT
V90H1904CA	G25862		Y-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT
V90H1905CA	G25863		Z-COMP SEC LDG SITE POS VCT IN EF	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90X1858XA	G25872	TACAN_CHAN_VALID_SL(1)	TACAN CHANNEL VALIDITY FLAG(TAC 1)	ENT SITE LOOKUP	0,1	
V90X1859XA	G47933	TACAN_CHAN_VALID_SL(2)	TACAN CHANNEL VALIDITY FLAG(TAC 2)	ENT SITE LOOKUP	0,1	
V90X1860XA	G47934	TACAN_CHAN_VALID_SL(3)	TACAN CHANNEL VALIDITY FLAG(TAC 3)	ENT SITE LOOKUP	0,1	
V90U1775CA	G25873	M_EFTOTD_TACAN_SL(1)	EF TO TOPO COORD AT TA SITE 1/1-1	ENT SITE LOOKUP		
V90U1776CA	G25874		EF TO TOPO COORD AT TA SITE 1/1-2	ENT SITE LOOKUP		
V90U1777CA	G25875		EF TO TOPO COORD AT TA SITE 1/1-3	ENT SITE LOOKUP		
V90U1778CA	G25876		EF TO TOPO COORD AT TA SITE 1/2-1	ENT SITE LOOKUP		
V90U1779CA	G25877		EF TO TOPO COORD AT TA SITE 1/2-2	ENT SITE LOOKUP		
V90U1780CA	G25878		EF TO TOPO COORD AT TA SITE 1/2-3	ENT SITE LOOKUP		
V90U1781CA	G25879		EF TO TOPO COORD AT TA SITE 1/3-1	ENT SITE LOOKUP		
V90U1782CA	G25880		EF TO TOPO COORD AT TA SITE 1/3-2	ENT SITE LOOKUP		
V90U1783CA	G25881		EF TO TOPO COORD AT TA SITE 1/3-3	ENT SITE LOOKUP		
V90U1784CA	G46537	M_EFTOTD_TACAN_SL(2)	EF TO TOPO COORD AT TA SITE 2/1-1	ENT SITE LOOKUP		
V90U1785CA	G46538		EF TO TOPO COORD AT TA SITE 2/1-2	ENT SITE LOOKUP		
V90U1786CA	G46539		EF TO TOPO COORD AT TA SITE 2/1-3	ENT SITE LOOKUP		
V90U1787CA	G46540		EF TO TOPO COORD AT TA SITE 2/2-1	ENT SITE LOOKUP		
V90U1788CA	G46541		EF TO TOPO COORD AT TA SITE 2/2-2	ENT SITE LOOKUP		
V90U1789CA	G46542		EF TO TOPO COORD AT TA SITE 2/2-3	ENT SITE LOOKUP		
V90U1790CA	G46543		EF TO TOPO COORD AT TA SITE 2/3-1	ENT SITE LOOKUP		
V90U1791CA	G46544		EF TO TOPO COORD AT TA SITE 2/3-2	ENT SITE LOOKUP		
V90U1792CA	G46545		EF TO TOPO COORD AT TA SITE 2/3-3	ENT SITE LOOKUP		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U1793CA	G46546	M_EFTOTD_TACAN_SL(3)	EF TO TOPO COORD AT TA SITE 3/1-1	ENT SITE LOOKUP		
V90U1794CA	G46547		EF TO TOPO COORD AT TA SITE 3/1-2	ENT SITE LOOKUP		
V90U1795CA	G46548		EF TO TOPO COORD AT TA SITE 3/1-3	ENT SITE LOOKUP		
V90U1796CA	G46549		EF TO TOPO COORD AT TA SITE 3/2-1	ENT SITE LOOKUP		
V90U1797CA	G46550		EF TO TOPO COORD AT TA SITE 3/2-2	ENT SITE LOOKUP		
V90U1798CA	G46551		EF TO TOPO COORD AT TA SITE 3/2-3	ENT SITE LOOKUP		
V90U1799CA	G46552		EF TO TOPO COORD AT TA SITE 3/3-1	ENT SITE LOOKUP		
V90U1800CA	G46553		EF TO TOPO COORD AT TA SITE 3/3-2	ENT SITE LOOKUP		
V90U1801CA	G46554		EF TO TOPO COORD AT TA SITE 3/3-3	ENT SITE LOOKUP		
V90H1861CA	G46532	RD_TAC_SL(1)	GEODETIC RADIUS AT TACAN SITE 1	ENT SITE LOOKUP		FT
V90H1862CA	G46533	RD_TAC_SL(2)	GEODETIC RADIUS AT TACAN SITE 2	ENT SITE LOOKUP		FT
V90H1863CA	G46534	RD_TAC_SL(3)	GEODETIC RADIUS AT TACAN SITE 3	ENT SITE LOOKUP		FT
V90H1925CA		R_CC_L_PRI	X-COMP POS VCT HAC LFT SIDE RW	ENT SITE LOOKUP		FT
V90H1926CA			Y-COMP POS VCT HAC LFT SIDE RW	ENT SITE LOOKUP		FT
V90H1927CA			Z-COMP POS VCT HAC LFT SIDE RW	ENT SITE LOOKUP		FT
V90H1928CA		R_CC_R_PRI	X-COMP POS VCT HAC RHT SIDE RW	ENT SITE LOOKUP		FT
V90H1929CA			Y-COMP POS VCT HAC RHT SIDE RW	ENT SITE LOOKUP		FT
V90H1930CA			Z-COMP POS VCT HAC RHT SIDE RW	ENT SITE LOOKUP		FT
V90H1931CA		R_CC_LMAG_PRI	MAG OF POS VCT HAC LFT SIDE RW	ENT SITE LOOKUP		FT
V90H1932CA		R_CC_RMAG_PRI	MAG OF POS VCT HAC RHT SIDE RW	ENT SITE LOOKUP		FT
V90H1933CA		R_CC_L_SEC	X-COMP POS VCT HAC LS SEC RW	ENT SITE LOOKUP		FT
V90H1934CA			Y-COMP POS VCT HAC LS SEC RW	ENT SITE LOOKUP		FT
V90H1935CA			Z-COMP POS VCT HAC LS SEC RW	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AREA NAVIGATION PROCESSING MODULE (ENT AREA NAV, 4.220)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H1936CA		R_CC_R_SEC	X-COMP POS VCT HAC RS SEC RW	ENT SITE LOOKUP		FT
V90H1937CA			Y-COMP POS VCT HAC RS SEC RW	ENT SITE LOOKUP		FT
V90H1938CA			Z-COMP POS VCT HAC RS SEC RW	ENT SITE LOOKUP		FT
V90H1939CA		R_CC_LMAG_SEC	MAG OF POS VCT HAC LS SEC RW	ENT SITE LOOKUP		FT
V90H1940CA		R_CC_RMAG_SEC	MAG OF POS VCT HAC RS SEC RW	ENT SITE LOOKUP		FT
V96X2101X	G44889	MODE_LEFT	LH HSI MODE SELECT	GN&C SW RM		
V96X2201X	G44890	MODE_RIGHT	RH HSI MODE SELECT	GN&C SW RM		
V96X2111X	G44891	SOURCE_LEFT	LH HSI SOURCE SELECT	GN&C SW RM	0,1	
V96X2211X	G44892	SOURCE_RIGHT	RH HSI SOURCE SELECT	GN&C SW RM	0,1	
V96J2105C	G44893	RCVR_LEFT	LH HSI RECEIVER SELECT	GN&C SW RM	1,3	
V96J2205C	G44894	RCVR_RIGHT	RH HSI RECEIVER SELECT	GN&C SW RM	1,3	
V90U2023CC	G48797	M	CURRENT VEHICLE MASS	DEORB GUID		SLUGS
V90H2212C	G47803	PSI_HSIMV	HEADING RELATIVE TO MAG NORTH	A/E ATT PROC	+/-3.14	RAD
V93X4466X	G75103	NEP	HORIZ SIT-ENTRY POINT SWITCH CMD	6.21		
V93X4476X	G50902	HI_WINDS	HORIZ SIT-HEAD WIND HI/LO IND	6.21		
V90X8161X	G47559	MM_CODE_304	MAJOR MODE 304 FLAG	MSC	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY PRECISE PREDICTOR MODULE (ENT PREC PRED 4.223)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90W9512CD	G47414	T_INIT	TIME AT BEGINNING OF PRED	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		SEC
V90U8500CC	G47405	DT_MAX	MAX ALLOW TIME STEP SIZE	AOA/ATO TGT, ENT NAV		SEC
V90U8502CC	G47407	GMO_PRED	GRAVITY MODEL ORDER	AOA/ATO TGT, ENT NAV		
V90U8501CC	G47406	GMD_PRED	GRAVITY MODEL DEGREE	AOA/ATO TGT, ENT NAV		
V90H8508CD	G47408	R_INIT	X-COMP SHUTTLE POS VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT
V90H8509CD	G47409		Y-COMP SHUTTLE POS VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT
V90H8510CD	G47410		Z-COMP SHUTTLE POS VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT
V90L8513CD	G47411	V_INIT	X-COMP SHUTTLE VEL VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT/SEC
V90L8514CD	G47412		Y-COMP SHUTTLE VEL VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT/SEC
V90L8515CD	G47413		Z-COMP SHUTTLE VEL VECTR AT T_INIT	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		FT/SEC
V90W8506CD	G47415	T_FINAL	TIME AT WHICH STATE IS DESIRED	AOA/ATO TGT, D/L NAV SEQ, ENT NAV		SEC
V90U8500CD	G47405	DT_MAX	MAX ALLOW TIME STEP SIZE	D/L NAV SEQ		SEC
V90U8502CD	G47407	GMO_PRED	GRAVITY MODEL ORDER	D/L NAV SEQ		
V90U8501CD	G47406	GMD_PRED	GRAVITY MODEL DEGREE	D/L NAV SEQ		
V90U8500CF	G47405	DTAVG	MAX ALLOW TIME STEP SIZE	DEORB GUID		SEC
V90H8508CF	G47408	RC1(1)	X-COMP SHUTTLE POS VECTR AT T_INIT	DEORB GUID		FT
V90H8509CF	G47409	RC1(2)	Y-COMP SHUTTLE POS VECTR AT T_INIT	DEORB GUID		FT
V90H8510CF	G47410	RC1(3)	Z-COMP SHUTTLE POS VECTR AT T_INIT	DEORB GUID		FT
V90L8513CF	G47411	VC1(1)	X-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB GUID		FT/SEC
V90L8514CF	G47412	VC1(2)	Y-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB GUID		FT/SEC
V90L8515CF	G47413	VC1(3)	Z-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB GUID		FT/SEC
V90W8512CF	G47414	TGD	TIME AT BEGINNING OF PRED	DEORB GUID		SEC
V90W8506CF	G47415	TP	TIME AT WHICH STATE IS DESIRED	DEORB GUID		SEC
V90U8501CF	G47406	GMD_PRED	GRAVITY MODEL DEGREE	DEORB GUID		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY PRECISE PREDICTOR MODULE (ENT PREC PRED 4.223)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U8502CF	G47407	GMO_PRED	GRAVITY MODEL ORDER	DEORB GUID		
V90U8502CG	G47407	GMO_PRED	GRAVITY MODEL ORDER	DEORB MNVR DIP		
V90U8501CG	G47406	GMD_PRED	GRAVITY MODEL DEGREE	DEORB MNVR DIP		
V90U8500CH	G47405	DT_RNG,DTMIN	MAX ALLOW TIME STEP SIZE	DEORB MNVR DIP		SEC
V90H8508CG	G47408	RNAV,RD1,RC1	X-COMP SHUTTLE POS VECTR AT T_INIT	DEORB MNVR DIP		FT
V90H8509CG	G47409		Y-COMP SHUTTLE POS VECTR AT T_INIT	DEORB MNVR DIP		FT
V90H8510CG	G47410		Z-COMP SHUTTLE POS VECTR AT T_INIT	DEORB MNVR DIP		FT
V90L8514CG	G47411	VNAV,VD1,VC1	X-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB MNVR DIP		FT/SEC
V90L8515CG	G47412		Y-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB MNVR DIP		FT/SEC
V90L8516CG	G47413		Z-COMP SHUTTLE VEL VECTR AT T_INIT	DEORB MNVR DIP		FT/SEC
V90W8512CH	G47414	TNAV,T1	TIME AT BEGINNING OF PRED	DEORB MNVR DIP		SEC
V90W8506CH	G47415	TIG,TGO	TIME AT WHICH STATE IS DESIRED	DEORB MNVR DIP		SEC
V90H2246C	G46905	ALPHAIN	NAV DERIVED ANGLE OF ATTACK	A/E ATT PROC	0,45	DEG
V90H2249C	G47143	BETAIN	INERTIAL SIDESLIP ANGLE	A/E ATT PROC	+/-10	DEG

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AUTO TACAN SELECT MODULE (ENT AUTO TAC SEL 4.239)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95H0155CA	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	ENT UPP		FT
V95H0156CA	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	ENT UPP		FT
V95H0157CA	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	ENT UPP		FT
V95H0155CC	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	TAEM UPP		FT
V95H0156CC	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	TAEM UPP		FT
V95H0157CC	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	TAEM UPP		FT
V95H0155CD	G46579	R_EF(1)	ORBITER X POSITION EF(TOD)	A/L UPP		FT
V95H0156CD	G46580	R_EF(2)	ORBITER Y POSITION EF(TOD)	A/L UPP		FT
V95H0157CD	G46581	R_EF(3)	ORBITER Z POSITION EF(TOD)	A/L UPP		FT
V90X8599X		ID_CHANGE_ REQUEST	ID CHANGE REQUEST	TACAN RM	0,1	
V90H1900CA	G25842	R_LS_EF	X-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1901CA	G25843		Y-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H1902CA	G25844		Z-COMP LDG SITE POS VCT - EF COORD	ENT SITE LOOKUP		FT
V90H3721CA	G50825	R_TAC_EF(1,1)	X-COMP EF POS VECTOR OF TAC SITE1	ENT SITE LOOKUP		FT
V90H3722CA	G50826	R_TAC_EF(1,2)	Y-COMP EF POS VECTOR OF TAC SITE1	ENT SITE LOOKUP		FT
V90H3723CA	G50827	R_TAC_EF(1,3)	Z-COMP EF POS VECTOR OF TAC SITE1	ENT SITE LOOKUP		FT
V90H3724CA	G50828	R_TAC_EF(2,1)	X-COMP EF POS VECTOR OF TAC SITE2	ENT SITE LOOKUP		FT
V90H3725CA	G50829	R_TAC_EF(2,2)	Y-COMP EF POS VECTOR OF TAC SITE2	ENT SITE LOOKUP		FT
V90H3726CA	G50830	R_TAC_EF(2,3)	Z-COMP EF POS VECTOR OF TAC SITE2	ENT SITE LOOKUP		FT
V90H3727CA	G50831	R_TAC_EF(3,1)	X-COMP EF POS VECTOR OF TAC SITE3	ENT SITE LOOKUP		FT
V90H3728CA	G50832	R_TAC_EF(3,2)	Y-COMP EF POS VECTOR OF TAC SITE3	ENT SITE LOOKUP		FT
V90H3729CA	G50833	R_TAC_EF(3,3)	Z-COMP EF POS VECTOR OF TAC SITE3	ENT SITE LOOKUP		FT
V90H3730CA	G50834	R_TAC_EF(4,1)	X-COMP EF POS VECTOR OF TAC SITE4	ENT SITE LOOKUP		FT

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY AUTO TACAN SELECT MODULE (ENT AUTO TAC SEL 4.239)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90H3731CA	G50835	R_TAC_EF(4,2)	Y-COMP EF POS VECTOR OF TAC SITE4	ENT SITE LOOKUP		FT
V90H3732CA	G50836	R_TAC_EF(4,3)	Z-COMP EF POS VECTOR OF TAC SITE4	ENT SITE LOOKUP		FT
V90H3733CA	G50837	R_TAC_EF(5,1)	X-COMP EF POS VECTOR OF TAC SITE5	ENT SITE LOOKUP		FT
V90H3734CA	G50838	R_TAC_EF(5,2)	Y-COMP EF POS VECTOR OF TAC SITE5	ENT SITE LOOKUP		FT
V90H3735CA	G50839	R_TAC_EF(5,3)	Z-COMP EF POS VECTOR OF TAC SITE5	ENT SITE LOOKUP		FT
V90H3736CA	G50840	R_TAC_EF(6,1)	X-COMP EF POS VECTOR OF TAC SITE6	ENT SITE LOOKUP		FT
V90H3737CA	G50841	R_TAC_EF(6,2)	Y-COMP EF POS VECTOR OF TAC SITE6	ENT SITE LOOKUP		FT
V90H3738CA	G50842	R_TAC_EF(6,3)	Z-COMP EF POS VECTOR OF TAC SITE6	ENT SITE LOOKUP		FT
V90H3739CA	G50843	R_TAC_EF(7,1)	X-COMP EF POS VECTOR OF TAC SITE7	ENT SITE LOOKUP		FT
V90H3740CA	G50844	R_TAC_EF(7,2)	Y-COMP EF POS VECTOR OF TAC SITE7	ENT SITE LOOKUP		FT
V90H3741CA	G50845	R_TAC_EF(7,3)	Z-COMP EF POS VECTOR OF TAC SITE7	ENT SITE LOOKUP		FT
V90H3742CA	G50846	R_TAC_EF(8,1)	X-COMP EF POS VECTOR OF TAC SITE8	ENT SITE LOOKUP		FT
V90H3743CA	G50847	R_TAC_EF(8,2)	Y-COMP EF POS VECTOR OF TAC SITE8	ENT SITE LOOKUP		FT
V90H3744CA	G50848	R_TAC_EF(8,3)	Z-COMP EF POS VECTOR OF TAC SITE8	ENT SITE LOOKUP		FT
V90H3745CA	G50849	R_TAC_EF(9,1)	X-COMP EF POS VECTOR OF TAC SITE9	ENT SITE LOOKUP		FT
V90H3746CA	G50850	R_TAC_EF(9,2)	Y-COMP EF POS VECTOR OF TAC SITE9	ENT SITE LOOKUP		FT
V90H3747CA	G50851	R_TAC_EF(9,3)	Z-COMP EF POS VECTOR OF TAC SITE9	ENT SITE LOOKUP		FT
V90H3748CA	G50852	R_TAC_EF(10,1)	X-COMP EF POS VECTOR OF TAC SITE10	ENT SITE LOOKUP		FT
V90H3749CA	G50853	R_TAC_EF(10,2)	Y-COMP EF POS VECTOR OF TAC SITE10	ENT SITE LOOKUP		FT
V90H3750CA	G50854	R_TAC_EF(10,3)	Z-COMP EF POS VECTOR OF TAC SITE10	ENT SITE LOOKUP		FT

APPENDIX H

OFT-1 CHANGE PAGES

The pages contained in this Appendix are replacement pages for the body of this document. These pages convert the expressed navigation requirements into the requirements approved for OFT-1.

Table 4.1.1-1.- OPS-3 Level B Events

Event No.*	Event Name	Nav Criteria	Nav Action
85	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition initialization. Initiate entry navigation (deorbit preparation phase).
59	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	Same as above
A20	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	Same as above
E1	OPS transition to OPS-2 from OPS-3	OPS transition to OPS-2 from OPS-3	Reduce three-state to one-state and save off OPS-2 initialization data.
E11A	Initiate power flight navigation	Deorbit maneuver begins in TBD seconds	Cancel entry navigation (deorbit preparation phase). Initiate entry navigation (deorbit execute phase).
E10	Mode transition to 301 from 302	Mode transition to 301 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (deorbit preparation phase).
E15	Mode transition to 303 from 302	Mode transition to 303 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (entry phase)
E16B	Mode transition to 301 from 303	Mode transition to 301 from 303	Cancel entry navigation (entry phase). Initiate entry navigation (deorbit preparation phase).
E20	Three-state to	MSBLS range and	Cancel entry navigation pre-land navigation.

*Current Level B event numbers.

(2) Deorbit execute navigation phase - The deorbit navigation phase will begin whenever the deorbit execute major mode (302) is active and the event flag indicating the deorbit burn is to begin in TBD seconds is on. This phase uses the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function and to initialize the deorbit burn flag to ON to prevent measurement processing. The capability will also be provided for sequencing the entry navigation principal function at the designated function at the designated repetition rate.

[This area is intentionally left blank]

(4) Entry navigation phase - The entry navigation phase will begin at initiation of the pre-entry monitor major mode (303). This phase will use the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function.

The deorbit burn flag will be set to OFF to enable measurement processing.

After completion of initialization, the capability will be provided for sequencing the entry navigation principal function at the designated repetition rate.

(5) Preland navigation phase - The preland navigation phase will begin whenever MSBLS is available at the landing site, Major mode 304 or Major mode 305 is active, and the selected MSBLS range and azimuth data are valid.

This phase will use the preland navigation principal function.

Upon satisfaction of the transition Criterion, repetition of the current entry navigation principal function will be cancelled. The flag indicating three-state-operation will be turned OFF.

NAV_THREE_STATE = OFF

Finally, a flag is to be set to indicate preland transition complete.

PRELAND_TRANSITION = ON

The capability also will be provided for sequencing the preland navigation principal function at a premission determined repetition rate.

B. Interface Requirements. The deorbit/landing navigation sequencer principal function will be sequenced at least once at the beginning of Major Modes 301 and 303. This principal function will be sequenced at a 0.52-Hertz rate upon entrance to Major Mode 302 until the requirements associated with the deorbit burn event flag are completed and upon entrance to Major Mode 304 and for Major Mode 305 until the requirements associated with valid MSBLS data are completed.

C. Processing Requirements. Before the OPS-2 initialization subfunction can be accomplished, entry navigation must be executed at least once.

D. Constraints. OPS_3_RECONFIGURE and PRELAND_TRANSITION shall be initialized to 'OFF'.

E. Supplemental Information. A suggested implementation of these requirements is illustrated in Appendix B, DEORBIT/LANDING_NAV_SEQUENCER.

TABLE 4.1.1-2.- DEORBIT/LANDING NAVIGATION SEQUENCER INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Major mode number (set by MSC for use by navigation)	MM_CODE	*	I	S			Seq rate
Flag inidicating (ON) that OPS-3 initialization is complete.	OPS_3_ RECONFIGURE	***	D		OFF/ON		Seq rate
Flag indicating (ON) that the deorbit burn begins in TBD seconds	INITIATE_PWR_ FLIGHT_NAV_ EVENT	*	D		OFF/ON		Seq rate
Sequencing time interval for entry navigation during coasting flight prior to deorbit burn	DT_DEORB_PREP _NAV	**	F	S		sec	Seq rate
Sequencing time interval for entry navigation during deorbit burn	DT_DEORB_PF_ NAV	**	F	S		sec	Seq rate
Sequencing time interval for entry navigation after completion of deorbit burn	DT_ENTRY_NAV	**	F	S		sec	Seq rate
Flag indicating (ON) a transition from OPS-3 to OPS-2	EVENT E1	*	I				Seq rate

*See Deorbit/landing principal function IN_LIST (Appendix G)
**See Section 4.9
***See Section 4.1.1.D. (constraints)

TABLE 4.1.1-2.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that transition to preland navigation principal function is complete	PRELAND_ TRANSITION	***	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_DATA _GOOD	*	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	*	D		OFF/ON		Seq rate
Flag indicating the availability of MSBLS data at the selected at the selected runway	MLS_AVAIL	*	D		OFF/ON		Seq rate
Sequencing time interval for MSBLS navigation sensor processing function	DT_LAND	**	F	S		sec	Seq rate
Previous value of selected accumulated IMU velocity	V _LAST_FILT	*	V	S		ft/sec	Seq rate
Shuttle position vector for OPS-3 initialization	R _FILT_INIT	*	V	DP		ft	Once
Shuttle velocity vector for OPS-3 initialization	V _FILT_INIT	*	V	S		ft/sec	Once
Time tag of R _FILT_INIT and V _FILT_INIT	T_FILT_INIT	*	F	DP		sec	Once
Past value for total acumulated velocity sensed by IMU 1	V _LAST_FILT_ ONE	*		S		ft/sec	Once

*See D/L navigation principal function in list (Appendix G)
**See Section 4.9
***See Section 4.1.1D. (constraints)

TABLE 4.1.1-2.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Flag indicating (ON) that transition to preland navigation principal function is complete	PRELAND_ TRANSITION	***	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSRANGE_DATA _GOOD	*	D		OFF/ON		Seq rate
Copy of current data good discrete reserved for measurement processing	MLSAZ_DATA_ GOOD	*	D		OFF/ON		Seq rate
Flag indicating the availability of MSBLS data at the selected at the selected runway	MLS_AVAIL	*	D		OFF/ON		Seq rate
Sequencing time interval for MSBLS navigation sensor processing function	DT_LAND	**	F	S		sec	Seq rate
Previous value of selected accumulated IMU velocity	$\underline{V}$ _LAST_FILT	*	V	S		ft/sec	Seq rate
Shuttle position vector for OPS-3 initialization	$\underline{R}$ _FILT_INIT	*	V	DP		ft	Once
Shuttle velocity vector for OPS-3 initialization	$\underline{V}$ _FILT_INIT	*	V	S		ft/sec	Once
Time tag of $\underline{R}$ _FILT_INIT and $\underline{V}$ _FILT_INIT	T_FILT_INIT	*	F	DP		sec	Once
Past value for total acumulated velocity sensed by IMU 1	$\underline{V}$ _LAST_FILT_ ONE	*		S		ft/sec	Once

*See D/L navigation principal function in list (Appendix G)
**See Section 4.9
***See Section 4.1.1D. (constraints)

TABLE 4.1.1-2.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Past value for total accumulated velocity sensed by IMU 2	V_LAST_FILT_TWO	*	F	S		ft/sec	Once
Past value for total accumulated velocity sensed by IMU 3	V_LAST_FILT_THREE	*	F	S		ft/sec	Once
Time tag associated with the past values for total accumulated velocity sensed by the IMU's	T_LAST_FILT	*	F	DP		sec	Once
Position vector propagated to current time	R_FINAL	*	V	DP		ft	Once
Velocity vector propagated to current time	V_FINAL	*	V	S		ft/sec	Once
Current gravity vector	G_FINAL	*	V	S		ft/sec^2	Once
Current middle selected position vector	R_FILT	*	V	DP		ft	Once
Current middle selected velocity vector	V_FILT	*	V	S		ft/sec	Once
Time step to propagate the state vector from the previous operation sequence	DEL_TIME_STEP	**	F	S		sec	Once
Square roots of the diagonal elements or the covariance matrix from OPS-2/premission load.	SIG_DIAG_UVW_INIT	*	V	DP		vary	Once

*See D/L nav principal function in list (Appendix G)

TABLE 4.1.1-2.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Correlation coefficients from OPS-2/premission load	CORR_COEFF_INIT	*	V	DP		-	Once

*See D/L nav principal function in list (Appendix G)
**See Section 4.9

TABLE 4.1.1-3.- DEORBIT/LANDING NAVIGATION SEQUENCER OUTPUT PARAMETERS

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration	R _FILT_ONE	*	V	DP		ft	Once
Shuttle initial position vector	R _INIT	*	V	DP		ft	Once
Current Shuttle position vector for three-state configuration	R _FILT_TWO	*	V	DP		ft	Once
Current Shuttle position vector for three-state configuration	R _FILT_THREE	*	V	DP		ft	Once
Shuttle velocity vector, state one	V _FILT_ONE	*	V	S		ft/sec	Once
Shuttle velocity vector-initial value	V _INIT	*	V	S		ft/sec	Once
Shuttle velocity vector, state two	V _FILT_TWO	*	V	S		ft/sec	Once
Shuttle velocity vector, state three	V _FILT_THREE	*	V	S		ft/sec	Once
Previously read accumulated IMU one velocity	V _LAST_LAST_ ONE	*	V	S		ft/sec	Once
Previously read accumulated IMU two velocity	V _LAST_FILT_ TWO	*	V	S		ft/sec	Once
Previously read accumulated IMU velocity	V _LAST_FILT_ THREE	*	V	S		ft/sec	Once
Updated vehicle position vector associated with current covariance matrix	R _COV_LAST	*	V	DP		ft	Once

*Refer to Deorbit/Landing Seq. principal function out list (Appendix G)

TABLE 4.1.1-3.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Time of the filter state vectors	T_LAST_FILT	*	F	DP		sec	Once
Time of initial state vectors	T_INIT	*	F	DP		sec	Once
Time of last state vectors	T_FINAL	*	F	DP		sec	Once
Integer indicating order of modeled accelerations	GMO_PRED	*	I	S		--	As needed
Integer indicating degree of modeled accelerations	GMD_PRED	*	I	S		--	As needed
Flag indicating whether the mode of operation is single state or three state	NAV_THREE_STATE	*	D		OFF/ON	--	Once
Vehicle position vector after all navigation updates reserved for reset of guidance integrator position vector R _AVG_G	R _RESET	*	V	DP		ft	Once
Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector V _AVG_G	V _RESET	*	V	S		ft/sec	Once
Copy of V_CURRENT_FILT reserved as velocity count at start of extrapolation interval when guidance integrator is reset	V _IMU_RESET	*	V	DP		ft/sec	Once

*See D/L nav principal function outlist (Appendix G)

TABLE 4.1.1-3.- Continued

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Time associated with reserved reset state	T_RESET	*	F	DP		sec	Once
Switch indicating (ON) that current measurement processing is complete	FILT_UPDATE	*	D		OFF/ON	--	Once
Flag to enable scheduling of the user parameter state propagation principal function	OPS_3_ INITIALIZE_ COMPLETE	*	D		OFF/ON	--	Once
Filter covariance matrix	E	*	M	DP		vary	Once
Previous value of selected accumulated IMU velocity	V _LAST_FILT	*	V	S		ft/sec	Seq rate
Vehicle gravity acceleration vector reserved for reset of guidance integrator acceleration vector	G _RESET	*	V	S		ft/sec	Once
Square roots of the diagonal elements of the covariance matrix for OPS-2 initialization	SIG_DIAG_UVW_ INIT	*	V	DP		ft, and ft/sec	Once
Correlation coefficients of covariance matrix for OPS-2 initialization	CORR_COEFF_ INIT	*	V	DP		-	Once
Shuttle position vector for OPS-2 initialization	R _FILT_INIT	*	V	DP		ft	Once

*See D/L nav principal function out list (Appendix G)

TABLE 4.1.1-3.- Concluded

Description	Symbol	Output destination	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector for OPS-2 initialization	V_FILT_INIT	*	V	S		ft/sec	Once
Flag indicating (ON) that major mode is deorbit maneuver execute	DEORBIT_BURN	*	D		OFF/ON		As needed

*See D/L nav principal function out list (Appendix G)

This is the perturbing gravitational acceleration vector needed for the equations of motion of the Shuttle. The values of GMD and of GMO may be set by the user independently. However, it is necessary that GMO $\leq$ GMD. A maximum value of 4 for GMD will be used, which will make the array ZONAL have 4 components, the arrays C and S have 9 components each, ZETA_REAL_ and ZETA_IMAG have 5 each, and A have a maximum dimension of 5 by 2.

The terms shown in the Earth's gravity calculations as C_L and S_L are usually represented by $C_{n,m}$ and $S_{n,m}$, respectively, but were renumbered for single subscript utilization; the terms called $ZONAL_N$ correspond to J_N.

A suggested implementation of this task is shown in the detailed flow chart, ACCEL_EARTH_GRAV CODE, in Appendix B.

The S. Pines formulation of the gravitational potential may be found, in condensed form, in the paper "Uniform Representation of the Gravitational Potential and its Derivatives," AIAA Journal, Vol. II, No. 11, November 1973. In expanded form, and with an earlier draft of the computer program herein presented, it may be found in JSC Internal Note No. 75-FM-29, of May 27, 1975, "Use of a Nonsingular Potential."

4.2.1.2.2 Drag.

The computation of drag accelerations will vary according to the values of an input indicator, designated here as GMD.

The value D of this acceleration will be set to zero when the acceleration function is called.

If GMD $\neq$ 4, the value of D shall not be changed.

If GMD = 4, D shall be computed as

D = - CD RHO DRAG_CONST |V_R| V_R

where the CD is the vehicle's drag coefficient; V_R = V_REL (V,R), where V and R are, respectively, the velocity and position vectors in M50 coordinates; V_REL is the function that computes the relative velocity of the vehicle with respect to the atmosphere (assuming no wind), described in Section 4.4.5.2; RHO is the density of the earth's atmosphere; and DRAG_CONST is one-half the cross-sectional area of the vehicle divided by the vehicle's mass, a premission-stored constant, updated in value by the Deorbit/Landing navigaiton sequencer principal function (section 4.1.1).

The calculations will be performed in the following order: First, the altitude (needed for the computation of the atmospheric density, RHO) will be obtained from the expression

ALT = H_ELLIPSOID(R)

H_ELLIPSOID is the function that computes altitude above the reference ellipsoid, described in section 4.4.5.1.

TABLE 4.3.1.5-1.- ENTRY STATE PROPAGATION INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current accumulated IMU 1 velocity counts reserved for measurement processing	V_CURRENT_FILT_ONE	Entry control	V	S		ft/sec	Filter rate
Current accumulated IMU 2 velocity counts reserved for measurement processing	V_CURRENT_FILT_TWO	Entry control	V	S		ft/sec	Filter rate
Current accumulated IMU 3 velocity counts reserved for measurement processing	V_CURRENT_FILT_THREE	Entry control	V	S		ft/sec	Filter rate
MTU or clock time when IMU was read	T_CURRENT_FILT	Entry control	F	DP		sec	Filter rate
Flag indicating whether the mode of operation is single or three state	NAV_THREE_STATE	*	D	-	OFF/ON	--	Filter rate
Time of filter state vectors	T_LAST_FILT	Entry control, *	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state one	R_FILT_ONE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate

*Refer to entry navigation principal function input list (Appendix G).

TABLE 4.3.1.5-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate
Current selected sensed accumulated IMU velocity	V _CURRENT_ FILT	Entry control	V	S		ft/sec	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V _FILT_ONE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate

*Refer to entry navigation principal function input list (Appendix G).

TABLE 4.3.1.5-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Shuttle velocity vector, state two	V_FILT_TWO	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate
Shuttle velocity vector, state three	V_FILT_THREE	Entry state and covariance measurement incorporation, entry control, delta state update, *	V	S		ft/sec	Filter rate
Previously read accumulated IMU 1 velocity	V_LAST_FILT_ONE	*	V	S		ft/sec	Filter rate
Acceleration function (force model) related constants	**	**					
Acceleration magnitude above which IMU data instead of drag modeling are employed in computing acceleration	ACC_PROP_MIN	**	F	DP		ft/sec^2	Filter rate

*See entry navigation principal function in list (Appendix G).

TABLE 4.3.1.5-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Angle of attack used in computing drag coefficient	ALPHA	Entry control	F	DP		rad	Filter rate
Sideslip angle used in computing drag coefficient	BETA	Entry control	F	DP		rad	Filter rate
Previously read accumulated IMU 2 velocity	V_LAST_FILT_TWO	*	V	S		ft/sec	Filter rate
Previously read accumulated IMU 3 velocity	V_LAST_FILT_THREE	*	V	S		ft/sec	Filter rate
Previous value of mid selected accumulated IMU velocity	V_LAST_FILT	*, Entry control	V	S		ft/sec	Filter rate

*See entry navigation principal function in list (Appendix G).

C_DRAG = C_DRAG_ZERO + ALPHAR (C_DRAG_ONE + ALPHAR C_DRAG_TWO)

Q_DRAG = H_S ℓn (C_DRAG DRAG_CONST RHO_ZERO

DT_FILT $\underline{V}$ _RHO · $\underline{V}$ _RHO)/|($\underline{I}$ _V_RHO · $\underline{DV}$)|) F3

where

$\underline{V}$ _REL($\underline{V}$,$\underline{R}$) is described in section 4.4.5.2.

and

M_SBODYM50 is obtained by executing the coordinate transformation subfunction SBODY TO M50 (Section 4.4.3.7)

DRAG_CONST will be defined as the vehicle reference area divided by twice the vehicl mass. Initially the DRAG_CONST is premission loaded and re-computed anytime a major mass change occurs, by the deorbit/landing navigation sequencer (section 4.1.1). The residual shall then be computed by

DQ = Q_DRAG - Q - BIAS_DRAG

The above calculations will be performed for each state vector. The variables used in these equations shall be set equal to the following parameters prior to execution of the calculations described herein:

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _RILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{DV}$ = $\underline{DV}$_FILT_ONE, $\underline{DV}$_FILT_TWO, or $\underline{DV}$_FILT_THREE

For each state vector, the resulting residual, DQ, will be saved as DELQ_ONE, DELQ_TWO, or DELQ_THREE. The vector selection subfunction (Section 4.2.5) will reduce the three residuals to a single residual, DELQ, for subsequent use in the residual edit test.

F_3This equation shall be protected against division by zero (Reference 3.6.3).

Drag Partials. The partial derivatives of the altitude measurement with respect to the state are to be computed as follows:

R_FILT = VECTOR SELECTION (R_FILT_ONE, R_FILT_TWO, R_FILT_THREE)

$B_{1 \text{ to } 3}$ = UNIT (R_FILT)

$B_{4 \text{ to } 6}$ = 0

The variance of the drag altitude measurement error will be defined by

VAR = VAR_DRAG

TABLE 4.3.1.7.1-1.- DRAG MEASUREMENT INPUT PARAMETERS

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Interval over which to propagate the covariance matrix	DT_FILT	Entry state propagation	F	DP		sec	Filter rate
M50-to-body coordinates quaternion	Q_M50_BODY	Data snap	V(4)	DP		--	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_ZERO	**	F	S		--	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_ONE	**	F	S		1/rad	Filter rate
Polynominal term for computing drag coefficient as function of angle of attack	C_DRAG_TWO	**	F	S		$1/rad^2$	Filter rate
Earth rotation rate	EARTH_RATE	**	F	DP		rad/sec	Filter rate
Vehicle reference area divided by twice the vehicle mass	DRAG_CONST	**	F	S		ft**2 / slugs	Filter rate
Earth ellipticity constant	ELLIPT	**	F	S		--	Filter rate
Time of filter state vector	T_LAST_FILT	State prop	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state one	R _FILT_ONE	2,3,4	V	DP		ft	Filter rate

2. Delta state update.
3. Entry state propagation.
4. Entry nav state and covariance measurement incorporation.
**See Section 4.9.

TABLE 4.3.1.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Unit vector in the direction of earth's axis of rotation	EARTH_POLE	**	V	DP		--	Filter rate
Current Shuttle position vector for three-state configuration, state two	R _FILT_TWO	2,3,4	V	DP		ft	Filter rate
Criterion for difference between measurement time and state time, above which the filter state will be interpolated	EPS_TAG	**	F	DP		sec	Filter rate
Current Shuttle position vector for three-state configuration, state three	R _FILT_THREE	2,3,4	V	DP		ft	Filter rate
Shuttle velocity vector, state one	V _FILT_ONE	2,3,4	V	S		ft/sec	Filter rate
Shuttle velocity vector, state two	V _FILT_TWO	2,3,4	V	S		ft/sec	Filter rate
Earth equatorial radius	EARTH_RADIUS_ EQUATOR	**	F	DP		ft	Filter rate
Shuttle velocity vector, state three	V _FILT_THREE	2,3,4	V	S		ft/sec	Filter rate
Scale factor on filter mean square residual used in residual edit test for drag measurement	K_EDIT_DRAG	**	F	S		--	Filter rate

2. Delta state update.
3. Entry state prop.
4. Entry nav state and covariance measurement incorp.
**See Section 4.9.

TABLE 4.3.1.7.1-1.- Continued

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-1 during three-state configuration	DV_FILT_ONE	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-2 during three-state configuration	DV_FILT_TWO	Entry state propagation	V	S		ft/sec	Filter rate
Difference between accumulated sensed IMU readings on present cycle and previous cycle for IMU-3 during three-state configuration	DV_FILT_THREE	Entry state propagation	V	S		ft/sec	Filter rate
Vector of deterministic drag biases for each layer, I = 1,4	$BIAS\_DRAG\_LAYER_I$	**	V	S		ft	Filter rate
Vector of scale heights for each layer, I = 1,4	$SCALE\_HT_I$	**	V	S		ft	Filter rate
Vector of base densities for each layer, I = 1,4	$BASE\_DEN_I$	**	V	S		slug/ft**3	Filter rate
Altitudes defining atmosphere model layers, I = 1,4	$DENSITY\_LIMIT_I$	**	V	S		ft	Filter rate
Drag altitude measurement error variance	VAR_DRAG	**	F	S		ft**2	Filter rate

**See Section 4.9.

TABLE 4.3.1.7.1-1.- Concluded

Description	Symbol	Input source	Type	Precision	Range	Units	Sample rate
Filter covariance matrix	E	2, entry covariance propagation	M	DP		vary	Filter rate
Flag used (ON) to override drag residual edit test	DRAG_EDIT_ OVERRIDE	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate
Flag indicating (ON) that drag data are to be processed for statistical display purposes only	DRAG_STAT	Entry sensor measurement selection	D	--	OFF/ON	--	Filter rate

2. Delta state update.

Table 4.9.- Mission Dependent Parameters (cont.)

Parameter	Units	Data Type	Precision	Definition
M_M50TOEF_AT_EPOCH		M(3)	S	Transformation matrix from M50 to earth-fixed coordinates at T_EPOCH
REF_AREA	ft^2	F	S	Orbiter Reference Area.
SCALE_HT	ft	Arr	S	Array of scale weights for each layer to model drag
T_EPOCH	See	F	DP	Time tag for EARTH_POLE M_M50TOEF_AT_EPOCH
		ACCELERATION MODEL PARAMETERS		
DENSE	Various	Arr	S	Density model constants
SEA_LEVEL_DENSITY	slugs/ft^3	F	S	Sea level atmospheric density
		USER PARAMETER PROCESSING PARAMETERS		
RADIUS_NEP	ft	F	S	Radius of nominal entry point heading alignment circle
R_HAC_RW	ft	V(S)	S	Position vector of HAC center in runway coordinates
X_NB_CG	ft	F	S	X_STRUCT_BODY distance from navigation base to cg
X_NEP	ft	F	S	Runway X-comonent of the HAC center
Z_NB_CG	ft	F	S	Z_STRUCT_BODY distance from navigation base to cg

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DNM	S	0	-	Variable used in Pine's formulation
DNSA	S	0	-	Variable used in density calculations
DNSB	S	0	-	Variable used in density calculations
DNSC	S	0	-	Variable used in density calculations
DO_BARO_NAV	BIT	Off	-	Flag indicating (ON) that barometric altimeter data are to be processed
DO_DELTA_UPDATE	BIT	Off	-	Flag indicating (ON) that delta update is to be performed
DO_DRAG_NAV	BIT	Off	-	Flag indicating (ON) that drag altitude data are to be processed
DO_MLS_NAV	BIT	Off	-	Flag indicating (ON) that MLS data are to be processed
DO_TACAN_NAV	BIT	Off	-	Flag indicating (ON) that TACAN data are to be processed
DQ	S	0	-	General term for measurement residual
DR	V(3)	0	M50	Ground computed position deviation to update onboard state vector (rotated to mean 50 coords)

*The DRAG_CONST is recomputed every time a major mass change occurs as described in Section 4.1.1

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
DRAG_AIF	CHAR	Auto	-	Drag/auto/inhibit/force flag
DRAG_AIR_RECD	CHAR	Auto	-	Flag indicating which DRAG_AIF command is in effect
DRAG_CONST	S	Pad,*	-	Drag constant equal to the vehicle reference area divided by twice the vehicle mass
DRAG_EDIT_ OVERRIDE	BIT	Off	-	Switch used to force incorporation of drag altitude measurement regardless of residual edit test
DRAG_MARK_NUM	INT	0		Counter indicating the number of times that drag measurement was selected for filter processing
DRAG_STAT	BIT	Off	-	Flag indicating (ON) that drag data are processed for statistical display only
D_R_RW	V(3)	0	RW	Ground computed position deviations to update onboard state vector
DT_DEORB_PF_NAV	S	Pad	-	Sequencing time interval for entry navigation during deorbit burn
DT_DEORB_PREP_ NAV	S	Pad	-	Sequencing time interval for entry navigation during coasting flight prior to deorbit burn
DT_ENTRY_NAV	S	Pad	-	Sequencing time interval for entry navigation after completion of deorbit burn
EDIT_ARRAY	ARR	0	-	Array of last 10 edit flags for display processing

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
EDIT_FLAG	BIT	Off	-	General variable for edit flags
ELEM 1	S	0	-	Variable used by midselect to select middle element
ELEM 2	S	0	-	Variable used by midselect to select middle element
ELEM 3	S	0	-	Variable used by midselect to select middle element
ELLIPT	S	Pad	-	Earth ellipticity constant
EPS_TAG	S	Pad	-	Criterion for difference between measurement time and state time, above which the filter state will be extrapolated for residual calculations
E_TEMP	M(6)	0	-	Temporary matrix for covariance matrix initialization
EVENT E1	I	-	-	Flag indicating (ON) a transition from OPS-3 to OPS-2
EV_LT	BIT	Off		Temporary flag used to set nav validity flag
EXP_SHAPE_FACTOR	S	Pad		Exponential shaping factor for drag coefficient model
EVENT E-14A	BIT	Off	-	MSC event - oms cutoff confirmation
FIFTY	M(3)	0	-	General transformation matrix from EF to M50 coordinates

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
FILT_UPDATE	BIT	Off	-	Switch indicating (ON) that current measurement processing is complete for UPP propagator reset
F1	S	0	-	Auxiliary variable in Pine's formulation
F2	S	0	-	Auxiliary variable in Pine's formulation
F3	S	0	-	Auxiliary variable in Pine's formulation
F4	S	0	-	Auxiliary variable in Pine's formulation
G	V(3)	0	M50	Gravity acceleration
Q	S	0	-	Measurement estimate
Q_AZMLS	S	0	-	MSBLS azimuth sensor measurement
Q_BARO	S	0	-	Barometric altimeter sensor measurement
Q_DRAG	S	0	-	Pseudo drag altitude generated sensor measurement
Q_ELMLS	S	0	-	MSBLS elevation sensor measurement
Q_M50_BODY	V(4)	0	M50	M50 body frame altitude quaternion
Q_RANGE	S	0	-	MSBLS range sensor measurement
Q_TAC_BRG	S	0	-	TACAN bearing seneor measurement
Q_TAC_R	S	0	-	TACAN range sensor measurement

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
R	V(3)	0	M50	General Shuttle position vector
RAD_PER_DEG	S	Pad	-	Conversion constant - radians per degree
RAW_RA_PROC	BIT	Off	-	Radar altimeter processing flag
R_AZ_COUNT	INT	0	-	Running count of number of consecutive MLS azimuth and range measurements failing data good test
R_AZ_COUNT_MAX	S	Pad	-	Prescribed number of consecutive MLS azimuth measurement data-good 'fails' to force inhibit of MLS processing and allow TACAN processing
R_AZMLS	V(3)	0	M50	Position vector of MLS azimuth scanner in M50 coordinates
R_AZMLS_EF	V(3)	Pad	EF	Earth-fixed MLS azimuth scanner position vector
R_COV_LAST	V(3)	0	M50	Updated vehicle position vector associated with current covariance matrix
R_EF	V(3)	0	EF	General position vector in earth-fixed coordinates
REF_AREA	S	Pad	-	Orbiter reference area
R_ELMLS	V(3)	0	M50	Position vector of MLS elevation scanner in M50 coordinates
R_ELMLS_EF	V(3)	0	EF	Earth-fixed MLS elevation scanner position vector

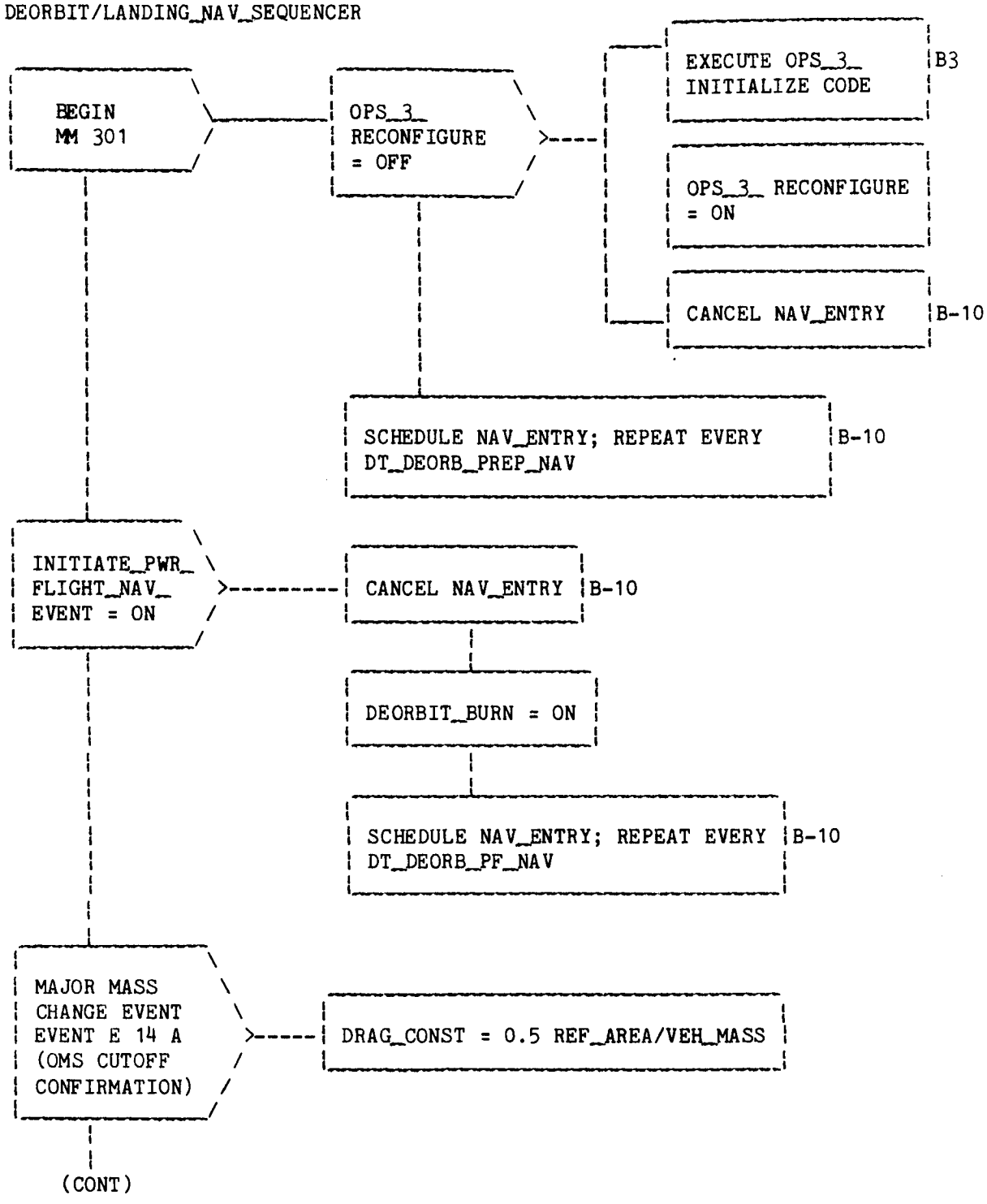
Variable List

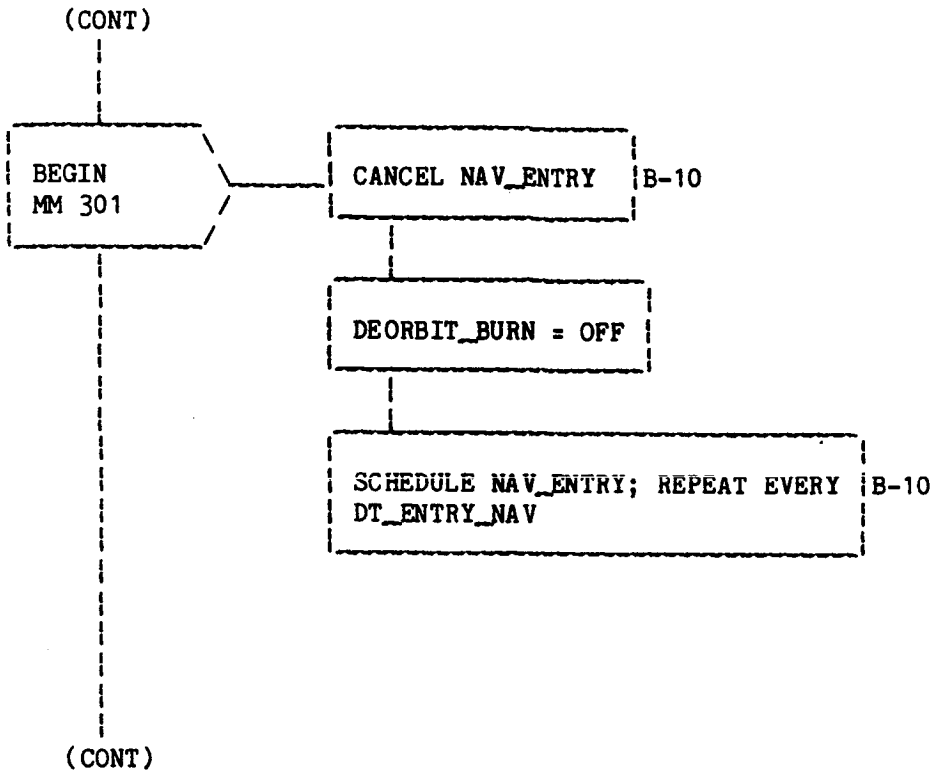
Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
REL_R	V(3)	0	M50	Vector from sensor ground station to vehicle
RESID_TEST	S	0	-	General resid test variable
V_CURRENT_FILT_THREE	V(3)	0	M50	Current accumulated IMU three velocity counts reserved for measurement processing
V_CURRENT_FILT_TWO	V(3)	0	M50	Current accumulated IMU two velocity counts reserved for measurement processing
VEH_MASS	S	0	-	Current orbiter mass
V_FILT	V(3)	0	M50	Shuttle current velocity vector
V_FILT_INIT	V(3)	OPS 3	M50	Shuttle velocity vector for OPS 3 initialization
V_FILT_ONE	V(3)	0	M50	Shuttle velocity vector, State 1
V_FILT_THREE	V(3)	0	M50	Shuttle velocity vector, State 3
V_FILT_TWO	V(3)	0	M50	Shuttle velocity vector, State 2
V_FINAL	V(3)	0	M50	Shuttle velocity vector predicted to current time
V_GND	V(3)	0	M50	Uplinked velocity vector for whole vector update
V_IMU_RESET	V(3)	0	M50	Copy of V_last_FILT reserved as velocity count at start of extrapolation interval when guidance integrator is reset
V_INIT	V(3)	0	M50	Initial velocity vector

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
V_LAST	V(3)	0	M50	General variable for previous IMU accumulated velocity
V_LAST_FILT	V(3)	0	M50	Previously read selected accumulated IMU velocity
V_LAST_FILT_ONE	V(3)	0	M50	Previously read accumulated IMU 1 velocity
V_LAST_FILT_ THREE	V(3)	0	M50	Previously read accumulated IMU 3 velocity
V_LAST_FILT_TWO	V(3)	0	M50	Vehicle relative velocity vector
V_R	V(3)	0	M50	Vehicle relative velocity vector
V_RESET	V(3)	0	M50	Vehicle velocity vector after all navigation updates reserved for reset of guidance integrator velocity vector
V_RHO	V(3)	0	M50	Vehicle relative velocity vector
V_RHO_BODY	V(3)	0	Body	Vehicle relative velocity vector in body coordinates

DEORBIT/LANDING_NAV_SEQUENCER




(CONT)
BEGIN
MM 301
CANCEL NAV_ENTRY
B-10
DEORBIT_BURN = OFF
SCHEDULE NAV_ENTRY; REPEAT EVERY
DT_ENTRY_NAV
B-10
(CONT)

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U8500CD	G47405	DT_MAX	MAX ALLOW TIME STEP SIZE	EN1 PREC PRED		SEC
V90X0535X	G46408	DEORBIT_BURN	FLAG INDICATING THRUSTING FLIGHT	EN1 NAV		
V90X0539X	G46409	OPS_3_INIT_ COMPLETE	SIG TO ENABLE CYCLIC EXEC OF UPSP	MSC, D/L UPP SEQ		
V90H0587CA	G25502	R_FILT_ONE(1)	X-COMP OF FILTER CURR POS STATE 1	ENT NAV, TLM		FT
V90H0588CA	G25503	R_FILT_ONE(2)	Y-COMP OF FILTER CURR POS STATE 1	ENT NAV TLM		FT
V90H0589CA	G25504	R_FILT_ONE(3)	Z-COMP OF FILTER CURR POS STATE 1	ENT NAV TLM		FT
V90H0590CA	G46510	R_FILT_TWO(1)	X-COMP OF FILTER CURR POS STATE 2	ENT NAV TLM		FT
V90H0591CA	G46511	R_FILT_TWO(2)	Y-COMP OF FILTER CURR POS STATE 2	ENT NAV TLM		FT
V90H0592CA	G46512	R_FILT_TWO(3)	Z-COMP OF FILTER CURR POS STATE 2	ENT NAV TLM		FT
V90H0593CA	G46519	R_FILT_THREE(1)	X-COMP OF FILTER CURR POS STATE 3	ENT NAV TLM		FT
V90H0594CA	G46520	R_FILT_THREE(2)	Y-COMP OF FILTER CURR POS STATE 3	ENT NAV TLM		FT
V90H0595CA	G46521	R_FILT_THREE(3)	Z-COMP OF FILTER CURR POS STATE 3	ENT NAV TLM		FT
V90L0639CA	G25505	V_FILT_ONE(1)	X-COMP OF FILTER CURR VEL STATE 1	ENT NAV TLM		FT/SEC
V90L0640CA	G25506	V_FILT_ONE(2)	Y-COMP OF FILTER CURR VEL STATE 1	ENT NAV TLM		FT/SEC
V90L0641CA	G25507	V_FILT_ONE(3)	Z-COMP OF FILTER CURR VEL STATE 1	ENT NAV TLM		FT/SEC
V90L0642CA	G46513	V_FILT_TWO(1)	X-COMP OF FILTER CURR VEL STATE 2	ENT NAV TLM		FT/SEC
V90L0643CA	G46514	V_FILT_TWO(2)	Y-COMP OF FILTER CURR VEL STATE 2	ENT NAV TLM		FT/SEC
V90L0644CA	G46515	V_FILT_TWO(3)	Z-COMP OF FILTER CURR VEL STATE 2	ENT NAV TLM		FT/SEC
V90L0645CA	G46522	V_FILT_THREE(1)	X-COMP OF FILTER CURR VEL STATE 3	ENT NAV TLM		FT/SEC
V90L0646CA	G46523	V_FILT_THREE(2)	Y-COMP OF FILTER CURR VEL STATE 3	ENT NAV TLM		FT/SEC
V90L0647CA	G46524	V_FILT_THREE(3)	Z-COMP OF FILTER CURR VEL STATE 3	ENT NAV TLM		FT/SEC
V90L0630CA	G25509	V_LAST_FILT_ONE (1)	X-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC
V90L0631CA	G25510	V_LAST_FILT_ONE (2)	Y-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0632CA	G25511	V_LAST_FILT_ONE (3)	Z-COMP OF ACCUM SENSED VEL STATE 1	ENT NAV		FT/SEC
V90L0633CA	G46516	V_LAST_FILT_TWO (1)	X-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0634CA	G46517	V_LAST_FILT_TWO (2)	Y-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0635CA	G46518	V_LAST_FILT_TWO (3)	Z-COMP OF ACCUM SENSED VEL STATE 2	ENT NAV		FT/SEC
V90L0636CA	G46525	V_LAST_FILT _THREE (1)	X-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90L0637CA	G46526	V_LAST_FILT _THREE (2)	Y-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90L0638CA	G46527	V_LAST_FILT _THREE (3)	Z-COMP OF ACCUM SENSED VEL STATE 3	ENT NAV		FT/SEC
V90W0534CD	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	ENT NAV		SEC
V90H0581CA	G25512	R_COV_LAST(1)	X-COMP OF POS VCT W CURR COV MTRX	ENT NAV		FT
V90H0582CA	G25513	R_COV_LAST(2)	Y-COMP OF POS VCT W CURR COV MTRX	ENT NAV		FT
V90H0583CA	G25514	R_COV_LAST(3)	Z-COMP OF POS VCT W CURR COV MTRX	ENT NAV		FT
V90X0224XD	G25515	FILT_UPDATE	FLAG IND NAV FILTER PROC COMPLETE	ENT UPP TAEM UPP A/L UPP		
V90A0243CD	G28207	G_RESET(1)	SEL X-COMP OF GRAV ACCEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC^2
V90A0244CD	G28208	G_RESET(2)	SEL Y-COMP OF GRAV ACCEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC^2
V90A0245CD	G28209	G_RESET(3)	SEL Z-COMP OF GRAV ACCEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC^2
V90X0537X	G25587	NAV_THREE_STATE	THREE-STATE FLAG ON/OFF	ENT NAV PRELAND NAV MSC TLM		
V90H0235CD	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT
V90H0236CD	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT
V90H0237CD	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RSTQ	ENT UPP TAEM UPP A/L UPP TLM		FT
V90L0239CD	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0240CD	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC
V90L0241CD	G28306	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT UPP TAEM UPP A/L UPP TLM		FT/SEC
V90U8502CD	G47407	GMO_PRED	GRAVITY MODEL ORDER	ENT PREC PRED TLM		
V90U8501CD	G47406	GMD_PRED	GRAVITY MODEL DEGREE	ENT PREC PRED TLM		
		DRAG_CONST	DRAG ACC MODEL CONSTANT	ENT NAV		FT^2/SLUGS
V90W0534CE	G25508	T_LAST FILT	TIME OF FILTER STATE VECTOR	IMURM		
V90W1287CB	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ASC NAV SEQ		SEC
V90H1276CB	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ASC NAV SEQ		FT
V90H1277CB	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ASC NAV SEQ		FT
V90H1278CB	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ASC NAV SEQ		FT
V90L1279CB	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90L1280CB	G50206	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90L1281CB	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90H1276CC	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1277CC	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1278CC	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90L1279CC	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1280CC	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1281CC	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90W1287CC	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ORB UPP SEQ		SEC
V90H0881CA	G47416	R_FINAL	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0882CA	G47417		Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0883CA	G47418		Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90L0885CA	G47419	V_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0856CA	G47420		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0887CA	G47421		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90A0889C	G48105	G_FINAL	X-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90A0890C	G48106		Y-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90A0891C	G48107		Z-COMP PREDICTED SHUTTLE GRAV VCTR	ENT PREC PRED		FT/SEC^2
V90Q8001C			MAJOR MODE CODE	MSC	1,5	
V90X8164X	G43204		MM 201 FROM MM 301 FLAG	MSC		
V90X8169X	G43205		OPS-1 TO OPS-3 TRNSITION EVENT FLG	MSC		
V90X8188X	G54409	INITIATE_PWR _FLIGHT_NAV _VENT	INITIATE PF FLAG	MSC		
		EVENT_E1	FLAG INDICATING A TRANS FROM OPS 3 TO OPS 2	MSC		
		EVENT E14A	OMS CUTOFF CONFIRMATION FLG	MSC		
V90U2023CC	G48797	VEH_MASS	CURRENT VEHICLE MASS	DEORB GUID		SLUGS

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0644CA	G46515	V_FILT TWO(3)	Z-COMP OF FILTER CURR VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0645CA	G46522	V_FILT_THREE(1)	X-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0646CA	G46523	V_FILT_THREE(2)	Y-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0647CA	G46524	V_FILT_THREE(3)	Z-COMP OF FILTER CURR VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0630CA	G25509	V_LAST_FILT_ONE (1)	X-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0631CA	G25510	V_LAST_FILT_ONE (2)	Y-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0632CA	G25511	V_LAST_FILT_ONE (3)	Z-COMP OF ACCUM SENSED VEL STATE 1	D/L NAV SEQ		FT/SEC
V90L0633CA	G46516	V_LAST_FILT_TWO (1)	X-COMP OF ACCUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0634CA	G46517	V_LAST_FILT_TWO (2)	Y-COMP OF ACCUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0635CA	G46518	V_LAST_FILT_TWO (3)	Z-COMP OF ACUM SENSED VEL STATE 2	D/L NAV SEQ		FT/SEC
V90L0636CA	G46525	V_LAST_FILT _THREE (1)	X-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0637CA	G46526	V_LAST_FILT _THREE(2)	Y-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90L0638CA	G46527	V_LAST_FILT _THREE (3)	Z-COMP OF ACCUM SENSED VEL STATE 3	D/L NAV SEQ		FT/SEC
V90W0534CD	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	D/L NAV SEQ		SEC
V90H0581CA	G25512	R_COV_LAST(1)	X-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90H0582CA	G25513	R_COV_LAST(2)	Y-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90H0583CA	G25514	R_COV_LAST(3)	Z-COMP OF POS VCT W CURR COV MTRX	D/L NAV SEQ		FT
V90X0537X	G25587	NAV_THREE_STATE	THREE-STATE FLAG ON/OFF	D/L NAV SEQ		
V90U0650CA	G25551	E(1,1)	COVARIANCE MATRIX ELEMENT 1-1	D/L NAV SEQ		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U0651CA	G25552	E(1,2)	COVARIANCE MATRIX ELEMENT 1-2	D/L NAV SEQ		
V90U0652CA	G25553	E(1,3)	COVARIANCE MATRIX ELEMENT 1-3	D/L NAV SEQ		
V90U0653CA	G25554	E(1,4)	COVARIANCE MATRIX ELEMENT 1-4	D/L NAV SEQ		
V90U0654CA	G25555	E(1,5)	COVARIANCE MATRIX ELEMENT 1-5	D/L NAV SEQ		
V90U0655CA	G25556	E(1,6)	COVARIANCE MATRIX ELEMENT 1-6	D/L NAV SEQ		
V90U0656CA	G25557	E(2,1)	COVARIANCE MATRIX ELEMENT 2-1	D/L NAV SEQ		
V90U0657CA	G25558	E(2,2)	COVARIANCE MATRIX ELEMENT 2-2	D/L NAV SEQ		
V90U0658CA	G25559	E(2,3)	COVARIANCE MATRIX ELEMENT 2-3	D/L NAV SEQ		
V90U0659CA	G25560	E(2,4)	COVARIANCE MATRIX ELEMENT 2-4	D/L NAV SEQ		
V90U0660CA	G25561	E(2,5)	COVARIANCE MATRIX ELEMENT 2-5	D/L NAV SEQ		
V90U0661CA	G25562	E(2,6)	COVARIANCE MATRIX ELEMENT 2-6	D/L NAV SEQ		
V90U0662CA	G25563	E(3,1)	COVARIANCE MATRIX ELEMENT 3-1	D/L NAV SEQ		
V90U0663CA	G25564	E(3,2)	COVARIANCE MATRIX ELEMENT 3-2	D/L NAV SEQ		
V90U0664CA	G25565	E(3,3)	COVARIANCE MATRIX ELEMENT 3-3	D/L NAV SEQ		
V90U0665CA	G25566	E(3,4)	COVARIANCE MATRIX ELEMENT 3-4	D/L NAV SEQ		
V90U0666CA	G25567	E(3,5)	COVARIANCE MATRIX ELEMENT 3-5	D/L NAV SEQ		
V90U0667CA	G25568	E(3,6)	COVARIANCE MATRIX ELEMENT 3-6	D/L NAV SEQ		
V90U0668CA	G25569	E(4,1)	COVARIANCE MATRIX ELEMENT 4-1	D/L NAV SEQ		
V90U0669CA	G25570	E(4,2)	COVARIANCE MATRIX ELEMENT 4-2	D/L NAV SEQ		
V90U0670CA	G25571	E(4,3)	COVARIANCE MATRIX ELEMENT 4-3	D/L NAV SEQ		
V90U0671CA	G25572	E(4,4)	COVARIANCE MATRIX ELEMENT 4-4	D/L NAV SEQ		
V90U0672CA	G25573	E(4,5)	COVARIANCE MATRIX ELEMENT 4-5	D/L NAV SEQ		
V90U0673CA	G25574	E(4,6)	COVARIANCE MATRIX ELEMENT 4-6	D/L NAV SEQ		
V90U0674CA	G25575	E(5,1)	COVARIANCE MATRIX ELEMENT 5-1	D/L NAV SEQ		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY NAVIGATION MODULE (ENT NAV 4.127)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90U0675CA	G25576	E(5,2)	COVARIANCE MATRIX ELEMENT 5-2	D/L NAV SEQ		
V90U0676CA	G25577	E(5,3)	COVARIANCE MATRIX ELEMENT 5-3	D/L NAV SEQ		
V90U0677CA	G25578	E(5,4)	COVARIANCE MATRIX ELEMENT 5-4	D/L NAV SEQ		
		DRAG_CONST	DRAG ACC MODEL CONST	D/L NAV SEQ		FT^2/SLUGS

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L0632CB	G25511		Z-COMP OF ACCUM SENSED VEL STATE 1	IMU RM		FT/SEC
V90L0633CB	G46516	V_LAST_FILT_TWO	X-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0634CB	G46517		Y-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0635CB	G46518		Z-COMP OF ACCUM SENSED VEL STATE 2	IMU RM		FT/SEC
V90L0636CB	G46525	V_LAST_FILT_ THREE	X-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
V90L0637CB	G46526		Y-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
V90L0638CB	G46527		Z-COMP OF ACCUM SENSED VEL STATE 3	IMU RM		FT/SEC
	G50308	MLS_AVAIL	FLG INDICATING THE AVAIL OF MLS DATA AT RUNWAY SELECTED	SITE LOOKUP		
V90L0621CC	G27908	V_LAST_FILT(1)	X-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90L0622CC	G27909	V_LAST_FILT(2)	Y-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90L0623CC	G27910	V_LAST_FILT(3)	Z-COMP OF SEL ACCUM VEL	IMU RM		FT/SEC
V90H0584CE	G27911	R_FILT(1)	X-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0585CE	G27912	R_FILT(2)	Y-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90H0586CE	G27913	R_FILT(3)	Z-COMP OF FLTR'S CURR POS VECTOR	ENT NAV		FT
V90L0624CE	G27904	V_FILT(1)	X-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0625CE	G27905	V_FILT(2)	Y-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90L0626CE	G27906	V_FILT(3)	Z-COMP OF FLTR'S CURR VEL VECTOR	ENT NAV		FT/SEC
V90W0534CE	G25508	T_LAST_FILT	TIME OF FILTER STATE VECTOR	IMU RM, ENT NAV		
V90W1287CB	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ASC NAV SEQ		SEC
V90H1276CB	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ASC NAV SEQ		FT
V90H1277CB	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ACS NAV SEQ		FT
V90H1278CB	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ACS NAV SEQ		FT
V90L1279CB	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ 4.123)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V90L1280CB	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90L1281CB	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ASC NAV SEQ		FT/SEC
V90H1276CC	G50262	R_FILT_INIT(1)	X-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1277CC	G50263	R_FILT_INIT(2)	Y-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90H1278CC	G50264	R_FILT_INIT(3)	Z-COMP SHUTTLE INIT POS VCTR	ORB UPP SEQ		FT
V90L1279CC	G50265	V_FILT_INIT(1)	X-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1280CC	G50266	V_FILT_INIT(2)	Y-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90L1281CC	G50267	V_FILT_INIT(3)	Z-COMP SHUTTLE INIT VEL VCTR	ORB UPP SEQ		FT/SEC
V90W1287CC	G50268	T_FILT_INIT	TIME OF NAV INIT VECTOR	ORB UPP SEQ		SEC
V90H0881CA	G47416	R_FINAL	X-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0882CA	G47417		Y-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90H0883CA	G47418		Z-COMP PREDICTED SHUTTLE POS VECTR	ENT PREC PRED		FT
V90L0885CA	G47419	V_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0886CA	G47420		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90L0887CA	G47421		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC
V90A0889C	G48105	G_FINAL	X-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90A0890C	G48106		Y-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90A0891C	G48107		Z-COMP PREDICTED SHUTTLE VEL VECTR	ENT PREC PRED		FT/SEC^2
V90Q8001C			MAJOR MODE CODE	MSC	1,5	
V90X8164X	G43204	EVENT_E1	MM 201 FROM MM 301 FLAG	MSC		
V90X8169X	G43205		OPS-1 TO OPS-3 TRNSITION EVENT FLG	MSC		
V90X8188X	G54409	INITIATE_PWR_ FLIGHT_NAVEVENT	INITIATE PF FLAG	MSC		

OUTPUT FUNCTIONAL PARAMETERS FROM THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (D/L NAV SEQ.4.123)

M/S ID	Level B No.		Nomenclature	Destination	Range	Units
V90H0235CD	G28201	R_RESET(1)	SEL X-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90H0236CD	G28202	R_RESET(2)	SEL Y-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90H0237CD	G28203	R_RESET(3)	SEL Z-COMP OF UPDATED POS VCTR RST	ENT UPP, TLM		FT
V90L0239CD	G28204	V_RESET(1)	SEL X-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90L0240CD	G28205	V_RESET(2)	SEL Y-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90L0241CD	G28206	V_RESET(3)	SEL Z-COMP OF UPDATED VEL VCTR RST	ENT UPP, TLM		FT/SEC
V90U8502CD	G47407	GMO_PRED	GRAVITY MODEL ORDER	ENT PREC PRED, TLM		
V90U8501CD	G47406	GMO_PRED	GRAVITY MODEL DEGREE	ENT PREC PRED, TLM		
V90W0225CD	G29701	T_RESET	TIME TAG OF SHUTTLE STATE VCTR RST	ENT UPP, TLM		SEC
V90L0247CD	G28210	V_IMU_RESET(1)	SEL X-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90L0248CD	G28211	V_IMU_RESET(2)	SEL Y-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90L0249CD	G28212	V_IMU_RESET(3)	SEL Z-COMP ACCUM SENSED VEL RST	ENT UPP		FT/SEC
V90U0650CA	G25551	E(1,1)	COVARIANCE MATRIX ELEMENT 1-1	ENT NAV, TLM		
V90U0651CA	G25552	E(1,2)	COVARIANCE MATRIX ELEMENT 1-2	ENT NAV		
V90U0652CA	G25553	E(1,3)	COVARIANCE MATRIX ELEMENT 1-3	ENT NAV		
V90U0653CA	G25554	E(1,4)	COVARIANCE MATRIX ELEMENT 1-4	ENT NAV		
V90U0654CA	G25555	E(1,5)	COVARIANCE MATRIX ELEMENT 1-5	ENT NAV		
V90U0655CA	G25556	E(1,6)	COVARIANCE MATRIX ELEMENT 1-6	ENT NAV		
V90U0656CA	G25557	E(2,1)	COVARIANCE MATRIX ELEMENT 2-1	ENT NAV		
V90U0657CA	G25558	E(2,2)	COVARIANCE MATRIX ELEMENT 2-2	ENT NAV, TLM		
V90U0658CA	G25559	E(2,3)	COVARIANCE MATRIX ELEMENT 2-3	ENT NAV		
V90U0659CA	G25560	E(2,4)	COVARIANCE MATRIX ELEMENT 2-4	ENT NAV		
V90U0660CA	G25561	E(2,5)	COVARIANCE MATRIX ELEMENT 2-5	ENT NAV		

INPUT FUNCTIONAL PARAMETERS FOR THE ENTRY SITE LOOKUP MODULE (ENT SITE LOOKUP 4.124)

M/S ID	Level B No.		Nomenclature	Source	Range	Units
V95A0160CB	G04205	ACC_DRAG	DRAG DECEL	ENT UPP		FT/SEC^2
V95H0175CC	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	ENT UPP	-10.+10000K	FT
V95H0175CD	G04207	ALT	CURR OBR ALT ABOVE REF ELLIPSOID	TEAM UPP	-10.+10000K	FT
V95A0160CC	G04205	ACC_DRAG	DRAG DECEL	TAEM UPP		FT/SEC^2
V95H0175CE	G04207	ALT	CURR ORB ALT ABOVE REF ELLIPSOID	A/L UPP	-10.+10000K	FT
V95A0160CD	G04205	ACC_DRAG	DRAG DECEL	A/L UPP		FT/SEC^2
V95W0002C	C92156	T_CURRENT_FILT	IMU INPUT TRANS TIME TAG	IMU INT PROC		SEC
V95L0065CA	C98001	V_CURRENT FILT_ ONE	IMU 1 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L0066CA	C98004		IMU 1 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L0067CA	C98007		IMU 1 ACCUM SENSED CHANGE Z VEL	IMU INT PROC		
V95L1065CA	C98002	V_CURRENT_FILT_ TWO	IMU 2 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L1067CA	C98005		IMU 2 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L1067CA	C98008		IMU 2 ACCUM SENSED CHANGE Z VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2065CA	C98003	V_CURRENT_FILT_	IMU 3 ACCUM SENSED CHANGE X VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2066CA	C98006		IMU 3 ACCUM SENSED CHANGE Y VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95L2067CA	C98009		IMU 3 ACCUM SENSED CHANGE Z VEL	IMU INT PROC	+/-1.0M	FT/SEC
V95H3001C	G06621	Q_BARO	ADS CORRECTED PRESSURE ALTITUDE	ADTA SOP	0,100K	FT
V95W3400C	G47148	T_BARO	ADS CORRECTED PRESS ALT TIME TAG	ADTA SOP		SEC
V95X3111X	G14424	BARO_DATA_GOOD	PRESSURE ALTITUDE DATA GOOD FLAG	ADTA SOP	0,1	
V95X3112X		MACH_JUMP	ADS MACH JUMP FLAG SNAPPED	ADTA SOP	0,1	
V90X2601X	G14707	IMU FAIL(1)	IMU 1 FAIL	IMU RM	0,1	

INPUT FUNCTIONAL PARAMETERS FOR THE DEORBIT/LANDING NAVIGATION SEQUENCER MODULE (DL NAV SEQ 4.123)

M/S ID	Level B No.	Nomenclature	Source	Range	Units

TABLE 4.9.2-1.- Continued

Parameter	Units	Data type	Precision	Definition
NAVIGATION RELATED PARAMETERS (Continued)				
K_EDIT_BARO	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for barometric altimeter and drag measurement
K_EDIT_DRAG	--	F	S	
K_EDIT_MLSAZ	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for MSBLS azimuth, MSBLS elevation, and MSBLS measurements
K_EDIT_MLSEL	--	F	S	
K_EDIT_MLSR	--	F	S	
K_EDIT_TACBR	--	F	S	Scale factor on filter mean square residuals used in residual edit tests for TACAN bearing and TACAN range measurements
K_EDIT_TACR	--	F	S	
K_UND_WGT	--	F	S	Scale factor used in measurement under weighting equation
M_M50TOEF_AT_EPOCH*	--	M(3)	S	Transformation matrix from M50 to earth-fixed coordinates at T_EPOCH
SCALE_HT	ft	Arr	S	Array of scale weights for each layer to model drag

*I-LOADS for principal functions 4.15 and 4.205 in memory configuration (MC) 1; carried across subsequent computer memory reconfigurations without alteration.

APPENDIX H

STS-1 CHANGE PAGES

The pages contained in this Appendix are replacement pages for the body of this document. These pages convert the expressed navigation requirements into the requirements approved for OFT-1.

TABLE 4.1.1-1.- OPS-3 LEVEL B EVENTS

Event No.*	Event Name	Nav Criteria	Nav Action
85	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition to OPS-3 (MM301) from OPS-2	OPS transition initialization. Initiate entry navigation (deorbit preparation phase).
59	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	OPS transition to OPS-3 (MM301) from OPS-1 (MM106)	Same as above.
A20	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	OPS transition to OPS-3 (MM301) from OPS-1 (MM105)	Same as above.
E1	OPS transition to OPS-2 from OPS-3	OPS transition to OPS-2 from OPS-3	Reduce three-state to one-state and save off OPS-2 initialization data.
E11A	Initiate power flight navigation	Deorbit maneuver begins in TBD seconds	Cancel entry navigation (deorbit preparation phase). Initiate entry navigation (deorbit execute phase.)
E10	Mode transition to 301 from 302	Mode transition to 301 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (deorbit preparation phase).
E15	Mode transition to 303 from 302	Mode transition to 303 from 302	Cancel entry navigation (deorbit execute phase). Initiate entry navigation (entry phase).

(2) Deorbit execute navigation phase - The deorbit execute navigation phase will begin whenever the deorbit execute major mode (302) is active and the event flag indicating the deorbit burn is to begin in TBD seconds is on. This phase uses the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function and to initialize the deorbit burn flag to ON to prevent measurement processing. The capability will also be provided for sequencing the entry navigation principal function at the designated repetition rate.

(4) Entry navigation phase - The entry navigation phase will begin at initiation of the pre-entry monitor major mode (303). This phase will use the entry navigation principal function. The deorbit/landing navigation sequencer will provide the capability to cancel the current entry navigation principal function.

The deorbit burn flag will be set to OFF to enable measurement processing.

After completion of initialization, the capability will be provided for sequencing the entry navigation principal function at the designated repetition rate.

(5) Preland navigation phase - The preland navigation phase will begin whenever MSBLS is available at the landing site, Major mode 304 or Major mode 305 is active, and the selected MSBLS range and azimuth data are valid.

This phase will use the preland navigation principal function.

Upon satisfaction of the transition criterion, repetition of the current entry navigation principal function will be cancelled. The flag indicating three-state-operation will be turned OFF.

NAV_THREE_STATE = OFF

Finally, a flag is to be set to indicate preland transition complete.

PRELAND_TRANSITION = ON

The capability also will be provided for sequencing the preland navigation principal function at a premission determined repetition rate.

B. Interface Requirements. The deorbit/landing navigation sequencer principal function will be sequenced at least once at the beginning of Major Modes 301 and 303. This principal function will be sequenced at a 0.52-hertz rate upon entrance to Major Mode 302 until the requirements associated with the deorbit burn event flag are completed and upon entrance to Major Mode 304 and for Major Mode 305 until the requirements associated with valid MSBLS data are completed.

C. Processing Requirements. Before the OPS-2 initialization subfunction can be accomplished, entry navigation must be executed at least once.

D. Constraints. OPS_3_RECONFIGURE and PRELAND_TRANSITION shall be initialized to 'OFF'.

E. Supplemental Information. A suggested implementation of these requirements is illustrated in Appendix B, DEORBIT/LANDING_NAV_SEQUENCER.

4.2.1.2.2 Drag. The computation of drag accelerations will vary according to the values of an input indicator, designated here as GMD.

The value $\underline{D}$ of this acceleration will be set to zero when the acceleration function is called.

If GMD $\neq$ 4, the value of $\underline{D}$ shall not be changed.

If GMD = 4, $\underline{D}$ shall be computed as

$$\underline{D} = - CD\ RHO\ DRAG\_CONST\ |\underline{V}\_R|\underline{V}\_R$$

where the CD is the vehicle's drag coefficient; $\underline{V}\_R = \underline{V}\_REL\ (\underline{V}, \underline{R})$, where $\underline{V}$ and $\underline{R}$ are, respectively, the velocity and position vectors in M50 coordinates; $\underline{V}\_REL$ is the function that computes the relative velocity of the vehicle with respect to the atmosphere (assuming no wind), described in Section 4.4.5.2; RHO is the density of the Earth's atmosphere; and DRAG_CONST is one-half the cross-sectional area of the vehicle divided by the vehicle's mass, a premission-stored constant.

The calculations will be performed in the following order: First, the altitude (needed for the computation of the atmospheric density, RHO) will be obtained from the expression

$$ALT = H\_ELLIPSOID(\underline{R})$$

H_ELLIPSOID is the function that computes altitude above the reference ellipsoid, described in Section 4.4.5.1.

The density then will be found, from different equations; the equation used will depend on the altitude range. For ALT $\leq$ ALT_ZONE_CHANGE,

$$RHO = SEA\_LEVEL\_DENSITY\ EXP\ (DENSE_1 + DENSE_2\ ALT + DENSE_3/ALT) \qquad F1$$

For ALT > ALT_ZONE_CHANGE,

$$RHO = SEA\_LEVEL\_DENSITY\ EXP\ (DENSE_4 + DENSE_5\ ALT + DENSE_6/ALT) \qquad F1$$

Once the atmospheric density has been obtained, the velocity $\underline{V}\_R$, relative to the atmosphere but expressed in M50 coordinates, will be found.

F1-This equation shall be protected against floating point overflow (Reference 3.6.1).

$$ALPHAR = |ARCTAN\ (V\_RHO\_BODY_3/V\_RHO\_BODY_1)| \qquad (F7,F3)$$

$$C\_DRAG = C\_DRAG\_ZERO + ALPHAR\ (C\_DRAG\_ONE + ALPHAR\ C\_DRAG\_TWO)$$

$$Q\_DRAG = H\_S\ \ell n\ (C\_DRAG\ DRAG\_CONST\ RHO\_ZERO$$

$$DT\_FILT\ (\underline{V}\ \_RHO \cdot \underline{V}\ \_RHO)/|(\underline{V}\ \_RHO \cdot \underline{D}V)|) \qquad F3$$

where

$\underline{V}$ _REL($\underline{V}$, $\underline{R}$) is described in Section 4.4.5.2.

and

M_SBODYM50 is obtained by executing the coordinate transformation subfunctin SBODY_TO_M50 (Section 4.4.3.7)

DRAG_CONST, defined as the vehicle reference area divided by twice the vehicle mass is premission loaded. The residual shall then be computed by

$$DQ = Q\_DRAG - Q - BIAS\_DRAG$$

The above calculations will be performed for each state vector. The variables used in these equations shall be set equal to the following parameters prior to execution of the calculations described herein:

$\underline{R}$ = $\underline{R}$ _FILT_ONE, $\underline{R}$ _FILT_TWO, or $\underline{R}$ _FILT_THREE

$\underline{V}$ = $\underline{V}$ _FILT_ONE, $\underline{V}$ _FILT_TWO, or $\underline{V}$ _FILT_THREE

$\underline{D}V$ = $\underline{D}V$_FILT_ONE, $\underline{D}V$_FILT_TWO, or $\underline{D}V$_FILT_THREE

For each state vector, the resulting residual, DQ, will be saved as DELQ_ ONE, DELQ_TWO, or DELQ_THREE. The vector selection subfunction (Section 4.2.5) will reduce the three residuals to a single residual, DELQ, for subsequent use in the residual edit test.

F3-This equation shall be protected against division by zero (reference 3.6.3).
F7-This equation shall be protected against arc tangents with both arguments equal to zero (reference 3.6.7).

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
EPS_TAG	S	Pad	-	Criterion for difference between measurement time and state time, above which the filter state will be extrapolated for residual calculations
E_TEMP	M(6)	0	-	Temporary matrix for covariance matrix initialization
EVENT E1	I	-	-	Flag indicating (ON) a transition from OPS-3 to OPS-2
EV_LT	BIT	Off	-	Temporary flag used to set nav validity flag
EXP_SHAPE_FACTOR	S	Pad	-	Exponential shaping factor for drag coefficient model
FIFTY	M(3)	0	-	General transformation matrix from EF to M50 coordinates
FILT_UPDATE	BIT	Off	-	Switch indicating (ON) that current measurement processing is complete for UPP propagator reset
F1	S	0	-	Auxiliary variable in Pine's formulation
F2	S	0	-	Auxiliary variable in Pine's formulation
F3	S	0	-	Auxiliary variable in Pine's formulation
F4	S	0	-	Auxiliary variable in Pine's formulation

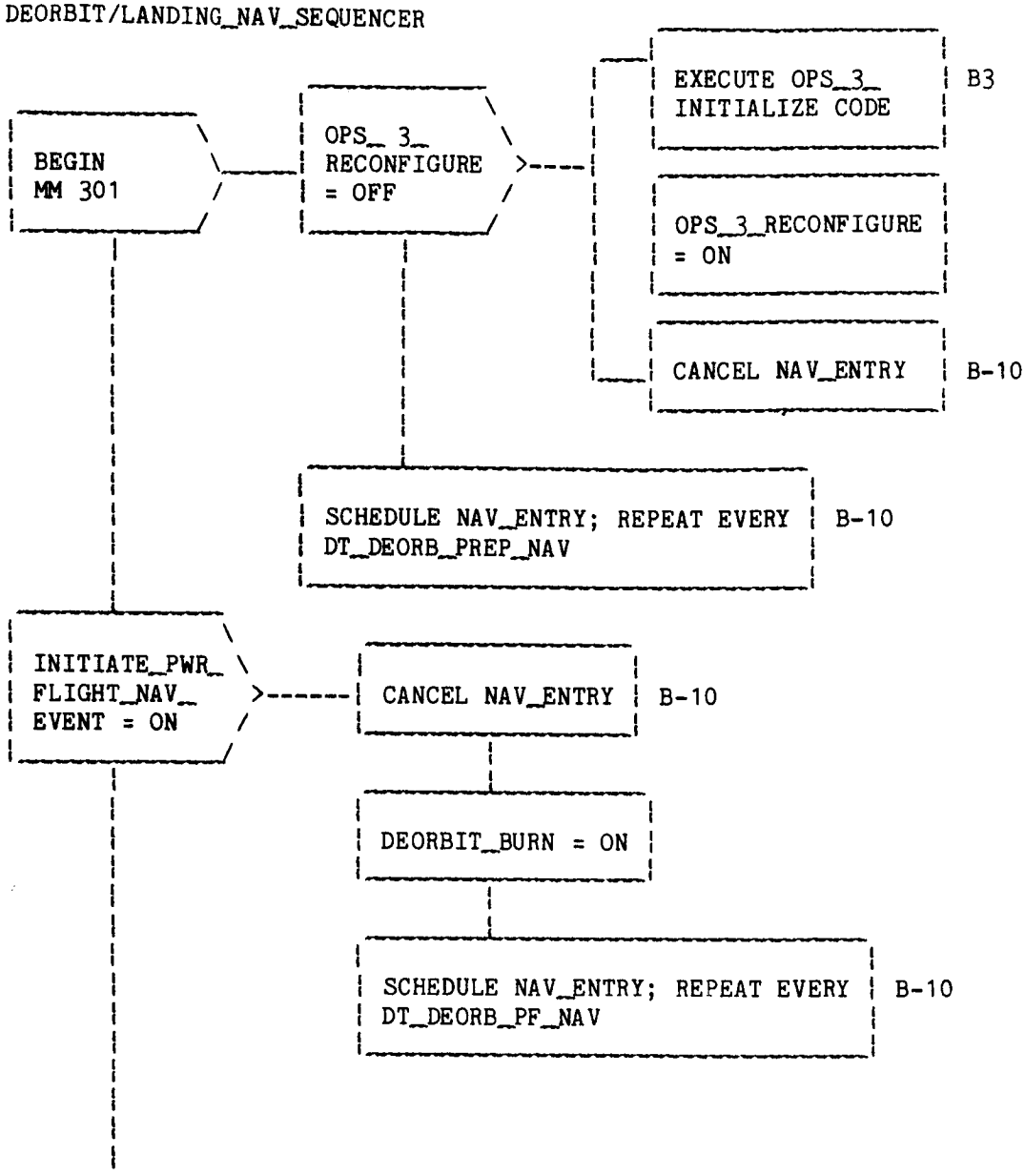
Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
Q_TAC_BRG	S	0	-	TACAN bearing sensor measurement
Q_TAC_R	S	0	-	TACAN range sensor measurement
R	V(3)	0	M50	General Shuttle position vector
RAD_PER_DEG	S	Pad	-	Conversion constant-radians per degree
RAW_RA_PROC	BIT	Off	-	Radar altimeter processing flag
R_AZ_COUNT	INT	0	-	Running count of number of consecutive MLS azimuth and range measurements failing data good test
R_AZ_COUNT_MAX	S	Pad	-	Prescribed number of consecutive MLS range/azimuth measurement data-good 'fails' to force inhibit of MLS processing and allow TACAN processing
R _AZMLS	V(3)	0	-	Position vector of MLS azimuth scanner in M50 coordinates
R _AZMLS_EF	V(3)	0	EF	Earth-fixed MLS azimuth scanner position vector
R _COV_LAST	V(3)	0	M50	Updated vehicle position vector associated with current covariance matrix
R _EF	V(3)	0	EF	General position vector in earth-fixed coordinates
R _ELMLS	V(3)	0	M50	Position vector of MLS elevation scanner in M50 coordinates

Variable List

Variable Name	Data Type	Initial Value	Coord Frame	Variable Description
VAR_UNMOD_ACC_DT_COAST	S	Pad	-	Variance of unmodeled acceleration times scale time during unpowered flight
VAR_UNMOD_ACC_DT_IMU	S	Pad	-	Variance of unmodeled acceleration times scale time during powered flight
V _CURRENT	V(3)	0	M50	General variable for current IMU accumulated velocity
V _CURRENT_FILT	V(3)	0	M50	Snap of IMU raw velocity counts reserved for measurement processing
V _CURRENT_FILT_ONE	V(3)	0	M50	Current accumulated IMU one velocity counts reserved for measurement processing
V _CURRENT_FILT_THREE	V(3)	0	M50	Current accumulated IMU three velocity counts reserved for measurement processing
V _CURRENT_FILT_TWO	V(3)	0	M50	Current accumulated IMU two velocity counts reserved for measurement processing
V _FILT	V(3)	0	M50	Shuttle current velocity vector
V _FILT_INIT	V(3)	OPS 2/ OPS 3		Shuttle velocity vector for OPS 3/OPS 2 initialization
V _FILT_ONE	V(3)	0	M50	Shuttle velocity vector, State 1
V _FILT_THREE	V(3)	0	M50	Shuttle velocity vector, State 3
V _FILT_TWO	V(3)	0	M50	Shuttle velocity vector, State 2

DEORBIT/LANDING_NAV_SEQUENCER



(CONT)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1979—671-014/5 25