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STS-1 Low-Speed Ground Navigation Console Procedures

Mission Planning and Analysis Division

August 1980

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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SHUTTLE PROGRAM

STS-1 LOW-SPEED GROUND NAVIGATION CONSOLE PROCEDURES

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PREFACE

This document contains the first delivery of the low-speed ground navigation onorbit procedures to be used for Space Transportation System (STS-1) mission support. A second delivery will be released in December/1980, followed by a third delivery to be released 1 month prior to STS-1 (third delivery date will fluctuate depending on any additional STS-1 launch date slips).

Similar documents containing the low-speed ground navigation onorbit procedures to be used for future STS/Operations Project Shuttle (OPS) missions will also be published.

McDonnell Douglas Technical Services Co. tasks J and N personnel assisted in writing and reviewing this document. The following people, in particular, made direct contributions to the text: J. A. Termini, R. M. Killen, R. J. LaCarna, J. S. French, R. A. Theis, D. B. Wissinger, and T. M. Rich.

Any questions concerning this document should be directed to Jon Weaver/FM8/3921.

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1.0 INTRODUCTION

1.1 PURPOSE

The Low-Speed Ground Navigation Console Procedures document has been designed to contain the necessary real-time navigation procedures to support the STS-1 onorbit mission profile. In lieu of the rather critical mission timeline following the ascent handover (along with the timeline prior to and including the postdeorbit Guam pass), it became necessary to develop and tabulate a detailed set of navigation procedures to ensure that no critical navigation duties related to the onorbit timeline would be omitted. In constructing such procedures, it was necessary to break the STS-1 onorbit mission phase into three distinct subphases; those subphases being the rev-1 through rev-6 contingency reentry opportunities, the general onorbit time period, and the rev-34 to the postdeorbit Guam pass inclusive (deorbit minus 6-hour procedures). In addition to the detailed onorbit mission procedures, this document contains the necessary information to ensure that sufficient data tables are accummulated in real time to support the postmission off-line ancillary data analysis studies designed to support postmission ancillary data generation and investigation of mission-related anomalies.

The Low-Speed Ground Navigation Console Procedures documents, being mission dependent, shall be modified accordingly and republished in their entirety for subsequent missions.

1.2 NAVIGATION CONCEPT

Ground navigation, for the purpose of this document, can be defined as performing, in the Mission Control Center (MCC), those data processing and mathematical computations related to determining the past and/or future position and velocity components of a given spacecraft. The process of determining the past position and velocity of the spacecraft shall be referred to as orbit determination (OD). The process of determining the future position and velocity shall be referred to as trajectory prediction (or simply prediction). The OD process utilizes observational data in the form of sensor measurements from ground tracking stations (referred to as navigation data or navigation tracking data) to derive the spacecraft position and velocity at some instant of time, usually near or within the data interval being processed. The prediction process utilizes the definition of the spacecraft position and velocity at some instant of time, plus mathematical models of all known forces that affect the spacecraft motion, to predict the position and velocity at some other time of interest, usually some time in the future.

The primary purpose of performing these navigation functions is to provide vehicle position and velocity vectors to support onorbit computations, such as maneuver definitions. The low-speed onorbit phase, for this document, is defined as the time interval from Orbiter Maneuvering System-1 (OMS-1) cutoff to the initiation of the high-speed landing phase prior to entry interface (EI). This interval includes the Orbiter navigation computations required to support a rendezvous with another spacecraft, plus navigation computations for any non-Orbiter

spacecraft (payload and/or a vehicle with which the Orbiter must rendezvous) for which the MCC has overall flight responsibility, or which requires accurate orbital elements. Navigation vectors are also required to support a large number of planning and scheduling processors used during mission operations. Among these are the processors used to generate groundstation acquisition predictions, spacecraft antenna pointing angles, and onboard sensor pointing angles.

1.2.1 Definition of Navigation Systems and Data Types

The STS-1 navigation program shall be capable of processing direct navigation data.

1.2.1.1 Direct Navigation System

The direct navigation system is based on obtaining direct navigation observational data from the world-wide network of Spaceflight Tracking and Data Network (STDN) and Department of Defense (DOD) Earth-based radar stations. These data are obtained from each station whenever the spacecraft is within line-of-sight view of the station. This system is to be used for orbital flight tests (OFT) and has been used for all previous projects. Two basic types of tracking radars are used to obtain direct data.

a. STDN and DOD C-band skin track

   In C-band skin tracking, the signal will be sent from a specific STDN or DOD groundstation to the spacecraft. It will then be returned by reflection off the spacecraft body to the same groundstation where the navigation data will be extracted and sent to the MCC via Goddard Space Flight Center (GSFC). Angular and range measurements will be obtained via C-band skin track.

b. STDN S-band

   In S-band tracking, the signal will be sent from a specific groundstation to the spacecraft where it will be transponded and returned to the original station. The mode in which the signal is received by the same station that transmitted it is known as the two-way mode. Angular, range, and Doppler measurements will be obtained via the S-band network. At the receiving station, the navigation data will be extracted and sent to the MCC via GSFC.

1.3 NAVIGATION RESPONSIBILITIES AND DUTIES

Low-speed ground navigation responsibilities for STS-1 include the following:

a. Maintaining a best available estimate of the current vehicle orbit.

b. Being prepared at all times to provide the Flight Dynamics Officer (FDO) with an estimate of the current prediction accuracy.

c. Providing maneuver target vectors to the FDO as required.

d. Maintaining a continual awareness of the ground ephemeris accuracy and providing update vectors to the FDO when required.

e. Maintaining a continual awareness of the onboard ephemeris accuracy.

f. Maintaining and evaluating incoming low-speed radar (LSR) tracking data.

g. Initializing and controlling the delta-T processor (DTP).

h. Controlling all vector compare processor queues.

i. Providing real-time planning and scheduling support for events affecting navigation, such as vents, burns, attitude maneuvers, and tracking support.

2.0 ACRONYMS

AOA	abort once around
AOS	acquisition of signal
ATL	attitude timeline
ATO	abort to orbit
BB	batch to batch
DC	differential correction
DDPS	digital data processing system
DOD	Department of Defense
DTP	delta-T (ΔT) processor
DYN	dynamics
EOT	end of transmision
FDO	Flight Dynamics Officer
GSFC	Goddard Space Flight Center
HSDL	high-speed data line
JSC	Johnson Space Center
LOS	loss of signal
LSIP	low-speed input processor
LSR	low-speed radar
MCC	Mission Control Center
MED	manual entry device
MSP	mission support plan
NOCC	Network Operations Control Center
OD	orbit determination
ODP	orbit determination processor
OFT	orbital flight test

OMS	Orbiter maneuvering system
OPS	Operations Project Shuttle
RATL	reentry attitude timeline
RVTL	reentry vent timeline
SCBB	Shuttle current batch to batch
SCSB	Shuttle current superbatch
SCT	station characteristics table
STDN	Spaceflight Tracking and Data Network
STS-1	Shuttle Transportation System Mission-1
SV	state vector
SVT	superbatch vector table
TTY	teletype
VAT	vector administration table
VIT	vent initialization table
VTL	vent timeline

3.0 PREMISSION LOW-SPEED NAVIGATION REQUIREMENTS

3.1 DESCRIPTION OF PREMISSION REQUIREMENTS

The ascent low-speed navigation team is responsible for prelaunch configuration of the low-speed input processor (LSIP) and the orbit determination processor (ODP), and for loading and verifying certain vent-related parameters and tables. These functions will be carried out in the period from launch minus 6 hours to launch minus 15 minutes. A detailed timeline and checklist is included in section 3.2. The prelaunch responsibilities are summarized below.

3.1.1 Prelaunch Team Meeting

Prior to launch, the low-speed ascent team leader will meet with all low-speed ascent team members at a specified time and location to assign and review their console positions and duties. At least one team member (to be specified by the team leader) will be required to monitor the ascent mission phase prior to high-to-low-speed handover to gain insight into any anomalies encountered that might affect the handover and subsequent data processing procedures. The actual start/stop times of the auxilliary power unit (APU)/H_2O vents, along with the mission status (nominal, abort to orbit, or abort once around), should be known at the low-speed handover time.

3.1.2 Low-Speed Input Processor Configuration

a. The minimum and maximum batch size limits should be set to 3 and 80 data frames, respectively. The minimum batch size limit defines the number of valid data frames that must be accumulated in order for the open batch, upon closing, to be stored for future processing. The maximum batch size limit defines the maximum number of valid data frames that an open batch may accumulate prior to closing (not to exceed 80). The default system values are 6 and 80 data frames, respectively. Station end-of-transmission (EOT) indicators, along with user generated EOT commands, could cause the open batch to close prior to the user-specified maximum batch size limit.

b. The minimum elevation parameter should be checked to ensure that all tracking data frames whose associated elevation angles are less than three degrees will not be saved for future processing. The default system value is three degrees. The lowest value to which the parameter can be set is one degree.

c. Load the correct Shuttle S-band transponder delay value to be applied to all incoming S-band range data. The transponder delay value will be subtracted from all incoming S-band range observations by the LSIP to account for signal turnaround time delays. The transponder delay value received from GSFC will account for the round-trip time delay. The value loaded into the MCC should be equal to one-half of the nominal round-trip time delay.

d. Verify the C-band and S-band data routing parameters. The nominal Shuttle numeric vehicle and beacon identifications (ID's) used to route incoming LSR tracking data will be 05 and 1, respectively.

3.1.3 Initialize Low-Speed Radar Disk Data Set

The LSR tracking data disk data set will be initialized when the MCC system is in a nonmission mode (actual bit must be turned off). To determine whether the MCC system is in a nonmission mode, the flight/test status indicator on the system status display (fig. 3-1) should be checked. If the status indicator is set to TEST, the manual entry device (MED) operator is cleared to initialize and enable for logging the LSR disk data set. If the status indicator is set to FLIGHT, the MED operator will need to coordinate the LSR disk initialization with the computer supervisor on the SDP INT communications loop to ensure that the actual bit is turned off at the time the initialization MED is entered. It should be noted that the LSR disk data set can be enabled or disabled independently of whether the actual bit is set to on or off. A DISK LOGGING ENABLED message appears on the on-line monitor (MSK 0005) when the S34 MED is entered to enable logging. All LSR C-band and S-band tracking data will be recorded onto the disk when the disk data set action mode is set to ENABLED.

The LSR disk data set provides the nav operator with a quick and easy way to read back into the program all or selected tracking data accumulated during the past should tracking data losses occur in the system.

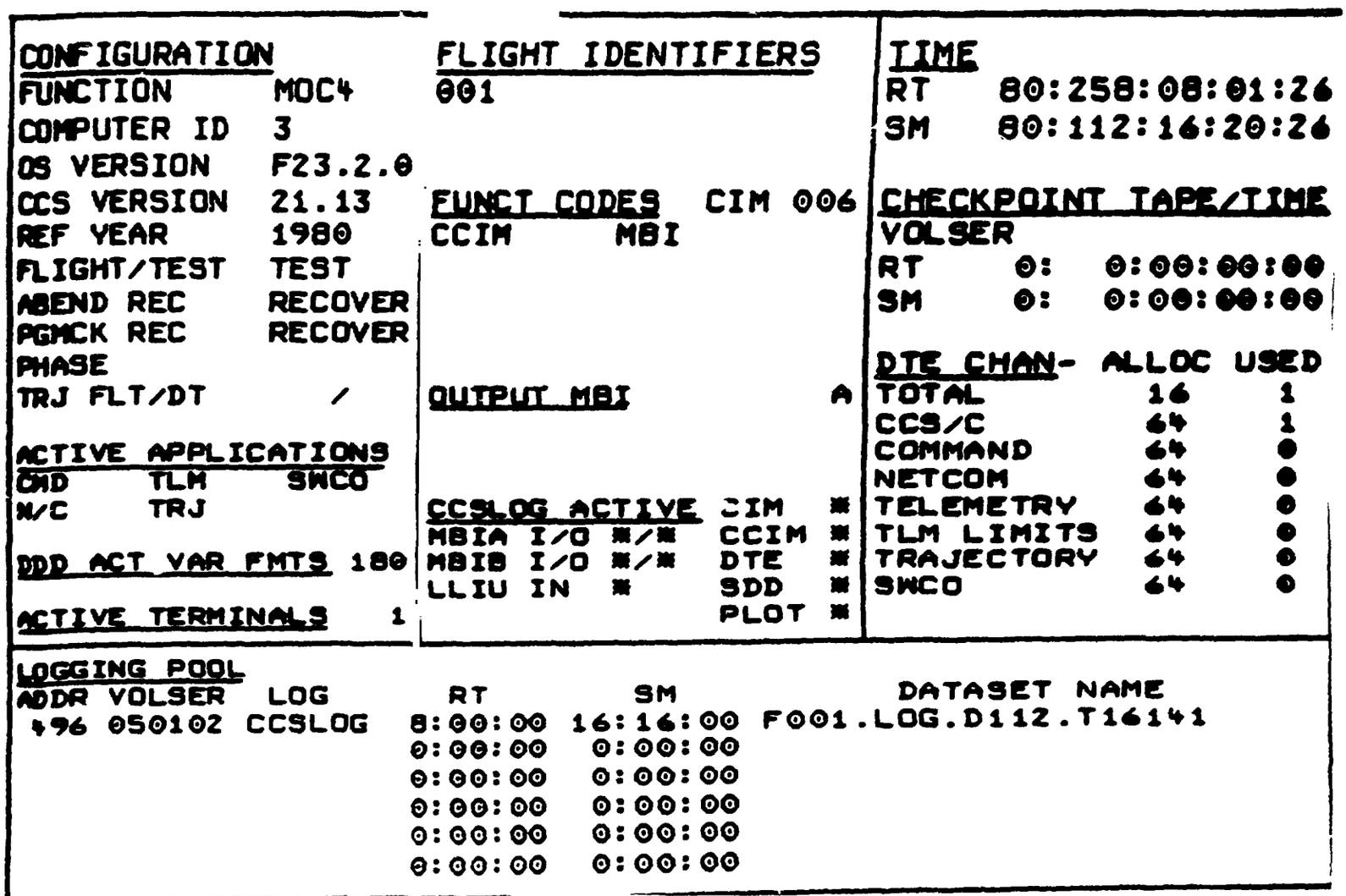


Figure 3-1.- System status.

3.1.4 Vent Timeline/Reentry Vent Timeline Initial Load

Load the vent timeline (VTL) and the reentry vent timeline (RVTL) with the appropriate vents, along with their respective start/stop times. The VTL/RVTL allows the low-speed navigation operator to model the effects of all major low-level thrusts that occur during the ascent, early onorbit, and deorbit time frames. Nominally, the VTL/RVTL will be configured to support an abort once around (AOA) mission timeline. In the event that the mission turns out to be non-AOA, the navigation operator will need to make the appropriate changes to the VTL.

3.1.5 Madrid/Orroral Valley Site Configuration Message Verification

The low-speed ascent team leader should review the Madrid/Orroral Valley S-band site configuration messages prior to launch to ensure that both sites are nominally scheduled to track. The 85-foot Madrid antenna (MAXS) should be scheduled to track as a backup to the nominal 30-foot Madrid antenna (MADS) in case a tracking problem should develop. Any rescheduling should be conducted with the OPS planner on the OPS PLNR communications loop.

3.1.6 Communication Checks

The GSFC OCF communications loop linking the Johnson Space Center (JSC) with the GSFC data analysis group should be verified prior to launch. The GSFC data analysis group will be using the call name "resident analyst."

3.1.7 Station Characteristics Table Verification

Verify the station characteristics parameters corresponding to all C-band and S-band stations scheduled for mission support. The MCC station characteristics table (SCT) will be compared with the current official GSFC release.

For each site, the following station-related parameters should be verified:

a. Numerical station identifier.

b. Latitude.

c. Longitude.

d. Station height.

e. Refraction multipliers.

f. Data weight multipliers.

g. Shuttle and payload frequency for each S-band site.

3.1.8 Madrid Refraction Computations

The first Madrid low-speed tracking pass has been singled out as a critical pass because it is required for crew safety in numerous contingency situations. Either partial- or full-pass solutions may be required. In order to provide the best possible single-station solution, near real-time weather data will be obtained from the site and will be used to compute refractivity and atmospheric scale height. These values will then be used to determine MCC inputs for the refraction parameters REFMULT and KFMULT, which will be entered via the SO1 MED.

The equations, the HP97 calculator program, and the console procedures required to carry out the above task are given in the following pages. The weather data required are pressure (millibars), temperature (degrees Kelvin), and relative humidity (fraction of 1). Note that 100-percent relative humidity is input as 1.0, 50-percent relative humidity is input as 0.5, and so forth. Conversion factors are given in the checklist for critical passes.

3.1.8.1 Equations

A program has been written for the HP97 calculator to compute refractivity and scale height. The equations utilized (ref. 1) are as follows:

$$\text{Define } N = (n-1) \times 10^6 \qquad \text{where } n = \text{index of refraction}, \; N = \text{refractivity}$$

Sea level refractivity, N_{SL}, is given by the following (ref. 2):

$$N_{SL} = \frac{77.6}{T}\left(P_{SL} + \frac{4810 e_s \, RH}{T}\right)$$

where T = temperature (^{o}K)
P = Pressure at sea level (millibars)
e_s = saturation vapor pressure of water (millibars)
RH = fractional relative humidity

Scale height, H_s, is given by (ref. 3)

$$H_s = A - (B \, N_{SL}) \exp \frac{H}{H_s}$$

where H = station height in meters
H_s = scale height in meters
A = 17 590 meters
B = 30.55
H_s = 7000 meters for first-guess approximation

3.1.8.2 HP97 Program

The program code for the HP97 calculator used to compute refractivity and scale height is given in table 3-I. Inputs that are required are listed in table 3-II, while tables 3-III and 3-IV present data needed to determine the saturation vapor pressure of water and the relative humidity (refs. 2 and 4), respectively.

TABLE 3-I.- PROGRAM CODE FOR REFRACTIVITY AND SCALE HEIGHT COMPUTATIONS

Label A		Label B		Label C	
RCL 7	ENTER	RCL 1	ENTER	RCL 1	ENTER
RCL 2	X	STO 7		R/S	
RCL 3	÷	1/X		1/X	(one divided by X)
4810	X	RCL 6	X	RCL 6	X
RCL 4	+	e^x		CHS	
77.6	X	RCL 5	X	e^x	
RCL 3	÷	30.55	X	RCL 5	X
STO 5		CHS		R/S	
		17590	+	RTN	
		STO 1			
		RCL 7	-		
		f ABS			
		1			
		f x > y			
		GTO C			
		GTO B			

3.1.8.3 Critical Pass Procedures Checklist

TIME (GMT) _____

EVENT: Prelaunch procedures for Madrid refraction and/or GWM, ORR

Check	Required action	Comments
	1. Obtain the following real-time weather data from the JSC weather office: temperature, dew point temperature or relative humidity (RH), and sea level pressure. Enter in table to the right.	
	2. Calculate relative humidity (if not provided in step 1) from T and T_d using table 3-IV. Enter RH in top table.	
	3. Look up saturation vapor pressure of water using table 3-III. Enter e_s in top table.	
	4. Convert pressures to millibars, temperature to degrees Kelvin, and relative humidity to a fraction of one; enter at table to the right.	

Parameter	Value	Units
T		
T_d		
P		
RH		
e_s		

Parameter	Value	Units
T		^oK
P		mbar
RH		fraction
e_s		mbar

To convert from	To	Formula
Millimeters of H_g	Millibars	P(mb) = 1.33322 P (mm)
Temperature ^oF	^oK	$T(^oK) = \frac{5}{9}$ (T - 32) + 273.16
Relative humidity, percent	RH (fraction)	Multiply by 0.01

5. Initialize the refraction program on the HP97. Turn to RUN PROGRAM and insert the magnetic card marked refraction.

   Input the data and copy below.

TIME (GMT) _____

EVENT: Prelaunch procedures for Madrid refraction and/or GWM, ORR - Concluded

Check	Required action	Comments

Parameter	Value	Register
Partial pressure of water vapor (mb)		7
Relative humidity (fraction)		2
Temp. (^{o}K)		3
Pressure (mb)		4
Height of station (m)		6
H_s (first guess)	7000	1

6. Press ! A !

7. Scale height will be displayed; copy the value.
   Press !R/S! to continue execution. H_s =

8. Refractivity at the station will be displayed. Copy the value. N_s =

9. Look up the default value of H_s in table 3-V. Copy the value. H_o =

10. Look up the default value of N_s in table 3-V. Copy the value. N_o =

11. Compute REFMULT: $REFMULT = \frac{N_s}{N_o}$; REFMULT =

    copy value and enter the MED:

    SO1, MADS, 21,/P3, REFMULT/$

12. Compute KFMULT: $KFMULT = \frac{H_s}{H^o}$; KFMULT =

    copy; enter MED:

    SO1, MADS, 25,/P3, KFMULT/$

TABLE 3-II.- INPUTS FOR HP97 REFRACTIVITY PROGRAM

Register	Value	Unit
1	7000	meters
2	Relative humidity	fraction of 1
3	Temperature	degrees kelvin
4	Pressure	millibars
6	Height of station	meters
7	Water vapor pressure	millibars

TABLE 3-III.- SATURATION VAPOR PRESSURE OF WATER (e_s)

Temperature, °F	Temperature, °C	Temperature, °K	e_s, millibars
20	-6.67	266.49	3.712951
21	-6.11	267.05	3.875404
22	-5.56	267.60	4.041523
23	-5.00	268.16	4.216975
24	-4.44	268.72	4.398293
25	-3.89	269.27	4.583690
26	-3.33	269.83	4.826256
27	-2.78	270.38	4.979577
28	-2.22	270.94	5.188892
29	-1.67	271.49	5.424872
30	-1.11	272.05	5.631404

TABLE 3-III.- Continued

Temperature, °F	Temperature, °C	Temperature, °K	e_s, millibars
31	-0.56	272.60	5.8630
32	0	273.16	6.100
33	0.56	273.72	6.3559
34	1.11	274.27	6.6157
35	1.67	274.83	6.893100
36	2.22	275.38	7.1646
37	2.78	275.94	7.456
38	3.33	276.49	7.752
39	3.89	277.05	8.065
40	4.44	272.60	8.388377
41	5.00	278.16	8.723283
42	5.56	278.72	9.070187
43	6.11	279.27	9.421758
44	6.67	279.83	9.792128
45	7.22	280.38	10.169164
46	7.78	280.94	10.558
47	8.33	281.49	10.961
48	8.89	282.05	11.416
49	9.44	282.60	11.824361
50	10.00	283.16	12.277657
51	10.56	283.72	12.745085
52	11.11	284.27	13.211

TABLE 3-III.- Continued

Temperature, °F	Temperature, °C	Temperature, °K	e_s, millibars
53	11.67	284.83	13.711
54	12.22	285.38	14.228296
55	12.78	285.94	14.759586
56	13.33	286.49	15.299875
57	13.89	287.05	15.868428
58	14.44	287.60	16.443981
59	15.00	288.16	17.049264
60	15.56	288.72	17.673480
61	16.11	289.27	18.305494
62	16.67	289.83	18.970906
63	17.22	290.38	19.643451
64	17.78	290.94	20.351393
65	18.33	291.49	21.067201
66	18.89	292.05	21.817206
67	19.44	292.60	22.579681
68	20.00	293.16	23.378077
69	20.56	293.72	24.201210
70	21.11	294.27	25.033275
71	21.67	294.83	25.907603
72	22.22	295.38	26.790597
73	22.78	295.94	27.717644
74	23.33	296.49	28.654110

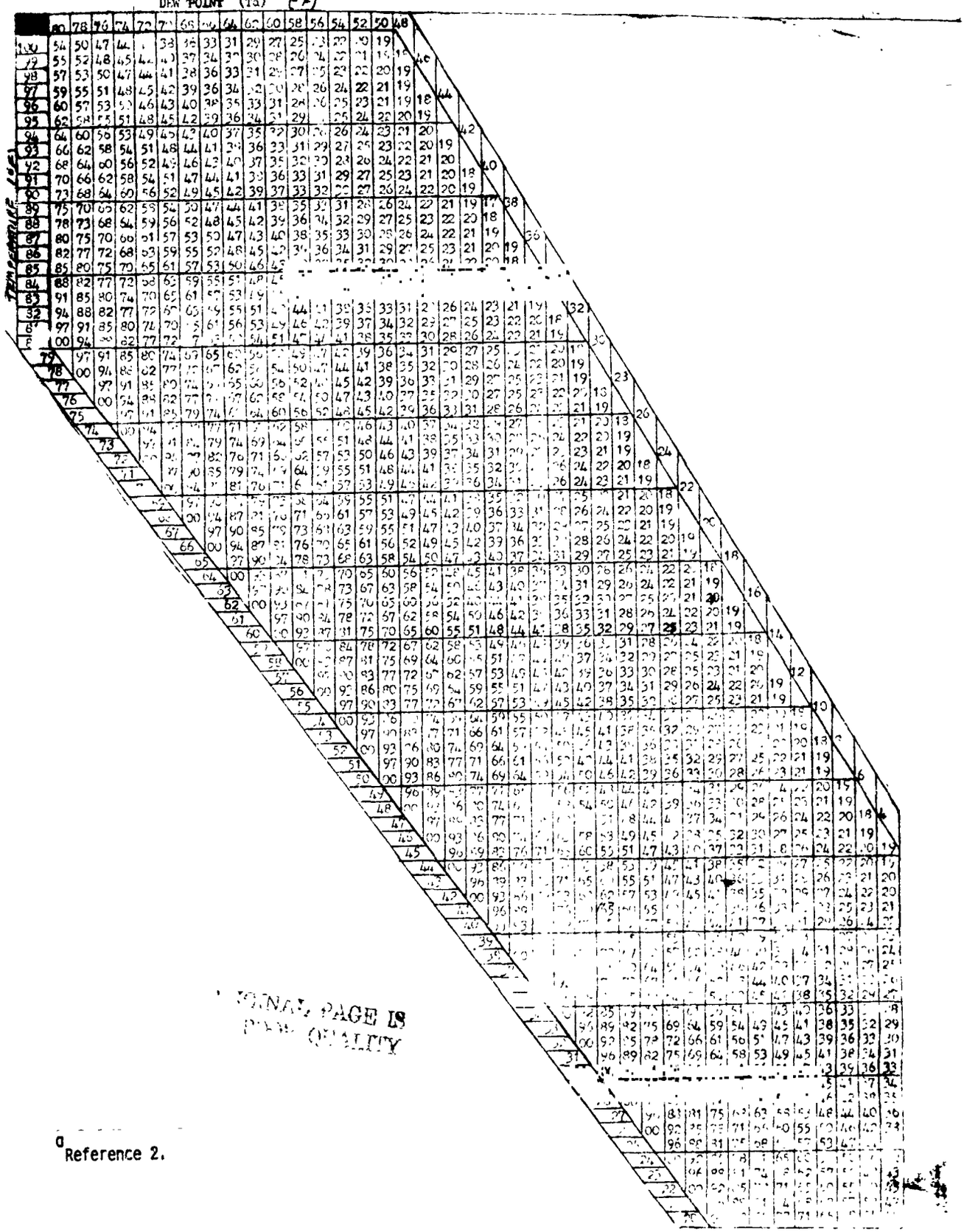
TABLE 3-III.- Continued

Temperature, °F	Temperature, °C	Temperature, °K	e_s, millibars
75	23.89	297.05	29.637762
76	24.44	297.60	30.633747
77	25.00	298.16	31.672062
78	25.56	298.72	32.742374
79	26.11	299.27	33.829218
80	26.67	299.83	34.963991
81	27.22	300.38	36.112897
82	27.78	300.94	37.314931
83	28.33	301.49	38.527165
84	28.89	302.05	39.800327
85	29.44	302.60	41.085154
86	30.00	303.16	42.428511
87	30.56	303.72	43.775
88	31.11	304.27	45.172
89	31.67	304.83	46.631
90	32.22	305.38	48.141241
91	32.78	305.94	49.646
92	33.33	306.49	51.240919
93	33.89	307.05	52.899
94	34.44	307.60	54.511
95	35.00	308.16	56.229
96	35.55	308.71	57.963

TABLE 3-III.- Concluded

Temperature, °F	Temperature, °C	Temperature, °K	e_s, millibars
97	36.11	309.27	59.772
98	36.67	309.83	61.631
99	37.22	310.38	63.507
100	37.78	310.94	65.466

TABLE 3-IV.- RELATIVE HUMIDITY TABLE
(Sea level values, percent[a])



[a] Reference 2.

TABLE 3-V.- NOMINAL REFRACTIVITY AND DECAY CONSTANTS

	Madrid			Orroral			Guam		
Month	Refractivity, N	Scale height, Hs (m)	Station height, H (m)	Refractivity, N	Scale height, Hs (m)	Station height, H (m)	Refractivity, N	Scale height, Hs (m)	Station height, H (m)
Jan.	298	7214	785	307	7058.1	929	336	6535.1	92
Feb.	300	7179.9		310	7005.1		336	6535.1	
Mar.	301	7162.7		308	7040.2		349	6294.7	
Apr.	301	7162.7		304	7110.4		369	5924.4	
May	306	7075.3		298	7214.3		364	6016.9	
Jun.	310	7005.1		293	7299.8		364	6016.9	
July	316	6898.0		292	7316.4		364	6016.9	
Aug.	317	6880.1		292	7316.4		363	6035.4	
Sept.	318	6862.3		293	7299.8		380	5721.2	
Oct.	309	7022.4		293	7266.0		359	5982.0	
Nov.	302	7145.5		295	7266.0		346	6350.2	
Dec.	299	7197.1		300	7179.9		341	6442.6	

3.1.9 Orbit Determination Program Initialization

The maximum number of iterations through the convergence processor (CP) for superbatch (SB) solutions should be changed from the nominal value of three to five iterations. The maximum number of iterations that can be specified is 10. The range observation data weighting factor should also be changed from the nominal value of 230 to 1. This will increase the weight of the range observation data used in the differential correction (DC) process to update the initial estimate of the input state vector.

3.2 PRELAUNCH CHECK LIST

To be determined.

4.0 GENERAL DATA PROCESSING PROCEDURES

All incoming tracking data should be plotted on the Shuttle batch plot (MSK 334) while they are being received in the MCC. The console operators should determine whether refraction and bias corrections are being properly applied to the data, and whether the data shows the existence of any tracker problems. If the residuals are larger than normal, possible causes that should be investigated are hardware problems at the tracker, the quality of the vector on which the data are plotted, and the presence of unmodeled forces on the vehicle since the last tracking data were processed. Each of these cases will be discussed in more detail later in this section.

Once a batch of data has been closed via the S22 MED, and any gross data have been edited, the previous solution should be accepted and the batch plot updated on its own batch-to-batch (BB) or SS4 solution. An SS1 (unconstrained) solution should then be performed, and the plot updated on this solution to assist in editing the batch. This latter process should be repeated until editing is completed. Finally, an SS4 solution should be performed, and this solution should be compared against the ground ephemeris via the S80 MED and MSK 337. This process should be repeated until all batches have been processed. From time to time (approximately twice each rev) solutions should be stored in the vector administration table (VAT) and used to update the ground ephemeris if so directed by the FDO.

4.1 REFRACTION CORRECTIONS

For DOD tracking stations, refraction corrections are applied to the data at the tracking site. For most National Aeronautics and Space Administration (NASA) stations, however, they are applied at the MCC. The data that are refracted in the MCC will be permanently corrected whenever a DC MED is processed or whenever a preedit (S08) or selection edit (S06) is performed. The refraction correction that is applied when a batch plot is executed is temporary; thus, it is wise to plot all incoming tracking data (U18 MED and MSK 334) prior to execution of a DC to verify that refraction corrections have been properly applied.

If refraction corrections are being improperly applied, the parameters REFMULT and KFMULT should be adjusted in the SCT (S01 MED and MSK 328). Three situations may require a change in the refraction parameters: (1) the correction has not been applied at all, (2) the correction has been applied twice, or (3) the tracking pass is a critical pass for which real-time values may be required for refractivity and atmospheric scale height.

In the case where no refraction correction has been applied, the parameters REFMULT and KFMULT should be changed to 1.0. In the case where the correction has been applied twice, these parameters should be changed to zero. For critical passes at Madrid, real-time weather data should be obtained from the JSC weather office via the "WEATHER NET" loop, and the refractivity and scale height should be computed using the procedures in the critical pass checklist (sec. 3.1.8.3).

Sample plots of data that are properly corrected for refraction, uncorrected for refraction, corrected with an error in the refraction index, corrected with an error in scale height, uncorrected with downtrack error, and twice corrected for refraction are given in figures 4-1 through 4-6, respectively.

4.2 DATA BIASES

If the residuals of the incoming data show a possible bias in one of the measurement types, the TRACK console operator should be notified of the situation so that he can ask the station to check their angles, or to reacquire the range signal should this be necessary. If the problem persists, and hardware/software problems at the site are not suspected, the current vector may be invalid or downgraded. However, if the operator has confidence in the quality of the vector (based on the history of previous batch residuals and data quality), he should determine whether maneuvers, venting, or other orbit perturbations have occurred since the previous data were processed. The onboard navigation console operator (O-NAV) should be consulted to determine if the inertial measurement units (IMU's) have sensed any accelerations.

The current state vector may be of poor quality for several reasons. Initially, the vector may be based on insufficient data or poor station geometry. In addition, long propagation periods will cause even small errors in a state vector to grow due to mismodeled and unmodeled forces. This is especially true for downtrack errors. For instance, the position error due to drag for a 200-n. mi. circular orbit will be between 0.2 and 3.0 kilometers per hour of propagation time, depending on the location within the 11-year cycle of solar flux activity. Unmodeled vent forces and attitude maneuvers will also result in large propagation errors. Figures 4-5 and 4-6 illustrate batch residual plots on a vector with downtrack error. The downtrack signature is quite evident in the range residuals: an S-curve with the break at maximum elevation or closest approach of the vehicle to the station. This break of the range residuals at maximum elevation distinguishes a downtrack position error from a range bias. The latter plots as a straight line. The Doppler signature for the downtrack error is similar to a bell curve with the largest residuals occurring at maximum elevation. These can be somewhat large even for a small downtrack error if it is a very high elevation pass. The angle residuals will also show a marked change at maximum elevation for downtrack position errors.

As a general rule, the expected standard deviation for a converged, unconstrained, single-station solution (SS1) is less than 0.5 milliradians in the azimuth angle (X), less than 0.2 milliradians in the elevation angle (Y), and less than 40 yards in range. Although the theoretical accuracy for the Doppler measurement is 0.005 Hz, the actual standard deviation may be as large as 1.5 Hz because errors in the force models employed in the MCC software, and errors in the other data types, will cause the vector to converge to a different value than that which would fit the Doppler data alone. Therefore, the Doppler standard deviation will always be larger than 0.005 Hz, but should not be larger than 1.5 Hz. For an SS1 solution, the Doppler standard deviation will usually be less than 0.25 Hz. Larger residuals may indicate that angle bias corrections have not been properly applied at the tracking site. The resident analyst at GSFC can be contacted on the "GSFC OCF" communications loop to verify what corrections are being applied.

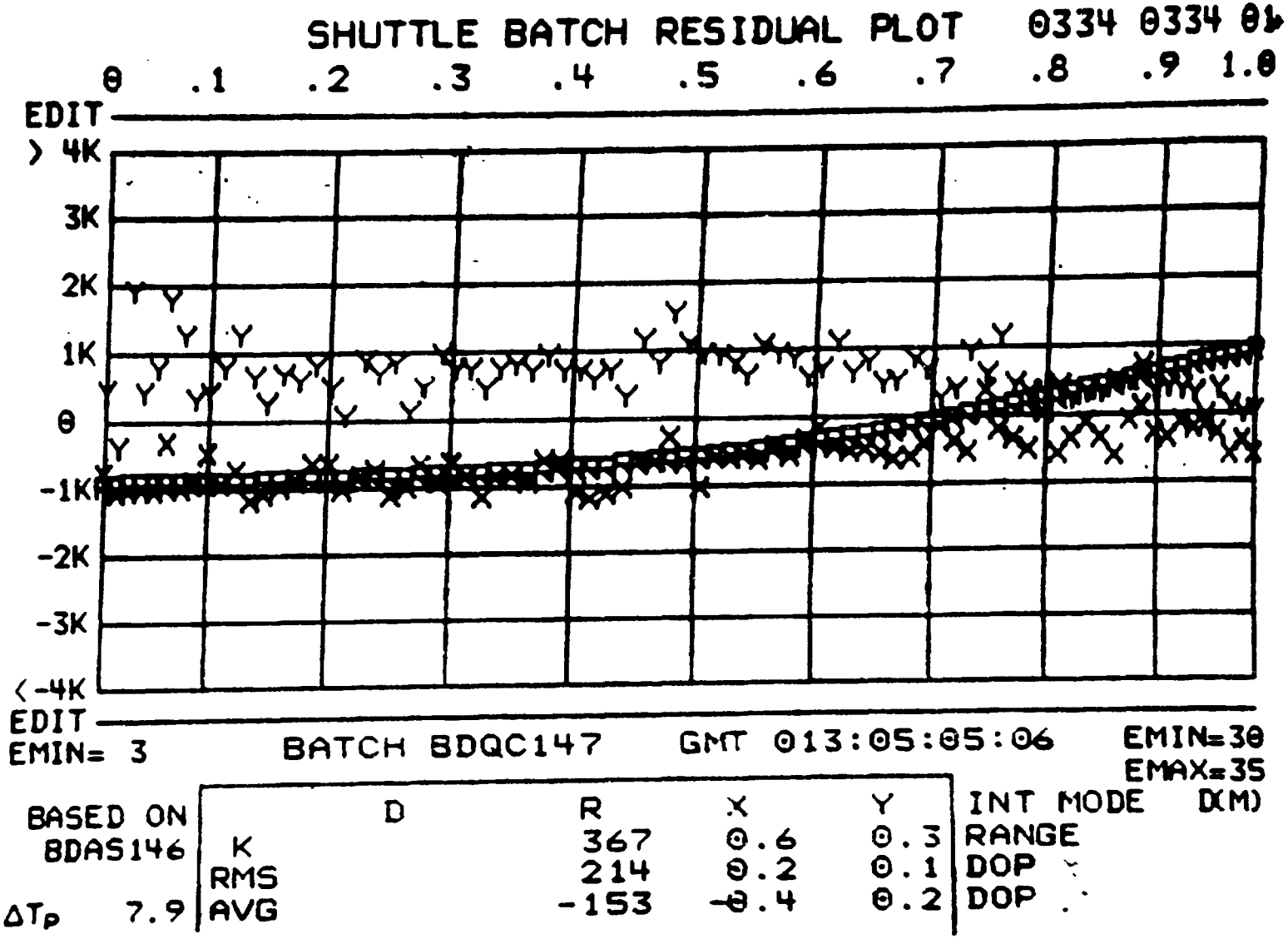


Figure 4.1-1.- Nominal refraction correction.

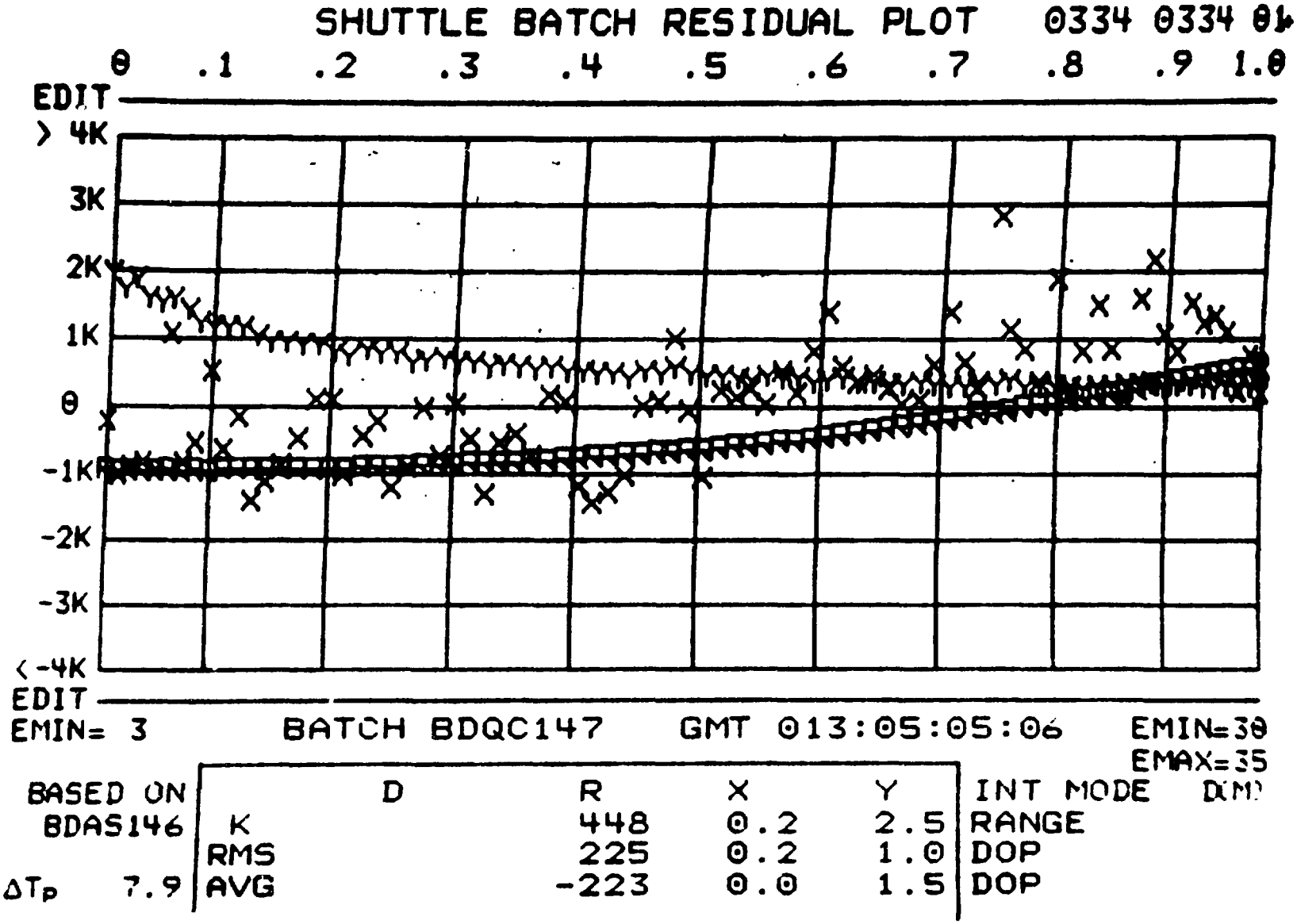


Figure 4.1-2.- No refraction correction.

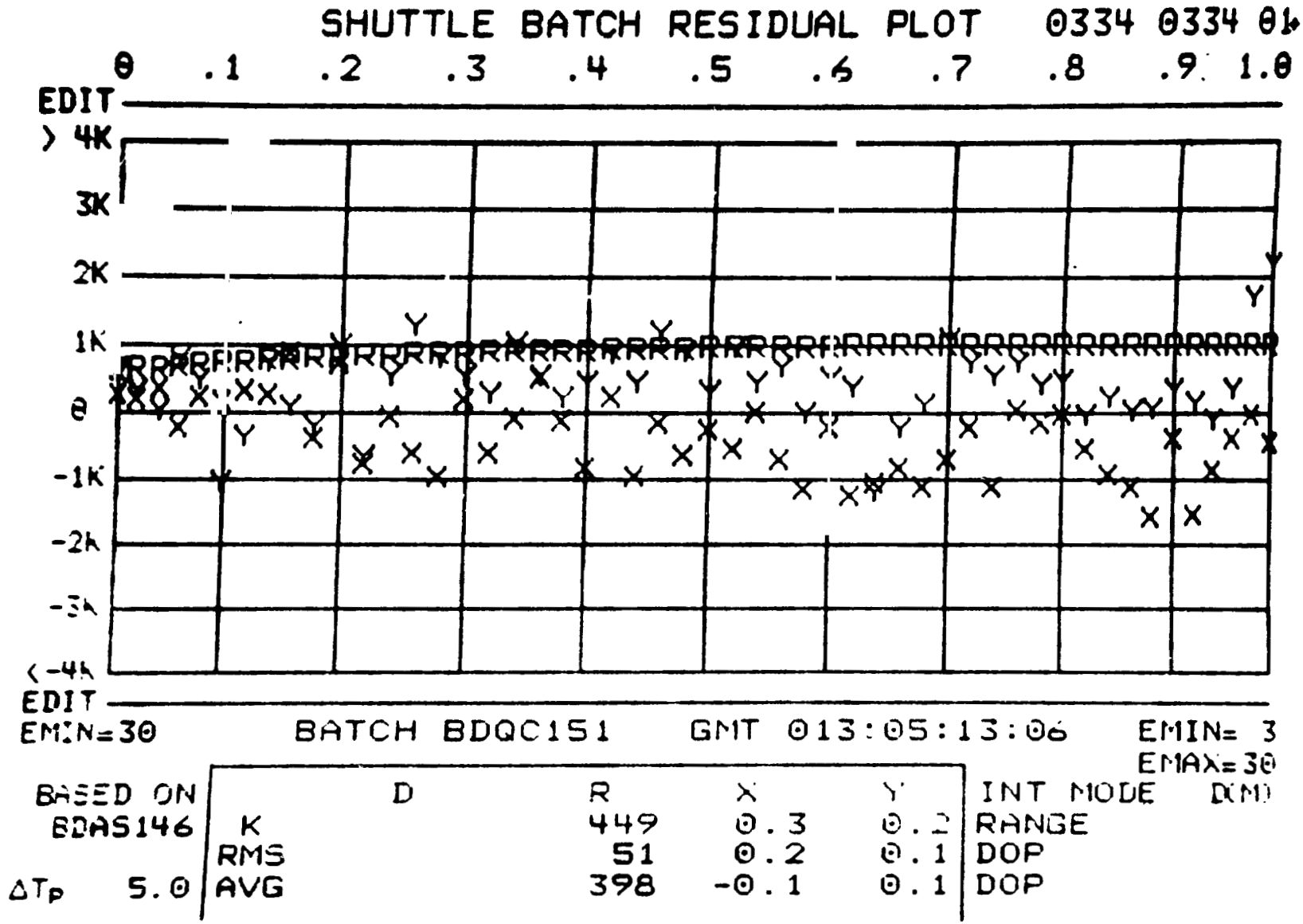


Figure 4.1-3.- Ten-percent error in refractivity.

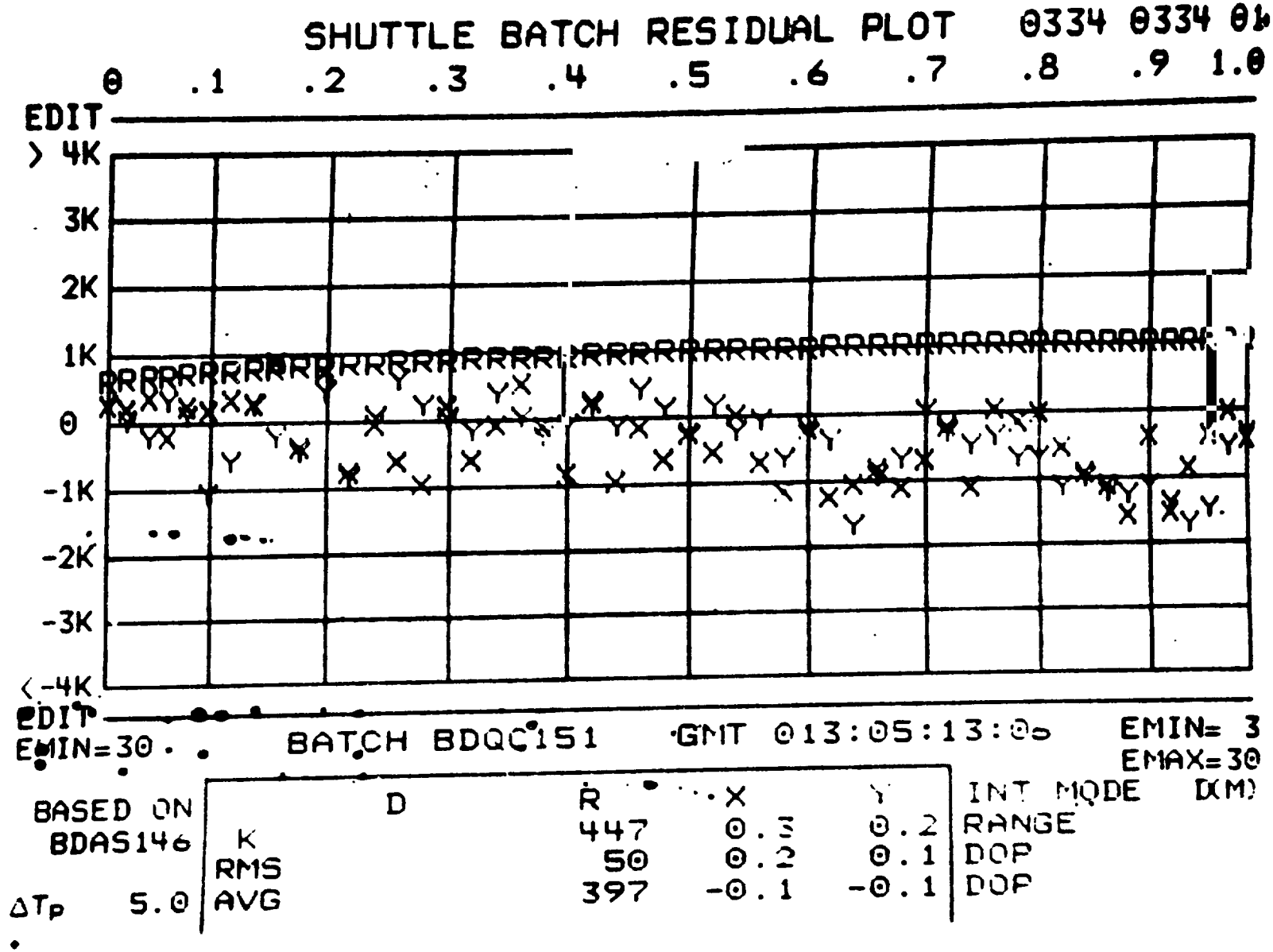


Figure 4.1-4.- Refraction correction with 400-percent error in scale height.

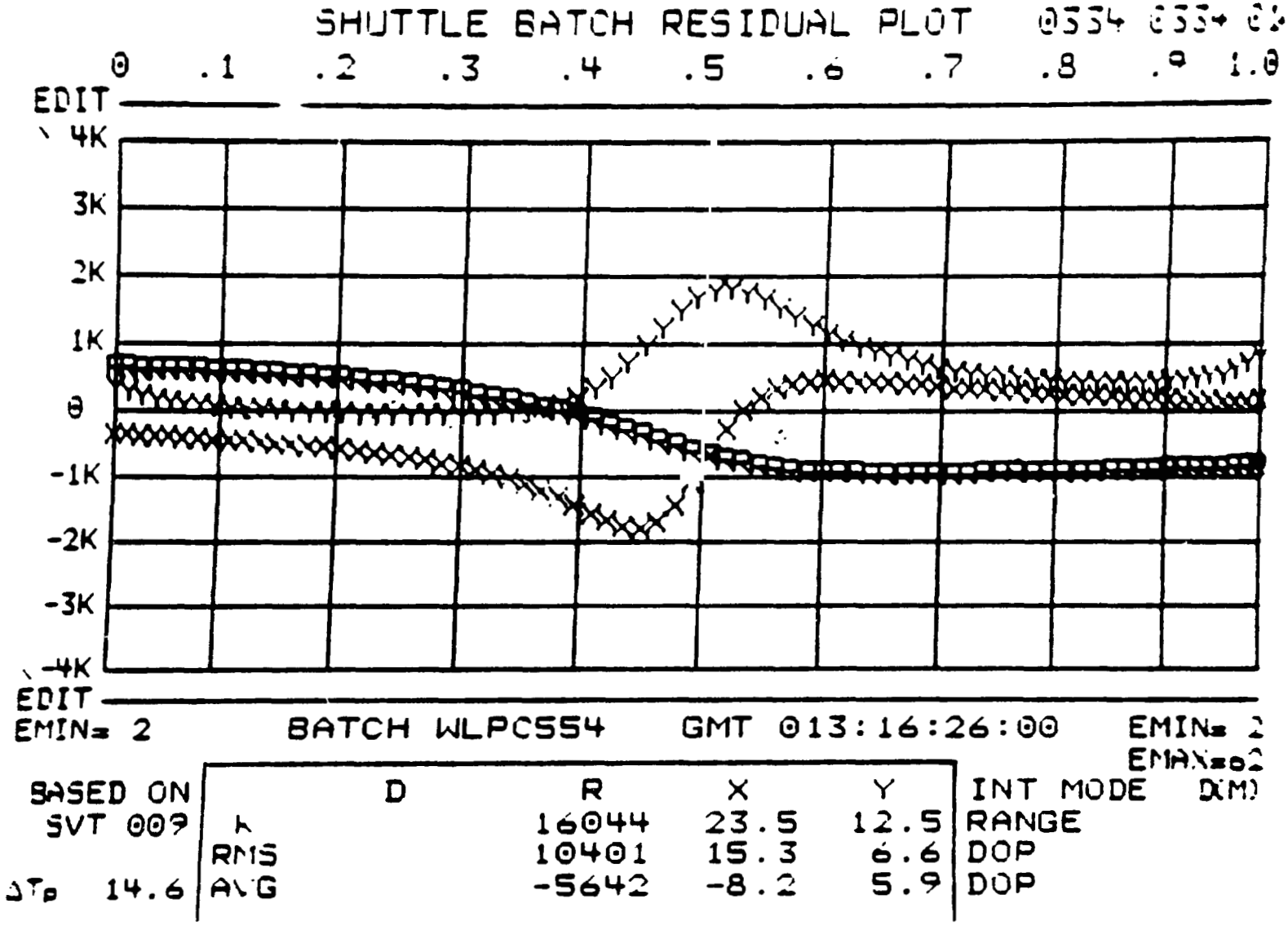


Figure 4.1-5.- No refraction correction with downtrack error.

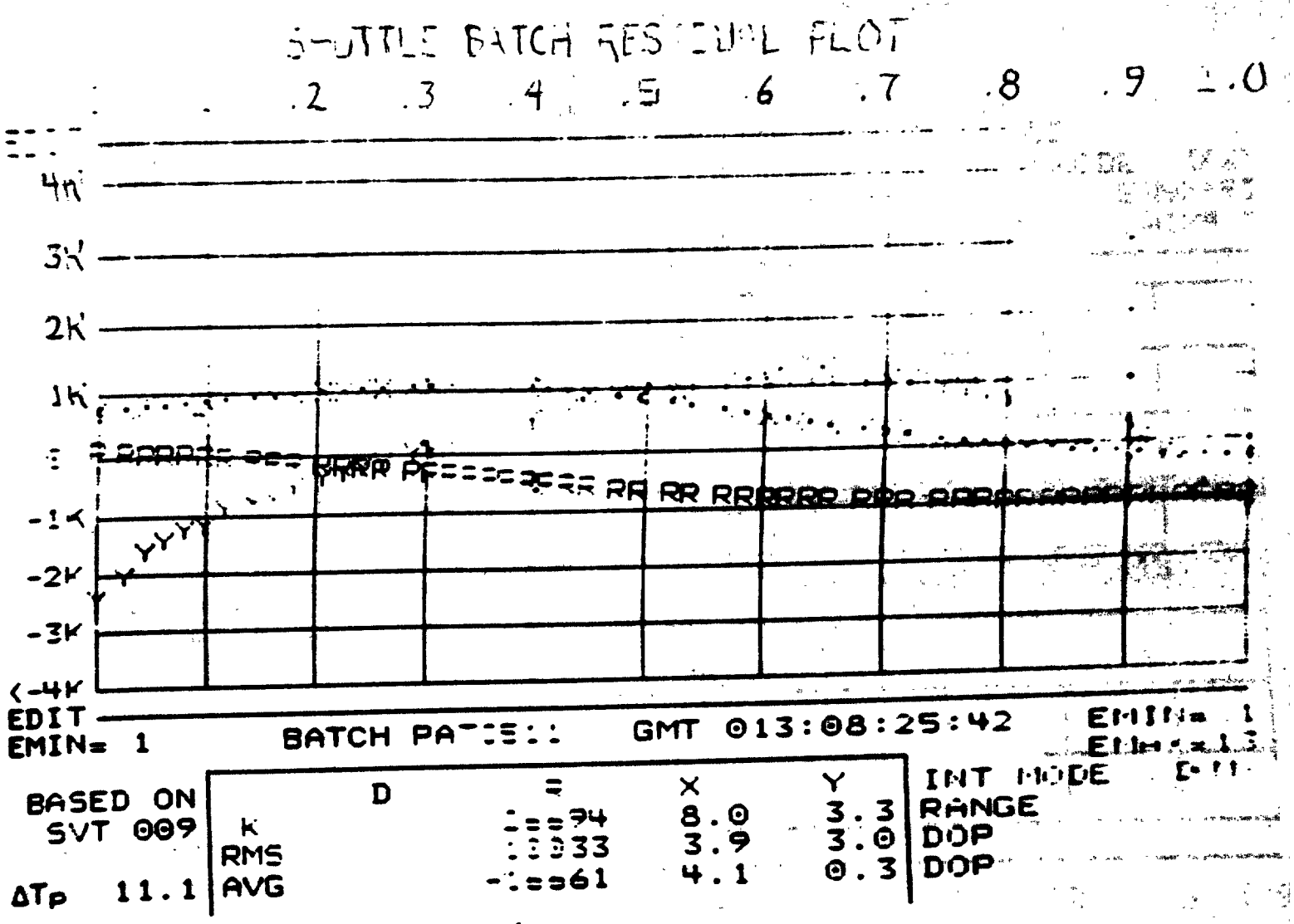


Figure 4.1-6.- Double refraction correction with downtrack error.

4.3 DATA PROCESSING IN THE SUPERBATCH MODE

In addition to processing the C-band and S-band radar tracking data in the BB mode, the data should be processed in the SB mode approximately every four hours. Depending on the quality of the fit (as determined from the DC), the residuals appearing on the DC summary display (MSK #326), and the computed residuals for each batch included in the solution appearing on the Shuttle residuals summary display (MSK #332), the 4-hour data arc may need to be broken into several arcs. Venting, uncoupled attitude control thrusting, attitude configuration changes, or other perturbative sources may cause discontinuities in the orbit that cannot be fit with one solution. As a general rule, the RMS of the range data type should be less than 130 yards after convergence of a SB. The data should be processed in the SB mode during non-busy operation periods (between stateside passes). Each converged SB solution should be stored in the next available storage slot in the superbatch vector table (SVT).

4.3.1 Superbatch Data Processing Procedures

The procedures for processing tracking data in the SB mode are as follows:

a. Determine the start and end batch numbers and the batch numbers to be excluded (if any), along with the input vector ID and covariance mode to initiate the SB DC.

   (1) S14, S $ to initiate the Shuttle SB processing mode.

   (2) S15, Batch #,...,$ to exclude any batches from the SB data arc. Up to eight batch entries are allowed. The batches can be entered individually or in groups separated by hyphens.

   (3) S17, BGN BATCH #, END BATCH #, VECTOR ID, COVARIANCE MODE $ to execute the SB.

b. Set the Shuttle residual summary limits such that residuals will be computed only for those batches that lie within the SB data arc, and compute residuals for each batch based on the converged Shuttle current superbatch (SCSB) vector.

   (1) S42, S, BGN BATCH # *

   (2) Request the Shuttle residual summary display (MSK #332) via the DRK panel to compute and display the residuals.

c. Determine whether any further editing or batch exclusions are necessary. If so, repeat steps a and b.

d. Accept and store the converged solution in the next available SVT slot. Request the SVT display (MSK #336) to determine the next available storage slot. If all storage slots are full, hardcopy the display prior to storing the solution in SVT storage slot 1.

5.0 REAL-TIME GROUND NAVIGATION PROCEDURES

5.1 REV-1 PROCEDURES

The following detailed procedures have been developed to assist the navigation console engineers during the tight mission timeline of rev-1. The S-band stations that will be involved are MADS (MAXS), IOSS, and ORRS. Both nominal and AOA procedures are included for ORRS.

5.1.1 MADS (MAXS), IOSS

5.1.1 MADS (MAXS), LOSS

TIME (GMT) _____

EVENT: OMS-1 cutoff (handover from high speed)

MED (left) operator	Center operator	Right operator
1. S80,,,1V1, 1V2$.	1. a. Vector compare on left monitor (337).	1. Initialize DDD formats: 1 = 500 3 = 497 2 = 496 4 = 678 5 = 499
2. Record V1-V2 (ΔA)--->|_____| also record in Δ^{A}MECO slot on the following page.	b. Shuttle batch plot on left center monitor (334).	2. a. Next station contacts (451) on overhead monitor.
3. Choose better vector.	c. Vector administration table (VAT) II (474) on right monitor.	b. Low sample rate data display (325) on right monitor.
4. Verify that the FDO plans to have Dynamics save GPCI and GPTI vectors in V44, V45, respectively, at MADS (MAXS) AOS.	2. Verify proper DDD configuration using MSK #0081.	3. Verify proper LSIP configuration: Batch size max = 80 min = 3 minimum elevation = 3 check transponder delay
5. a. Confer with the FDO about APU, H_2O vent status.		4. If MADS (MAXS) tracking station data is not on-line at AOS - 2 min, contact track on TRJ COORD, and instruct track to start transmitting data immediately to ensure that data is on-line prior to AOS.
b. Update VTL, if necessary, to reflect current vent status.		5. Respond to all O-NAV questions on SSR DYN2 loop.
c. If VTL was changed, recommend a ground ephemeris update.		
6. S23, NOCHECK $ to ignore any station EOT messages.		

5.1.1.- Continued

TIME (GMT) _____

EVENT: MADS (MAXS) AOS (Rev 1)

MED (left) operator	Center operator	Right operator
1. Plot incoming MADS (MAXS) data based on the stored onboard telemetry vector; U18,S#,V44$.	1. Notify MED operator as soon as telemetry vectors are stored in V44,V45.	1. Notify MED operator as soon as MADS (MAXS) data are being saved, along with batch number.
2. Plot incoming MADS (MAXS) data based on the high-speed main engine cutoff (MECO) vector integrated through the nominal burn; U18,S#,V1$.	2. Fill in the table below for each of the three cases generated by the MED operator.	2. Monitor incoming data on the LSIP.
3. Give FDO a gross estimate as to which vector appears to be better, based on the MADS (MAXS) data.		
4. Determine whether OMS-1 has been confirmed.		
5. As soon as OMS-1 has been confirmed:		
a. Plot the MADS (MAXS) data based on high-speed MECO vector integrated through the confirmed burn; U18,S#,V1$___		
b. S80,,,1V1,1V44$ ΔA_{MECO} ___		
Record V1-V44 ΔA_{MADS} _____		
Report $\Delta\Delta A$ to FDO: $\Delta\Delta A$ _____ N.M.		
6. Based on the residual table results, discuss with the FDO the results of the confirmed burn/nominal burn and confirmed burn/onboard cases.		3. When valid data are no longer being saved (LOS), have MED operator EOT MADS (MAXS) batch.

	Doppler RMS / AVG	Range RMS / AVG	X RMS / AVG	Y RMS / AVG
Onboard (from step 1)				
H/S with nominal burn (from step 2)				
H/S with confirmed burn (step 5(a))				

5.1.1.- Continued

TIME (GMT) _____

EVENT: MADS (MAXS) AOS (Rev 1) - Concluded.

MED (left) operator	Center operator	Right operator
7. S20,S,GMT TIME, CUR1$. 8. U18,S0,SCBB $. 9. After MADS (MAXS) processing, S80,,,CUR1,1SCBB,1V44$. 10. Advise FDO; recommend best vector. a. V17 if MADS (MAXS) solution looks good. b. The better of CUR1 and V44. 11. If FDO decides to update the ground ephemeris: a. S80,,,CUR1,1SCBB,1V39, 1V17$; to verify the ephemeris update. b. Otherwise, S80,,,1SCBB, 1V17$; to verify the vector move.	3. Call out data editing bounds to MED operator and reprocess MADS (MAXS) data. 4. a. Check VAT II to ensure that no vectors are stored in in V17-V29. b. Have DYN move SCBB to V17; LABEL=MAD001. 5. If V17 is selected for ground ephemeris update, have DYN move V17 to V39. LABEL=MAD001. 6. If V44 is selected for ground ephemeris update, have DYN move V44 to V39. LABEL=TMAD001.	4. Assist in processing MADS (MAXS) tracking data and analyzing DC results.

5.1.1.- Concluded

TIME (GMT)_____

EVENT: IOSS (Rev 1) nominal

MED (left) operator	Center operator	Right operator
1. If FDO has DYN save a GPCI and GPTI in V44, V45, respectively; S80,,,CUR1,1V44,1V45$.	1. a. Notify MED operator as soon as DYN has moved GPCI, GPTI vectors to V44, V45, respectively.	
2. Otherwise; S80,,,CUR1,1GPCI,1GPTI$.	b. Otherwise, notify MED operator when GPCI/GPTI vectors are being received.	
3. Advise FDO.		
4. If an SV is uplinked to the Orbiter over IOSS, verify update: S80,,,CUR1,1SCBB, 1GPCI$.		
5. Obtain from FDO the current mission status (AOA or nominal).		
6. If the status is AOA, go to AOA procedures.		
7. Update the VTL, if necessary, to reflect the current mission and vent status.		
8. If the VTL was changed, recommend a ground ephemeris update.		

5.1.2 ORRS (AOA)

5.1.2 ORRS (AOA)

TIME (GMT)

EVENT: ORRS AOS - 5 minutes (AOA case)

MED (left) operator	Center operator	Right operator
1. Set minimum elevation angle to 1 degree: S28,S,1$. 2. Enable the ΔT processor on the current ephemeris: S38,S,THRESHOLD GMT, ORRS, CUR1,START,2$. 3. Verify that FDO plans to have a GPCI/GPTI vector moved to V44 and V45, respectively, at ORRS AOS.	1. Displays needed for ORRS AOS: LM: DELTA-T DIGITALS (338) LC: SHUTTLE BATCH PLOT (334) RC: VAT II (474)	1. Displays needed for ORRS AOS: RM: LOW SPEED INPUT (325) OVERHEAD: NEXT STATION CONTACTS (451) 2. If ORRS data are not on-line at AOS-2 minutes, contact TRACK immediately to ensure that data are on-line prior to AOS.

5.1.2.- Continued

TIME (GMT)_____

EVENT: ORRS AOS-LOS (AOA case)

MED (left) operator	Center operator	Right operator
1. Validate the ORRS batch: U18,S0,CUR1$. 2. Observe the preliminary ΔT based on the ground ephemeris. 3. Enable the ΔT processor based on the stored telemetry vector: S38,S,THRESHOLD GMT, ORRS,V44,START,2$. 4. S80,,,CUR1,1V44,1GPCI,1V45$. a. Verify that V44 is consistent with GPCI vector. b. Report to FDO the preliminary ΔT based on the range. 5. Final ΔT to FDO based on the Doppler. Verify downtrack range residual pattern (MSK 334). 6. Monitor the flight director loop and A/G loops to verify ΔT update. 7. Verify digital-wise ΔT update: S38,S,THRESHOLD GMT, ORRS, GPCI, START, 2$.	1. Verify that DYN has moved a GPCI vector to V44.	1. a. Notify MED operator as soon as the ORRS open batch has saved two data points. b. Also pass on the batch number. 2. Move vector compare display (337) to the right and overhead monitors.

5.1.2.- Concluded

TIME (GMT) _____

EVENT: ORRS AOS-LOS (AOA case) - Concluded

MED (left) operator	Center operator	Right operator
8. Notify FDO immediately if any anomaly is found (wrong ΔT sign, etc.).		
9. At ORRS LOS: S80,,,CUR1,1GPCI,1GPTI$.		3. When valid data are no longer being saved (LOS), have MED operator EOT ORRS batch.
10. Notify FDO of the final vector compare at ORRS LOS and also of the ΔT uplink results.		
11. After ORRS LOS, process the ORRS data using the nominal maneuver uncertainty multipliers. Check the maneuver uncertainty multipliers to ensure that they are 1's.	2. Call-out data editing bounds to MED operator and reprocess ORRS data. 3. Have DYN move SCBB to V39 and V18; LABEL=ORR001.	
12. a. S80,,,1SCBB,1V39,1V18$; to verify the vector moves. b. S80,,,CUR1,1SCBB$.		
13. Notify FDO of the vector and recommend ground ephemeris update. This will be the vector used to compute the reentry acquisition times for the tracking network.		
14. S80,,,CUR1,1SCBB,1V39$; to verify the ephemeris update.		

5.1.3 ORRS (Nominal)

5.1.3 ORRS (Nominal)

TIME (GMT) _____

EVENT: ORRS (Rev 1) nominal case

MED (left) operator

1. Monitor incoming residuals and validate tracking data.

2. Advise FDO.

3. S80,,,CUR1,1GPCI$

4. After EOT ORRS: S23, CHECK$

5. Verify with FDO that the OMS-2 maneuver has been confirmed.

6. a. Generate ORRS SS-4 solutions using maneuver uncertainty multipliers listed in (b) below. To change uncertainty multipliers to 10: S05,S,maneuver#,10,10,10$

   b.

VALUE	VAT SLOT	COMMENT
	V20	SS1
σx1000	V21	SIG1000
σx99	V22	SIG099
σx10	V23	SIG010
σx1	V24	SIG001

7. a. S80,,,1V20,1V21,1V22,1V23$

   b. S80,,,1V20,1V24,1V22,1V23$

8. Change uncertainty multipliers back to their selected values.

Center operator

1. Monitor VAT II. When current telemetry data are being received, notify MED operator.

2. After closing ORRS,

   a. Accept previous solution.
   b. Edit ORRS data.
   c. Generate ORRS SS1 solution and have dynamics store it in V20.

3. Assist in generating and storing ORRS SS4 maneuver uncertainty solutions and fill in the delta table.

	1000	99	10	1
ΔA				
ΔI				
ΔΩ				

4. Choose the best among V20-V24 and have DYN move to V18. LABEL = ORRS 001.

5. Re-do ORRS so the selected solution is waiting.

Right operator

1. Monitor LSIP between ORRS AOS-LOS. At LOS, when ORRS batch is no longer receiving valid data, notify MED operator to EOT the batch.

2. Assist in processing ORRS solutions.

5.1.3.- Concluded

TIME (GMT) _____

EVENT: ORRS (Rev 1) nominal case - Concluded

MED (left) operator	Center operator	Right operator
9. S80,,,1SCBB,1V18, step 7 vector$ to verify.		
10. S80,,, CUR1, 1SCBB, 1V44$.		
11. Advise FDO.		
12. Recommend a ground ephemeris update on V18. This will be the preliminary vector for DEORB-2, and will be used for maneuver computations.		
13. If FDO decides to update the ground ephemeris: a. Have DYN move SCBB to V39; LABEL=ORRS 001. b. S80,,,CUR1,1SCBB,1V39, 1V18$ to verify the ephemeris update.		

5.2 REV-2 THROUGH REV-6 CONTINGENCY REENTRY OPPORTUNITIES

5.2 REV-2 THROUGH REV-5 CONTINGENCY REENTRY OPPORTUNITIES

TIME (GMT) _____

EVENT: VDBC/GDSS REV 2

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1GPCI$ over GDSS.	
	3. EOT VDBC/GDSS.	
	4. Accept the previous solution and edit/process VDBC/GDSS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the final vector for a rev-2 contingency deorbit.	
	6. Have DYN move SCBB to V19; label = GDS 002.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = GDS 002.	
	9. S80,,,CUR1,1SCBB,1V39,1V19$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: MILS/WLPC/BDAS REV 2

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1GPCI$ over MILS/BDAS. Uplink of the deorb-2 vector, if required, should occur over the BDAS pass.	
	3. Verify the SV uplink, if it was performed: S80,,,CUR1,1GPCI$.	
	4. EOT all batches.	
	5. Accept the previous solution and edit/process MILS/WLPC/BDAS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	

5.2.- Continued

TIME (GMT) _____

EVENT: MADS(MAXS) REV 2

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$.	
	3. EOT MADS (MAXS).	
	4. Accept the previous solution and edit/process MADS (MAXS).	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the best pre-deorb-2 vector in case of a rev-2 contingency deorbit.	
	6. Have DYN move SCBB to V20; label = MADS 002.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = MADS 002.	
	9. S80,,,CUR1,1SCBB,1V39,1V20$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: ORRS REV 2 _____

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$.	
	3. EOT ORRS.	
	4. Accept the previous solution and edit/process ORRS. This will be the preliminary vector for deorb-3, and will be used for maneuver computations.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Have DYN move SCBB to V21; label = ORRS 002.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ORRS 002.	
	9. S80,,,CUR1,1SCBB,1V39,1V21$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: KPTC/HAWS REV 3

Check	Required action	Comments
	Beware of low elevations! KPTC = 4.5° (NO K-GAMMA) HAWS = 2.8°	
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over HAWS.	
	3. EOT KPTC/HAWS.	
	4. Accept previous solution and edit/process KPTC/HAWS.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Advise FDO.	

5.2.- Continued

TIME (GMT) _____

EVENT: VDBC/GDSS REV 3

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over GDSS.	
	3. EOT VDBC/GDSS.	
	4. Accept the previous solution and edit/process VDBC/GDSS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the final vector for deorb-3, if required, and should be uplinked over MILS/BDAS.	
	6. Have DYN move SCBB to V22; label = GDS 003.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = GDS 003.	
	9. S80,,,CUR1,1SCBB,1V39,1V22$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: WLPC/BDAS REV 3

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI over BDAS.	
	3. EOT WLPC/BDAS.	
	4. Accept the previous solution and edit/process WLPC/BDAS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the best pre-deorb-3 vector in case of a rev-3 contingency deorbit.	
	6. Have DYN move SCBB to V23; label = BDA 003.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = BDA 003.	
	9. S80,,,CUR1,1SCBB,1V39,1V23$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: ORRS REV 3

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over ORRS.	
	3. EOT ORRS.	
	4. Accept previous solution and edit/process ORRS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the preliminary vector for deorb-4, and will be used for maneuver computations.	
	6. Have DYN move SCBB to V24; label = ORRS 003.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ORRS 003.	
	9. S80,,,CUR1,1SCBB,1V39,1V24$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: KMRC/KPTC/HAWS REV 4

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over HAWS.	
	3. EOT KMRC/KPTC/HAWS when valid data are no longer being received.	
	4. Accept previous solution and edit/process KMRC/KPTC/HAWS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the final vector for deorb-4.	
	6. Have DYN move SCBB to V25; label = HAW 004.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = HAW 004.	
	9. S80,,,CUR1,1SCBB,1V39,1V25$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: PTPC/GDSS/WLPC/MILS/BDAS/BDQC REV-4 stateside pass

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data as required for each station.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over S-band stations to monitor onboard vector status.	
	3. EOT batches as required.	
	4. Accept previous solution and edit/process stateside passes as required.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Advise FDO.	

5.2.- Continued

TIME (GMT) _____

EVENT: ACNS/ASCC REV 4

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. Uplink should occur during the ACNS pass to update the onboard state vector.	
	3. S80,,,CUR1,1GPCI$ to verify uplink and/or monitor onboard status.	
	4. EOT ACNS/ASCC.	
	5. Accept previous solution and edit/process ACNS/ASCC.	
	6. S80,,,CUR1,1SCBB,1GPCI$. This vector will be the best pre-deorb-4 vector and will be the preliminary vector for deorb-5 (used for maneuver computations.)	
	7. Have DYN move SCBB to V26; label = ACN 004.	
	8. Advise FDO.	
	9. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ACN 004.	
	10. S80,,,CUR1,1SCBB,1V39,1V26$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: KMRC/KPTC/HAWS REV 5

Check	Required action	Commer.' s
	1. Monitor incoming residuals and validate tracking data as required.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over HAWS.	
	3. EOT KMRC/KPTC/HAWS.	
	4. Accept the previous solution and edit/process KMRC/KPTC/HAWS.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Advise FDO.	

5.2.- Continued

TIME (GMT) _____

EVENT: PTPC/GDSS REV 5 _____ _____

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over GDSS.	
	3. EOT PTPC/GDSS.	
	4. Accept the previous solution and edit/process PTPC/GDSS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the final vector for deorb-5 and will be uplinked, if required, over BDAS/ACNS.	
	6. Have DYN move SCBB to V27; label = GDS 005.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = GDS 005.	
	9. S80,,,CUR1,1SCBB,1V39,1V27$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: MILS/MLAC/BDAS REV 5

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data as required.	
	2. S80,,,CUR1,1SCBB,1GPCI$ to verify SV uplink over BDAS, if required, and monitor onboard vector status.	
	3. EOT MILS/MLAC/BDAS as required.	
	4. Accept the previous solution and edit/process MILS/MLAC/BDAS.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Advise FDO.	

5.2.- Continued

TIME (GMT) _____

EVENT: ACNS/ASCC REV 5

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over ACNS.	
	3. EJT ACNS/ASCC.	
	4. Accept the previous solution and edit/process ASCC/ACNS.	
	5. S80,,,CUR1,1SCBB,1GPCI$ This will be the best pre-deorbit-5 vector in case a contingency deorbit in rev-5 is necessary. It will also be the preliminary vector for deorbit-6, and will be used for the maneuver computations.	
	6. Have DYN move SCbB to V28; label = ACN 005.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ACN 005.	
	9. S80,,,CUR1,1SCBB,1V39,1V28$ to verify.	

5.2.- Continued

TIME (GMT) _____

EVENT: GWMS REV 6 _____

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$.	
	3. EOT GWMS.	
	4. Accept the previous solution and edit/process GWMS.	
	5. S80,,,CUR1,1SCBB,1GPCI$. This will be the final uplink vector for a rev-6 contingency deorbit, if required.	
	6. Have DYN move SCBB to V29; label = GWM 006.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = GWM 006.	
	9. S80,,,CUR1,1SCBB,1V39,1V29$ to verify.	

5.2.- Concluded

TIME (GMT) _____

EVENT: PTPC/GDSS/MILS/PATC REV 6

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data as required.	
	2. S80,,,CUR1,1SCBB,1GPCI$ to verify SV update over GDSS/MILS, if required, and/or monitor onboard SV quality.	
	3. EOT PTPC/GDSS/MILS/PATC as required.	
	4. Accept the previous solution and edit/process PTPC/GDSS/MILS/PATC.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. a. Hardcopy VAT II display.	
	b. Have DYN move SCBB to V17; label = PAT 006.	
	c. Have DYN delete vectors in VAT slots 18 through 24.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris:	
	Have DYN move SCBB to V39; label = PAT 006.	
	9. S80,,,CUR1,1SCBB,1V39,1V17$ to verify.	

5.3 ONORBIT PROCEDURES

To be determined.

5.4 DEORBIT - 6 HOURS

5.4 DEORBIT - 6 HOURS

TIME (GMT) _____

EVENT: MILS/WLPC/BDAS REV 33

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1GPCI,1SCBB$ over MILS and BDAS.	
	3. Advise FDO if necessary.	
	4. EOT all batches.	
	5. Accept previous solution and edit/process MILS/WLPC/BDAS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. a. Advise FDO.	
	b. Hardcopy VAT II.	
	8. Have DYN move SCBB to V20; label = BDA 033.	
	9. If FDO decides to update the ground ephemeris:	
	Have DYN move SCBB to V39; label = BDA 033.	
	10. S80,,,CUR1,1SCBB,1V39,1V20$ to verify. This will be the rev-33 uplink vector.	

5.4.- Continued

TIME (GMT) _____

EVENT: MADS (MAXS) REV 33

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. EOT MADS (MAXS).	
	5. Accept previous solution and edit/process MADS (MAXS).	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	
	8. Have DYN move SCBB to V21; label = MADS 033.	
	9. S8C,,,1SCBB,1V21$ to verify.	

5.4.- Continued

TIME (GMT) _____

EVENT: ORRS REV 33

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. EOT ORRS.	
	5. Accept previous solution and edit/process ORRS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	
	8. Have DYN move SCBB to V22; label = ORRS 033.	
	9. S80,,,1SCBB,1V22$ to verify.	

5.4.- Continued

TIME (GMT) _____

EVENT: VDBC/GDSS REV 34

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over GDSS to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. EOT VDBC/GDSS.	
	5. Accept previous solution and edit/process VDBC/GDSS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	
	8. Have DYN move SCBB to V23; label = GDS 034.	
	9. S80,,,1SCBB,1V23$ to verify.	

4.- Continued

TIME (GMT) _____

EVENT: MILS/WLPC REV 34

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over MILS to monitor the onboard vector status.	
	3. Notify FDO if necessary.	
	4. EOT MILS/WLPC.	
	5. Accept previous solution and edit/process MILS/WLPC.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	

5.4.- Continued

TIME (GMT) _____

EVENT: BDQC/BDAS REV 34

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over BDAS to monitor the onboard vector status.	
	3. EOT BDQC/BDAS.	
	4. Accept the previous solution and edit/process BDQC/BDAS.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Have DYN move SCBB to V24; label = BDA 034.	
	7. Advise FDO.	
	8. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = BDA 033.	
	9. S80,,,CUR1,1SCBB,1V39,1V24$ to verify. This will be the rev-34 uplink vector.	

5.4.- Continued

TIME (GMT) _____

EVENT: ORRS REV 34

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. If SV is uplinked over ORRS, S80,,,CUR1,1GPCI$ to verify.	
	5. EOT ORRS.	
	6. Accept previous solution and edit/process ORRS.	
	7. Advise FDO if necessary.	
	8. Have DYN move SCBB vector to V25; label = ORRS 034.	
	9. S80,,,1SCBB,1V25$ to verify.	

5.4.- Continued

TIME (GMT) _____

EVENT: KPTC/HAWS/PTPC/GDSS REV 35

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB, 1GPCI$ over HAWS and GDSS to monitor the onboard vector status.	
	3. EOT all batches.	
	4. Accept previous solution and edit/process KPTC/HAWS/PTPC/GDSS.	
	5. S80,,,CUR1,1SCBB,1GPCI$.	
	6. Advise FDO if necessary.	
	7. Have DYN move SCBB to V26; label = GDS 035.	
	8. S80,,,1SCBB,1V26$ to verify.	

5.4.- Continued

TIME (GMT) _____

EVENT: WLPC/BDAS/ASCC/ACNS REV 35

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1GPCI,1SCBB$ over BDAS and ACNS to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. EOT all batches.	
	5. Accept previous solution and edit/process WLPC/BDAS/ASCC/ACNS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Have DYN move SCBB to V27; label = ACN 035.	
	8. Advise FDO.	
	9. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ACN 035.	
	10. S80,,,CUR1,1SCBB,1V39,1V27$ to verify. This will be the rev-35 uplink vector.	
	11. Run a superbatch over the last three hours of data. This is the quiescent interval to be used to obtain the deorbit vector, which will be used to generate the de-orbit maneuver.	

5.4.- Continued

TIME (GMT) _____

EVENT: KMRC/KPTC/HAWS REV 36

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1GPCI,1SCBB$ over HAWS to monitor the onboard vector status.	
	3. a. Advise FDO if necessary.	
	b. Also verify SV uplink over HAWS; S80,,,CUR1,1GPCI$.	
	4. EOT all batches.	
	5. Accept previous solution and edit/process KMRC/KPTC/HAWS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Have DYN move SCBB to V28; label = HAW 036.	
	8. Advise FDO.	
	9. If FDO decides to update the ground ephemeris:	
	Have DYN move SCBB to V39; label = HAW 036.	
	10. S80,,,CUR1,1SCBB,1V39,1V28$ to verify. This will be the first ground ephemeris update over the rev-36 stateside pass.	

5.4.- Continued

TIME (GMT) _____

EVENT: PTPC/GDSS REV 36

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over GDSS.	
	3. Advise FDO if necessary.	
	4. EOT all batches.	
	5. Acc[illegible]the previous solution and edi[illegible]ss PTPC/GDSS.	
	6. S80,,,CUR1,1SCBB,1GPCI$.	
	7. Advise FDO.	

5.4.- Continued

TIME (GMT) _____

EVENT: MILS/WLPC/BDAS/ANTC REV 36

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,,CUR1,1SCBB,1GPCI$ over MILS/BDAS to monitor the onboard vector status.	
	3. Advise FDO if necessary.	
	4. S80,,,CUR1,1SCBB,1GPCI$ to verify SV uplink. Primary uplink site is MILS with BDAS as backup.	
	5. EOT all batches.	
	6. Accept previous solution and edit/process MILS/WLPC/BDAS/ANTC.	
	7. S80,,,CUR1,1SCBB,1GPCI$.	
	8. a. Have DYN move SCBB to V29; label = ANT 036. b. Hardcopy VAT II.	
	9. Advise FDO.	
	10. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ANT 036.	
	11. S80,,,CUR1,1SCBB,1V39,IV29$ to verify. This will be the second scheduled ground ephemeris update over the rev-36 stateside pass.	

5.4.- Continued

TIME (GMT) _____

EVENT: ACNS AOS - 5 MINUTES REV 36

Check	Required action	Comments
	1. S^3,NOCHECK $.	
	2. S28,S,1$.	
	3. S38,S,THRESHOLD GMT,ACNS,CUR1, START,2$.	
	4. Delta-T display (338) on left monitor.	
	5. Verify with FDO that at ACNS AOS an onboard telemetry vector will be moved to V44.	

5.4.- Continued

TIME (GMT) _____

EVENT: ASCC/ACNS REV 36

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. a. S80,,,CUR1,1SCBB,1GPCI$ at ACNS to monitor the onboard vector status.	
	b. S38,S,THRESHOLD GMT,ACNS,V44, START,2$.	
	c. S80,,,1V44,1GPCI$ to verify V44.	
	3. a. Advise FDO if necessary.	
	b. Preliminary delta-T to FDO based on range.	
	c. Final delta-T to FDO based on Doppler. Verify downtrack range residual pattern (MSK 334).	
	4. If SV was not uplinked over MILS/BDAS: S80,,,CUR1,1SCBB,1GPCI$ over ACNS (backup uplink site).	
	5. EOT all batches.	
	6. Accept previous solution and edit/process ASCC/ACNS.	
	7. S80,,,CUR1,1SCBB,1GPCI$.	
	8. a. Have DYN move SCBB TO V17. label = ACN 036.	
	b. Have DYN delete vectors in VAT slots 18 through 24.	

5.4.- Concluded

TIME (GMT) _____

EVENT: ASCC/ACNS REV 36

Check	Required action	Comments
	9. Advise FDO.	
	10. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = ACN 036.	
	11. S80,,,CUR1,1SCBB,1V17,1V39$ to verify.	

5.5 NOMINAL DEORBIT

5.5 NOMINAL DEORBIT

TIME (GMT) _____

EVENT: GWMS AOS - 5 MINUTES

Check	Required action	Comments
	1. S23,NOCHECK$.	
	2. S28,S,1$.	
	3. S38,S,THRESHOLD GMT,GWMS,CUR1, START,2$.	
	4. Displays needed for AOS: LM = DELTA-T - DISPLAY (338) LC = SHUTTLE BATCH PLOT (334) RC = VAT II (474) RM = LOW-SPEED INPUT (325) OVERHEAD = NEXT STATION CONTACTS (451)	
	5. If GWM data is not on-line at AOS - 2 minutes, contact TRACK immediately to ensure that data is on-line prior to AOS.	

5.5.- Continued

TIME (GMT) _____

EVENT: GWMS

Check	Required action	Comments
	1. Operator monitoring low-sample rate display should notify MED operator when GWM open batch has saved two pts and also pass on batch number. Operator should move vector compare display (337) to overhead monitor and to right monitor.	
	2. Validate GWMS batch; U18,S#,CUR1$.	
	3. Observe preliminary delta-t based on ground ephemeris.	
	4. If a one-rev late deorbit, go to one-rev late deorbit procedures.	
	5. Verify that DYN has moved a GPCI vector to V44.	
	6. S38,S,THRESHOLD GMT,GWMS,V44, START,2$.	
	7. S80,,,CUR1,1V44,1V45,1GPCI$.	
	a. Report the preliminary delta-t based on the range.	
	b. Verify V44 is consistent with GPCI; S80,,,1V44,1GPCI$.	
	inal delta-t to FDO based on Doppler. Verify downtrack range residual pattern (MSK 334).	

5.5.- Continued

TIME (GMT) _____

EVENT: GWMS - Continued.

Check	Required action	Comments
	9. Monitor flight director loop and A/G loops to verify delta-t update, if required. ΔT update criteria: a. 2NM < |Downtrack correction| < 8NM as computed from either the range or range-rate solution. b. |Downtrack correction| > 8NM as computed from both the range and range-rate solution.	
	10. Verify digital-wise delta-t update: a. S38,S,THRESHOLD GMT, GWMS, GPCI,START,2$ b. U18,S#,GPCI$	
	11. Notify FDO immediately of any anomalies (opposite sign, etc.).	
	12. At GWM LOS; S80,,,CUR1,1GPCI, 1GPTI$.	
	13. Notify FDO of the final vector compare at LOS, and also of delta-t uplink results.	
	14. Check the maneuver uncertainty multipliers to ensure that they are 1's.	

5.5.- Concluded

TIME (GMT) _____

EVENT: GWMS - Concluded.

Check	Required action	Comments
	15. Process the GWMS data using the nominal maneuver uncertainty multipliers. Do not take the time to reprocess using different uncertainty multipliers, as in the rev-1 ORRS case, unless necessary.	
	16. Have DYN move SCBB to V39 and V18; label = GWM 037.	
	17. S80,,,1SCBB,1V18,1V39$ to verify.	
	18. Notify FDO of the vector and recommend ground ephemeris update. This will be the vector used to compute the reentry acquisition times for the tracking network.	
	19. S80,,,CUR1,1SCBB,1V39$ to verify the ephemeris update.	
	20. Notify FDO that you are handing over to the high-speed entry team.	

5.6 ONE-REV LATE DEORBIT: NO BURN/PARTIAL BURN

5.6 ONE-REV LATE DEORBIT: NO BURN/PARTIAL BURN

TIME (GMT) _____

EVENT: GWMS 37 (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. Reset MINEL to 3°; S28, S, 3$.	
	2. Reset the mode to check station EOT indicators; S23, CHECK $.	
	3. Monitor incoming residuals based on current onboard telemetry vector; U18, S#, GPCI$.	
	4. Update the VTL to reflect the actual APU/H2O vent start/stop times (see vent timeline update procedures (p. 5-54)).	
	5. Determine the status of the ground ephemeris, best radar vector, and current telemetry vector. a. NO BURN - If the maneuver has not been deleted from the MPT, S80,,, 1ANC1, 1SCBB, 1GPCI,,, VA$; otherwise, S80,,, CUR1, 1SCBB, 1GPCI$. b. PARTIAL BURN - Determine from FDO whether the maneuver has been confirmed. If the maneuver has been confirmed, S80,,, CUR1, 1SCBB, 1GPCI$. c. Plot GWMS batch on ground ephemeris as soon as burn has been deleted or confirmed for ephemeris 1; U18, S#, CUR1$.	
	6. Advise FDO.	
	7. Schedule VDBC, PTPC (rev 37) if available through TRACK.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWMS 37 (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	8. Accept the previous solution and edit/process GWMS. If a partial deorbit maneuver has occurred, refer to the GWMS data processing procedures following this page.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWMS REV 37 (PARTIAL BURN GWMS DATA PROCESSING PROCEDURES

Check	Required action	Comments
	1. Accept the previous solution and edit/process GWMS in the SS-1 mode.	
	2. Have DYN move SCBB to V20; COMMENT = SS1.	
	a. Generate and store GWMS SS-4 solutions using maneuver uncertainty multipliers listed in (b) below. To change uncertainty multipliers to 1000: S05, S, MANEUVER #, 1000, 1000, 1000$	
	b.	

Value	VAT slot	Comment
σX 1000	V21	SIG 1000
σX 99	V22	SIG 099
σX 10	V23	SIG 010
σX 1	V24	SIG 001

	3. Choose best vector among V20-V24 and have DYN move to V18; label = GWM 037. a. S80,,, 1V20, 1V21, 1V22, 1V23$ b. S80,,, 1V20, 1V24, 1V22, 1V23$	
	4. Change the uncertainty multipliers back to their selected values and re-do the GWMS selected solution.	
	5. S80,,, 1SCBB, 1V18, STEP3 VECTOR$ to verify.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWMS REV 37 (PARTIAL BURN GWMS DATA PROCESSING PROCEDURES) - Concluded

Check	Required action	Comments
	6. S80,,, CUR1, 1SCBB, 1V44, 1GPCI$; advise FDO.	
	7. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = GWM 037.	
	8. S80,,, CUR1, 1SCBB, 1V18, 1V39$ to verify the ephemeris update. This will be the best available one-rev-late vector to be uplinked to the Orbiter at GDSS with MILS as the backup uplink site.	

C-2

5.6.- Continued

TIME (GMT) _____

EVENT: VENT TIMELINE UPDATE (1 REV LATE NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. Obtain the following from FDO: a. New deorbit tig time b. APU/H2O vent on/off times.	
	2. Modify the nominal deorbit entries in the VTL prior to GWMS to reflect the actual APU/H2O start times.	
	3. Using the P42 MED, add the VTL entries for the APU/H2O vents referenced to the new deorbit tig. The start times will be equal to deorbit tig minus 3 minutes. The end times should be after landing.	
	4. Notify FDO of the VTL update and recommend an ephemeris update.	

5.6.- Continued

TIME (GMT) _____

EVENT: PTPC/VDBC/GDSS (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,, CUR1, 1SCBB, 1GPCI$ over CDSS.	
	3. a. Advise FDO if necessary.	
	b. If GWMS radar vector is uplinked over GDSS, verify uplink; S80,,, CUR1, 1GPCI$.	
	4. EOT all batches.	
	5. Accept previous solution and edit/process PTPC/VDBC/GDSS so result can be uplinked at MILS.	
	6. S80,,, CUR1, 1SCBB, 1V44, 1GPCI$.	
	7. Advise FDO.	
	8. a. Have DYN move SCBB to V19; label = GDS 037.	
	b. S80,,, 1SCBB, 1V19$ to verify.	
	9. If FDO decides to update the ground ephemeris:	
	Have DYN move SCBB to V39; label = GDS 037.	
	10. S80,,, CUR1, 1SCBB, 1V19, 1V39$ to verify.	

5.6.- Continued

TIME (GMT) _____.

EVENT: PATC/MILS REV 37 (1 REV LATE NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. Monitor incoming residuals and validate tracking data.	
	2. S80,,, CUR1, 1SCBB, 1GPCI$ over MILS.	
	3. If a SV uplink occurs over MILS, S80,,, CUR1, 1GPCI$ after uplink has been confirmed.	
	4. Advise FDO.	
	5. EOT all batches.	
	6. Accept previous solution and edit/process PATC/MILS.	
	7. S80,,, CUR1, 1SCBB, 1V44, 1GPCI$.	
	8. Advise FDO.	
	9. Have DYN move SCBB to V20; label = MIL 037.	
	10. S80,,, 1SCBB, 1V20$ to verify.	
	11. If FDO decides to update the ground ephemeris: Have DYN move SCBB to V39; label = MIL 037.	
	12. S80,,. CUR1, 1SCBB, 1V20, 1V39$ to verify.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWM AOS-5 MINUTES (REV 38) (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. S23, NO CHECK$.	
	2. S28, S, 1 $.	
	3. S38, S, Threshold GMT, GWMS, CUR1, START, 2$.	
	4. Displays needed for AOS: LM = Delta-T display (338) LC = Shuttle batch plot (334) RC = VAT II (474) RM = Low-speed input (325) OVERHEAD = Next station contacts (451)	
	5. If GWMS data is not on-line at AOS - 2 minutes, contact TRACK immediately to ensure that data are on-line prior to AOS.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWMS AOS (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	1. Operator monitoring low-sample rate display should notify MED operator when GWMS open batch has saved two pts and also pass on the batch number. This operator should also move vector compare display (337) to overhead and right monitors.	
	2. Validate GWMS batch; U18, S#, CUR1$.	
	3. Observe preliminary ΔT based on the ground ephemeris.	
	4. Verify that DYN has moved a GPCI vector to V44.	
	5. S38, S, Threshold GMT, GWMS, V44, START, 2$.	
	6. S80,,, CUR1, 1V44, 1V45, 1GPCI$ a. Report the preliminary ΔT based on the range to FDO. b. Verify that V44 is consistent with GPCI; S80,,,1V44, 1GPCI$.	
	7. Report the final ΔT to FDO based on the Doppler. Verify downtrack range residual pattern (MSK 334).	
	8. Monitor flight director loop and A/G loops to verify delta-T update.	

5.6.- Continued

TIME (GMT) _____

EVENT: GWMS (REV 38) (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	9. ΔT update criteria:	
	a. 2NM< |Downtrack correction| <8NM, as computed from either the range or range-rate solution.	
	b. |Downtrack correction|>8NM as computed from both the range and range-rate solution.	
	10. Verify digital-wise ΔT update:	
	a. S38, S, Threshold GMT, GWMS, GPCI, START, 2$.	
	b. U18, S#, GPCI$.	
	11. Notify FDO immediately of any anomalies (opposite sign, etc.).	
	12. At GWMS LOS, S80,,,CUR1, 1GPCI, 1GPTI$.	
	13. Notify FDO of the final vector compare at LOS and also of the ΔT results.	
	14. Check the maneuver uncertainty multipliers to ensure that they are 1's.	
	15. Process the GWMS data using the nominal maneuver uncertainty multipliers.	
	Do not take time to reprocess using different uncertainty multipliers as in the rev-1 ORRS case u less absolutely necessary.	

5.6.- Concluded

TIME (GMT) _____

EVENT: GWMS (REV 38) (1 REV LATE DEORBIT: NO BURN/PARTIAL BURN)

Check	Required action	Comments
	16. Have DYN move SCBB to V39; label = GWM 038.	
	17. S80,,,1SCBB, 1V39$ to verify.	
	18. Notify FDO of the vector and recommend ground ephemeris update. This will be the vector used to update the reentry acquisition times for the tracking network.	
	19. S80,,,CUR1, 1SCBB, 1V39$ to verify the ephemeris update.	
	20. Notify FDO that you are handing over to the high-speed entry team.	

5.7 REFERENCES

1. Siler, Richard K.: Mean Monthly Radio Refractivity for Tracking Stations in the Manned Space Flight Network. U.S. Weather Bureau, Jan. 1965.

2. Weast, Robert, ed.: Handbook of Chemistry and Physics. The Chemical Rubber Co., 45th edition (1964) D92.

3. Lear, William M.: Computing Atmospheric Scale Height for Refraction Corrections. JSC-16462, March 1980.

4. U. S. Weather Bureau.

APPENDIX A

MISSION BOOKKEEPING AND RECORDS

Throughout the duration of the mission, each support team will be required to maintain the following information:

a. Mission log forms (MLF).

The MLF (fig. A-1) will contain a chronological arrangement of all important navigation-related mission events. These will be recorded at their GMT time of occurence, along with a description of the event. Failure to receive expected tracking data, changes to the expected tracking schedule noticeable trajectory perturbations encountered during data processing intervals, tracking data biases or irregularities, and station refraction problems are among the types of events that should be recorded in the MLF.

b. Mission hardcopies.

For each mission, the following displays will be hardcopied and filed for postmission evaluation and analysis purposes.

(1) Shuttle DC summary (MSK #326).

(a) Final SS-1 for each batch.

(b) Final SS-4 for each batch.

(c) Any superbatch saved in the SVT.

(2) Shuttle batch residual plot (MSK #334) if any abnormal residual patterns are observed.

(3) Vector compares (MSK #337) used to generate solution-ephemeris delta tables.

(4) Shuttle residual summary (MSK #332).

(a) BB

(b) SB

(5) Delta-T processor.

(a) Delta-T digitals (MSK #'s 338, 339).

(b) Delta-T plot (MSK # 340) if abnormal range or Doppler patterns are observed.

(6) Checkout monitor (MSK #2300).

(a) Each vector stored in VAT II.

(b) Each superbatch vector stored in the SVT.

FLIGHT/SIM/TEST ID	DATE	ORB	CONSOLE POSITION	PAGE

TIME	FLIGHT EVENTS/HISTORY/BRIEFING

Figure A-1.- Mission log form (MLF).

(7) VAT II (MSK # 474) each time slots V17 through V29 are filled.

(8) Mission plan table (MSK # 475) whenever there has been an alteration to a maneuver that has occurred in the past.

(9) Trajectory profile status table (MSK # 2310) after each ephemeris update.

(10) Approximately every 4 hours the following displays will be hardcopied and assembled as a set with a reference time indicating when the set was taken.

(a) Superbatch vector table (MSK # 336).

(b) Attitude timeline (MSK # 2330).

(c) Vent timeline (MSK # 2340).

(d) Mission plan table (MSK # 475).

(e) Shuttle batch summary display (MSK # 330).

(f) REFSMMAT, RELMAT timeline for ATL (matrix locker, MSK # 487).

(g) Superbatch DC summary (MSK #326) containing all batches received since the previous 4-hour set along with a plot of each batch based on the converged superbatch DC vector.

(h) Weight loss/gain table (MSK #2321).

c. Station characteristics change sheet (SCCS) (fig. A-2).

Following the transition from LAUNCH to OPS phase, any changes to the SCT corresponding to any mission-active (C-band or S-band) tracker will be recorded on the SCCS. The following information will be recorded for each change:

(1) Alphanumeric station name.

(2) Parameter changed.

(3) Previous parameter value.

(4) New parameter value.

(5) Reason for changing the parameter value.

The last onorbit low-speed navigation team should inform the high-speed entry team of all SCT changes.

Station ID	Parameter changed	Previous value	New value	Comment

Figure A-2.- Station characteristics change sheet.

d. Low-speed radar disk data set to tape copy.

At the end of each onorbit navigation shift, the MED operator will copy the current contents of the low-speed radar disk data set to a 6250 bit/inch tape. The new tape number and data set name will appear on the on-line monitor (MSK # 0005) upon completion of the disk-to-tape copy. The MED operator should proceed as follows:

(1) Hardcopy and file MSK #0005, which includes the tape number and data set name corresponding to the disk-to-tape copy.

(2) Record the disk-to-tape copy on the Mission log form along with the tape number and data set name of the output tape.

Figure A-3 illustrates the S31 MED format required to copy the contents of the disk data set to a 6250 bit/inch tape.

e. Data tables

The orbital elements table (OET) and the solution-ephemeris compare table (SECT) will be maintained by all low-speed ground navigation teams during MCC mission operations. The team leader will assign a team member with the responsibility of initializing and maintaining the OET and SECT. The designated team member should leave several blank rows before making any entries in the OET or SECT in order to distinguish between consecutive shift entries. The team member should also mark his or her initials in the blank area.

(1) Orbital elements table (fig. A-4).

The OET is designed to accumulate a table of mission-computed vectors (at least one per rev) to be used as input for ancillary or postmission off-line data processing. The Keplerian orbital elements shall be obtained from the checkout monitor display (MSK #2300) where the recorded elements are referenced to the Aries mean-of-1950 coordinate system. The OET will contain entries for all low-speed navigation vectors stored in VAT II slots 17 through 29. The team member assigned to the dynamics communications loop must request each required checkout monitor generation.

Below is a list and description of each parameter that appears on the OET:

(a) STATION - Column containing the VAT slot and alphanumeric station ID followed by the rev number corresponding to the vectors stored in VAT slots 17 through 29.

Example: = V17MAD 001

(b) ANCHOR TIME - Time tag of the first valid data point saved for the station.

```
*9316
#01/RT          ******** TRACKING DATA REPLAY MED MENU ********

          ACTION ===> ___ TI=TAPE INPUT----DI=DISK INPUT----STOP=STOP REQUEST
                      TT=TAPE INPUT/TAPE OUTPUT--DT=DISK INPUT/TAPE OUTPUT
                      TTF=TT+WRITE EOF----------DTF=DT+WRITE EOF
     INPUT TAPE ===> _____ TAPE NUMBER (READ FOR TI,IT,TTF)
READ DATASET NAME ===> ____________________________ DATASET NAME ON READ TAPE
    OUTPUT TAPE ===> _____ TAPE NUMBER (READ FOR TT,TTF,DT,DTF)
WRIT DATASET NAME ===> ____________________________ DATASET NAME ON WRITE TAPE
          TLEFT ===> _____________ TIME TO BEGIN READING
         TRIGHT ===> _____________ TIME TO END READING
     READ OPTION ===> _ N=READ ONLY TO TIME > TRIGHT
                       NE=READ ONLY TO TIME > TAPE END
     SITE OPTION ===> _ P,D : P=PROCESS DATA,D=DISCARD
        SITE 1   ===> ___ VALID STDN SITE ID
        SITE 2   ===> ___ VALID STDN SITE ID
        SITE 3   ===> ___ VALID STDN SITE ID
        SITE 4   ===> ___ VALID STDN SITE ID
        SITE 5   ===> ___ VALID STDN SITE ID
        SITE 6   ===> ___ VALID STDN SITE ID

931 MENU
```


Figure A-3.- Tracking data replay MED menu.

Obtain Keplerian elements from checkout monitor (MSK # 2300)

(Reference frame = M50)

Station	Anchor time	Maxe	Solution type	a	e	i	ω	Ω	m	υ

Figure A-4.- Orbital elements table.

(c) MAXEL - Maximum elevation of the pass in degrees.

(d) SOLUTION TYPE - Type of solution that generated the output vector.

(1) SS-1 - unconstrained solution (no a priori convariance)

(2) SS-2 - solution constrained to the orbital plane

(3) SS-3 - user-specified constraints

(4) SS-4 - previous solution vector and covariance matrix used as input for the current solution

(e) a - semimajor axis in n. mi.

(f) e - Eccentricity.

(g) i - Inclination in degrees.

(h) w - Argument of perigee in degrees.

(i) Ω - Longitude of the ascending node in degrees.

(j) m - Mean anomaly in degrees.

(k) υ - True anomaly in degrees.

All significant digits appearing on the checkout monitor for each orbital element should be copied into the OET.

(2) Solution-ephemeris compare table (fig. A-5)

The SECT is designed to maintain a history of radar solution-ephemeris compares to help determine trends in the vehicle trajectory over a period of time. An example of a trend would be a gradual increase in energy with time, indicating the presence of low-level thrusting. The Keplerian orbital element delta's will be obtained for the radar vector occupying the base column of the vector compare display. The vector used to generate the ephemeris that was current at the time the radar data was batched shall be the compare vector used to compute the orbital element delta's. The SECT shall be updated for each final batch-to-batch DC solution. Care should be taken to keep the SECT table as up to date as possible so that the nav console operators can use it to help confirm current data processing results and trends.

A listing and a description of the parameters appearing in the SECT are as follows:

Sim Date: ______________

Training: Run #: ______________

Type: ______________

SOLUTION - EPHEMERIS

COMPARES

Station	Anchor time	Maxel	$\kappa\Gamma$	Sol. type	Ephemeris vector	ΔA	ΔE	ΔI	$\Delta\Omega$	ΔU	ΔV	ΔW

Figure A-5.- Solution-ephemeris compares table.

(a) STATION - Batch ID corresponding to each solution-ephemeris compare.

(i) Batch ID - Alphanumeric station ID plus batch number

(ii) Example - ORRS 001

(b) ANCHOR TIME - Time tag of the first valid data point saved for the batch. This is the time that the batch-to-batch solution-ephemeris vector delta's are computed.

(c) MAXEL - Maximum elevation of the pass in degrees.

(d) $K\Gamma$ - An integer value indicating the number of times the K-gamma covariance downweighting pushbutton indicator (PBI) has been applied to the final solution.

(e) SOL TYPE - Type of solution that generated the output vector.

(i) SS1 - Unconstrained solution (no a priori covariance)

(ii) SS2 - Solution constrained to the orbital plane

(iii) SS3 - User-specified constraints

(iv) SS4 - Previous solution vector and covariance matrix used as input for the current solution

(f) EPHEMERIS VECTOR - Vector that was used to generate the ground ephemeris that was current at the time the batch was processed.

(g) ΔA - Change in semimajor axis in n. mi.

(h) ΔE - Change in eccentricity.

(i) ΔI - Change in inclination in degrees.

(j) $\Delta\Omega$ - Change in longitude of ascending node in degrees.

(k) ΔU - Change in radial position in feet.

(l) ΔV: Change in downtrack position in feet.

(m) ΔW: Change in crosstrack position in feet.

All significant digits appearing on the vector compare for each delta parameter should be copied in the SECT with the exception of the UVW delta's, which should be rounded to the nearest foot.

Note - All delta's are computed by subtracting the vector representing the appropriate ground ephemeris from the base vector (radar data solution).

APPENDIX B

VENT TIMELINE INITIALIZATION AND MAINTENANCE

B-1.0 VENT TIMELINE INITIALIZATION AND MAINTENANCE

The vent timeline (VTL) will provide the navigation console engineer with the capability to model Orbiter vents and low-level thrusts. These forces, when modeled, will be included in the force model used by the numerical integrator. The MED operator for each low-speed navigation shift shall be responsible for maintaining the VTL, the RVTL, and the vent initialization table (VIT).

Following any VTL/RVTL update, the VTL digital display driver (DDD) will be driven to indicate that the current ephemeris does not include the VTL changes. The low-speed navigation MED operator should advise the FDO after any VTL/RVTL update and recommend a Shuttle ground ephemeris update to incorporate the modified VTL. The VTL DDD will be extinguished following any ephemeris update (not necessarily the Shuttle ephemeris).

B-1.1 VENT INITIALIZATION TABLE (MSK #2342)

The VIT contains a list of all currently defined vent ID's that are applicable to VTL/RVTL initialization and maintenance. The VIT also contains the magnitude of each vent's force components along each of the three mutually perpendicular body axes. Figure B-1 contains a listing and a description of the current entries in the VIT.

B-1.1.1 VIT Maintenance

The navigation console engineer has the capability via manual entry device (MED) inputs to add, modify, or delete VIT entries. The applicable MED and its general format is given below.

a. Applicable MED - P43.

b. General format - P43, OPTION, VENT ID, FX, FY, FZ$.

c. Field comments.

(1) OPTION

(a) A = add
(b) M = modify
(c) D = delete

(2) VENT ID - Alphanumeric (four characters)

(3) FX, FY, FZ - Range is -1000 to +1000 pounds force in body coordinates

Should it become necessary to add an additional entry to the VIT to model any known Orbiter trajectory perturbation, it will be the responsibility of the currently active MED operator to do the following:

PRECEDING PAGE BLANK NOT FILMED

DESCRIPTION	VENT ID	X-THRUST	Y-THRUST	Z-THRUST
Air lock depressurization	ALD	0	-3.000	0
APU-1 exhaust	APU1	0	0	9.000
APU-2 exhaust	APU2	0	0	9.000
APU-3 exhaust	APU3	0	0	9.000
Cabin overpressure relief valve	CCO	53.000	0	0
Cabin overpressure relief valve	CCR	53.000	0	0
ECLSS nitrogen pressure regulator failure	CNV	0	-4.900	0
ECLSS oxygen pressure regulator failure	COV	0	-4.600	0
ECLSS potable water dump	CPW	0	-1.275	0
ECLSS urine dump	CU	0	-1.275	0
Fuel cell hydrogen purge	FCHP	0	0.050	0
Fuel cell hydrogen reactant regulator failure	FCHR	0	0.300	0
Fuel cell oxygen purge	FCOP	0	-0.050	0
Fuel cell oxygen reactant regulator failure	FCOR	0	-0.600	0
Fuel cell water relief	FCWR	0	-0.010	0
High load evaporator	HLE	0	-1.500	0
Hydraulic water boiler vent #1	H2O1	0	0	3.000
Hydraulic water boiler vent #2	H2O2	0	0	3.000
Hydraulic water boiler vent #3	H2O3	0	0	3.000
OMS fuel pressure relief (PLB)	OMSF	0	-24.700	0
OMS oxidizer pressure relief (PLB)	OMSO	0	24.700	0

Figure B-1.- Vent initialization table.

DESCRIPTION	VENT ID	X-THRUST	Y-THRUST	Z-THRUST
OMS fuel pressure relief (LHS)	OPFL	-24.670	0.940	-0.900
OMS fuel pressure relief (RHS)	OPFR	-24.670	-0.940	-0.900
OMS oxidizer pressure relief (LHS)	OPOL	-24.670	0.940	-0.900
OMS oxidizer pressure relief (RHS)	OPOR	-24.670	-0.940	-0.900
Multiple-tank hydrogen relief vent	PHMV	0	1000.000	0
PRSD hydrogen relief vent (2 tanks)	PHR1	0	60.000	0
PRSD hydrogen relief vent (3 tanks)	PHR2	0	130.000	0
Oxygen relief vent (12 tanks)	POMV	0	-600.000	0
Oxygen relief vent (2 tanks)	PORV	0	-17.000	0
RCS aft fuel pressure relief (LHS)	RAFL	-19.770	0.750	-0.720
RCS aft fuel pressure relief (RHS)	RAFR	-19.770	-0.750	-0.720
RCS aft oxidizer pressure relief (LHS)	RAOL	-19.770	0.750	-0.720
RCS aft oxidizer pressure relief (RHS)	RAOR	-19.770	-0.750	-0.720
RCS forward fuel pressure relief	RFF	8.950	16.040	-7.380
RCS forward oxidizer pressure relief	RFO	8.950	-16.040	-7.380

Figure B-1.- Concluded.

a. Make the appropriate changes to the VIT.

b. Record the VIT entry or change on the MLF along with the reason for making the entry or change.

B-1.2 VENT TIMELINE/REENTRY VENT TIMELINE

The navigation console engineer has the capability via MED input to add, modify, or delete VTL/RVTL entries. The applicable MED and its general format is given below.

a. Applicable MED - P42 (The P42 MED has a menu format (fig. B-2). The format is obtained by transmitting a P42? to the MOC).

b. General format - P42, OPTION, TABLE, /ENTRY, VENT ID, START TIME, STOP TIME/$.

c. Field comments

(1) OPTION

(a) A = add

(b) M = modify

(c) D = delete

(2) Table

(a) VTL

(b) RVTL

(3) ENTRY #

(a) 1 - 200 (VTL)

(b) 1 - 50 (RVTL)

(4) VENT ID

4 alphanumeric characters. Vent must be defined in the VIT.

(5) START TIME

(a) VTL - GMT start time.

(b) RVTL - Delta time in hr:min:sec format (negative before deorbit ignition).

********** VTL/RVTL MAINTENANCE MENU **********

OPTION = A(ADD), M (modify), D (delete) : for modify, enter entry no(s) and delta time to add to times

TABLE NAME = VTL, RVTL

** ENTRY NO. ** (NNN, NNN - NNN)	**VENT ID ** (4 CHAR.)	**GMT START** OR DELTA T	**GMT STOP** OR DELTA T

**** Maximum number of entries for VTL is 200; for RVTL is 50
This MED has permanent MED capability

P42 MENU

Figure B-2.- VTL/RVTL maintenance menu.

(6) STOP TIME

(a) VTL - GMT stop time.

(b) RVTL - Delta time (positive after deorbit ignition).

B-1.2.1 VTL/RVTL Premission Load

The VTL/RVTL will be configured premission to model an AOA contingency mission. The start and stop times for the high-load evaporator (HLE), APU, and water boiler vents listed below should be configured to run from launch through entry. Figures B-3 and B-4 illustrate the initial rev-one vent and reentry vent timeline loads referenced to a March 1980 launch.

VIT label	Comment
HLE	High-load evaporator
APU1	Auxilliary power unit-1
APU2	Auxilliary power unit-2
APU3	Auxilliary power unit-3
H201	Water boiler unit-1
H202	Water boiler unit-2
H203	Water boiler unit-3

B-1.2.2 Rev-1 VTL/RVTL Maintenance

During the ascent mission phase, the low-speed navigation team leader will monitor the flight director and navigation support communication loops to determine the Orbiter vent status. Prior to low-speed Madrid acquisition of signal, the MED operator will need to reconfigure the VTL if the APU's were turned off. He should confirm this with the FDO and obtain the APU/H_2O vent stop times. The APU and H_2O vents will operate for approximately 12 minutes for a nominal launch.

Over the rev-1 Indian Ocean pass, the MED operator should obtain the missior status (AOA or nominal) from the FDO. The appropriate deorbit vents (AOA or nominal) should be added to the VTL at this time.

VENT TIMELINE

GMT 93:05:15:52 PET 93:05:15:52 MED TIME 0:00:00:00 PAGE 1 OF 1

ENTRY	ACT	VENT	START TIME	END TIME
1		HLE	93:14:40:04	93:21:00:00
2		APU1	93:16:56:04	93:21:00:00
3		APU2	93:16:56:04	93:21:00:00
4		APU3	93:16:56:04	93:21:00:00
5		H2O1	93:16:56:04	93:21:00:00
6		H2O2	93:16:56:04	93:21:00:00
7		H2O3	93:16:56:04	93:21:00:00

Figure B-3.- Prelaunch vent timeline.

REENTRY VENT TIMELINE AL23412341 01

GMT 60:01:13:00 PET 60:01:13:00 PAGE 1OF2

ENTRY	VENT	DELTA START	DELTA END
1	HLE	- 0:02:16:00	0:01:30:00
2	APU1	- 0:00:05:00	0:01:30:00
3	APU2	- 0:00:05:00	0:01:30:00
4	APU3	- 0:00:05:00	0:01:30:00
5	H2O1	- 0:00:05:00	0:01:30:00
6	H2O2	- 0:00:05:00	0:01:30:00
7	H2O3	- 0:00:05:00	0:01:30:00

Figure B-4.- Reentry vent timeline.

B-1.2.3 Nominal Deorbit VTL Maintenance

Figure B-5 illustrates the VTL configuration for a nominal deorbit maneuver referenced to a March launch. The HLE is activated simultaneously with the cargo bay doors close (approximately 2 hours 16 minutes before deorbit ignition). The GMT at which the cargo bay doors close can be obtained from the cargo bay door status timeline display (Fig. B-6). The HLE should be configured to start at a GMT of 10 minutes prior to the door closing time.

The APU/H_2O vents should be activated 3 minutes prior to deorbit ignition. The deorbit ignition GMT can be obtained from the mission plan table display (Fig. B-7).

The HLE/APU/H_2O vents should be configured to run through entry.

B-1.2.4 Nominal Deorbit RVTL Maintenance

The RVTL will be loaded premission and should remain unchanged unless the vent start times relative to deorbit ignition change during the mission. Figure B-4 illustrates the nominal RVTL configuration. The times are delta times relative to deorbit ignition. The times are negative prior to ignition and positive after ignition. The HLE vent activates 2 hours 16 minutes prior to deorbit ignition and remains on through entry. The APU/H_2O vents are activated 3 minutes prior to deorbit ignition and remain on through entry.

B-1.2.5 Contingency Deorbit VTL Maintenance

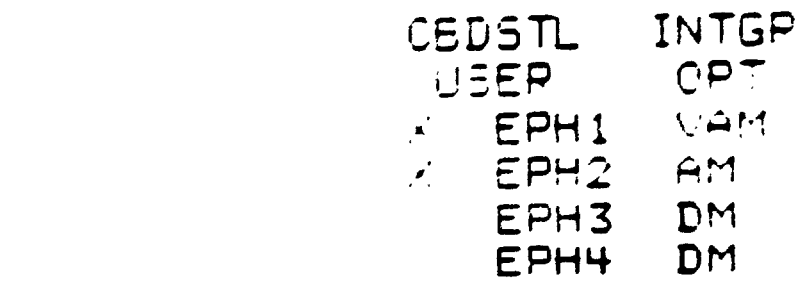
In the event that a contingency deorbit is planned, the VTL should be modified to reflect the new deorbit ignition time (sec. B-1.2.3).

VENT TIMELINE

EXT 93:05:16:48 PET 93:05:16:48 MED TIME 0:00:00:00 PAGE 1

ENTRY	ACT	VENT	START TIME	END TIME
1		APU1	91:11:30:00	91:13:30:00
2		APU2	91:11:30:00	91:13:30:00
3		APU3	91:11:30:00	91:13:30:00
4		HLE	91:11:30:00	91:13:30:00
5		H2O1	91:11:30:00	91:13:30:00
6		H2O2	91:11:30:00	91:13:30:00
7		H2O3	91:11:30:00	91:13:30:00

Figure B-5.- Nominal deorbit vent timeline.



GMT	STATUS	MET
0:00:00:00.00	CLOS	0:00:00:00.00
93:00:00:00.00	OPEN	93:00:00:00.00
93:14:45:04.00	CLOS	93:14:45:04.00

Figure B-6.- Cargo bay door status timeline.

FDO MISSION PLAN TABLE

[illegible] MAD 1 GMT 093:12:18:33 TGT VID

[illegible] 093:11:03:00 EPH1/S EPH / GMTAV

CODE	GMTIGN	ΔT	ΔV	ΔV_{REM}	h_a	h_p
[illegible]	093:17:01:04.0		287.3	178	151.3	0.0

Figure B-7.- FDO mission plan table.

APPENDIX C

SITE CONFIGURATION MESSAGE RECEPTION AND VERIFICATION

C-1.0 SITE CONFIGURATION MESSAGE RECEPTION AND VERIFICATION

Site configuration messages, generated by the OPS coordinator in conjunction with GSFC, are the actual teletype messages sent to the scheduled trackers identifying their tracking pass and station configuration requirements for STS mission support. SCM's will periodically be sent to navigation support station 44 during the mission. The SCM's list those C-band and S-band trackers that are scheduled to track the Orbiter along with a set of information describing the tracking configuration of each pass.

It is the responsibility of the navigation team leader or an assigned team member to review all SCM's in order to verify that the STDN and DOD tracking configurations are acceptable for navigation. If alterations need to be made, the navigation console engineer should contact the OPS planner on the OPS PLNR communications loop to negotiate all such changes. In order to schedule additional tracking sites, it is advisable to contact the OPS planner at least 30 minutes prior to the desired passes. Should an emergency situation occur where additional tracking sites need to be scheduled within 5 to 10 minutes of their expected acquisition times, the negotiations should be conducted with TRACK on the TRAJ COORD loop. All C-band and S-band SCM's should be chronologically filed after they have been reviewed and verified.

The following section gives, in considerable detail, a description of SCM structure and format, which should aid the navigation console engineers in interpreting the SCM's.

C-1.1 SCM STRUCTURE AND FORMAT[a]

Information required by the message addressee to support the Orbiter will be provided in the SCM's. These messages, GSTDN for S-band stations and general purpose for C-band stations and continuation messages, will be formatted in 4800-bit blocks for transmission to the recipient by HSDL. Figures C-1 and C-2 illustrate the format of these messages. Numbers in parentheses refer to the following notes defining data content.

a. SCM reference number

b. JSC station routing indicator from table C-I

c. Vehicle identification code (05 = Shuttle)

d. Support identification code (2001 = Shuttle #102)

e. Orbit number

---

[a]See JSC 10476 (June 1, 1978) Contract NAS 9-15014 DRL LI 54, prepared by: Ford Aerospace & Communications Corporation, Space Information Systems Operation, 1002 Gemini Avenue, Houston, Texas 77058.

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f. Day of year.

g. Predicted acquisition of signal (from the predicted site acquisition table (PSAT)) based on a zero-degree antenna elevation plus masking.

h. Predicted loss of signal (from PSAT) based on a zero-degree antenna elevation plus masking.

i. Link frequency.

j. Support modes

(1) Support mode as defined in table C-I.

(2) Support mode as defined in table C-II.

(3) Support mode "M" requires the station to monitor and record development flight instrumentation (DFI) data in real time for postflight shipment. Table C-III identifies DFI downlink characteristics by channel number and is included here for reference purposes in the remarks/notes portion of the SCM if required.

(4) Support mode as defined in table C-IV.

k. Number(s) referencing applicable note in figure C-3.

l. Note 1 is reserved for carrier on/off or handover times if applicable. If time is not specified, this note will indicate not applicable.

m. Note 2 will always contain maximum antenna elevation of pass and keyhole/masking information, if applicable.

n. Additional commentary concerning a vehicle, system, and/or special support requirements, as necessary.

o. Radar system requested.

p. Mode will always appear as SKIN.

q. Specifies HSR (10 samples per second) or LSR (one sample per 6 seconds).

r. Maximum antenna elevation of pass.

s. Additional commentary concerning a vehicle, system, and/or special requirements, as necessary.

t. Continuation of note commentary from previous page.

C-1.2 ROUTING

SCM's will be transmitted to GSFC/(NOCC) in 4800-bit blocks for subsequent retransmission to the addressee (fig. C-3). Message routing shall be determined by reading the user destination code in the HSDB header. The user destination code in the HSDB header is obtained from the JSC station acronym supplied in the first line of the SCM. Table C-V provides the JSC acronyms that will be used on the SCM for message routing. The "S" or "C" suffix on the JSC acronym designates an S-band or C-band station. Table C-VI provides a summary of network and user header codes used in the HSDB for outgoing SCM data.

Figure C-4 provides an example of a typical S-band SCM that would be received during a mission or a simulation.

C-1.3 FORMATTING

SCM's will be packed in the data field of the 4800-bit blocks and coded in ASCII. The 4626-bit data field is the maximum number of data bits allowed in one 4800-bit block. This limitation constrains the SCM to a maximum of 40 characters per line, including appropriate TTY machine characters at the end of each line, and a maximum of 16 lines.

C-1.4 SCM NUMBERING SCHEME

An SCM will be prepared for each S-band and C-band station with an Orbiter view period as shown on the operational flight profile obtained from Mission Planning and Analysis Division (MPAD), and numbered sequentially with a five-character alphanumeric identifier. The first character will be an "S" or "C" to identify the type of station for which the SCM is intended. The next three characters are sequential numbers ranging from 001 to 999. The first number that will be used for both S-band and C-band stations is 001. The last character will be an alpha suffix. Alpha character "A" will identify the original SCM. Alpha characters "B", "C", "D", etc., will be used to identify updates to the original SCM. All continuation messages (page 2) will be assigned the same number as page 1.

If the trajectory changes sufficiently so that a station is called up that previously did not have a view period, the next consecutive unused number will be used, beginning with the last SCM in the MSP.

C-1.5 RISE AND SET TIMES

AOS/LOS times represent a zero-degree antenna elevation plus masking.

C-1.6 MODE DEFINITIONS

Station configurations that are required to support flight operations activities are defined on the SCM's as modes. For a definition of the codes used for PM/UL, OD/DL, DF/DL, and FM/DL modes, refer to tables C-I and C-IV.

The DFI configuration remains constant and is defined in the NOSP. The letter "M" in the mode column of the SCM indicates that the station will monitor and record the DFI data in real time for postflight shipment.

S-band stations whose coverage is totally overlapped by a two-way station will not have an uplink requirement but will configure for and track the downlink. These stations will be identified on the SCM with a 00 PM uplink mode.

The C-band station configuration mode will always be identified as SKIN.

C-1.7 FREQUENCY UTILIZATION

S-band and UHF usage can be found in tables C-VII and C-VIII, respectively.

TABLE C-I.- S-BAND PHASE MODULATION (PM) UPLINK MODES (GSTDN)

GSTDN-to-SSC			
DOD mode	GSTDN mode	Function	Modulation
00	Off	No carrier	N/A
01	000	Carrier only	None
02	24L	32 kb/s (1 voice @24 and 1 command @8 kb/s)	PSK
03	24H	72 kb/s (2 voice @32 and 1 command @8 kb/s)	PSK
04	25L	32 kb/s (1 voice @24 and 1 command @8 kb/s + tone ranging)	PM
05	25H	72 kb/s (2 voice @32 kb/s each and 1 command @8 kb/s + tone ranging)	PM

TABLE C-II.- S-BAND PM DOWNLINK MODES (GSTDN)

SSO to GSTDN		
Mode	Function	Modulation
00	No carrier	N/A
01	Carrier only	None
02	96 kb/s (1 voice @32 and 1 telemetry @64 kb/s)	PM
03	192 kb/s (2 voice @32 kb/s each and 1 telemetry @128 kb/s)	PM
04	96 kb/s (1 voice @32 and 1 telemetry @64 kb/s + ranging)	PM
05	192 kb/s (2 voice @32 kb/s each and 1 telemetry @128 kb/s + ranging)	PM

TABLE C-III.- S-BAND DFI FREQUENCY MODULATION (FM)
DOWNLINK CHARACTERISTICS

Chan no.	Signal format	Bandwidth or bit rate	Frequency	Modulation
1	Analog	500 Hz	12 kHz	FM
2	Analog	500 Hz	16 kHz	FM
3	Analog	500 Hz	20 kHz	FM
4	Analog	500 Hz	24 kHz	FM
5	Analog	500 Hz	28 kHz	FM
6	Analog	500 Hz	32 kHz	FM
7	Analog	500 Hz	36 kHz	FM
8	Analog	2 kHz	48 kHz	FM
9	Analog	2 kHz	64 kHz	FM
10	Analog	2 kHz	80 kHz	FM
11	Analog	2 kHz	96 kHz	FM
12	Analog	2 kHz	112 kHz	FM
13	Analog	2 kHz	128 kHz	FM
14	Analog	2 kHz	144 kHz	FM
15	Bi-ϕ-L	12 kbps	148 kHz	FM
PCM	Bi-ϕ-L	128 bps	1.024 MHz	PSK

TABLE C-IV.- S-BAND PM DOWNLINK MODES (GSTDN)

SSO to GSTDN					
Mode	Function	Playback rate	Forward/ reverse	Modulation	
00	No carrier		F	N/A	
01	Carrier only			Node	
02	P/B 192 kb/s (PCM/TLM @1:1)	192KB/S	F	FM	
03	P/B 192 kb/s (PCM/TLM @5:1)	960KB/S	F	FM	
04	P/B 128 kb/s (PCM/TLM @1:1)	128KB/S	F	FM	
05	P/B 128 kb/s (PCM/TLM @8:1)	1024KB/S	F	FM	
06	P/B 60 kb/s (SSME data @1:1)	60KB/S	F	FM	
07	P/B 60 kb/s (SSME data @16:1)	960KB/S	F	FM	
08	(Unassigned)				
09	(Unassigned)				
10	(Unassigned)				
11	(Unassigned)				
12	P/B 192 kb/s (PCM/TLM @1:1)	192KB/S	R	FM	
13	P/B 192 kb/s (PCM/TLM @5:1)	960KB/S	R	FM	
14	P/B 128 kb/s (PCM/TLM @1:1)	128KB/S	R	FM	
15	P/B 128 kb/s (PCM/TLM @8:1)	1024KB/S	R	FM	
16	P/B 60 kb/s (SSME data @1:1)	60KB/S	R	FM	
17	P/B 60 kb/s (SSME data @16:1)	960KB/S	R	FM	
18	(Unassigned)				
19	(Unassigned)				
20	(Unassigned)				
21	(Unassigned)				
22	R/T SSME data (3 SCO's: 476KHz, 768KHz, and 1,024KHz - 60 kb/s each)			FM	
23	Television			FM	
24	Payload (analog)			FM	
25	Payload (digital)			FM	
26	DOD (narrow band)			FM	

TABLE C-V.- SITE ACRONYM/ID TABLE

JSC	OSCF	Local	Alias	Center	Antenna	Location
ACNS	ACN-3			STDN	9M(X-Y)NS USB	ASCENSION ISLAND, U.K.
AGOS	AGO-3			STDN	9M(X-Y)NS USB	SANTIAGO, CHILE
ANTC	ANT-Q	91.14	GOLD 91	ETR	FPQ-14 C-BAND	ANTIGUA ISLAND, U.K.
ASCC	ASC-Q	12.15	GOLD 12B	ETR	FPQ-15 C-BAND	ASCENSION ISLAND, U.K.
ASTC	AS2-Q	12.18	GOLD 12A	ETR	TPQ-18 C-BAND	ASCENSION ISLAND, U.K.
BDAS	BDA-3			STDN	9M(X-Y)NS USB	BERMUDA ISLAND, U.K.
BDQC	BDA-Q	67.18	GOLD 2A	ETR	FPQ-6 C-BAND	BERMUDA ISLAND, U.K.
BUCS	BUC-S[a]			STDN	4M(AZ/EL) USB	BUCKHORN LAKE, EAFB, CA
BUXS	BU2-S[a,b]			STDN	4M(AZ/EL) USB	BUCKHORN LAKE, EAFB, CA
CNMC	CNM-F[b]			ETR	MPS-36 C-BAND	CAPE CANAVERAL, FLA
CNVC	CNV-F	1.16	GOLD 1	ETR	FPS-16 C-BAND	CAPE CANAVERAL, FLA
EAFC	EAF-F[b]	R-38		WTR	FPS-16 C-BAND	AFFTC, EAFB, CA
EFFC	EA2-F[b]	R-41		WTR	FPS-16 C-BAND	AFFTC, EAFB, CA
ETCS	ETC-3			STDN	9M(X-Y)NS USB	GSFC, GREENBELT, MD
ETXS	ETC-A			STDN	9M(X-Y)EW USB	GSFC, GREENBELT, MD
FRCC	FRC-F[b]	R-34		WTR	FPS-16 C-BAND	DFRC, EAFB, CA
FTHC	FTH-F[b]			WSMR	FPS-16 C-BAND	AEPG, FORT HUACHUCA, ARIZ
GBIC	GBI-Q	3.13	GOLD 3	ETR	FPQ-13 C-BAND	GRAND BAHAMA ISLAND, U.K.
GDSS	GDS-3			STDN	9M(X-Y)NS USB	GOLDSTONE, CA
GDXS	GDS-8			STDN	26M(X-Y)EW USB	GOLDSTONE, CA
GTKC	GTK-Q	7.14	GOLD 7	ETR	FPQ-14 C-BAND	GRAND TURK ISLAND

[a]Not used for metric tracking data.
[b]Ascent or entry only.

TABLE C-V.- Continued

JSC	OSCF	Local	Alias	Center	Antenna	Location
GWMS	GWM-3			STDN	9M(X-Y)NS USB	GUAM ISLAND, MARIANA ISLANDS
HAWS	HAW-3			STDN	9M(X-Y)NS USB	KOKEE PARK, KAUAI, HAWAII
HOLC	HOL-F[b]	R-123		WSMR	FPS-16 C-BAND	HOLLOMAN AFB, NM
IOSS	SEY-S[a]	INDY		AFSCF	18M(AZ/EL) SGLS	MAHE, SEYCHELLES
KMRC	KMR-Q			WTR	ALCOR USB	KWAJALEIN ISLAND
KMTC	KMR-T			WTR	TPQ-18 C-BAND	KWAJALEIN ISLAND
KPTC	KPT-Q			WTR	FPQ-14 C-BAND	KAENA POINT, HAWAII
MADS	MAD-3			STDN	9M(X-Y)NS USB	MADRID, SPAIN
MAXS	MAD-8			STDN	26M(X-Y)EW USB	MADRID, SPAIN
MILS	MIL-3			STDN	9M(X-Y)NS USB	MERRITT ISLAND, FLA
MLAC	MLA-Q	19.14	GOLD 19	ETR	FPQ-14 C-BAND	MERRITT ISLAND, FLA
MLMC	MIM-F[b]	19.16		ETR	FPS-16 C-BAND	MERRITT ISLAND, FLA
MLXS	MIL-A			STDN	9M(X-Y)EW USB	MERRITT ISLAND, FLA
MTLC	MTL-F[b]	R-179	CAPRI	WSMR	4.9M(AZ/EL) C-BAND	MOUNT LEMMON, ARIZ
ORRS	ORR-3			STDN	9M(X-Y)NS USB	ORRORAL VALLEY, AUSTRALIA
PAFC	PA2-Q	0.13	GOLD OA	ETR	FPQ-13 C-BAND	PATRICK AFB, FLORIDA
PATC	PAT-Q	0.14	GOLD O	ETR	FPQ-14 C-BAND	PATRICK AFB, FLORIDA
PDLS	PDL-S[a,b]			STDN	4.3M S-BAND	PONCE De LEON INLET, FLA
PPTC	PPT-F[b]		ROMEO 81	WTR	FPS-16V C-BAND	POINT PILLAR, CALIF.

[a]Not used for metric tracking data.
[b]Ascent or entry only.

TABLE C-V.- Continued

JSC	OSCF	Local	Alias	Center	Antenna	Location
PTPC	CAL-Q		ROMEO 82	WTR	FPQ-6 C-BAND	POINT PILLAR, CALIF.
PTTS	PTT-Y[a]		TANGE 84	WTR	12M TLM S-BAND	POINT PILLAR, CALIF.
QUIS	QUI-S			STDN	4.3M(X-Y)NS USB	QUITO,ECUADOR
ROSS	ROS-S			STDN	4M(X-Y)NS USB	ROSMAN, NORTH CAROLINA
SNFC	SN2-F[b]	#3	ARMATURE 63	WTR	FPS-16 C-BAND	SAN NICOLAS ISLAND, CA
SNIC	SN1-F[b]	#2	ARMATURE 62	WTR	FPS-16 C-BAND	SAN NICOLAS ISLAND, CA
SNSC	SN3-F[b]	#4	ARMATURE 64	WTR	FPS-16 C-BAND	SAN NICOLAS ISLAND, CA
SPKC	FT2-F[b]			WSMR	FPS-16 C-BAND	SCOTTS PEAK, ARIZ
TULS	TUL-S[b]			STDN	4.1M(AZ/EL) S-BAND	TULA PEAK, WSMR, NM
VDBC	CAL-T		ROMEO 14	WRT	TPQ-18 C-BAND	VANDENBERG AFB, CA
VDFC	CA2-F[b]	#2	ROMEO 12	WTR	FPS-16 C-BAND	VANDENBERG AFB, CA
VDSC	CAL-F[b]	#1	ROMEO 11	WTR	FPS-16 C-BAND	VANDENBERG AFB, CA
VDTS	GSVB[a]		TANGO 17	WTR	30/35 FT S-BAND	VANDENBERG AFB, CA
WHSC	WHS-F[b]	R-113		WSMR	FPS-16 C-BAND	WHITE SANDS, NM
WLIC	WLP-F[b]	ISLAND 16		ETR	FPS-16 C-BAND	W.F.C., WALLOPS ISLAND, VA
WLPC	WLP-Q	86.6		ETR	FPS-16 C-BAND	W.F.C., WALLOPS ISLAND, VA
WLRC	WL2-F[b]	RUNWAY 16		ETR	FPS-16V C-BAND	W.F.C., WALLOPS ISLAND, VA
WSPC	WH9-F[b]	R-124		WSMR	FPS-16 C-BAND	PHILLIPS HILL, NM

[a]Not used for metric tracking data.
[b]Ascent or entry only.

TABLE C-V.- Concluded

JSC	OSCF	Local	Alias	Center	Antenna	Location
WSSC	WH6-F[b]	R-127		WSMR	FPS-16 C-BAND	STALLION STATION, NM
WSWC	TUL-F[b]	R-125		WSMR	FPS-16 C-BAND	WILDE SITE, NM

[a]Not used for Metric tracking data.
[b]Ascent or Entry only.

TABLE C-VI.- NETWORK AND USER HEADER CODES SUMMARIZED FOR OUTGOING SCM DATA

Site acronym		Network header			User header		
OSCF	JSC	Source octal	Destination octal	Binary FMT type	Message type octal	Destination octal	TTY RI
MIL3	MILS	160	273	1 0 1 0 1	232/231	001	GMIL
MILA	MLXS						GMIL
PDLS	PDLS					001	GMIL
BDA3	BDAS					002	GBDA
ACN3	ACNS					003	GACN
ETCA	ETXS					037	TBD
ECT3	ETCS					037	TBD
MAD8	MAXS					004	LMAD
MAD3	MADS					004	LMAD
ORR3	ORRS					005	AORR
GWM3	GWMS					006	PGWM
HAW3	HAWS					007	PHAW
GDS8	GDXS					010	GGDS
GDS3	GDSS					010	GGDS
AGO3	AGOS					011	GAGO
QUIS	QUIS					012	GQUI
SEYS	IOSS					035	GSVL
SEYS	IO2S					044	GSLE
BUCS	BUCS					014	GBUC
BU2S	BUXS					014	GBUC
CA2Y	PTTS					036	GPTP
TULS	TULS					050	GTUL
CALY	VDTS	160	273	1 0 1 0 1	232/231	051	GSVD

TABLE C-VI.- Concluded

Site acronym		Network header			User header		
OSCF	JSC	Source octal	Destination octal	Binary FMT type	Message type octal	Destination octal	TTY RI
FRCF	FRCC	160	273	1 0 1 0 1	231	016	GFRC
EAFF	EAFC					042	GAFT
EA2F	EFFC					042	GAFT
BDAQ	BDQC					017	GBDA
MLAQ	MLAC					020	GMLA
CNVF	CNVC					041	GCVL
PATQ	PATC					021	GPAT
PA2Q	PAFC					021	GPAT
GBIQ	GBIC					022	GGBI
ANTQ	ANTC					023	GANT
GTKQ	GTKC					024	GGTK
WLPF	WLIC					025	GWAB
WL2F	WLRC					025	GWAB
WLPQ	WLPC					025	GWAB
ASCQ	ASCC					026	GASC
AS2Q	ASTC					026	GASC
KMRQ	KMRC					027	GKMR
KMRT	KMTC					027	GKMR
KPTQ	KPTC					030	GKPT
CALQ	PTPC					036	GPTP
CALT	VDBC					031	GVNB
CALF	VDSC					015	GVNB
CA2F	VDFC					015	GVNB
CA3F	TBD	160	273	1 0 1 0 1	231	036	GPTP

S-BAND FORMAT

```
JSC SCM S (1)          (2)      ,_____ ,_____ , _____
VID (3)  SIC (4)  ORB (5)  DAY (6)
ADS (7): _____ : _____  LOS (8): ____ :_____
VEH LINK FREQ       M - REMARKS
SSO PM UL __(9) _____   (10A)'_____(11) ____'
SSO OD DL _____________  (10B) _____________'
SSO DF DL _____________  (10C) _____________'
SSO FM DL _____________  (10D) _____________'
```

NOTES

```
'1. _____(12)_____________________________________'
'2. _____(13)_____________________________________'
'3. _____(14)_____________________________________'
'_____________________________________________'
'_____________________________________________'
'_____________________________________________'
'_____________________________________________'
'_____________________________________________'
```

Figure C-1.- STDN SCM format (message type 232) S-band.

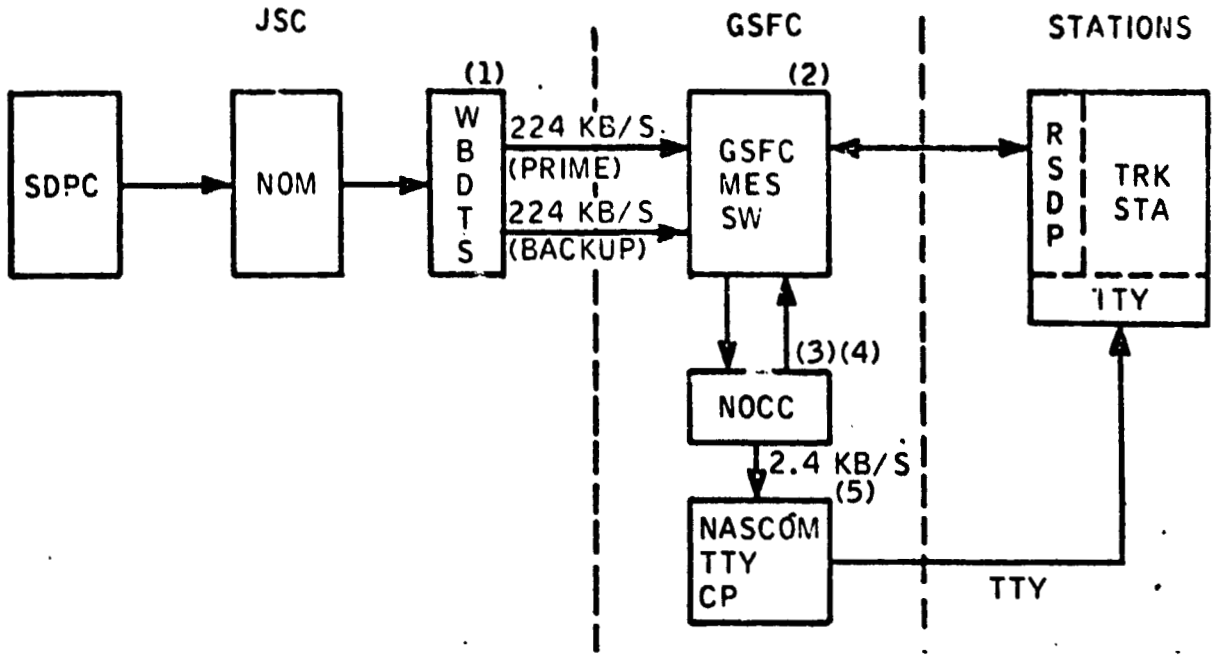
C-BAND FORMAT

```
JSC FORM  (1)      (2)    , _____ , _____,
' C BAND SUPPORT
' VID (3)  SIC (4)     ORB (5)  DAY (6)  '
' AOS  (7) _____       LOS:  (8) _____   '
' VEH  SYS       MODE  D/RA    MAX EL.    '
' SSO  (15)      (16)  (17)    (18)       '

'NOTES                                    '

' _________(19)_____________________________'
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
 ------------------------------------------
```

CONTINUATION FORMAT

```
JSC FORM __(1)__     (2)__,_____, _____,
'                                '
'                                          '
'                                          '
'_________(20)_____________________________'
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
'                                          '
 ------------------------------------------
```

Figure C-2.- General purpose SCM format (message type 231) C-band and continuation.



Notes:

a. All SCM's leave JSC with a network destination code of 273_8 (NOCC) in word 5, and a user destination code in word 10 of the HSDB header.

b. The message switch reads the network header, word 5, and routes the SCM HSDB tc the NOCC.

c. The NOCC reads the user destination code, word 10, and retransmits the data content intact to the appropriate station over HSDL or TTY via the GSFC message switcher or the NASCOM TTY switch.

d. For stations capable of receiving SCMs in HSDB format, the NOCC makes up to three attempts to transmit the SCM via HSDL. If confirmation of a successful transmission is not received back to the NOCC, the message will be automatically routed to the NASCOM TTY CP for reformatting and transmission.

e. SCM's will be automatically routed directly tc the NASCOM TTY stations without a HSDB capability.

f. SCM data format should be DDPS compatible.

Figure C-3.- SCM data flow.

```
JSC#                                                    001/RT
JSC SCM S 009A   MLXS ,     ,     ,
VID 05  SIC 2001 ORB 002 DAY 258
AOS 13 : 36 : 27   LOS 13 : 43 : 05
VEH LINK FREQ      M     REMARKS
SSO PM UL 2106.4   25H ' 1,2      '
SSO OD DL 2287.5   05  '          '
SSO DF DL 2205.0   M   '          '
SSO FM DL 2250.0   23  ' 3,4      '

NOTES

' 1.  CXR ON 13:35:30, H/O TO          '
'     BDA 13:42:00                     '
' 2.  MAX EL. 10.9                     '
' 3.  TV REMOTING REQUIREMENT TBD      '
' 4.  CHG TO MODE 13 ON H/O TO BDA.    '
' 5.  COMM CONFIG CHARLIE              '


JSC#                                                    001/RT
JSC SCM S 010    ETCS ,     ,     ,
VID 05  SIC 2001 ORB 002 DAY 258
AOS 13 : 39 : 37   LOS 13 : 44 : 56
VEH LINK  FREQ     M     REMARKS
SSO PM UL 2106.4   00  ' 2        '
SSO OD DL 2287.5   05  '          '
SSO DF DL 2205.0   M   '          '
SSO FM DL 2250.0   23  ' 3        '

NOTES

' 1.  N/A                              '
' 2.  MAX EL.  32.5                    '
' 3.  CHG TO MODE 13 AT 13:42:00       '
' 4.  COMM CONFIG CHARLIE              '
' 5.  NOT SCHEDULED FOR SUPPORT.       '
'                                      '
'                                      '
```

Figure C-4.- Typical S-band SCM.

APPENDIX D

TEAM RESPONSIBILITIES

D-1.1 TEAM RESPONSIBILITIES

Effective April 18,1980, the team assignments for STS simulation and mission support are as follows.

a. Team 1 - Dick Osburn (team leader)
Jon Weaver
Jeanette French (MDTSCO)
Brad Wissinger (MDTSCO)

b. Team 2 - Bruce Williamson (team leader)
Ronald LaCarna (MDTSCO)
Thomas Rich (MDTSCO)
James Termini (MDTSCO)

c. Team 3 - Will York (team leader)
August Lau
Richard Theis (MDTSCO)
Richard McGuire (MDTSCO)

D-1.2 SHIFT HANDOVER PROCEDURES

In addition to regular onorbit navigation team shift changes, there will also be team handovers with the high-speed navigation teams. Procedures are detailed below.

D-1.2.1 Ascent (High-Speed) to OPS (Low-Speed) Handover:

a. One low-speed controller (to be assigned by the team leader) should monitor, as a minimum, the NAV SUPPORT, FLIGHT DIRECTOR, and AIR TO GROUND communications loops during the ascent mission phase to obtain information concerning the high-speed filter onboard vector status at MECO along with any other mission-related events that could impact subsequent low-speed processing.

b. All other team members should remain outside the navigation staff support room (SSR) until handover time.

c. After the shift handover has occurred, the low-speed team members should follow the rev-1 MAD (MAX), IOS procedures (sec. 5.1.1).

D-1.2.2 Nominal Shift Changes

a. The lead engineer of the next low-speed navigation team should report to the nav console approximately 60 minutes prior to the shift handover. The other team members should report to the navigation console approximately 15

minutes prior to shift handover. The current team leader should be available for 30 minutes after the handover to answer any questions that may arise relating to the previous shift.

b. The team leaders should review the following:

(1) Mission log form entries made by the previous team.

(2) The tracking station solution-ephemeris compare tables used to review any Orbiter trajectory data trends that may have developed during the previous shift.

(3) Hardcopies verifying any Orbiter trajectory data trends or other mission anomalies.

(4) Any decisions made during the previous shift that would affect procedures during the upcoming shift.

(5) Current network status.

(6) Other system status information yet to be determined.

D-1.2.3 OPS (Low-Speed) to Entry (High-Speed) Handover

a. The lead engineer should review the SCCS and any other changes that would affect the high-speed trajectory processing software with the high-speed entry lead engineer.

b. One low-speed controller (to be assigned by the team leader) will monitor the voice loops during the descent mission phase to be available to answer any questions that may arise relating to the trajectory processing prior to the onorbit/entry handover.

c. The other low-speed team members should leave the area around the navigation support room as soon as possible.

APPENDIX E

NAV INTERFACE REQUIREMENTS

E-1.0 NAV INTERFACE REQUIREMENTS

During the mission the low-speed navigation console engineers will be continually interfacing with the FDO along with other mission staff support groups. Figure E-1 illustrates the low-speed navigation position relative to the FDO and the Ground Data Systems Division (GDSD) Track and Dynamics staff-support groups.

E-1.1 PRIMARY INTERFACE GROUPS

The following sections describe the primary groups with which the low-speed navigation console engineers will be interfacing.

E-1.1.1 Flight Dynamics Officer

The FDO console is located in the mission operations control room (MOCR). As shown in figure E-1, the NAV team directly supports the FDO. For a list of NAV responsibilities (i.e., what the FDO expects from NAV), refer to section 1.3.

The FDO is primarily responsible for all trajectory-related processing, including maneuver definitions, execution and confirmation, and spacecraft ephemeris maintenance.

The team leader of each low-speed ground NAV team shall assign one of the team members to interface with the FDO during mission and simulation operations.

E-1.1.2 Dynamics

The Dynamics staff-support group also supports the FDO during mission and simulation operations. Responsibilities include program control for all ephemeris generation and maintenance, along with all maneuver and deorbit-related computations. The low-speed navigation operator in charge of PBI and display request keyboard (DRK) operations (assigned by the team leader) shall interface with the Dynamics staff support personnel during mission and simulation operations.

Other responsibilities that involve NAV/DYNAMICS interface are as follows:

a. Vector storage and move functions

b. All vector checkout monitor-related processing

c. Specifying the B-vent plot scales.

E-1.1.3 Track

The Track staff-support group supports the FDO during mission and simulation operations. Responsibilities include incoming tracking data validation, generation and maintenance of PSAT, interfacing with all supporting tracking stations

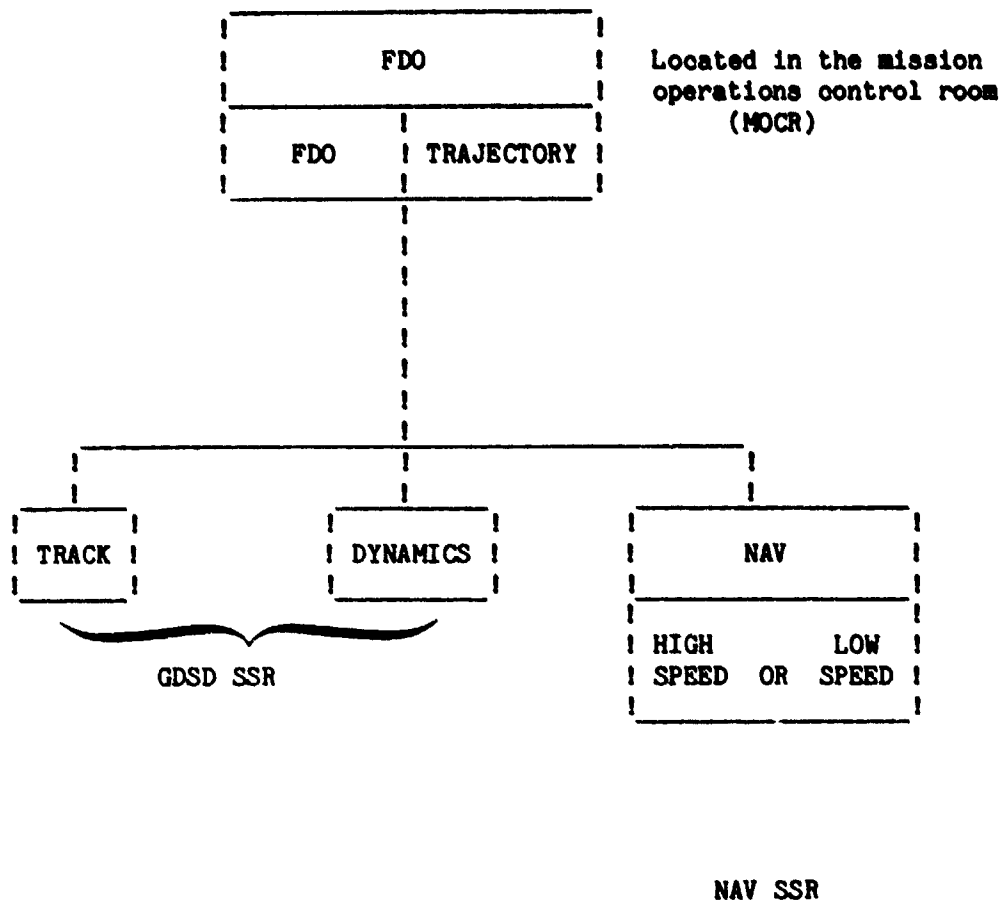


Figure E-1.- Flight Dynamics Officer and Associated Mission Support Groups.

to report data anomalies, conducting data transmission validation tests, and maintaining the proper data routing parameters for all mission active vehicles. The low-speed navigation operator (to be assigned by the team leader) in charge of monitoring the LSIP display during mission and simulation operations shall be in charge of interfacing with the Track staff support personnel.

Other responsibilities that involve NAV/TRACK interfacing are as follows:

a. Providing interface with remote tracking sites to report any tracking related anomalies encountered by the navigation operators

b. Including or excluding specified stations from the next station contacts and predicted site acquisition displays

E-1.2 ADDITIONAL INTERFACE GROUPS

The following sections describe additional groups that the low-speed navigation console engineers will be interfacing with on a less-frequent basis.

E-1.2.1 Operations Project Shuttle Planner

The OPS planner (in conjunction with GSFC) schedules the STDN and DOD tracking configuration for MCC real-time support. The OPS planner shall be responsible for sending C-band and S-band SCM's, along with any SCM updates to the navigation console. The OPS PLNR communications loop will be used to interface with the OPS planner during mission and simulation operations.

Other OPS planner responsibilities that involve NAV/OPS planner interface are as follows:

a. SCM reception and verification

b. Changes (scheduling of additional tracking) to the current SCM tracking configuration

c. Emergency tracking scheduling

E-1.2.2 Computer Supervisor

The computer supervisor is primarily responsible for supervising MCC computer operations. Any software-related problem should be reported to the computer supervisor by the MED operator over the SDP INT communications loop.

The major computer supervisor responsibility that involves NAV/computer supervisor interfacing is the identification of all MCC hardware/software problems. Some coordination with the computer supervisor is also required for enabling disk data sets and the reading and writing of data tapes.

E-1.2.3 Onboard Navigation Status Group

The O-NAV group is primarily responsible for monitoring the health of all onboard navigation related software/hardware system units. The guidance officer is the primary O-NAV interface.

The duties of the O-NAV operators include the following:

a. Onboard navigation status

b. Need for ground update

d. Onboard IMU-sensed effects of low-level thrusting

e. Redundancy management (RM)/NAV interactive effects

Some O-NAV responsibilities that involve NAV/O-NAV interfacing are as follows:

a. Onboard state vector/ground ephemeris status

b. IMU status

c. Vehicle trajectory perturbations due to venting or attitude reconfigurations

The low-speed navigation console operator (to be assigned by the team leader) in charge of monitoring the LSIP will interface with the O-NAV operators on the SSR-DYN2 communications loop.

E-1.2.4 Resident Analyst

The navigation analysis group, located at GSFC, will continuously monitor and process all mission tracking data. Should JSC nav console operators note any unexplained problems with the tracking data, they may contact the resident analyst team to verify those tracking data problems. All resident analyst interactions will be conducted on the GSFC OCF communications loop.

APPENDIX F

OFF-LINE PROCESSING REQUIREMENTS

During the mission, MCC navigation support console operators will be required to provide data to the nav off-line processing team. The results of the off-line processing may be used later in the mission by the nav console operators. Details of the analysis to be performed and procedures for off-line personnel will be published later in a separate document (STS-1 Onorbit Off-line Navigation Procedures).

F-1.0 TRACKING DATA REQUIREMENTS

A 9-track 800 BPI tape containing low-sample rate tracking data is created by executing the following procedures:

a. Request a 6250 BPI tape drive from the COM SUP using SDP INT communications loop.

b. Input the S31 MED with the DT option to copy low-sample rate tracking data from the logging disk data set onto a 6250 BPI output tape.

```
S31,DT,,,,,TLEFT,TRIGHT,N,P$;
```

where TLEFT and TRIGHT delimit the data span of the output tape.

c. Obtain the new 6250 BPI tape number and data set name from the on-line monitor (MSK 0005); the tape number should begin with 05, and the data set name should be TDR LOG.TAPE.

d. The MED console operator should convert this 6250 BPI tape to an 800 BPI tape. When the conversion is finished, obtain the tape number of the 800 BPI output tape. This tape number should begin with 04.

e. The 800 BPI tape is then checked out from the input/output (I/O) desk on the first floor of building 30.

Procedures for Building 12 processing of this output tape will be documented separately.

F-2.0 PROCESSING AND HARDCOPY REQUIREMENTS

NAV console personnel will define the superbatch time spans and data batches to be processed by the off-line team. Superbatches will be executed for data arcs requiring successive use of the K-gamma PBI (possibly indicating times of excessive venting or mismodeling) and for arcs covering special events (such as the deorbit rehearsal period).

For each case, the SCSB solution will be saved in the SVT, and hardcopies of the displays indicated on the superbatch summary checklist (fig. F-1) will be obtained. The superbatch summary form will be filled out and stapled to the hardcopies for each case. This package will be used by the off-line team to update the HOPE program input timelines and initial state vectors, and to facilitate data editing, processing, and analysis.

Date_____Time _____ Initials _____

GMT time span of DC ARC: _____ to _____

Superbatch includes batches _____ to _____

Superbatch excludes batches _____

_____

_____

Orbital elements (M50) from checkout monitor

a = _____ n. mi. w = _____ deg

e = _____ Ω = _____ deg

i = _____ deg n = _____ deg

Hardcopy check list:

! ! Batch summary (MSK 330)

! ! Checkout monitor of SB vector (MSK 2300)

! ! Residual summary on SB solution vector (MSk 332)

! ! Residual plots (MSK 334) of all edited batches based on SB solution vector

! ! SVT (MSK 336)

! ! ATL (MSK 2330)

! ! VTL (MSK 2340)

! ! VIT (MSK 2342)

! ! Cargo bay door status timeline (MSK 2320)

! ! EPH1 weight loss/gain timeline (MSK 2321)

! ! Matrix locker (MSK 487) If RELMATS used by the ATL are revised (other than due to reinitialization after checkpoints), the hardcopies of the matrix locker with the elements of each of the matrices will be obtained. Call dynamics to display any RELMATS that have changed.

Figure F-1.- Superbatch summary checklist.

|__| MPT (MSK 475)

|__|yes |__|no Have any station characteristics changed? If yes, list changes in comments on next page.

Comments--List any anomalies over the superbatch interval processed.

Figure F-1.- Concluded.

APPENDIX G

FREQUENTLY USED DISPLAYS

G-1.0 FREQUENTLY USED DISPLAYS

This section describes in detail the console displays used most frequently by low-speed navigation personnel.

Below is a list of the contents in this appendix, which is arranged in order of ascending manual select keyboard (MSK) numbers.

G-1.1 LOW SAMPLE RATE TRACKING DATA INPUT (MSK 0325)

This display enables the controller to monitor the status (and to some extent the quality) of the tracking data currently being received. In addition, it displays parameters that affect the flow of data from tracking stations, such as minimum acceptable elevation angles, fault indicators, etc.

Additional information is provided regarding the number of valid data frames (observation sets) from each station, the total number of data frames, the antenna band type (C-band or S-band), the Doppler mode (two-way or three-way), and the time interval between data frames.

This display is invoked by either MSK 0325 or the appropriate DRK entry.

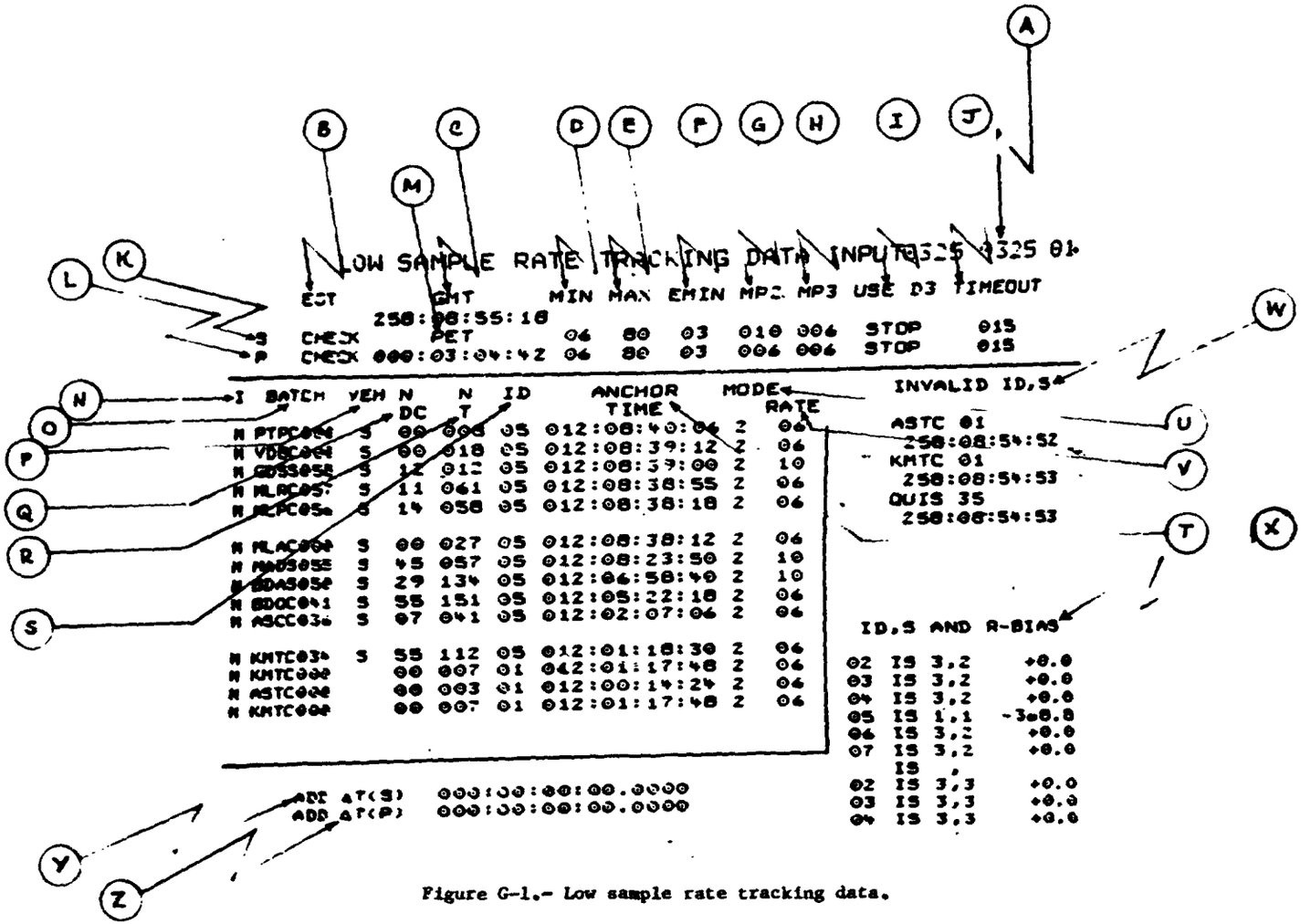


Figure G-1.- Low sample rate tracking data.

TABLE G-I

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	0325	none	
B	EOT indicator for CHECK or NOCHECK. If in CHECK mode, automatically forces EOT if USB station sends last message indicator. If in NOCHECK mode, no action taken even if USB station sends last message indicator (i.e., requires manual EOT).	none	CHECK	S23 MED	
C	GMT, updated every 6 seconds.	day:hr:min:sec	Program computed	none	Day is the day number from the first of the year.
D	Minimum number of valid observations required for a batch to be saved.	none	6	S27 MED	
E	Maximum number of observations allowed in a single batch.	none	80	S27 MED	
F	Minimum elevation angle for a valid observation.	deg	3	S28 MED	
G	Multipoint two-way option. Minimum time between collected observations within a batch.	sec	6 for C-band 10 for S-band	S29 MED	Two-way Doppler
H	Multipoint three-way option. Minimum time between collected observations within a batch.	sec	6	S29 MED	Three-way Doppler (not used)
I	Save/No Save flag for three-way Doppler. Always set to STOP.	none	STOP	none	Not used
J	Time gap between observations after which tracking data are considered missing.	sec	15	S33 MED	
K	All data on this line pertain to Shuttle.	none	S	none	
L	All data on this line pertain to payload	none	P	none	

TABLE G-I.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
M	Phase elapsed time.	day:hr:min:sec	Program computed	none	Day is the day number from the last phase.
N	Fault indicator appears before each batch in which fault occurs. The following are fault indicators and their definitions: V - invalid vehicle Z - time tag of OBS $\leq$ time tag of previous OBS I - C-band data invalid D - Doppler invalid or is not non-destruct R - range invalid A - angles invalid X - transmitting antenna is not same as receiving antenna N - data type is not real time M - Δt between OBS $\geq$ time-out - data is valid (no fault)	none	Program computed	none	
O	Three-character station name, band type (C-band or S-band), and batch number. Batch number will remain 000 until valid data have been received. Example: BDAS 005 - Batch 5, Bermuda S-band	none	Program computed	S22 MED	Maximum of 15 stations displayed at any one time. EOT must be done manually via S22 MED if (1) Station does not transmit last message indicator, or (2) station does send last message indicator, but EOT indicator is set to NOCHECK.
P	Vehicle indicator.	none	S	none	
Q	Number of data frames available for DC processing.	none	Computed	none	
R	Total number of data frames received.	none	Computed	none	NT is always $\geq$ NDC
S	Numeric vehicle ID for these data.	none	5	none	

TABLE G-I.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
T	If no valid observations have been received from the station, it is the GMT of the first point received. If a valid observation has been received, it is the time tag associated with that first observation.	day:hr:min:sec	Computed	none	Day is the day number from the first of the year.
U	Doppler mode indicator (two-way or three-way).	none	2		
V	Δt between consecutive data points received.	sec	6 (C-band) 10 (S-band)		
W	Tracking data associated with an invalid vehicle ID is placed in this area (maximum of five invalid vehicles). The site ID (three letter plus C or S) is followed by the input ID. The anchor time associated with it is on the next line.	Anchor time is day:hr:min:sec	N/A	S22 MED	Use "S22$" to remove elements from this area of the display. Day is the day number from the first of the year.
X	Input vehicle ID, vehicle number assigned to that ID, beacon number, and one-way range bias associated with each input ID (Maximum of 10 displayed). Example: 05 is 3,2 -1265.2 - data received for input ID 5 will be interpreted as vehicle ephemeris 3, transponder 2 data, with a range bias of -1265.2 yds.	Range bias in yards	N/A	S26 MED	Input a negative value for the range bias.
Y	Time bias applied to incoming radar data for Shuttle.	day:hr:min:sec	0	S24 MED	
Z	Time bias applied to incoming radar data for payload.	day:hr:min:sec	0	S24 MED	

G-1.2 SHUTTLE DC SUMMARY (MSK 0326)

This display provides the controller with the information required to evaluate a differential correction necessary to the orbit determination process. Information is provided concerning the fit of the data to the orbit and the corrections to the orbit caused by the latest data. This display is refreshed automatically every six seconds.

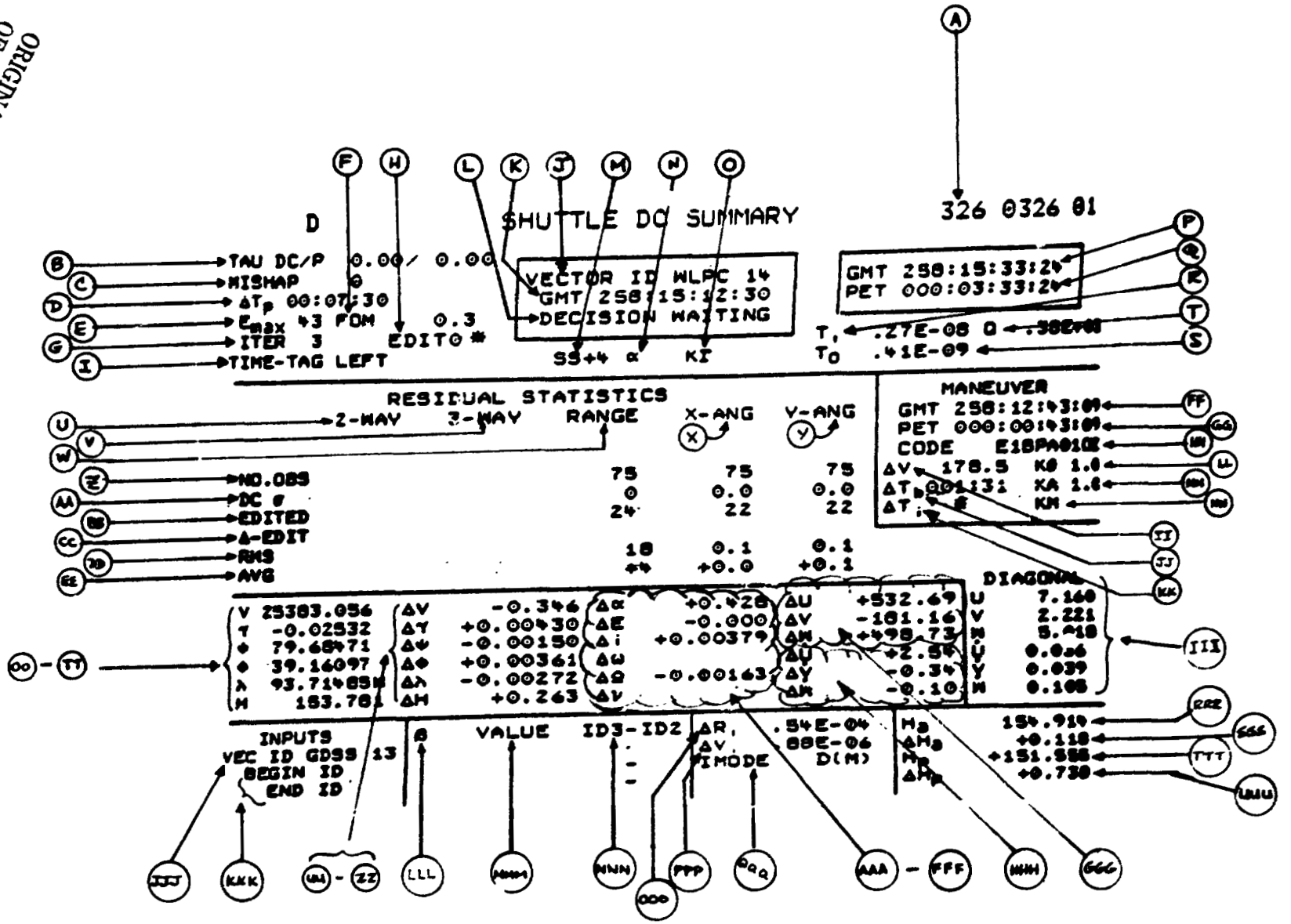


Figure G-2.- Shuttle DC summary.

TABLE G-II

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	0326	MSK	
B	Exponential downweight time values for the differential correction/ propagation functions.	hours			
C	Error situation error codes are as follows: 1 - DC RNP matrices not loaded 2 - Integration error 3 - Error detected during DC execution; accompanied by on-line error message 4 - Two-way site timeline error (should not happen during CFT) 5 - Requested bias cannot be estimated (should not happen during OFT) 6 - DC selection editing error 7 - DC DWT TAU illegal 8 - DC terminated by stop immediately MED (S09)	none	--	S09 MED	
D	Elapsed time of current pass for DC.	hr:min:sec		User can control batch size via S22 and S27 MEDS	
E	Maximum elevation angle during pass.	deg	Computed	Computed	
F	Figure of merit - an indication of how well the solution fits the data.	none		Computed	
G	Number of iterations performed during last DC loop; asterisk indicates solution was converging and exit was due to maximum iteration limits being reached.	none		S09 MED	

TABLE G-II.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
H	Number of editing loops performed; an asterisk indicates that the program is in zero-edit mode.	none		Computed	
I	Indicates whether vector is anchored to the beginning (left) or end (right) of the time interval; applies only for superbatch solutions.	none	left or right	S09 MED	
J	Batch on which solution was based (batch-to-batch) or vehicle identification and superbatch no. for superbatch. E.G. - MADS001 (batch-to-batch) SCSB 1 (superbatch)				
K	GMT anchor time of station (time of first valid DC data frame).	day:hr:min:sec		Computed	Day is the day number from the first of the year.
L	Status of the solution Waiting - solution has not been accepted or rejected Accept - use this solution Reject - do not use this solution	none	"waiting"		
M	Indicates covariance matrix used in the solution. If negative, no propagation took place. SS ± 1 - uncontrained solution SS ± 2 - constrained plane SS ± 3 - constrained by user-specified UVW diagonal covariance SS ± 4 - constrained by the full 6 x 6 covariance associated with the input vector	none	±1, ±4	PBI, S17, S07	

TABLE G-II.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
N	Alpha downweighting indicator - indicates whether factor has been applied to station weighting.	none	blank or "1"	PBI	
O	K-gamma downweighting indicator - indicates whether covariance matrix has been multiplied by 5.	none	blank or "1"	PBI	NB: shows "1" even for multiple applications of K-gamma
P	Current GMT.	day:hr:min:sec		Computed	Updated every 6 seconds
Q	Current phase elapsed time.	day:hr:min:se			Updated every 6 seconds
R	Trace input - trace of covariance at start of DC.				
S	Trace output - trace of covariance matrix at end of DC.				
T	Quadratic form	none			
Residual statistics					
U	Two-way Doppler statistics column.	none	Two-way	none	This column is blank if station is C-band.
V	Three-way Doppler statistics column.	none	Three-way	none	No three-way Doppler data will be processed for the Shuttle.
W	Range statistics column.	none	range	none	
X	X-angle statistics column.	none	X-ang	none	X-angle for S-band, azimuth for C-band.
Y	Y-angle statistics column.	none	Y-ang	none	Y-angle for S-band, and evelation for C-band.
Z	Number of valid observations.	none	$6 \leq n \leq 80$		
AA	One sigma edit criterion used in the last DC edit loop.	yds for range; cycles/sec for Doppler; mrad for angles		PBI (zero edit/normal edit)	Zeros if DC is in zero edit mode; blank if in superbatch mode

TABLE G-II.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
BB	Number of edited points for each measurement type.	none		S11 MED	
CC	Subsequent points edited after DC; blank for batch-to-batch solutions; also blank for superbatch solutions where no subsequent editing was done. If present, negative value indicates less points were edited than in the DC; positive means more were edited than in the DC.	none			
DD	Root mean square of residuals (computed about the mean of the residuals).	range - yd Doppler - Hz angles - mrad		none	
EE	Average value of residuals.	range - yd Doppler - Hz angles - mrad		none	
Maneuver data					
FF	GMT of most recently executed maneuver.	day:hr:min:sec			Day is the day number from the first of the year.
GG	Phase elapsed time of last maneuver.	day:hr:min:sec			
HH	Code used to describe maneuver as specified in the mission plan table (MSK 0475).	none			
II	Maneuver $\Delta\bar{V}$ magnitude.	ft/sec			
JJ	Total duration of the burn, including ullage and tailoff.	min:sec			
KK	Time until start of next maneuver (start of ullage burn); if no maneuver is currently planned, an asterisk is present.	min:sec			

TABLE G-II.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
LL	Coefficient of uncertainty multiplier in thrust direction.	none	1	S05 MED	
MM	Coefficient of uncertainty multiplier in accelerometer error.	none	1	S05 MED	
NN	Coefficient of uncertainty multiplier in thrust magnitude.	none	1	S05 MED	
Orbital parameters					
OO	Velocity magnitude (inertial).	ft/sec			
PP	Flightpath angle (inertial).	deg		Computed	
QQ	Azimuth (inertial).	deg		Computed	
RR	Latitude (geodetic).	deg		Computed	
SS	Longitude.	deg		Computed	
TT	Height above ellipsoid.	n. mi.		Computed	
UU	Change in velocity between current solution and input vector.	ft/sec		Computed	
VV	Change in flightpath angle vector between current solution and input vector.	deg		Computed	
WW	Change in azimuth between current solution and input vector.	deg		Computed	
XX	Change in latitude between current solution and input vector.	deg		Computed	
YY	Change in longitude between current solution and input vector.	deg		Computed	
ZZ	Change in height between current solution and input vector.	n. mi.		Computed	

TABLE G-II.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
Orbital parameters (Concluded)					
AAA	Change in semimajor axis between current solution and input vector.	n. mi.		Computed	
BBB	Change in eccentricity between current solution and input vector.	none		Computed	
CCC	Change in inclination between current solution and input vector.	deg		Computed	
DDD	Change in argument of perigee between current solution and input vector.	deg		Computed	Not computed if eccentricity <0.001
EEE	Change in longitude of ascending node between current solution and input vector.	deg		Computed	
FFF	Change in true anomaly between current solution and input vector.	deg		Computed	Not computed if eccentricity < 0.001
GGG	Change in UVW position between current solution and input vector.	yd		Computed	
HHH	Change in UVW velocity between current solution and input vector.	ft/sec		Computed	
III	Diagonal elements of the covariance matrix.	U,V,W in yd U,V,W in fps		Computed	
Inputs					
JJJ	Input vector ID upon which DC is based; three-letter station code followed by band type and batch number for batch-to-batch.	none		S17 MED, S20 MED, ACCEPT, or S07 MED	
KKK	Used in superbatch only. The beginning and ending batch numbers over which the DC was performed.	none		S17 MED	

TABLE G-II.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
Inputs (Concluded)					
LLL MMM NNN	No longer used				
OOO	RSS position correction obtained during the last iteration.	yd			
PPP	RSS velocity correction obtained during the last iteration.	ft/sec			
QQQ	Integrator modes used to compute ephemeris: D - constant area drag model M - consider maneuvers A - variable area drag model V - vents considered	none	VAM (ephemeris 1)	S03 MED	Either "D" or "A" may be selected, but not both.
RRR	Final state height of apogee.	n. mi.		Computed	
SSS	Change in height of apogee between current solution and input vector.	n. mi.		Computed	
TTT	Final state height of perigee.	n. mi.		Computed	
UUU	Change in height of perigee between current solution and input vector.	n. mi.		Computed	

G-1.3 NAVIGATION SUMMARY (MSK 0328)

This display presents characteristic information concerning the user-specified station, as well as parameters controlling DC execution and low-sample rate data evaluation and batching.

The nav summary display may be requested via MSK 0328 or the appropriate DRK entry, but it will not contain any information concerning the station characteristics unless an SO1 or SO2 MED is input.

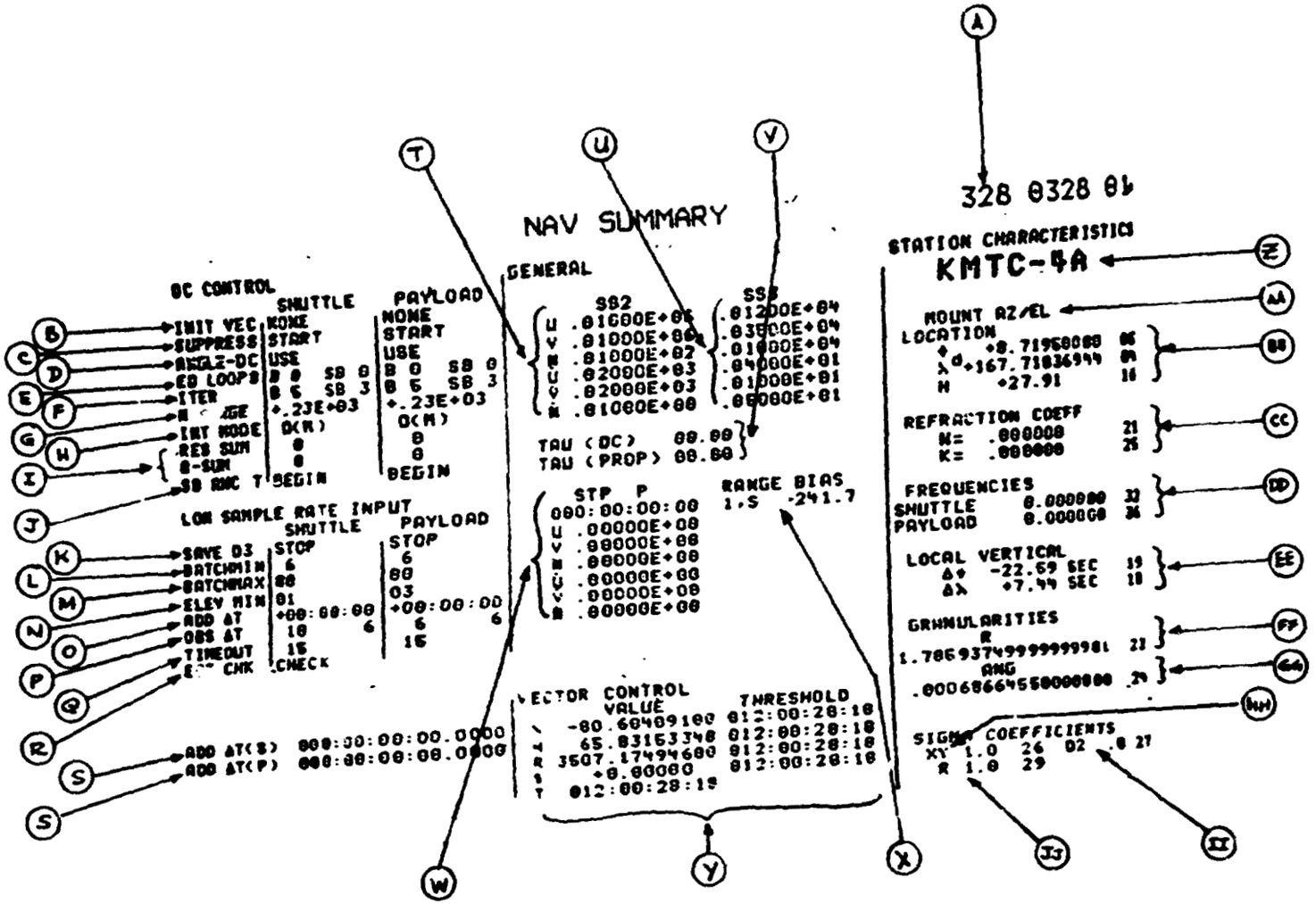


Figure G-3.- NAV summary.

TABLE G-III

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number	none	'0328'		
DC control					
B	Vector used to initialize batch-to-batch DC.			S20 MED	
C	'STOP' indicates that the DC is suppressed; 'START' indicates that the DC is unsuppressed.	none	'START'	S10 MED, PBI	
D	'USE' indicates that angles are used in the DC; 'NO USE' indicates that angles are not being used.	none	'USE'	S18 MED	
E	For each vehicle, a value is listed for both batch-to-batch ('B') and superbatch ('SB'), which indicates allowable number of edit loops if in normal edit loop mode; zero if in zero edit modes. Superbatch value is always zero.	none	0	none	
F	Number of allowable iterations for batch-to-batch ('B') and superbatch ('SB') mode.	none	B-5, SB-3 (both vehicles)	S09 MED	
G	Value of the Nth range option. This option causes S-band range observation to be downweighted for a given vehicle. Effect is to use every Nth range observation.		230	S19 MED	Reset this value to 1 for proper S-band operation.
H	Integrator mode used to compute ephemeris: V - vents considered A - attitude dependent drag model M - maneuvers considered D - attitude independent drag model	none	Shuttle - VA(M) Payload - D(M)	S03 MED	

TABLE G-III.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
DC control (Concluded)					
	Batch number through which the residual summary ('RES SUM') and the batch summary ('B SUM') can be provided.	none		S42 MED	
J	Superbatch anchor time tagging 'BEGIN' - begin time tagging 'END' - end time tagging.	none	'BEGIN'	S03 MED	
Low-sample rate input					
K	Save/no save three-way Doppler indicator; always set to 'STOP'.	none	'STOP'	none	
L	Minimum number of data frames in a batch for it to be saved.	none	6	S27 MED	
M	Maximum number of data frames in a batch.	none	80	S27 MED	
N	Minimum elevation angle; no data accepted below this limit.	deg	5	S28 MED	Lowest allowable value is 1.
O	Time bias applied to incoming tracking data.	±:hr:min:sec	00:00:00:00.0	S24 MED	
P	Minimum Δt required between consecutive observations in a batch; a value is given for both batch-to-batch and superbatch modes for each vehicle.	sec	6	S29 MED	
Q	Time interval after which data is considered missing in a batch.	sec	15	S33 MED	
R	Indicates whether stations are being checked for end-of-transmission ('CHECK') flags or they are not being checked ('NOCHECK'); applies only to Shuttle.	none	'CHECK'	S23 MED	

TABLE G-III.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
Low-sample rate input (Concluded)					
S	Same as item 'O' above - measurement time bias for Shuttle (S) and payload (P).	±day:hr:min:sec	00:0:00:00.0	S24 MED	
General information					
T	Values of the diagonal of the SS2 covariance matrix.	U,V,W - yd U,V,W - ft/sec	10 000,10 000, 10 000 20,20,.01	none	A priori covariance that constrains orbital plane.
U	Values of the diagonal of the SS3 covariance matrix.	U,V,W - yd U,V,W - ft/sec	120,350,100 .4,.1,.5	S12 MED	A priori covariance that constrains magnitude of solution vector change.
V	Exponential downweighting factor for the DC function and the propagation function.	hr	0.0	S09 MED	
W	Small thrust model inputs:			S21 MED	
	- Vehicle - S (Shuttle) or P (payload)	None	P		
	- Time to begin small thrust (GMT or PET)	day:hr:min:sec	00:00:00:00		GMT is day of year while PET is days from reference time point.
	- Uncertainties in position and velocity (UVW coordinates)	position - yd velocity - ft/sec	0.0 0.0		
X	Range bias applied to vehicle/beacon pair indicated; only non-zero values are shown. A maximum of two S-band and/or C-band biases are shown. Example: 1, S -241.7 vehicle 1; S-band bias is -241.7 yards	yd	0.	S25 MED	

TABLE G-III.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
Vector control					
Y	Vector compare cutoff conditions, comparison parameter/threshold time associated with comparison parameter:			S80 MED	
	'λ' - longitude	deg			
	'H' - altitude	n. mi.			
	'R' - radius	n. mi.			
	'γ' - flightpath angle	deg			
	'T' - time (default) (GMT)	day:hr:min:sec			
Station characteristics					
	Supplies data concerning the user-requested station; beside each parameter is the station characteristics table word number associated with that parameter.			S01 MED	
Z	Station code/band identifier; three-letter station code plus band letter plus external station number.	none	CRP load		
AA	Antenna mount type.	none	CRP load		
	C-band - 'AZ/EL'				
	S-band - 'XY/NS' or 'XY/EW'				
BB	Station location.		CRP load	S02 MED	
	ϕ_d - geodetic latitude	deg			Parameter no. 5
	λ - longitude	deg			Parameter no. 4
	H - altitude	m			Parameter no. 16

TABLE G-III.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
Station characteristics (Concluded)					
CC	Refraction coefficients.			SO1 MED	
	- multiplier of refraction modulus ('N')	none	CRP load		Parameter no. 21
	- K-factor ('K') (multiplier for refraction decay constant - associated with scale height).	none	CRP load		Parameter no. 25
DD	S-band transmission frequencies for Shuttle and payload.	MHz	CRP load	SO1 MED	Parameters no. 32, 36, respectively
EE	Local vertical deflections.	arc second		SO1 MED	
	$\Delta\phi$d - latitude deflection				Parameter no. 19
	$\Delta\lambda$ - longitude deflection				Parameter no. 18
FF	Range granularity (least significant bit weight for converting range information to internal units).	m/bit	CRP load	SO1 MED	Parameter no. 23
GG	Angle granularity (see above).	deg/bit	CRP load	SO1 MED	Parameter no. 24
HH	X-angle and Y-angle standard deviation (sigma) coefficient.	none	CRP load	SO1 MED	Parameter no. 26
II	Two-way Doppler sigma coefficient.	none	CRP load	SO1 MED	Parameter no. 27
JJ	Range sigma coefficient.	none	CRP load	SO1 MED	Parameter no. 29

G-1.4 SHUTTLE BATCH RESIDUAL PLOT (MSK 0334)

This display is used to graphically evaluate tracking data from any single station. The data can be examined for both consistency throughout the pass and for fit against another user-specified previous solution.

The measurement residuals (observed - expected) are plotted versus time for each measurement type (range, two angles, and, if S-band, Doppler shift). This display does not automatically update and can only be altered via MED inputs or by reexecuting the MSK 0334.

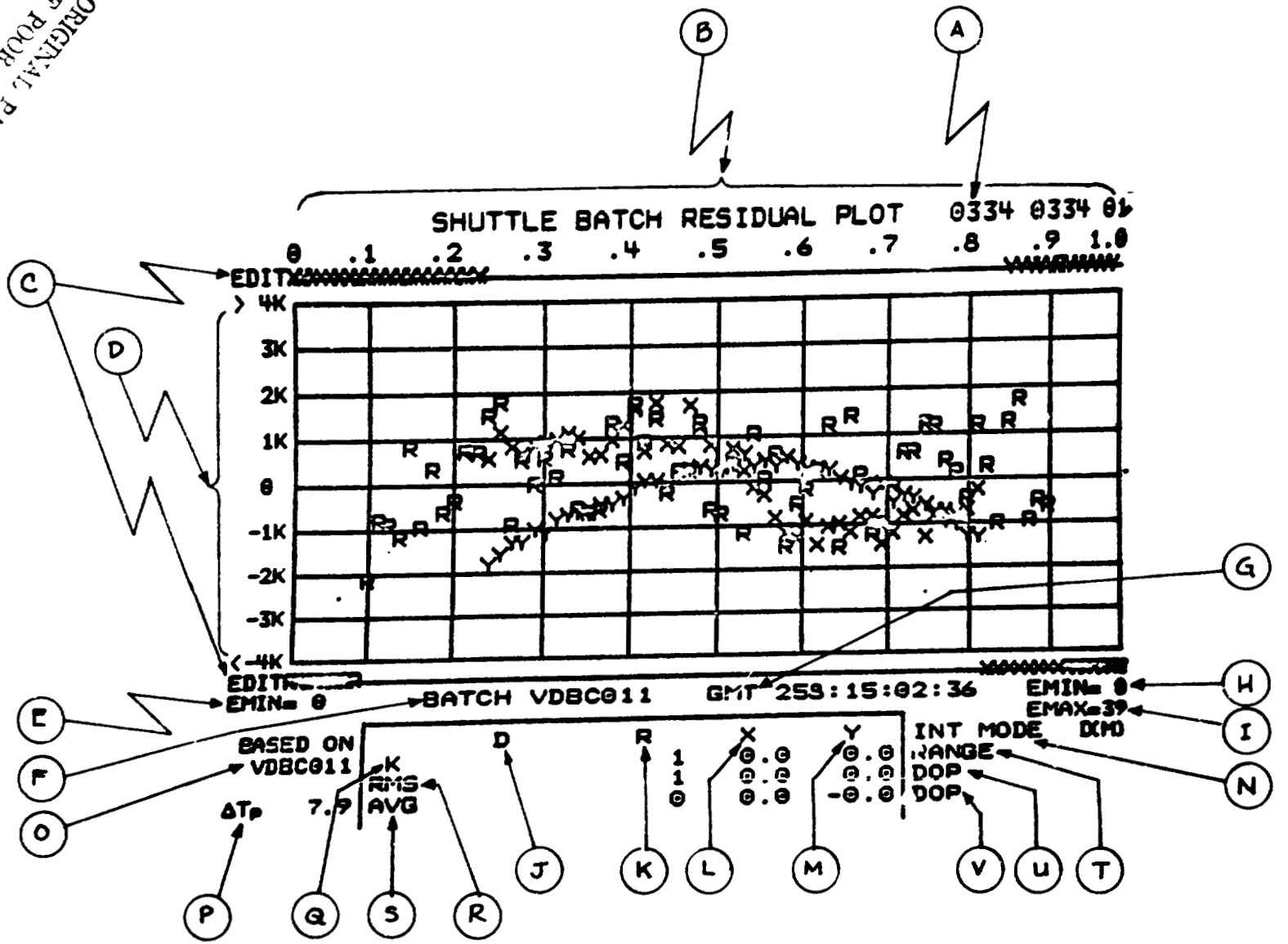


Figure G-4.- Shuttle batch residual plot.

TABLE G-IV

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	0334	none	
B	Editing range - corresponds to time axis; all time tags associated with observations are scaled such that they fit a 0-1 range.	none	0-1	none	
C	All edited residuals are placed on these lines.	none	none	S11 MED	
D	Residual axis - all residuals are tabulated and a scale is constructed (see definition of K below, legend Q).	range - yd Dop - Hz angles - mrad	variable	S11 MED	Scales will be recomputed whenever editing is done.
E	Elevation angle of the first good observation in the batch (for C-band stations, this is the actual value; for S-band stations, it is computed from the X- and Y-angles).	deg	variable		EMIN set to zero if angles are edited out
F	The station associated with the data (a four-letter code) followed by the batch number: Example: BDAS065 - Bermuda S-band, batch number 65	none	none	none	
G	GMT of first valid data frame.	day:hr:min:sec	none	none	
H	Elevation angle of last valid observation.	deg	variable	Computed	Set to zero if angles are edited out.
I	Maximum elevation angle during this pass.	deg	variable	Computed	
J	Refers to Doppler measurements.	none	none	none	
K	Refers to range measurements.	none	none	none	
L	Refers to X-angle measurements (azimuth if C-band).	none	none	none	

TABLE G-IV.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
M	Refers to Y-angle measurements (elevation angle if C-band).	none	none	none	
N	Integration mode used to compute ephemeris: DM - constant area drag model, consider maneuvers AM - variable area drag model (attitude dependent), consider maneuvers VAM,AMV,MAV - vent model, variable area drag model, consider maneuvers	none	none	S03 MED	
O	Vector used to generate the ephemeris from which the residuals for this batch are computed.	none	user specified	U18 MED	
P	Δt of the pass (elapsed time of the pass).	min	none	none	
Q	K is computed for each measurement type by adding the absolute value of the AVG (mean) to the RMS (about the mean) for that data type.	Hz for Doppler; yd for range; mrad for angles	none	none	Scale is recomputed every time editing is done.
R	Root mean square of residuals. Does not include edited measurements.	Hz for Doppler; yd for range; mrad for angles	none	none	Recomputed whenever editing is done.
S	AVG (mean) of residuals.	Hz for Doppler; yd for range; mrad for angles	none	none	Recomputed whenever editing is done.
T U V	Not used				

G-1.5 VECTOR COMPARISON DISPLAY (MSK 0337)

This display allows for comparison of up to three sets of vector elements against a base vector. The comparison vectors are propagated to the time at which the user-specified cutoff conditions are satisfied.

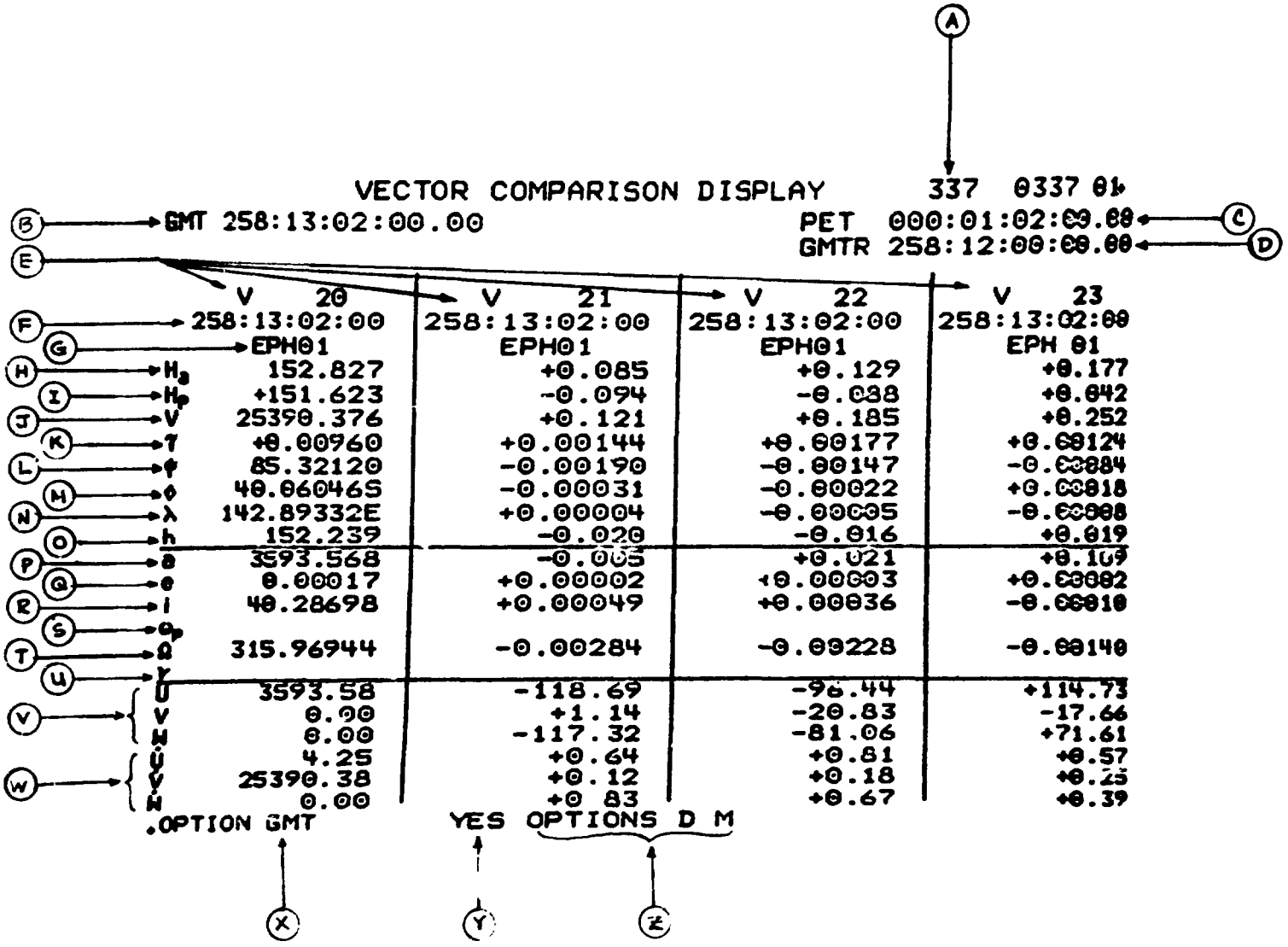


Figure G-5.- Vector comparison display.

TABLE G-V

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	'337'	MSK	
B	Time at which base vector achieved cutoff conditions.	day:hr:min:sec	--	Computed	Nav summary (MSK 0328) gives the threshold time and the cut-off condition and/or options.
C	Phase elapsed time from GMTR at which base vector achieved cutoff conditions.	days:hr:min:sec			
D	Reference GMT.	day:hr:min:sec	--		Day is day of the year.
E	Vector ID column of vectors being compared or identifying labels (column 1 is base vector; columns 2 through 4 are compared vectors).	none	--	S80 MED	
F	GMT time tag associated with above vector (time of vector before integration).	day:hr:min:sec	--		
G	Reference ephemeris used to integrate above vector to specified cutoff conditions.	none	--	S80 MED	
H	Keplerian height of apogee (1st column); difference in height of apogee from reference vector (2d through 4th columns).	n. mi.	--		Cannot be computed for hyperbolic or parabolic orbits.
I	Keplerian height of perigee (1st column); difference in height of perigee from reference vector (2d through 4th columns).	n. mi.	--		Cannot be computed for parabolic orbit.
Local spherical elements					
J	Inertial velocity magnitude (1st column); difference in velocity from reference vector (2d through 4th columns).	ft/sec	--		

TABLE G-V.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
Local spherical elements (Concluded)					
K	Flightpath angle (1st column); difference in angle from reference vector (2d through 4th columns).	deg	--	Program computed	
L	Azimuth (1st column); difference in azimuth from reference vector (2d through 4th columns).	deg	--	Program computed	
M	Latitude (1st column); difference in latitude from reference vector (2d through 4th columns).	deg	--	Program computed	
N	Longitude (1st column); difference in longitude from reference vector (2d through 4th columns).	deg	--	Program computed	
O	Height above ellipsoid (1st column); difference in height from reference vector (2d through 4th columns).	n. mi.	--	Program computed	
Classical elements					
P	Semimajor axis (1st column); difference in semimajor axis from reference vector (2d through 4th columns).	n. mi.	--	Program computed	Cannot be computed for parabolic orbit.
Q	Eccentricity (1st column); difference in eccentricity from reference vector (2d through 4th columns).	none	--	Program computed	
R	Inclination (1st column); difference in inclination from reference vector (2d through 4th columns).	deg	--	Program computed	Cannot be computed if $\lvert\bar{H}\rvert = 0.0$.

TABLE G-V.- Continued

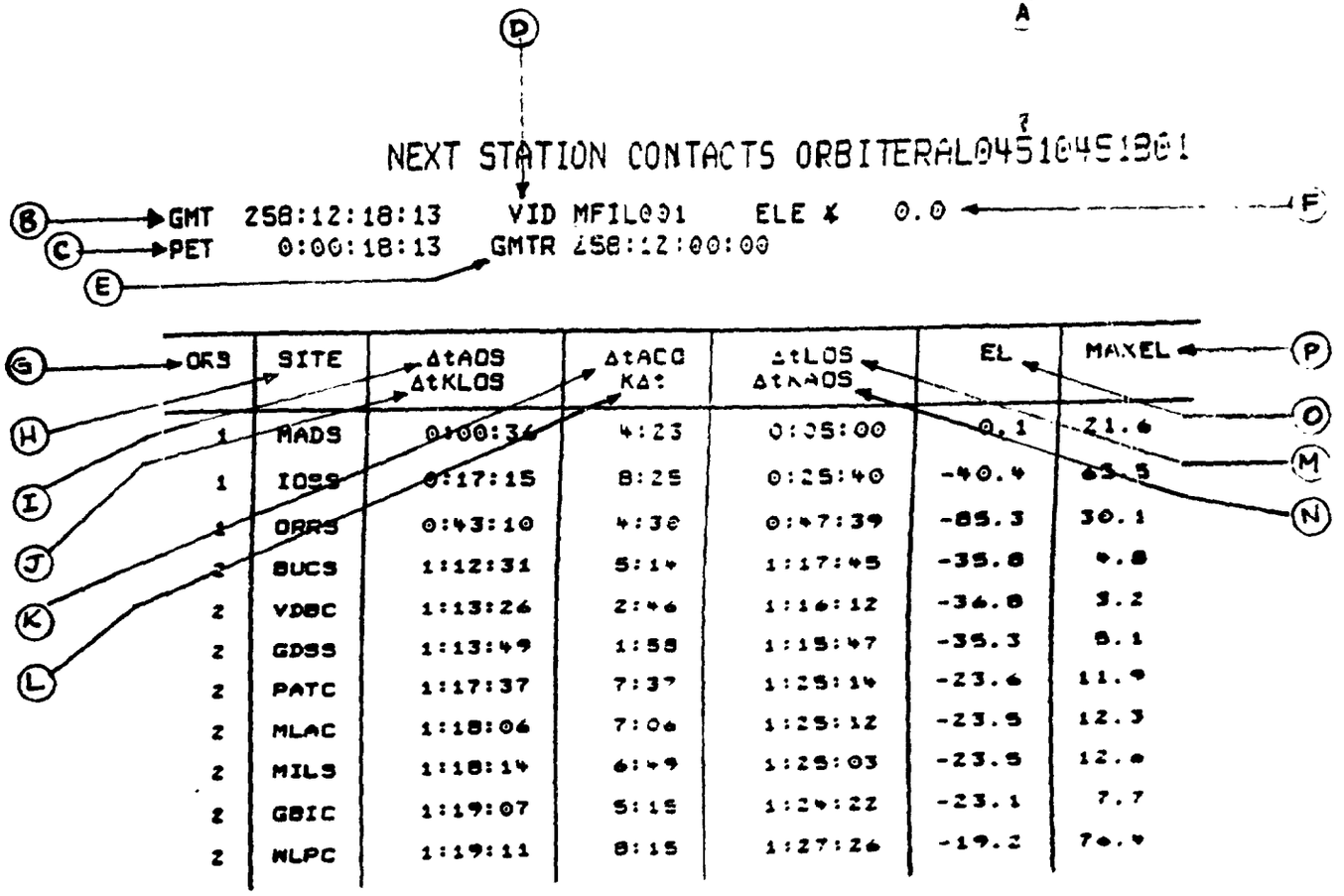
Legend	Definition	Unit	Nominal value	User control	Comments
Classical elements (Concluded)					
S	Argument of perigee (1st column); difference in ω_p from reference vector (2d through 4th columns).	deg	--	Program computed	Cannot be computed for e <0.001; or for i = 0° or i = 180°; or if $\|\bar{H}\|$ = 0.
T	Right ascension of the ascending node (1st column); difference in Ω from reference vector (2d through 4th columns).	deg	--	Program computed	Cannot be computed for i = 0° or i = 180°, or if $\|\bar{H}\|$ = 0.0.
U	True anomaly (1st column); difference in true anomaly from reference vector (2d through 4th columns).	deg	--	Program computed	Cannot be computed for e < .001, or if $\|\bar{H}\|$ = 0.
UVW elements					
V	UVW position coordinates of vehicle (1st column); difference in UVW coordinates from reference vector in feet (2d through 4th columns).	n. mi., ft	--	Program computed	Differences are computed in feet.
W	UVW velocity components (1st column); difference in UVW velocity from reference vector (2d through 4th columns).	ft/sec	--	Program computed	
X	Vector compare option (cutoff parameter): 'GMT' - time cutoff 'FPA' - flightpath angle 'LON' - longitude 'ALT' - altitude 'RAD' - radius	none	--	S80 MED	
Y	Mission plan table indicator: 'YES' - maneuvers are considered 'NO' - maneuvers are not considered	none	--	S80 MED	

TABLE G-V.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
UVW elements (Concluded)					
Z	Integration options: 'V' - vents considered 'A' - attitude dependent drag model 'D' - attitude independent drag model 'M' - maneuvers considered	none	--	SOS MED	
Note:	Base system is X-axis through Greenwich, midnight of Dec. 31 of the year prior to launch (Shuttle TEI system). Care should be taken when referencing vectors taken from this display.		Vectors to be used for referencing should be obtained from C/O Monitor (MSK 2300).		

G-1.6 NEXT STATION CONTACTS (ORBITER) (MSK 0451)

This display provides Orbiter/tracker acquisition data for those tracking stations tagged eligible by the station characteristics table. It stores up to 48 different station contacts. It is automatically updated whenever ephemeris 1 (EPH1 (see MSK 2310, trajectory profile status table)) is updated. This job is normally left to the dynamics staff support group (DYNAMICS) during simulations and missions. This display is accessed with a MSK 0451 entry.



ORB	SITE	ΔtAOS ΔtKLOS	ΔtACQ KΔ:	ΔtLOS ΔtAAOS	EL	MAXEL
1	MADS	0:00:36	4:23	0:05:00	0.1	21.6
1	IOSS	0:17:15	8:25	0:25:40	-40.4	63.5
1	ORRS	0:43:10	4:30	0:47:39	-85.3	30.1
2	BUCS	1:12:31	5:14	1:17:45	-35.8	9.8
2	VDBC	1:13:26	2:46	1:16:12	-36.8	3.2
2	GDSS	1:13:49	1:58	1:15:47	-35.3	5.1
2	PATC	1:17:37	7:37	1:25:14	-23.6	11.9
2	MLAC	1:18:06	7:06	1:25:12	-23.5	12.3
2	MILS	1:18:14	6:49	1:25:03	-23.5	12.8
2	GBIC	1:19:07	5:15	1:24:22	-23.1	7.7
2	WLPC	1:19:11	8:15	1:27:26	-19.2	70.9

Figure G-6.- Next station contacts Orbiter.

TABLE G-VI.- NEXT STATION CONTACTS

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	'0451'	MSK	
B	Current GMT (updated every 6 sec).	day:hr:min:sec	none	Program computed	Day is day of the year.
C	Phase elapsed time.	days:hr:min:sec	none	Program computed	
D	Anchor vector ID - four-letter code followed by up to three numbers.				
E	Reference time for PET.	day:hr:min:sec			
F	Next station contacts minimum elevation angle.	deg	none	BOS MED for initiation or reset.	Used for generation of NSC. Does not affect incoming data; that is controlled by S28 MED. Includes masking effects. Note: During simulations/ missions this MED is the responsibility of "TRACK" and is off-limits to NAV personnel.
G	Orbit number.	none	none		
H	Transmitting/receiving station ID; four-letter code consisting of three-letter station mnemonic and band type.	none	none		
I	Time until acquisition of signal (GMT of AOS - current GMT).	hr:min:sec	none	Program computed	Equal to 0 at AOS; thereafter appears as '*'.
J	Time until temporary loss of signal due to antenna "keyhole" (direction outside gimbal limits or "blind spot"); GMT of keyhole LOS - current GMT.	hr:min:sec	none	Program computed	'*' if KLOS occurs before start of ephemeris.

TABLE G-VI.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
K	Elapsed time tracking data are available (AOS to LOS).	min:sec	none	Program computed	Refreshed every 6 seconds; '*' appears if in acq. at end of ephemeris.
L	ΔT during which data will not be available due to keyhole or blind spot.		none	Program computed	Refreshed every 6 seconds, '*' appears if extends beyond end of ephemeris.
M	Time until loss of signal (GMT of LOS - current GMT).	hr:min:sec	none	Program computed	'*' appears if within acquisition at end of ephemeris.
N	Time until signal is reacquired after being inhibited by keyhole.	hr:min:sec	none	Program computed	'*' appears if KAOS occurs after end of ephemeris.
O	Current elevation angle from tracking station to vehicle (negative indicates below horizon).	deg	none	Program computed	
P	Maximum elevation angle of vehicle relative to station this pass.	deg	none	Program computed	Processed via B03 MED. Maximum number of 48 contacts computed.

G-1.7 PREDICTED SITE ACQUISITION TABLE IN GMT AND PET (MSK 0453/MSK 0454)

This display provides information concerning predicted AOS/LOS times of upcoming tracking passes from the listed tracking stations. Stations may appear more than once in the PSAT. The length of the PSAT is determined by the length of the ephemeris. The PSAT is generated with a U15 MED and is normally updated during simulations and missions by the TRACK flight controller. The display is accessed by MSK 0453 or MSK 0454.

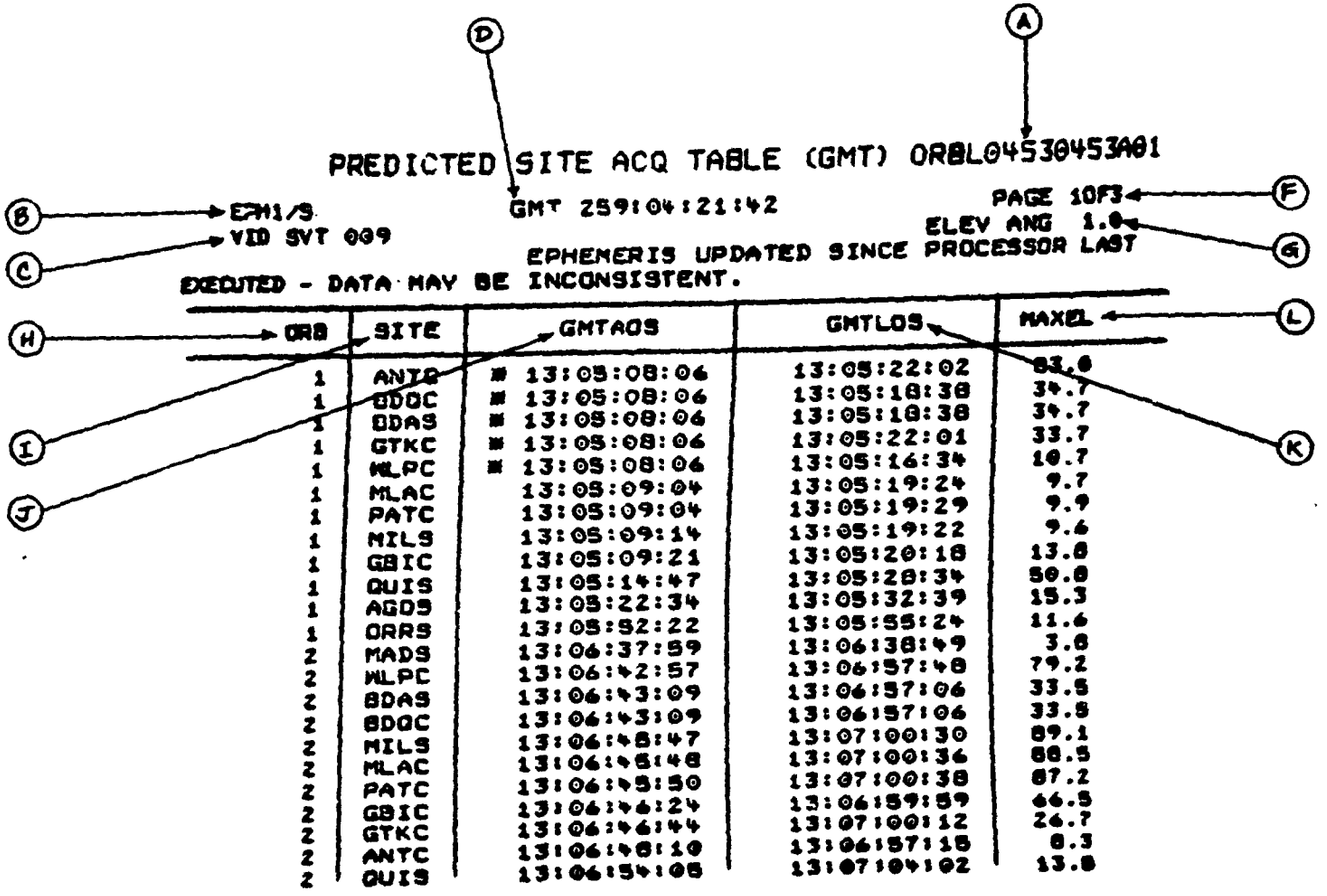


Figure G-7.- Predicted site acquisition table (GMT).

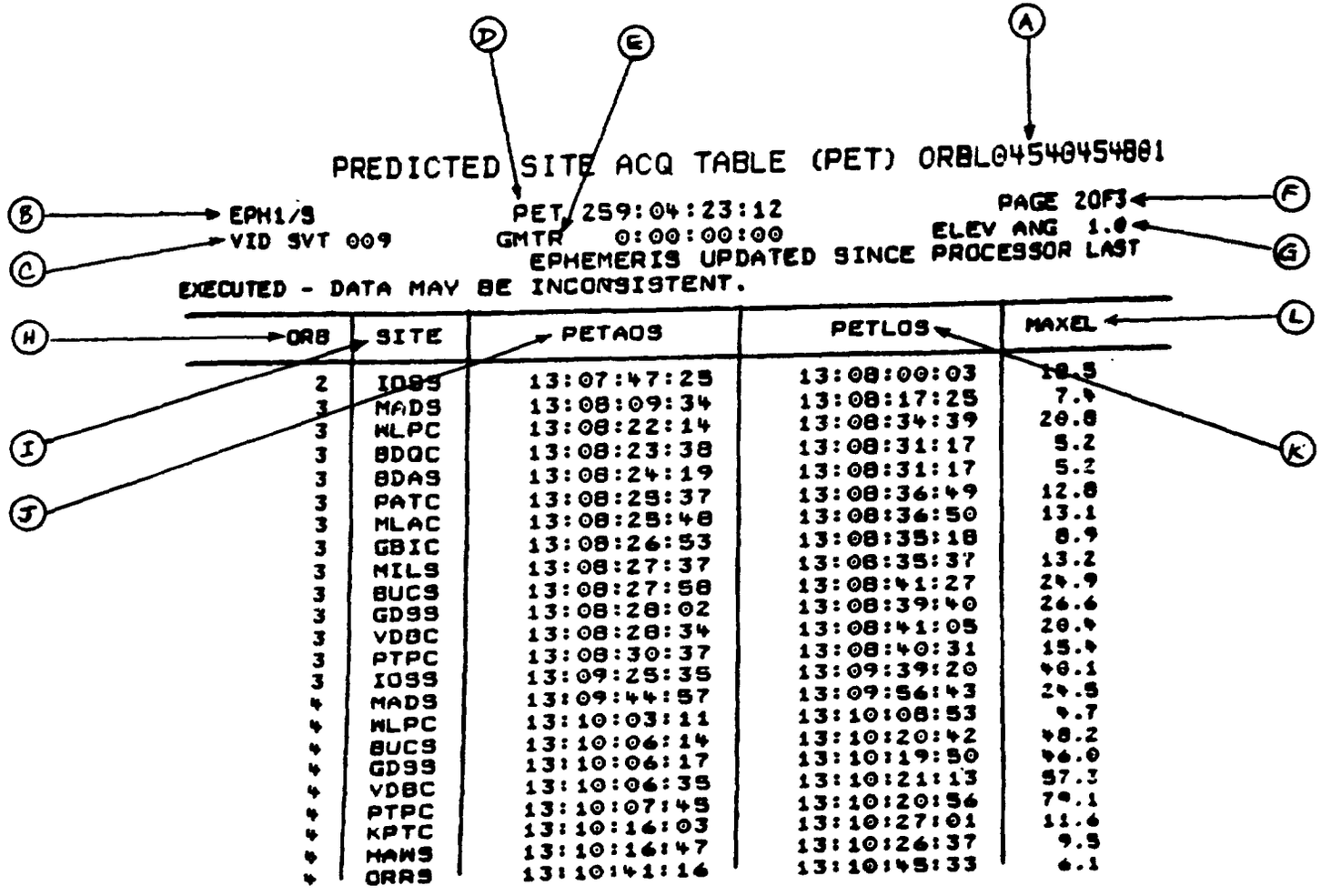


Figure G-8.- Predicted site acquisition table (PET).

TABLE G-VII.- PREDICTED SITE ACQUISITION TABLE (ORBITER) GMT/PET

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	'453' (GMT) '454' (PET)	MSK	
B	Ephemeris ID used to compute data, followed by a current/static indicator: ' ' - Current 'S' - Static	none			
C	Anchor vector ID - three alphabetic characters followed by four numbers; example - 'SVT 009'.	none			
D	Current GMT (MSK 453) or current PET (MSK 454).	day:hr:min:sec		Program computed	Day entry for PET is days from reference time point.
E	Reference GMT for PET (appears only in MSK 454).	day:hr: min:sec			
F	Page number (1, 2, or 3).	none		Step to next page by PBI	
G	Minimum elevation angle used in computation of station contacts.	deg			
H	Orbit number during which station acquires vehicle.	none		Program computed	
I	Station ID - three letters followed by band type (C-band or S-band).	none			
J	GMT at which station is expected to acquire vehicle (MSK 453); for MSK 454, it is the PET of acquisition	day:hr: min:sec		Program computed	
K	GMT at which station is expected to lose contact with vehicle (MSK 453); for MSK (454), it is the PET of signal loss.	day:hr: min:sec		Program computed	

TABLE G-VII.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
L	Maximum elevation angle of vehicle with respect to station during indicated pass.	deg		Program computed	

G-1.8 CHECKOUT MONITOR (MSK 2300)

This display provides extensive information concerning any user-specified vector with a valid vector ID format. The display is accessed via an MSK 2300 entry and is normally generated by the Dynamics staff support group (DYNAMICS) during simulations and missions.

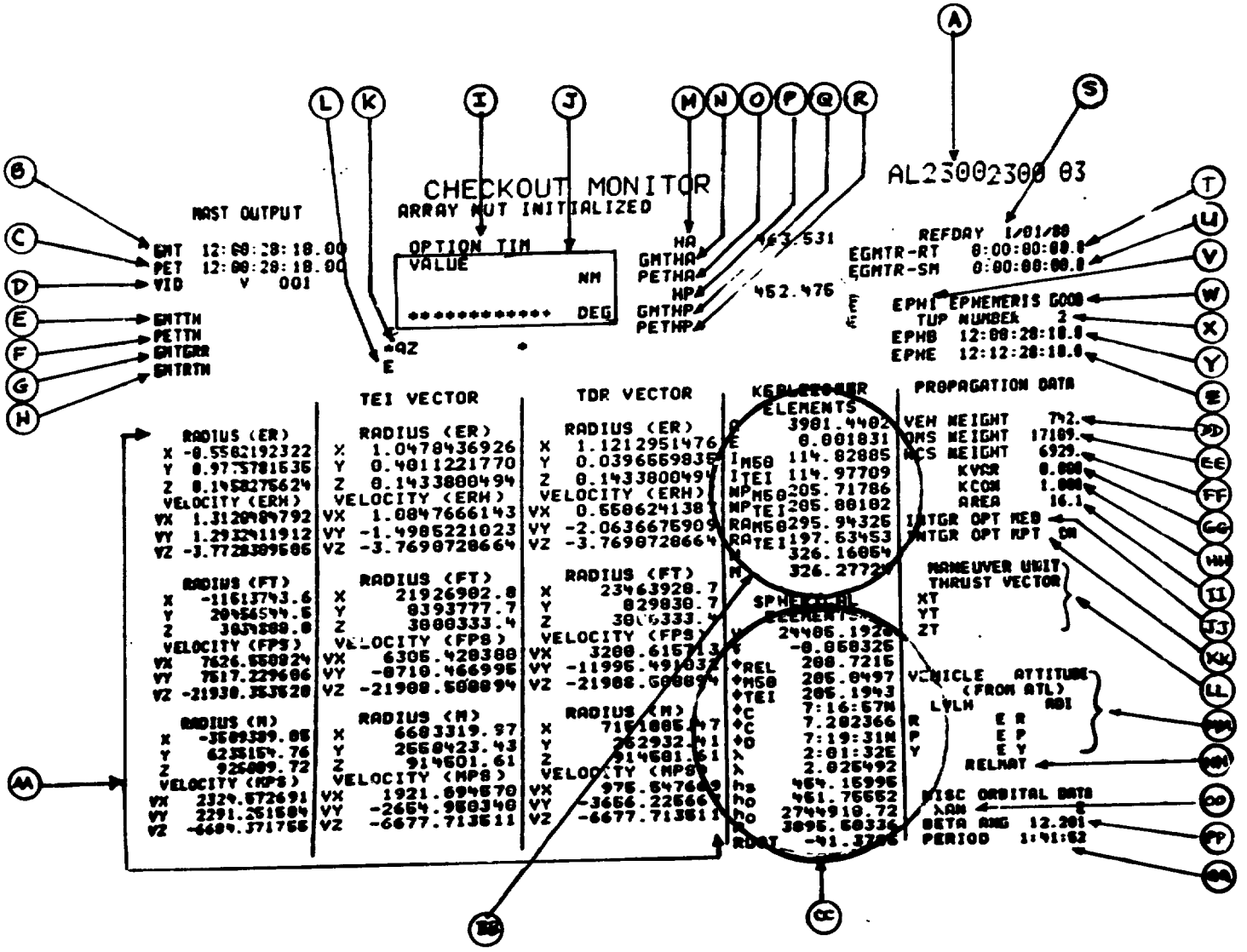


Figure G-9.- Checkout monitor.

TABLE G-VIII.- CHECKOUT MONITOR

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	'2300'	MSK	
B	Vector time in GMT at specified cutoff conditions.	day:hr:min:sec	none	Program computed	Day is day number from first of year.
C	Vector time in PET at specified cutoff conditions.	day:hr:min:sec		Program computed	Day is day number from current reference time point.
D	Vector ID.				
E	GMT of threshold time (see item I for certain options).	day:hr:min:sec		Program computed	
F	PET of threshold time.	day:hr:min:sec		Program computed	
G	GMT of guidance reference release time.	day:hr:min:sec		Program computed	
H	GMT of reentry threshold.	day:hr:min:sec		Program computed	
I	Cutoff option specified in U02 MED: 'TIM' - time (GMT) 'RAD' - radius 'ALT' - altitude 'LON' - longitude 'FPA' - flightpath angle 'MVI' - maneuver initiate 'MVE' - maneuver burnout	none	'TIM'	U02 MED	U02 MED done by "Dynamics" flight controller during simulation/mission.
J	Numerical value of cutoff option. Values for 'RAD' and 'ALT' are in nm; values for 'LON' and 'FPA' are in deg. 'MVI' and 'MVE' are MNVR numbers from the MPT.	'RAD' n. mi. 'ALT' n. mi. 'LON' deg 'FPA' deg 'MVI' none 'MVE' none	blank	U02 MED	U02 MED done by "Dynamics" flight controller during simulation/mission.
K	Azimuth for guidance reference release alignment.	deg			U02 MED done by "Dynamics" flight controller during simulation/mission.

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TABLE G-VIII.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
L					
M	Height of apogee.	n. mi		Program computed	
N	GMT of upcoming apogee.	day:hr:min:sec		Program computed	
O	PET of upcoming apogee.	day:hr:min:sec		Program computed	
P	Height of perigee.	n. mi.		Program computed	
Q	GMT of upcoming perigee.	day:hr:min:sec		Program computed	
R	PET of upcoming perigee.	day:hr:min.sec		Program computed	
S	Initialization month, day, and year.	mm/dd/yy		P80 MED	Done by "Dynamics" flight controller during simulation and mission.
T	GMT reference time for PET for real time.	day:hr:min:sec			"Day" is day of year.
U	GMT reference time for PET for SIM timer.	day:hr:min:sec			"Day" is day of year.
V	Ephemeris ID.	none			
W	Ephemeris profile indicator ('GOOD' or 'BAD').	none			
X	Trajectory update number.	none			
Y	Begin time (GMT) of ephemeris.	day:hr:min:sec			
Z	End time (GMT) of ephemeris.	day:hr:min:sec			

TABLE G-VIII.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
AA	Position and velocity vectors displayed in three units groups (Earth radii and Earth radii/hr, ft and ft/sec, meters and meters/sec) and in three coordinate systems (mean-of-1950 inertial, true-of-epoch inertial, and true-of-date rotating).	E.r., E.r./h, ft, ft/sec, m, m/sec			See MCC level C requirements for OFT, Vol. II, sec. 7.2.1, for discussion of coordinate systems (JSC-11028).
BB - Keplerian elements					
Symbol					
A	Semimajor axis.	n. mi.		Program computed	
E	Eccentricity.	none		Program computed	
I_{M50} I_{TEI}	Inclination in M50 or in TEI coordinate system.	deg		Program computed	
WP_{M50} WP_{TEI}	Argument of perigee in M50 or TEI coordinates.	deg		Program computed	
RA_{M50} RA_{TEI}	Right ascension of ascending node in M50 or TEI coordinates.	deg		Program computed	
N	True anomaly.	deg		Program computed	
M	Mean anomaly.	deg		Program computed	
CC - Spherical elements					
Symbol					
V	Inertial velocity vector magnitude	ft/sec	--	Program computed	--
γ	Flightpath angle	deg	--	Program computed	--

TABLE G-VIII.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
CC - Spherical elements (Concluded)					
Symbol					
ψ_{REL}	Earth-relative azimuth.	deg	--	Program computed	
ψ_{M50}	Inertial azimuth.	deg	--	Program computed	
ψ_{TEI}	"True" azimuth (TEI system).	deg	--	Program computed	
ϕ_c	Geocentric latitude - displayed two ways.	deg:min:sec and deg	--	Program computed	
ϕ_D	Geodetic latitude.	deg:min:sec	--	Program computed	
λ	Longitude - displayed two ways.	deg:min:sec and deg	--	Program computed	
h_S	Altitude above spherical Earth.	n. mi.	--	Program computed	
h_o	Altitude above oblate Earth - displayed two ways.	n. mi. and ft	--	Program computed	
R	Magnitude of radius vector.	n. mi.	--	Program computed	
RDOT	Earth-relative altitude rate	ft/sec	--	Program computed	
Propagation data					
DD	Total vehicle weight	lb			
EE	OMS propellant weight (fuel and oxidizer).	lb			
FF	RCS propellant weight (fuel and oxidizer).	lb			

TABLE G-VIII.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
Propagation data (Concluded)					
GG	Variable K-factor.	none	1	MED MED	
HH	Constant K-factor.	none	1	MED MED	
II	Vehicle cross-sectional area used for constant area drag model.	ft^2		MED MED	
JJ	Integration options specified in VO2 MED: 'V' - vents considered 'A' - attitude dependent drag 'M' - maneuvers considered 'D' - attitude independent drag Note - Either 'A' or 'D' may be input, but not both.	none	blank	VO2 MED	VO2 MED handled only by Dynamics during simulations/missions.
KK	Default integrator options from selected ephemeris.	none	'DM' (see above under JJ)		
Maneuver unit thrust vector					
LL	Components of unit thrust vector for this maneuver.	none	--	VO2	Displayed only if stopping indicator is 'MVI' or 'MVE' (see item I).
Vehicle attitude information from attitude timeline					
MM	Roll, pitch, and yaw attitude angles in either LVLH or ADI coordinates.	deg			ADI angles are displayed only when in non-LVLH mode.
NN	Relmat ID.	none			

TABLE G-VIII.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
Miscellaneous orbital data					
OO	Earth-fixed longitude of the upcoming ascending node.	deg:min:sec		Program computed	
PP	Angle between Sun and orbital plane.	deg		Program computed	
QQ	Orbital period.	hr:min:sec		Program computed	

G-1.9 TRAJECTORY PROFILE STATUS TABLE (MSK 2310)

This display provides information concerning the status of up to four ephemerides (seven when the tracking data relay satellite system (TDRSS) becomes fully active). Included in this display is information for each ephemeris regarding start/stop times, integrator options, drag model parameters, vehicle subsystem weights, and anchor vector IDs. Normally, EPH1 is used for Orbiter purposes, and EPH3 is used for the payload. This display is accessed via MSK 2310 or the appropriate DRK entry.

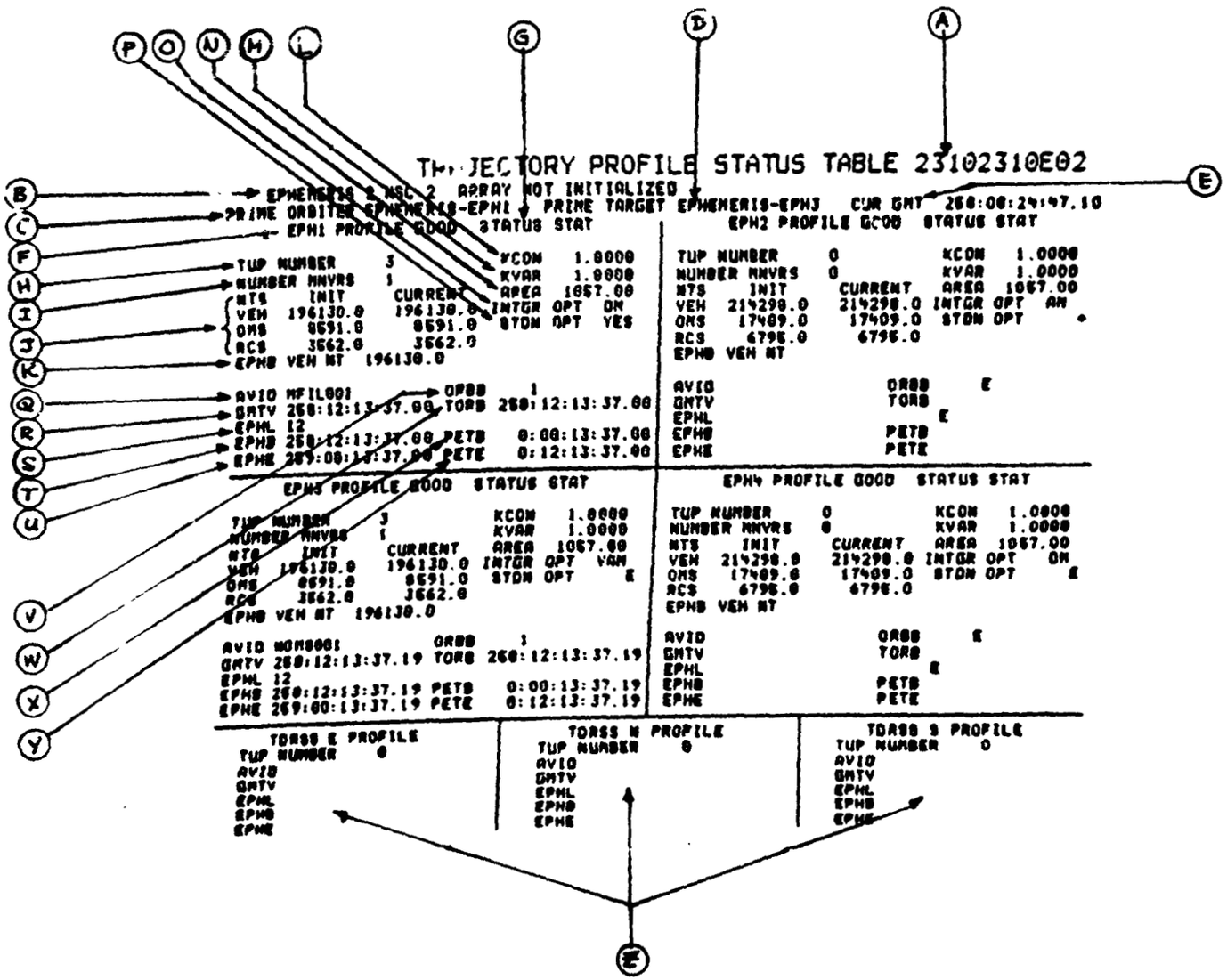

Figure G-10.- Trajectory profile status table.

TABLE G-IX.- TRAJECTORY PROFILE STATUS

Legend	Definition	Unit	Nominal value	User control	Comments
A	MSK number.	none	'2310'	MSK	
B	Error maneuver messages appear here. Most often indicates that the next station contacts array has not been generated for the stated ephemeris.	none			
C	Number of prime Orbiter ephemeris.	none	EPH1		
D	Number of prime target ephemeris.	none	EPH3		Will not appear if there is no target vehicle.
E	Current GMT.	day:hr:min:sec		Program computed	Day is day of year.
	The following items apply to each of the four blocks of information marked "EPH1" through "EPH4":				
F	Ephemeris profile indicator: "GOOD" - indicates ephemeris can be used - reflects vehicle weight/area changes "BAD" - Ephemeris needs to be updated or is being updated - Ephemeris generation failed	none		P16, M51 MEDS	These MED's are handled only by Dynamics flight controller during simulations/missions.
G	Ephemeris status indicator:				
	"STAT" - static ephemeris - fixed start/stop times	none		P16 MED	Executed by Dynamics during simulations/missions.
	"LIVE" - ephemeris start time "slides" with stop time	none			
H	Trajectory update number - indicates number of trajectory updates since system initialization.	none	$\pm$n		Negative number indicates values in the MPT header have been changed, but trajectory ephemeris has not been updated.

TABLE G-IX.- Continued

Legend	Definition	Unit	Nominal value	User control	Comments
I	Number of maneuvers occurring (planned) within the timespan covered by the ephemeris.	none			
J	Component weights of the vehicle at system initialization ("INIT") and at present time ("CURRENT"); includes total vehicle weight ("VEH"), OMS propellant (fuel and oxidizer) remaining ("OMS"), and RCS propellant remaining ("RCS").	lb		M51 MED	M51 MED executed only by Dynamics during simulations/ missions.
K	Total vehicle weight at beginning of ephemeris.	lb			
L	Constant area K-factor - used to adjust attitude independent drag estimate.	none	1.0		
M	Variable area K-factor - used to adjust attitude dependent drag estimate.	none	1.0	M51 MED	Executed by Dynamics only.
N	Cross-sectional area of vehicle. Used in constant area drag calculations.	ft^2	1057.		
O	Integration options: 'D' - constant area drag 'A' - attitude dependent drag 'V' - vents considered 'M' - maneuvers considered	none			
P	Satellite tracking data network option: 'YES' - generate next station contacts (MSK 0451) 'NO' - will not generate next station contacts (MSK 0451)				
Q	Anchor vector ID.	none			

TABLE G-IX.- Concluded

Legend	Definition	Unit	Nominal value	User control	Comments
R	GMT associated with anchor vector.	day:hr:min:sec			
S	Timespan covered by ephemeris.	hrs		MOO MED	Entered by Dynamics only during simulations/mission.
T	GMT at beginning of ephemeris.	day:hr:min:sec			
U	GMT at end of ephemeris.	day:hr:min:sec			
V	Orbit number at beginning of ephemeris.	none			
W	Time at beginning of the orbit.	day:hr:min:sec			Usually the same as the vector anchor time.
X	Phase elapsed time at beginning of ephemeris.	day:hr:min:sec			
Y	Phase elapsed time at end of ephemeris.	day:hr:min:sec			
Z	Not currently used; they will display the:				
	Anchor vector ID	none			
	GMT of anchor vector	day:hr:min:sec			
	Ephemeris length	hrs			
	Ephemeris begin GMT	day:hr:min:sec			
	Ephemeris end GMT	day:hr:min:sec			
	for the TDRSS east, west, and spare stations.				

APPENDIX H

CONSOLE MODULE DESCRIPTION

APPENDIX H

H-1.0 GROUND NAVIGATION CONSOLE

There are three phases of trajectory processing: launch, operations, and landing. The first and third are high-speed phases, while the second is low-speed. Figure H-1 presents a display and sectional description of the MCC ground navigation console, which will be used for in-flight and simulation support of the Shuttle OFT orbit determination functions. The rest of this appendix presents a detailed description of the console.

8-15-78

LOC	DESCRIPTION	TYPE	NOTE	LOC	DESCRIPTION	TYPE	NOTE
01	EVENT INDICATOR	36E		28	VOICE COMM POSITION-2235	V48- D	
02	EVENT INDICATOR	36E		29	VOICE COMM POSITION-2233	H48- D	
03	EVENT INDICATOR	36E		30	DISPLAY REQUEST KEYBOARD	DRK2	
04	EVENT INDICATOR	36E		31	SWITCH MODULE	US48	
05	EVENT INDICATOR	36E		32	SWITCH MODULE	US48	
20	TV MONITOR 14 PRECISION	M9		58	STATUS REPORT	4CR2	
21	TV MONITOR 14 PRECISION	M9		60	BLANK PANEL	D11/6	
22	TV MONITOR 14 PRECISION	M9		61	BLANK PANEL	D11/8	
23	TV MONITOR 14 PRECISION	M9		62	BLANK PANEL	D11/14	
25	MANUAL SELECT KEYBOARD	MSK3		63	BLANK PANEL	D11/13	
26	MANUAL SELECT KEYBOARD	MSK3		65	BLANK PANEL	D11/15	
27	VOICE COMM POSITION-2234	V48-FD					

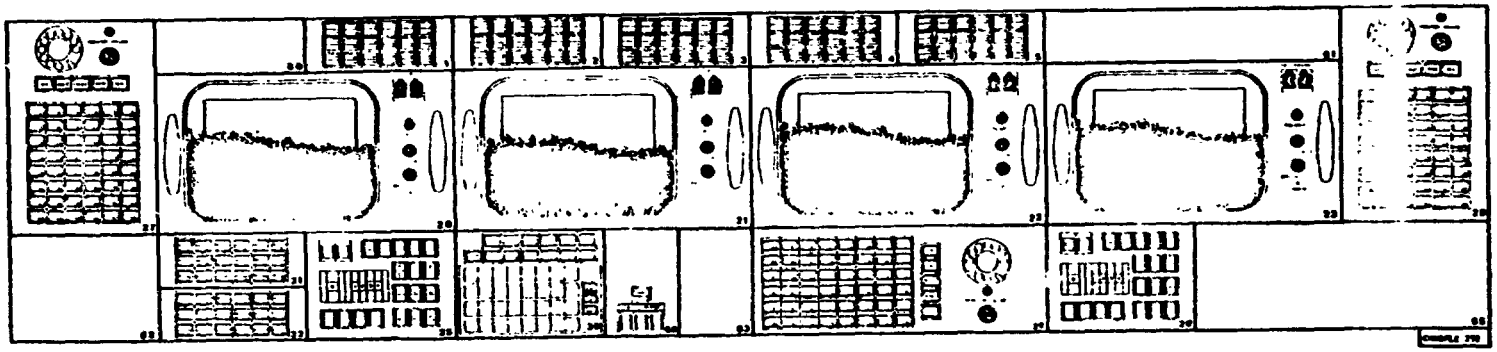

Figure H-1.- Ground navigation console number 292, room number 227A.

H-2.0 DIGITAL DISPLAY DRIVER (DDD)

The DDD's are updated every 10 seconds and provide the following information:

a. Data are being processed.

b. Quality of the data.

c. Occurrence of a change in the data base.

d. Which stations are sending data.

e. Which processors are currently active.

Although the console has accommodations for five DDD panels, o[illegible]our currently are used for low-sample rate NAV operations. They are describe[illegible]ow according to the panel numbers by which they are sequentially positioned [illegible]e console: 500A, 496E, 497D, and 678.

DDD Format No. 500A

UDF 46C LSR IN TX	HSR IN TRANS UDF	UDF TDRS IN TRANS	L/L DATA IN TRANS		ENCKT
UDF 46C ILL SITE	UDF 46C INVAL FMT	UDF 46C ILL VEH			ΔT P
DC ORB	ORB USER DECISION	RESIDUAL COMPS ORB	ORB B/B	ORB S/B	
DC TGT	TGT USER DECISION	RESIDUAL COMPS TGT	TGT B/B	TGT S/B	
BFS O/B	BFS GND	BFS VAT			STATE 1
STATE 2	STATE 3		VECTOR RECEIVED	TDR TAPE	NAV ONLINE

DDD name	Processing initiating DDD	Processing terminating DDD
LSR IN TX	LSR IN TRANSMISSION	
ILL SITE	RECEIVER PAD ID DOES NOT MATCH STATION ID	NO MORE RECORDS BEING RECEIVED FROM THIS SITE
HSR IN TRANS UDF	HSR S-BAND UDF BLOCK RECEIVED BY HSIP	NO MORE HSR S-BAND DATA BLOCKS RECEIVED
INVAL FMT	START OR END OF MESSAGE WORD OF UDF RECORD INVALID	RECORD DISCARDED
UDF TDRS IN TRANS	TDRSS DATA ROUTED TO SDP TAS VIA NCIC INTERFACE	LOSS OF DATA BY SDP
ILL VEH	TRACKING DATA TRANSMITTED WITH INVALID VEHICLE ID	
L/L DATA IN TRANS	DATA IN L/L FORMAT ROUTED TO SDP TAS VIA L/L INTERFACE	DATA LOSS OR TRANSFER TO OPERATIONS PHASE
ENCKE	INTEGRATION STARTED	INTEGRATION FINISHED
DC ORB	ORBIT DETERMINATION PROCESSOR INVOKED	SOLUTION COMPUTATION COMPLETED
DC TGT	PAYLOAD	
ORB USER DECISION	PROCESSING COMPLETED: WAITING FOR ACCEPTANCE OR REJECTION	ACCEPTANCE OR REJECTION OF SOLUTION
RESIDUAL COMPS ORB	RESIDUAL COMPUTATION	COMPLETION OF COMPUTATION
COMPS TGT		
ORB B/B	ORBIT DETERMINATION PROCESSOR IN B/B MODE	B/B MODE TERMINATION
ORB S/B	ORBIT DETERMINATION PROCESSOR IN S/B MODE	S/B MODE TERMINATION
TGT S/B		
BFS O/B	VALID RECEIPT OF THE BFS ONBOARD PBI	BFS ONBOARD PBI

DDD name	Processing initiating DDD	Processing terminating DDD
STATE 2	NA	
BFS GND	VALID RECEIPT OF THE BFS GROUND PBI	BFS GROUND PBI
STATE 3	NA	
BFS VAT	VALID RECEIPT OF THE TARGET/BFS PBI	TARGET/BFS PBI
VECTOR RECEIVED	RECEIPT OF TDRSS/INTERCEPTER VECTOR	TERMINATE ON-LINE MONITOR DDD
TDR TAPE	READING DATA FROM TAPE OR DISK	READING OF DATA TERMINATED
STATE 1	NA	
NAV ONLINE	ON-LINE COMMENT GENERATED FOR NAV CONSOLE	DEPRESS PBI's: NAV L. SPEED, ON-LINE MON. DDD CLEAR, EXECUTE

DDD Format No. 496 E

LAUNCH PHASE	OPS PHASE	LANDING PHASE	HI PRIORITY	VECTOR COMPARE	ENCKE
DC ORB	RESIDUAL COMPS ORB	PSAD SHUTTLE	LO PRIORITY	TDR TAPE	CHECKOUT MONITOR
DC TGT	RESIDUAL COMPS TGT	PSAD PAYLOAD	MPT-TO TAPE	TAPE-TO MPT	DMP
SAT CURRENT	SAT PLANNING	EPSAT	GND TGT CONTACTS	RENDEZVOUS PLANNING	EPP
NSC1	NSC2	NSC3	NSC4	ΔT P	
SRSS1	SRSS2	SRSS3	SRSS4	DY ON-LINE	NAV ON-LINE

DDD name	Processing initiating DDD	Processing terminating DDD
LAUNCH PHASE	MCC CONFIGURED FOR LAUNCH	SWITCH TO OPS PHASE
DC ORB	ORBIT DETERMINATION PROCESSOR INVOKED	SOLUTION COMPUTATION COMPLETED
OPS PHASE	MCC CONFIGURED FOR OPS	SWITCH TO LANDING PHASE
RESIDUAL COMPS ORB	RESIDUAL COMPUTATION IN PROCESS	COMPLETION OF COMPUTATION
LANDING PHASE	MCC CONFIGURED FOR LANDING	TERMINATION OF THIS PHASE
PREDICTED SITE ACQUISITION DISPLAY SHUTTLE (PSAD)	WHILE PSAP IS BUILDING PSAD SHUTTLE TABLE	ALL OTHER TIMES
HI PRIORITY		
LO PRIORITY		
VECTOR COMPARE	PROCESSOR IS INTEGRATING VECTORS	ALL OTHER TIMES
TDR TAPE	I/O TDR TAPE	END OF TAPE I/O
ENCKE	INTEGRATION STARTED	INTEGRATION FINISHED
CHECKOUT MONITOR	WHILE THE C/O MONITOR PROCESSOR IS INTEGRATING VECTORS	ALL OTHER TIMES
DC TGT	PAYLOAD DC IN PROGRESS	DC COMPLETED
SITE ACQUISITION TABLE CURRENT (SAT)	WHILE SAP IS BUILDING TABLE FOR CURRENT SAT	ALL OTHER TIMES
RESIDUAL COMPS TGT		
SAT PLANNING	WHILE SAP IS BUILDING TABLE FOR CURRENT SAT	ALL OTHER TIMES
PSAD PAYLOAD	WHILE PSAP IS BUILDING PSAD PAYLOAD TABLE	ALL OTHER TIMES
EPSAT	WHILE EPSAT BUILDING GTN, TACAN, AND TDRS TABLES	ALL OTHER TIMES

DDD name	Processing initiating DDD	Processing terminating DDD
MPT-TO-TAPE	MPT TO TAPE (DUMP)	MPT TO TAPE COMPLETED
GND TGT CONTACTS	WHILE GTCP BUILDING GROUND TARGET CONTACTS TABLE	ALL OTHER TIMES
TAPE-TO-MPT	MPT INTO CORE FROM TAPE (READ)	TAPE TO MPT COMPLETED
RENDEZVOUS PLANNING		
DMP	DEORBIT MANEUVER PROCESSOR IN PROGRESS	COMPLETION OF MANEUVER COMPUTATION
EPH	ENTRY PROFILE PROCESSOR IN PROGRESS	EPHEMERIS GENERATION COMPLETION
NSC1	NEXT STATION CONTACTS PROCESSOR BUILDING TABLE ASSOCIATED WITH EPH1	ALL OTHER TIMES
SRSS1	WHILE SRSS PROCESSOR BUILDING SRSS TABLE ASSOCIATED WITH EPH1	ALL OTHER TIMES
NSC2	WHILE NSC PROCESSOR BUILDING NSC TABLE ASSOCIATED WITH EPH2	ALL OTHER TIMES
SRSS2	WHILE SRSS PROCESSOR BUILDING SRSS TABLE ASSOCIATED WITH EPH2	ALL OTHER TIMES
NSC3	WHILE NSC PROCESSOR BUILDING NSC TABLE ASSOCIATED WITH EPH3	ALL OTHER TIMES
SRSS3	WHILE SRSS PROCESSOR BUILDING SRSS TABLE ASSOCIATED WITH EPH3	ALL OTHER TIMES
NSC4	WHILE NSC PROCESSOR BUILDING NSC TABLE ASSOCIATED WITH EPH4	ALL OTHER TIMES
SRSS4	WHILE SRSS PROCESSOR BUILDING SRSS TABLE ASSOCIATED WITH EPH4	ALL OTHER TIMES

DDD name	Processing initiating DDD	Processing terminating DDD
DY ON-LINE	ONLINE COMMENT GENERATED FOR DY CONSOLE	DEPRESS PBIs: VECTOR CNTL1, ONLINE MON DD CLEAR, EXECUTE
NAV ON-LINE	ONLINE COMMENT GENERATED FOR NAV CONSOLE	DEPRESS PBIs: NAV L. SPEED, ONLINE MON DDD CLEAR, EXECUTE

DDD Format No. 497D

EPH1 UPDATE	EPH2 UPDATE	EPH3 UPDATE	EPH4 UPDATE	HI PRIORITY	ENCKE
EPH1-UPD INCOMPLETE	EPH2-UPD INCOMPLETE	EPH3-UPD INCOMPLETE	EPH4-UPD INCOMPLETE	LO PRIORITY	MPT-TO TAPE
EAST UPDATE	WEST UPDATE	SPARE UPDATE			TAPE-TO MPT
EAST-UPD INCOMPLETE	WEST-UPD INCOMPLETE	SPARE-UPD INCOMPLETE	BFS O/B	BFS GND	BFS VAT
VENT* UPDATE	ATTITUDE* TIMELINE	CBDS-T/L* UPDATE	STATE 1	STATE 2	STATE 3
EPH1-WGL UPDATE	EPH2-WGL UPDATE	EPH3-WGL UPDATE	EPH4-WGL UPDATE	DY ON-LINE	NAV ONLINE

*Will be extinguished by updating <u>any</u> of the EPHEMERIDES.

DDD name	Processing initiating DDD	Processing terminating DDD
EPH1 UPDATE	EPH1 TRAJECTORY UPDATE	COMPLETION OF EPH1 TRAJECTORY UPDATE
EPH1-UPD INCOMPLETE	ABNORMAL TERMINATION OF EPH 1 UPDATE	EPH1 TRAJECTORY UPDATE
EPH2 UPDATE	EPH2 TRAJECTORY UPDATE	COMPLETION OF EPH2 TRAJECTORY UPDATE
EPH2-UPD INCOMPLETE	ABNORMAL TERMINATION OF EPH2 UPDATE	EPH2 TRAJECTORY UPDATE
EPH3 UPDATE	EPH3 TRAJECTORY UPDATE	COMPLETION OF EPH3 TRAJECTORY UPDATE
EPH3-UPD INCOMPLETE	ABNORMAL TERMINATION OF EPH3 UPDATE	EPH3 TRAJECTORY UPDATE
EPH4 UPDATE	EPH4 TRAJECTORY UPDATE	COMPLETION OF EPH4 TRAJECTORY UPDATE
EPH4-UPD INCOMPLETE	ABNORMAL TERMINATION OF EPH4 UPDATE	EPH4 TRAJECTORY UPDATE
HI PRIORITY		
LO PRIORITY		
ENCKE	INTEGRATION STARTED	INTEGRATION FINISHED
MPT-TO-TAPE	MPT TO TAPE (DUMP)	MPT TO TAPE COMPLETED
EAST UPDATE	EAST TRAJECTORY UPDATE	COMPLETION OF EAST TRAJECTORY UPDATE
EAST-UPD INCOMPLETE	ABNORMAL TERMINATION OF EAST UPDATE	EAST TRAJECTORY UPDATE
WEST UPDATE	WEST TRAJECTORY UPDATE	COMPLETION OF WEST TRAJECTORY UPDATE
WEST-UPD INCOMPLETE	ABNORMAL TERMINATION OF WEST UPDATE	WEST TRAJECTORY UPDATE
SPARE UPDATE	SPARE TRAJECTORY UPDATE	COMPLETION OF SHARE TRAJECTORY UPDATE

DDD name	Processing initiating DDD	Processing terminating DDD
SHARE-UPD INCOMPLETE	ABNORMAL TERMINATION OF SPARE UPDATE	SPARE TRAJECTORY UPDATE
BFS O/B	VALID RECEIPT OF THE BFS ONBOARD PBI	BFS ONBOARD PBI
BFS GND	VALID RECEIPT OF THE BFS GROUND PBI	BFS GROUND PBI
TAPE-TO-MPT	MPT INTO CORE FROM TAPE (READ)	TAPE TO MPT COMPLETED
BFS VAT	VALID RECEIPT OF THE TARGET/BFS PBI	TARGET/BFS PBI
VENT UPDATE	VENT TIMELINE/FORCE UPDATE	COMPLETION OF TRAJECTORY UPDATE
EPH1-WGL UPDATE	EPH1 WEIGHT GAIN/LOSS CHANGE	COMPLETION OF EPH1 TRAJECTORY UPDATE
ATTITUDE TIMELINE	ATTITUDE TIMELINE CHANGED	COMPLETION OF TRAJECTORY UPDATE
EPH2-WGL UPDATE	EPH2 WEIGHT GAIN/LOSS CHANGE	COMPLETION OF EPH2 TRAJECTORY UPDATE
CBDS-T/L UPDATE	CARGO BAY DOORS TIMELINE CHANGE	COMPLETION OF TRAJECTORY UPDATE
EPH3-WGL UPDATE	EPH3 WEIGHT GAIN/LOSS CHANGE	COMPLETION OF EPH3 TRAJECTORY UPDATE
STATE 1	NA	
EPH4-WGL UPDATE	EPH4 WEIGHT GAIN/LOSS CHANGE	EPH4 TRAJECTORY UPDATE
STATE 2	NA	
DY ON-LINE	ON-LINE COMMENT GENERATED FOR DY CONSOLE	DEPRESS PBIs: VECTOR CNTL 1, ONLINE MON DDD CLEAR, EXECUTE
STATE 3	NA	

DDD name	Processing initiating DDD	Processing terminating DDD
NAV ONLINE	ONLINE COMMENT GENERATED FOR NAV CONSOLE	DEPRESS PBIs: NAV L. SPEED, ONLINE MON. DDD CLEAR, EXECUTE

DDD Format No. 678E

MLAC	PATC	PAFC	CNVC	BDQC	KPTC
PTPC	VDBC	VDFC	VDCC	WLPC	WLIC
WLRC	GBIC	GTKC	ANTC	ASCC	ASTC
KMRC		MILS	MLXS	BDAS	MADS
MAXS	ORRS	GDSS	GDXS	ROSS	AGOS
ACNS	GWMS	HAWS	ETCS	ETXS	QUIS

DDD name	Processing initiating DDD	Processing terminating DDD
MLAC	MERRITT ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
PTPC	POINT PILLAR C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
PATC	PATRICK AFB C-BAND (FPQ-14) TRACKING DATA RECEIVED	ALL OTHER TIMES
VDBC	VANDENBERG AFB C-BAND (TPQ-18) TRACKING DATA RECEIVED	ALL OTHER TIMES
PAFC	PATRICK AFB C-BAND (FPQ-13) TRACKING DATA RECEIVED	ALL OTHER TIMES
VDFC	VANDENBERG AFB C-BAND (FPS-16) TRACKING DATA RECEIVED	ALL OTHER TIMES
CNVC	CAPE CANAVERAL C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
VDCC	VANDENBERG AFB C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES

DDD name	Processing initiating DDD	Processing terminating DDD
BDQC	BERMUDA ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
WLPC	WALLOPS ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
KPTC	KAENA POINT C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
WLIC	WALLOPS ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
WLRC	WALLOPS ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
KMRC	KWAJALEIN C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
GBIC	GRAND BAHAMA ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
GTKC	GRAND TURK ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
MILS	MERRITT ISLAND S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ANTC	ANTIGUA ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
MLXS	MERRITT ISLAND S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ASCC	ASCENSION ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
BDAS	BERMUDA ISLAND S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ASTC	ASCENSION ISLAND C-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
MADS	MADRID S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
MAXS	MADRID S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES

DDD name	Processing initiating DDD	Processing terminating DDD
ACNS	ASCENSION ISLAND S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ORRS	ORRORAL VALLEY S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
GWMS	GUAM ISLAND S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
GDSS	GOLDSTONE S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
HAWS	HAWAII S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
GDXS	GOLDSTONE S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ETCS	GFSC S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ROSS	ROSMAN S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
ETXS	GSFC S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
AGOS	SANTIAGO S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES
QUIS	QUITO S-BAND TRACKING DATA RECEIVED	ALL OTHER TIMES

H-3.0 MANUAL SELECT KEYBOARD (MSK)

The MSK panel contains thumb wheel switches used in conjunction with PBI's to place displays on any of the console CRT's and on the overhead TV monitor. In addition, this panel can be used to generate hard copies of any display and to format the DDD panels.

Figure H-2 presents an example of MSK request number 332, which results in the computation and display of residuals for Shuttle tracking data batches, based on the current Shuttle DC (BB or SB) vector. This display appears on the center operator's left CRT when the following sequence of buttons are depressed: DISP REQ, LEFT MON ENTER. A hard copy of this display is generated by depressing LEFT HC.

An example in which DDD 496 is formatted is shown in figure H-3. The manual select dials show 4962, of which the first three digits are the DDD panel number, and the fourth digit is the panel position; namely, the second from left. Activation of the DDD is completed by depressing DDD FMT SEL and RIGHT MON ENTER.

Figure H-3 also contains the PBI's for placing a display on the overhead TV monitor. This can be accomplished after dialing the MSK request number and depressing the following sequence of buttons: DISP REQ, O/H MON ENTER. A display already on a CRT can be placed on the overhead TV monitor or any other CRT by dialing the TV channel number on the thumb wheel switches and depressing TV CHAN and the appropriate monitor PBI (i.e., O/H MON ENTER for the overhead TV monitor).

The operator uses the thumb wheel switch on the extreme left to specify a function code of 1 to 15, whose name will appear on the small panel immediately above the switch. A function code of 1 designates a mission, and any other function code (2 through 15) designates a nonmission function.

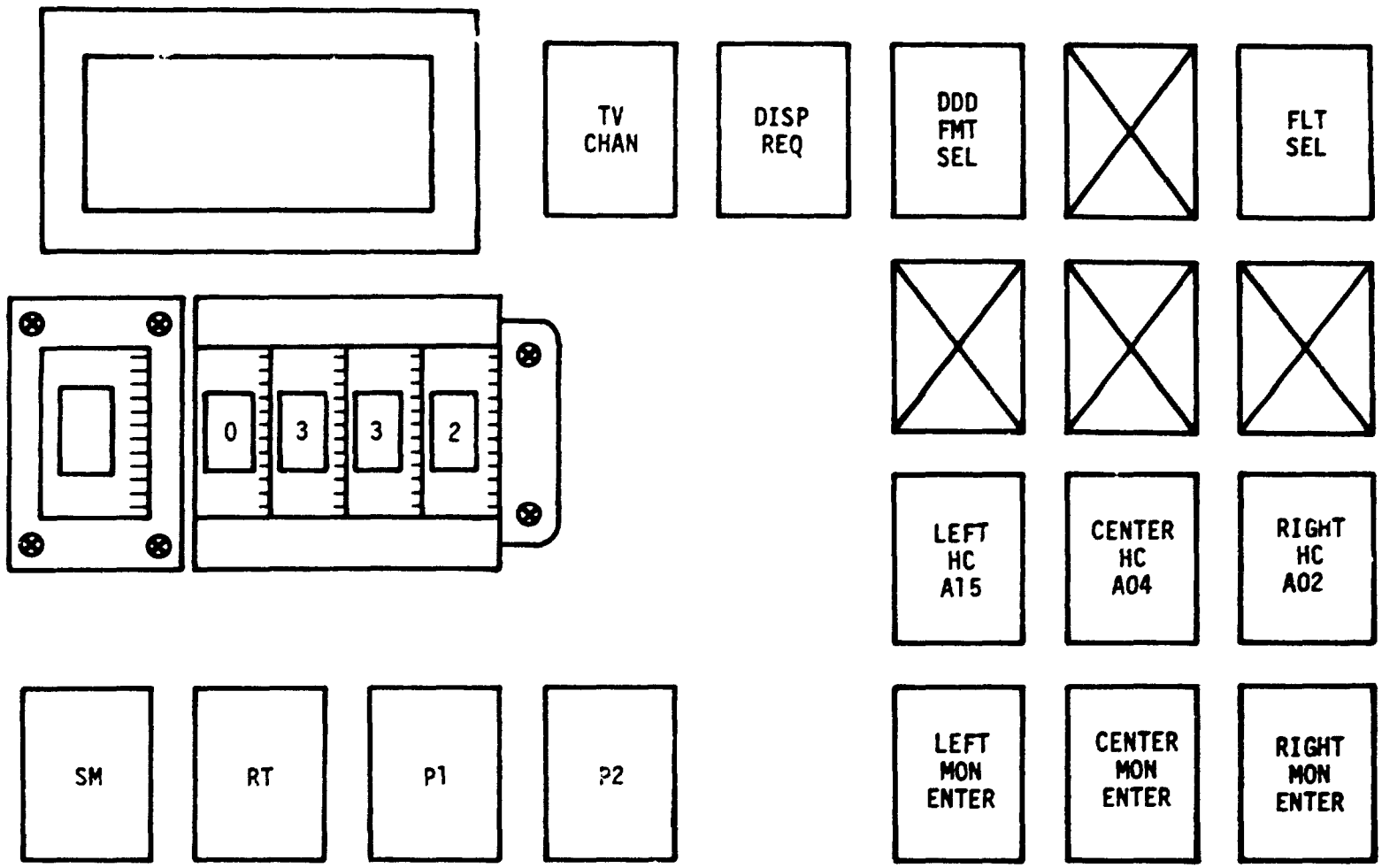

Figure H-2.- Manual select keyboard configured for MSK 332 request.

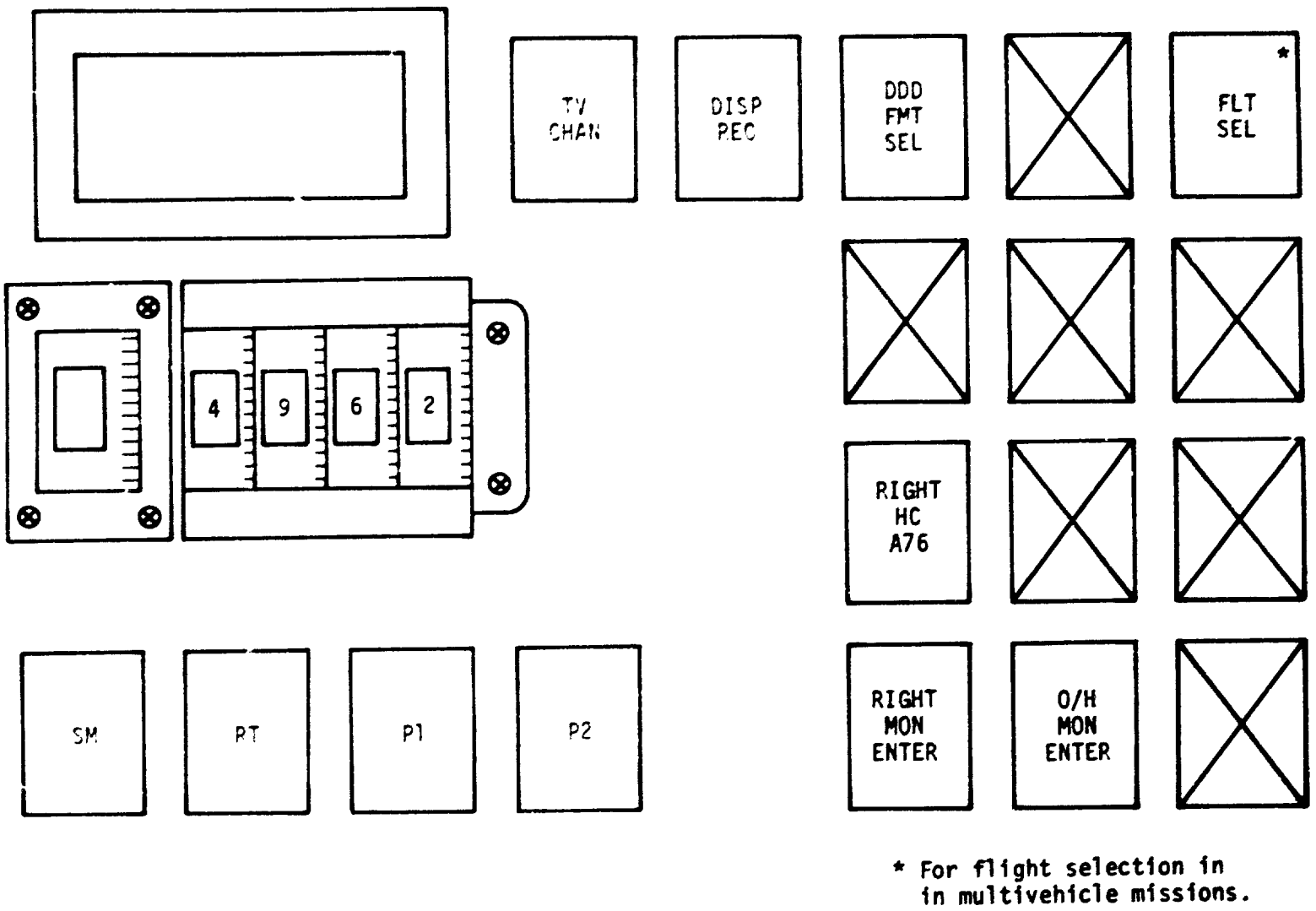

Figure H-3.- Manual select keyboard configured for DDD format 496 initialization.

H-4.0 VOICE COMMUNICATION PANELS

Communications among the command, control, and support personnel are accomplished with three voice communications panels, figures H-4, H-5, and H-6. The figures are coded with (y) for yellow and (w) for white to represent the color of the PBI's and to designate listening only and listening and speaking loops, respectively. Any number of listening loops can be operated simultaneously, whereas only one talking loop can be used at a time. Telephone communication is activated by depressing PABX and is released by depressing RLS or RELEASE.

	HOLD	BUZZER	RING	RLS

(w) PABX	(w) LANDING SUPPORT	(y) OPS COORD	(w) GSFC ODF	(y) SDP INT	(w) SDP INT
(y) FD	(y) MOCR CMD	(y) AFD CONF	(w) DATA	(y) NAV SUPPORT	(w) NAV SUPPORT
(y) MOCR DYN	(w) MOCR DYN	(y) SSR DYN 1	(w) SSR DYN 1	(y) SSR DYN 2	(w) SSR DYN 2
(y) AERO	(w) AERO	(y) TRACK COORD	(w) TRACK COORD	(y) TRAJ COORD	(w) TRAJ COORD
(y) A/G 1	(w) FAO	(y) SITE COORD	(w) SITE COORD	(y) SDP TRACK	(w) SDP TRACK
(y) A/G 2	(y) SDL COORD	(y) RTC	(y) LL + DS COORD	(y) SDP DYN	(w) SDP DYN
(y) A/G UHF	(w) SPAN	(y) WTR/DFRC	(w) NORAD	(y) OPS PLNR	(w) OPS PLNR
(w) SSR 1 CONF/T/S OIS 183	(w) SSR 2 CONF/PE-1	(w) MER	(w) DFE	(w) GC CALL	(w) DISPLAY

Figure H-4.- Left voice communications panel.

(Y) FAO	(y) SDP INT	(y) SDP DYN	(y) SSR DYN 2	(y) AERO	(y) SITE COORD	(y) TRACK COORD	(w) PABX
(w) FAO	(w) SDP INT	(w) SDP DYN	(w) SSR DYN 2	(w) AERO	(w) SITE COORD	(w) TRACK COORD	(y) FD
(w) DFE	(w) GC CALL	(y) SDL COORD	SSR 1 (w) CONF/T/S DIS 183	(y) RTC	(y) TRAJ COORD	(y) SSR DYN 1	(y) AFD CONF
(w) DATA	(w) OPS COORD	SSR 2 (w) CONF/PE-1 OIS 161	(w) MER	LL + DS (y) COORD	(w) TRAJ COORD	(w) SSR DYN 1	(y) A/G 1
(w) COMM CONTROL	(y) OPS COORD	(y) MOCR CMD	(y) WTR/DFRC	(y) SDP TRACK	(y) NAV SUPPORT	(y) MOCR DYN	(y) A/G 2
(w) DISPLAY	(w) SPAN	(w) LANDING SUPPORT	(w) NORAD	(w) SDP TRACK	(w) NAV SUPPORT	(w) MOCR D/N	(y) A/G UHF

HOLD
BUZZER
RING
RELEASE

Figure H-5.- Center voice communications panel.

	HOLD	BUZZER	RING	RLS

(w) PABX	(y)	(y) OPS COORD	(w) GSFC ODF	(y) SDP INT	(w) SDP INT
(y) FD	(y) MOCR CMD	(y) AFD CONF	(w) DATA	(y) NAV SUPPORT	(w) NAV SUPPORT
(y) MOCR DYN	(w) MOCR DYN	(y) SSR DYN 1	(w) SSR DYN 1	(y) SSR DYN 2	(w) SSR DYN 2
(y) AERO	(w) AERO	(y) TRACK COORD	(w) TRACK COORD	(y) TRAJ COORD	(w) TRAJ COORD
(y) A/G 1	(w) FAO	(y) SITE COORD	(w) SITE COORD	(y) SDP TRACK	(w) SDP TRACK
(y) A/G 2	(y) SDL COORD	(y) RTC	(y) LL + DS COORD	(y) SDP DYN	(w) SDP DYN
(y) A/G UHF	(w) SPAN	(y) WTR/DFRC	(w) NORAD	(y) OPS PLNR	(w) OPS PLNR
SSR 1 (w) CONF/T/S OIS 183	SSR 2 (w) CONF/PE-1 OIS 161	(w) MER	(w) DFE	(w) GC CALL	(w) DISPLAY

Figure H-6.- Right voice communications panel.

H-5.0 DISPLAY REQUEST KEYBOARD - SIMULATION OF MED ENTRIES

The capability of simulating selected MED's is provided by the display request keys, which are organized into three functional categories, as described below:

a. Field selection keys - The set of display selection keys to be used are indicated by the field selection keys (fig. H-7). Some fields are reserved for MED simulation, while all other keys provide the display selection capability.

b. Monitor selection keys - There are three monitor selection keys (fig. H-7) which are used as follows:

   (1) Enter - The request is entered into the MED simulation.

   (2) Execute - The request is entered and the accumulated MED simulation is executed.

   (3) Clear - The accumulated MED simulation and the associated accumulated PBI field are cleared.

c. Display selection keys - These keys are used to build a MED by indicating parameters to be used in the Sim MED.

NAV Low Speed (fig. H-8)

The following is a list and explanation of the NAV low-speed DRK PBI entries:

Field	PBI	MED entry
NAV L. SPEED	ONLINE MON. DDD CLEAR	MEDCODE, NV
NAV L. SPEED	SHUTTLE BATCH RES. PLOT	MEDCODE, SBRP
NAV L. SPEED	PAYLOAD BATCH RES. PLOT	MEDCODE, PBRP

ONLINE MONITOR DDD CLEAR: causes the NAV on-line DDD, which is illuminated because of various processing errors, or messages to be extinguished.

SHUTTLE BATCH RESIDUALS PLOT: causes the next sequential batch (in ascending time order) for the Shuttle vehicle to be displayed using as input either the last vector entered on the batch plot MED or the current DC vector (BB or SB). The vector will be integrated and stored for each plot (rather than integrating the original vector each time for each plot).

PAYLOAD BATCH RESIDUALS PLOT: same as for Shuttle, except applicable to payload vechicle batches.

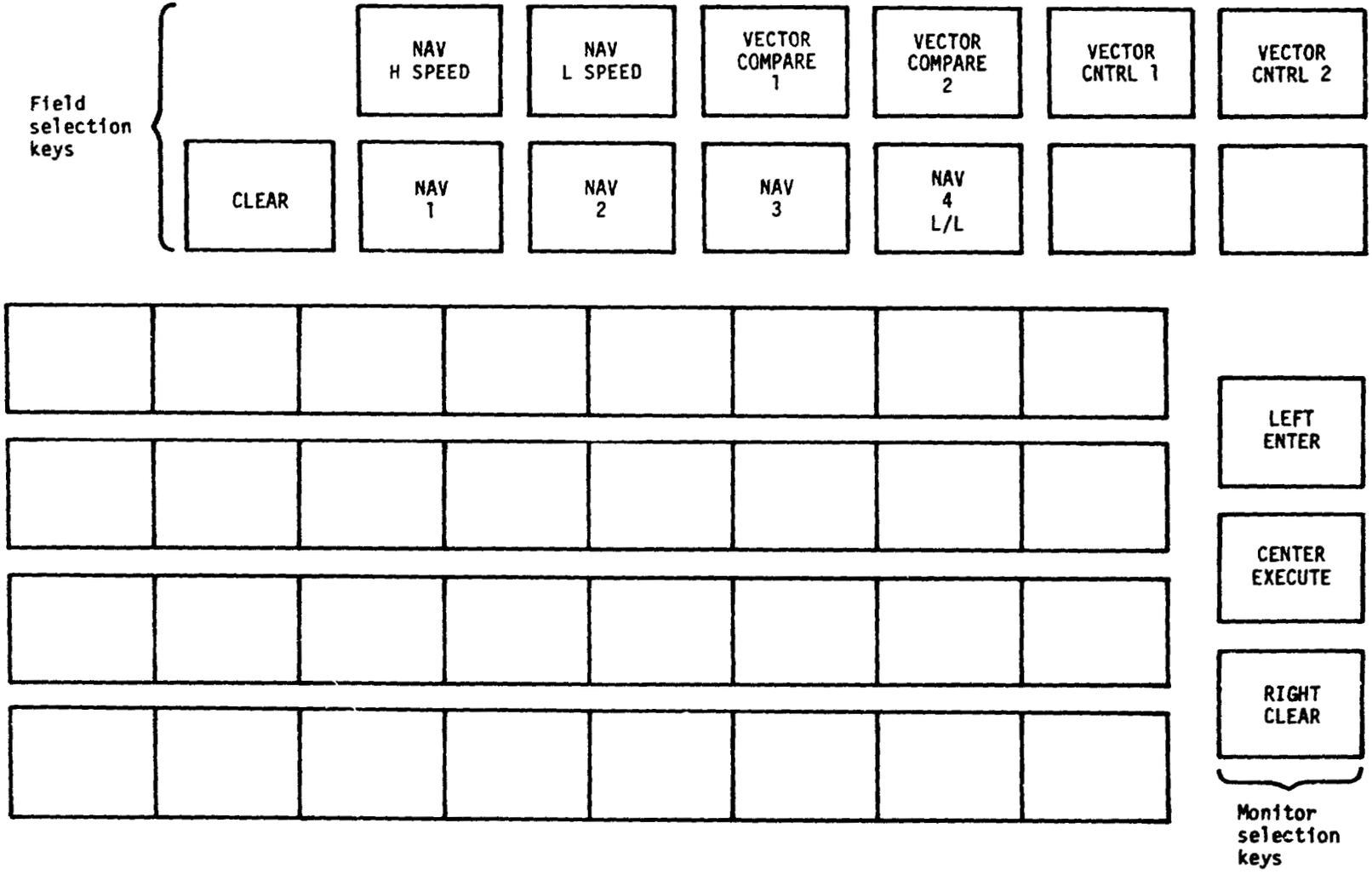

Figure H-7.- Field and monitor selection keys.

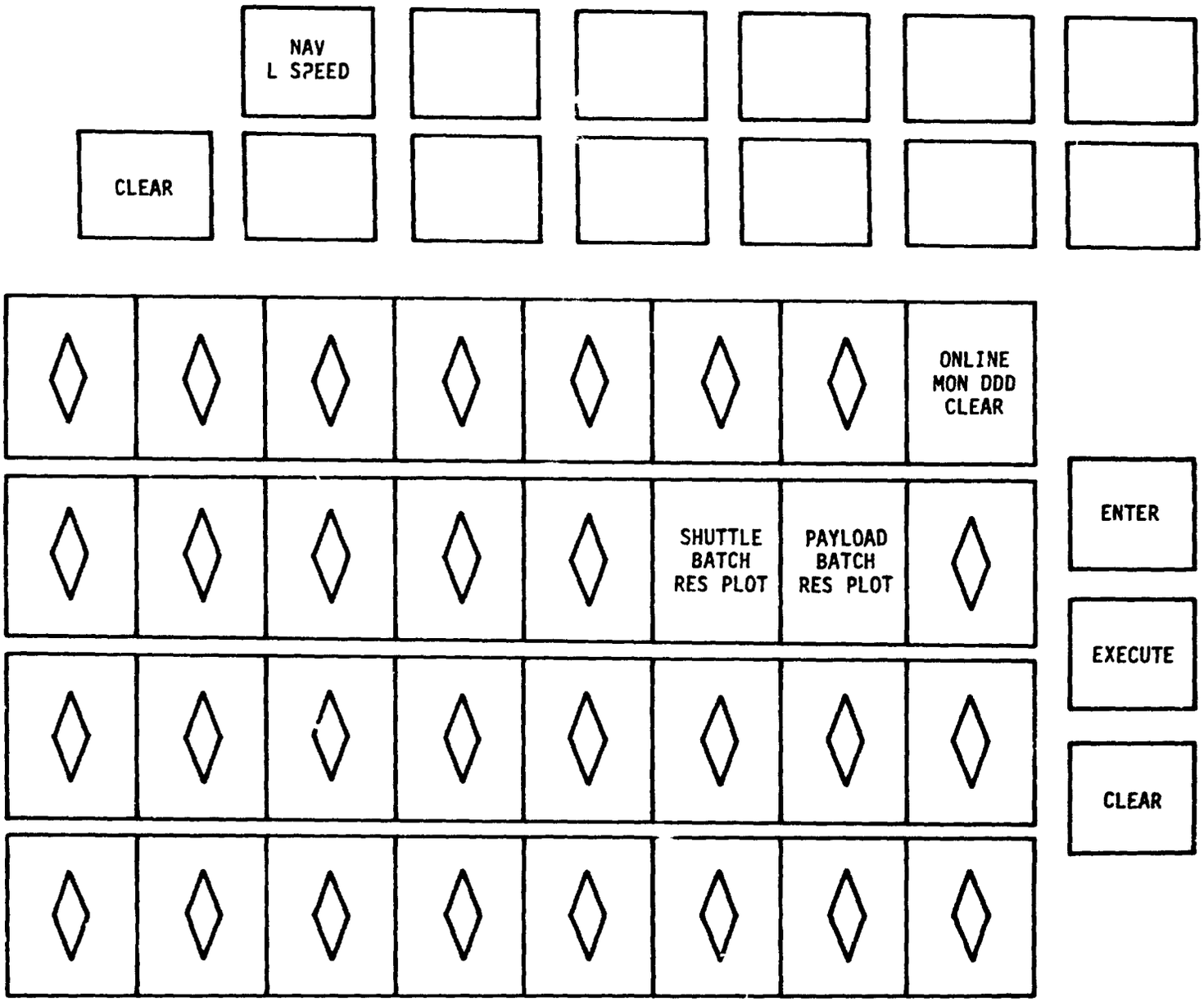

Figure H-8.- NAV low-speed DRK PBI entries.

Vector Compare

The vector compare DRK provides the following PBI entries and are illustrated in figures H-9 and H-10.

Field	PBI	MED entry	MED parameter plot
VECTOR COMPARE 1 & 2	V SLOT	V	ACCUMULATOR
VECTOR COMPARE 1 & 2	P (PAYLOAD)	P	ACCUMULATOR
VECTOR COMPARE 2	E	E	ACCUMULATOR
VECTOR COMPARE 2	W	W	ACCUMULATOR
VECTOR COMPARE 1 & 2	S (SHUTTLE)	S	ACCUMULATOR
VECTOR COMPARE 1 & 2	0	0	ACCUMULATOR
VECTOR COMPARE 1 & 2	1	1	ACCUMULATOR
VECTOR COMPARE 1 & 2	2	2	ACCUMULATOR
VECTOR COMPARE 1 & 2	3	3	ACCUMULATOR
VECTOR COMPARE 1 & 2	4	4	ACCUMULATOR
VECTOR COMPARE 1 & 2	5	5	ACCUMULATOR
VECTOR COMPARE 1 & 2	6	6	ACCUMULATOR
VECTOR COMPARE 1 & 2	7	7	ACCUMULATOR
VECTOR COMPARE 1 & 2	8	8	ACCUMULATOR
VECTOR COMPARE 1 & 2	9	9	ACCUMULATOR
VECTOR COMPARE 1 & 2	VECTOR ID1	ACCUMULATOR, MEDCODE	3, 0
VECTOR COMPARE 1 & 2	VECTOR ID2	ACCUMULATOR	4
VECTOR COMPARE 1	VECTOR ID3	ACCUMULATOR	5
VECTOR COMPARE 1	VECTOR ID4	ACCUMULATOR	6
VECTOR COMPARE 2	V	V	ACCUMULATOR
VECTOR COMPARE 2	A	A	ACCUMULATOR

Field	PBI	MED entry	MED parameter plot
VECTOR COMPARE 2	M	M	ACCUMULATOR
VECTOR COMPARE 2	D	D	ACCUMULATOR
VECTOR COMPARE 2	INTEGRATOR OPTIONS	ACCUMULATOR	8
VECTOR COMPARE 1 & 2	.	.	ACCUMULATOR
VECTOR COMPARE 1 & 2	:	:	ACCUMULATOR
VECTOR COMPARE 1 & 2	TIME	TIME, ACCUMULATOR	1, 2
VECTOR COMPARE 2	ALTITUDE	ALT	1
VECTOR COMPARE 2	FPA	FPA	1
VECTOR COMPARE 2	LONGITUDE	LON	1
VECTOR COMPARE 2	VALUE	ACCUMULATOR	7
VECTOR COMPARE 1	CURRENT BB	CBB	ACCUMULATOR
VECTOR COMPARE 1	CURRENT SB	CSB	ACCUMULATOR
VECTOR COMPARE 1	SUPERBATCH HISTORY	SVT	ACCUMULATOR
VECTOR COMPARE 1	SDC (Slot V39)	SDC	ACCUMULATOR
VECTOR COMPARE 1	PDC (Slot V40)	PDC	ACCUMULATOR
VECTOR COMPARE 1	SELECT	SEL	ACCUMULATOR
VECTOR COMPARE 1	TARGET	TARG	ACCUMULATOR
VECTOR COMPARE 1	GPC	GPC	ACCUMULATOR
VECTOR COMPARE 1	TDRSS EAST	EAST	ACCUMULATOR
VECTOR COMPARE 1	TDRSS WEST	WEST	ACCUMULATOR
VECTOR COMPARE 2	MISCELLANEOUS	MISC	ACCUMULATOR

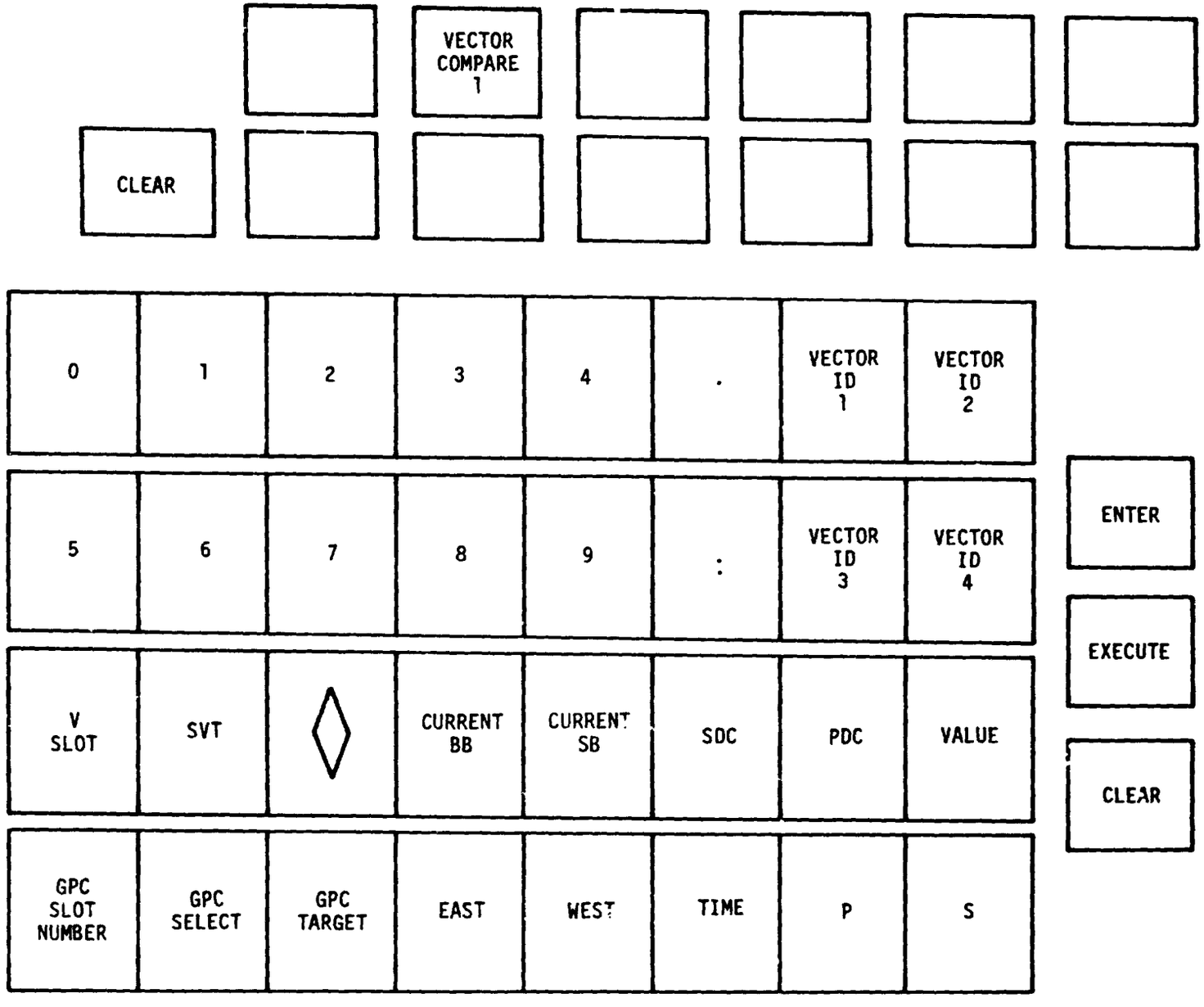

Figure H-9.- Vector compare 1 DRK PBI entries.

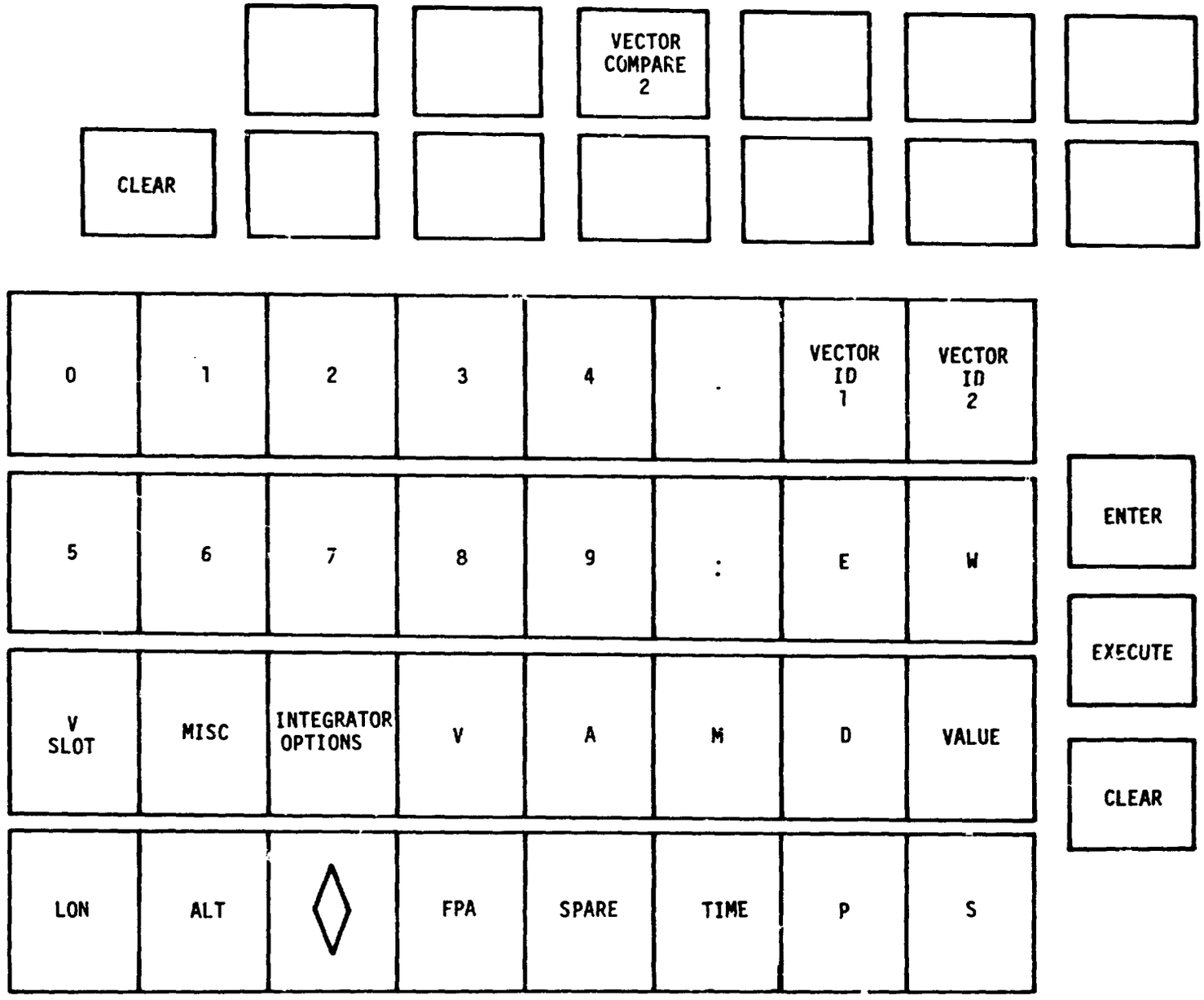

Figure H-10.- Vector compare 2 DRK PBI entries.

Sample PBI sequence for vector compare of current batch-to-batch solution with current superbatch solution:

VECTOR COMPARE1, 1, ENTER, S(or P),ENTER, CURRENT BB, ENTER, VECTOR ID1, ENTER, 1, ENTER, S, ENTER, CURRENT SB, ENTER, VECTOR ID2, EXECUTE

The PBI's of the NAV1, NAV2, NAV3, and NAV4 fields (figs. H-11, H-12, H-13 and H-14) produce displays, of which the most commonly used are described in appendix G. A display described on a PBI can also be produced by the MSK request number shown on the lower portion of that PBI. With the exception of the Shuttle batch plot, the Shuttle batch summary, the payload batch plot, and the payload batch summary, all displays are automatically updated.

The residual summary PBI computes and displays present differences between the measured and computed values for each observation and data type for each batch within limits specified by the S42 MED. An initial MED input is not required for Shuttle or payload residual summary displays, but input of the U19 MED is required for the vector residual summary.

BVENT and LVENT provide the capability to analyze and assess the effects of venting on a trajectory. The vent timeline vent forces are presented in the Orbiter body axes coordinate system by the BVENT display and the UVW coordinate system by the LVENT display. The P45 MED allows inputs to these two processors and causes them to be activated.

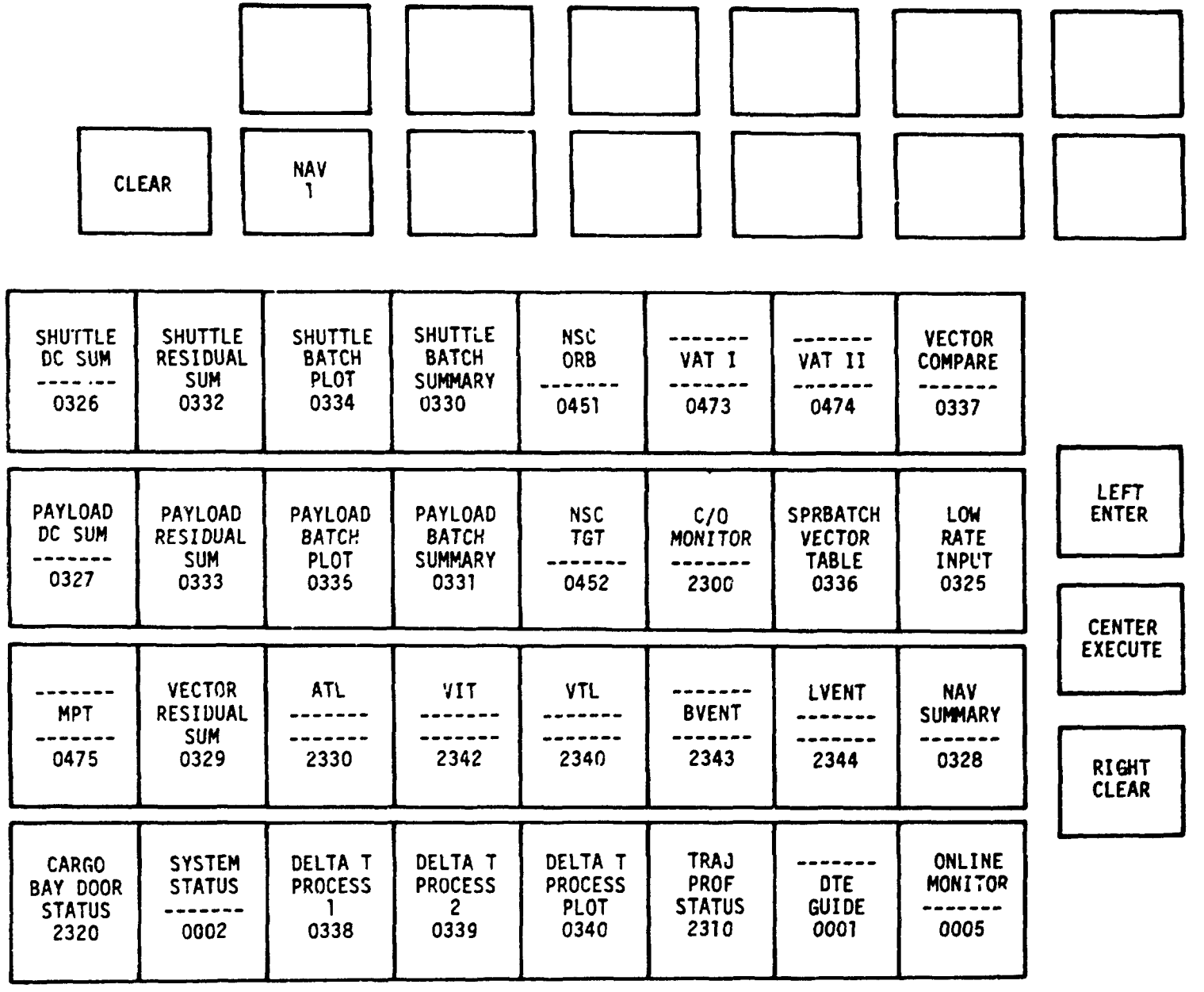

Figure H-11.- V 1 DRK PBI entries.

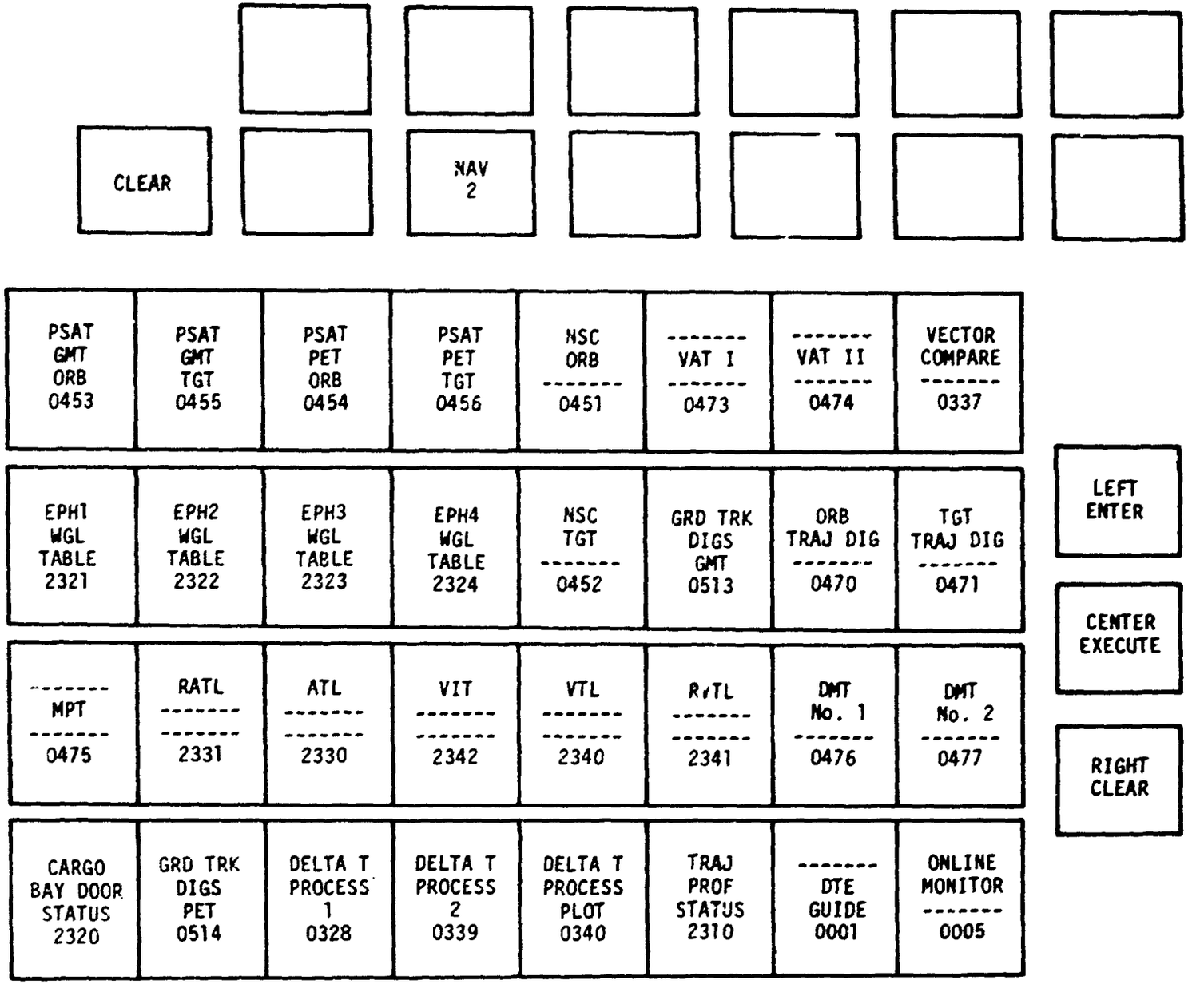

Figure H-12.- Nav 2 DRK PBI entries.

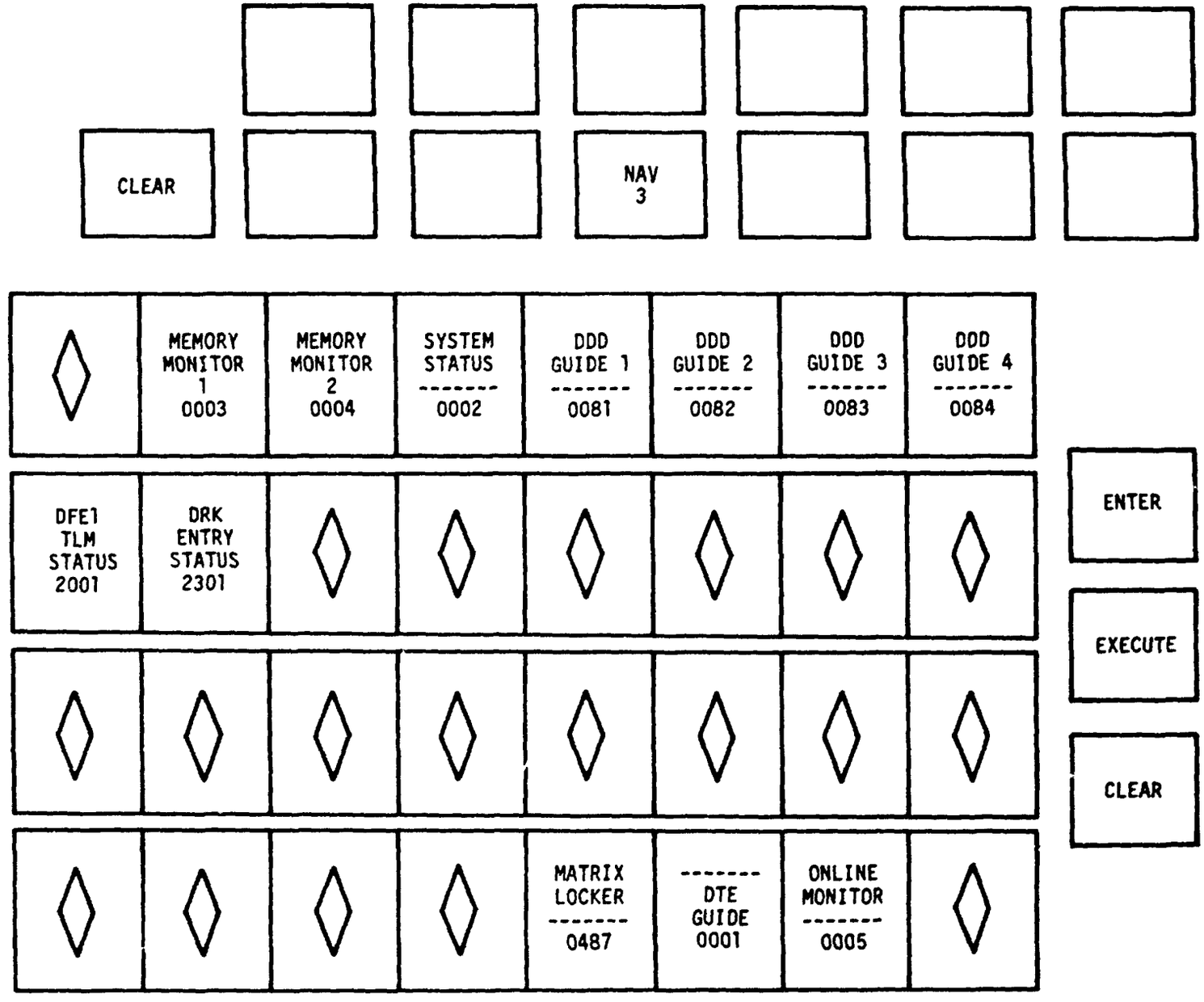

Figure H-13.- NAV 3 DRK PBI entries.

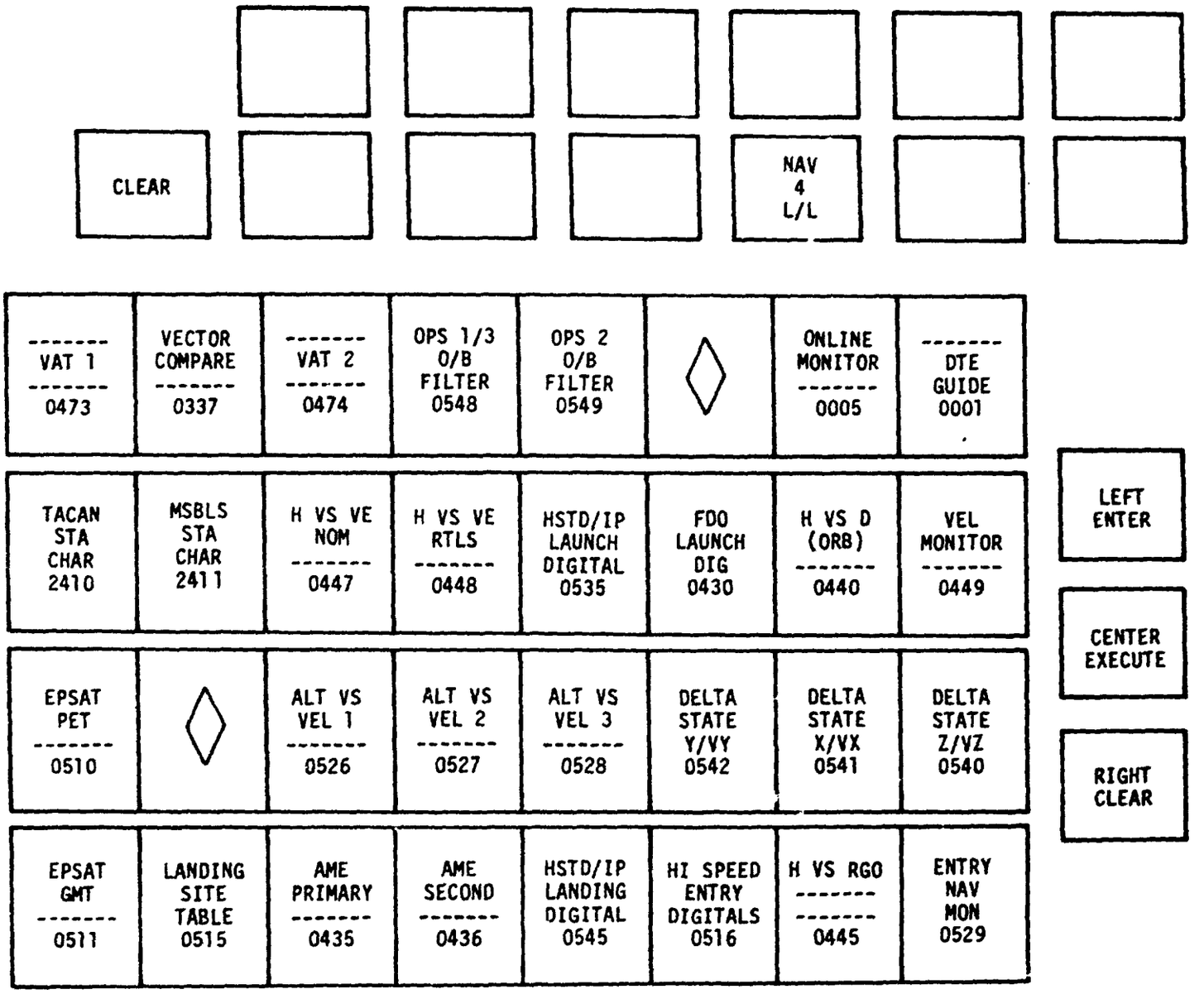

Figure H-14.- NAV 4 L/L DRK PBI entries.

H-6.0 SWITCH MODULE

Differential correction is the process of computing an updated estimate of a vehicle trajectory from low sample rate tracking data. The switch modules (fig. H-15) are composed of PBI's pertinent to this process, as described below:

PBI	Function
SHUTTLE/PAYLOAD	Specifies vehicle for which other PBI's apply
ACCEPT/REJECT	Accept or reject a DC solution
SS1	No a priori covariance matrix to be used in processing current data set (unconstrained solution)
SS2	Covariance matrix constrains solution to orbital plane of input vector
SS3	Predefined nominal a priori covariance constrains solution to small changes of state
SS4	Covariance matrix from previous batch solution constrains current batch solution
S1-S10	SB vector slots to store current SB vector
BB/SB	DC processing modes
FORCE	Causes another iteration on current DC solution
K GAMMA	Recompute current DC solution using original input covariance multiplied by a constant (5)
ZERO/NORMAL EDIT LOOPS	Does not or does apply 3σ RMS residual editing to the current batch
α DWNWT	Data weights for this station are multiplied by a constant
EXECUTE	Initiates function of above PBI's
CLEAR	Clears module

SHUTTLE	PAYLOAD			B-B MODE	S-B MODE
ACCEPT	REJECT	SS1	SS2	SS3	SS4
ZERO EDIT LOOPS	NORMAL EDIT LOOPS	K GAMMA	α DWNWT		FORCE

S1	S2	S3	S4	S5	
S6	S7	S8	S9	S10	
			CLEAR		EXECUTE

Figure H-15.- Switch module PBI entries.

H-7.0 STATUS REPORT

The flight director has the capability of checking the readiness and status of each console through the use of the status report PBI's (fig. H-16). A blinking STATUS button indicates that a checkpoint status report is requested. In response, the center operator will depress one of the three color-coded PBI's. Green indicates a ready and problem-free condition, whereas red indicates that a serious problem is being encountered. Yellow would indicate a temporary unreadiness, such as might be encountered with equipment adjustment or any minor problem that can be rectified quickly.

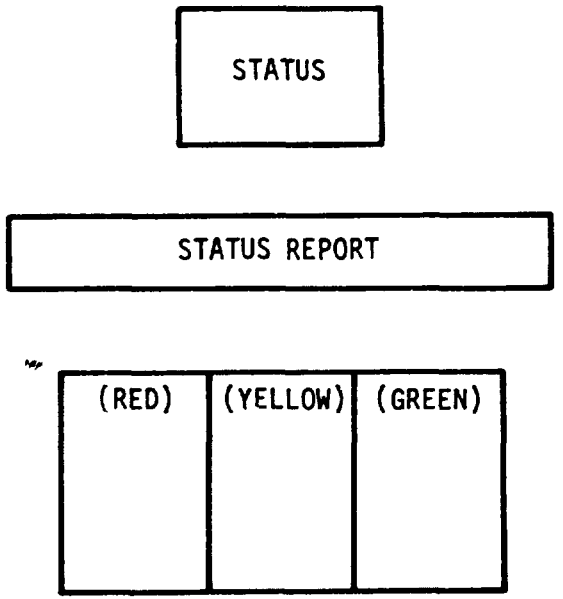

Figure H-16.- Status report PBI's.

APPENDIX I

GUIDE TO ON-LINE ERROR MESSAGES

APPENDIX I CONTENTS

Load module name — Page

This appendix contains the commonly encountered error messages and an explanation and/or corrective action applicable to each. The error messages are grouped under the load module name that will appear on the on-line monitor display along with the error message. The load module names are arranged alphabetically to enable the user to quickly locate the error message explanation and/or corrective action. Because of the similarity of the load module names, an index has also been included to allow reference to the load module name by page number. A copy of the on-line monitor display is included to illustrate the location of the load module name and error message as they will appear on the display screen.

Batch residuals plot processor (BMDPLT)

Display message/on-line message	Corrective action or explanation
ILLEGAL PHASE/ERROR NUMBER 1	Residuals cannot be requested except in OPS phase.
DC NOT INITIALIZED/ERROR NUMBER 2	Perform a DC.
NI ERROR/ERROR NUMBER 3	See BMSTIC error messages.
VECTOR NOT FOUND/(VEC. ID) NOT AVAILABLE	Request a different vector ID.
INITIALIZE BY ENTERING A U18 MED/ERROR NUMBER 5	Enter a U18 MED.
BATCH NOT FOUND/BATCH(ES)____UNAVAILABLE FOR U18 MED	Request a different batch number.
RESIDUALS WERE NOT COMPUTED/ERROR NUMBER 7	See BMRSDC error messages.
BATCH NOT FOUND FOR DRK/ERROR NUMBER 8	Enter a U18 MED to reinitialize batch plot.
NO OBS IN TRANSMITTING BATCH/ERROR NUMBER 9	This batch is in transmission, and no observations have been stored. Request another batch number or request this one again later.
NO INTEGRATED VECTOR, ENTER U18 MED/ERROR NUMBER 11	NBP DRK was entered prior to U18 MED; enter U18 MED with an integrated vector.
BATCH IS THREE WAY/ERROR NUMBER 12	Processing three-way data is not allowed in OFT (when this batch is closed, it will be deleted).

Residuals summary processor (BMDRESID)

Message (display only)	Corrective action or explanation
INVALID PHASE	Residual requests are valid in OPS phase only.
NO U19 ENTERED	Enter a U19 MED to initialize vector residual summary.
VECTOR NOT AVAILABLE	Enter available vector on U19 MED.
NO DC YET	Perform a DC.
NO DATA IN CHAIN	No batches available in data chain for display.
INTEGRATION ERROR	See BMSTIC error messages.
NO RESIDUALS COMPUTED	See BMRSDC error messages.

Load module BMEDTC

Message	Corrective action or explanation
INPUT BATCH LIST NOT AVAILABLE IN CHAINING TABLE	Check requested batch numbers (on S06 or S08 MED) against the vehicle batch summary. Input a different set of batches.
A NON-ZERO DELTA V MANEUVER IN BATCH LIST TIME SPAN	A maneuver was found within the batches requested. Input a different set of batches.
ERROR RETURNED FROM BMSTIC - NO EPHEMERIS	See BMSTIC error messages.
ERROR RETURN FROM BMRSDC - EDIT/RESIDUAL MODULE	See BMRSDC error messages.
ERROR RETURN FROM BMSVCTL - VECTOR FETCH - CHECK INPUT VECTOR ID	Input a different vector ID.
NO VALID DEFAULT VECTOR - S06, S08	Perform a DC or input a vector ID.

Load module BMMAN

Message	Corrective action or explanation
MANEUVER UNCERTAINTIES SIGMA(A) = (attitude) SIGMA(P) = (acceleration) SIGMA(W) = (weight) Example: MANEUVER UNCERTAINTIES SIGMA(A)= .220E-02 SIGMA(P) = .230E-03 SIGMA(W) = .7	Printed whenever a covariance matrix is propagated through a maneuver.

Load module BMMPRI

Message	Corrective action or explanation
SMALL THRUST CONSIDERED IN FREE FLIGHT PROPAGATION INTERVAL	Printed whenever a small thrust (S21) MED is input during a DC propagation interval.

Load module BMMTPE

Message	Corrective action or explanation
BATCH(ES)__ __UNAVAILABLE FOR S11 MED	Check batch(es) requested against the vehicle batch summary. Input new batches.

Residuals math processor (BMRSDC)

Message (on-line only)	Corrective action or explanation
BMRSDC CANNOT BUILD RNP TABLES	Size of the RNP exceeds buffer (or error from EMLOAD). Try again later.
RESIDUALS CANNOT BE COMPUTED FOR (code) STATUS BITS (TUVW)	The residual computations failed 'code' corresponds to the reason residuals were being computed: Value of code — Reason ED-CNTRL — S06 or S08 MED (editing). 1577-9 — Residual summary 1580-1 — residual batch plot or ΔT processor. Status bits (TUVW) are 4 HEX numbers, as follows: T corresponds to the function that failed. T - value — Failing function 4 — Doppler frequency comps. 3 — Speed of light delay. 2 — Vector rotation routine. If T equals 4 or 3, then UVW describes the reason the function failed: U - Value — Reason 4 — The ephemeris was not in either the M50 or the TEI coordinate system. 2 — The iterative procedure used to estimate T_V or T_{TR} failed to converge after 10 loops.

Residuals math processor (BMRSDC) - Continued

Message (on-line only)	Corrective action or explanation	
	U - value	Reason
	1	A rotation (if the ephemeris was in M50) was not completed in the coordinate system transformation function.
	V - value	Reason
	8	Less than two vectors were provided.
	4	Invalid order of interpolation was requested.
	2	Time for requested interpolation precedes first time in ephemeris.
	1	Time of requested interpolation exceeds ephemeris end time.
	W - value	Reason
	8	Amount of extrapolation required exceeds allowable limit on left side.
	4	Amount of extrapolation required exceeds allowable limit on right side.

Residuals math processor (BMRSDC) - Concluded

Message (on-line only)	Corrective action or explanation	
	W - value	Reason
	2	Order of extrapolation performed was less than the order of interpolation requested.
	1	Extrapolation was performed.

Note that not all of the above are mutually exclusive. If more than one condition occurs, the error code will equal the sum of the corresponding HEX values (i.e., if extrapolation was exceeded on the left, and extrapolation was performed - W will equal 9 (8 + 1)).

Load module BMSBURN

Message	Corrective action or explanation
UNABLE TO FIND DESIRED MANEUVER IN CURRENT MPT	Maneuver does not exist in current mission plan table for this vehicle. (Anchor time is less than burn initiate time of the maneuver.)

The following four messages are the result of nonfatal errors from the powered flight numerical integrator. In all cases, integration proceeds to normal end conditions.

MAX. NUMBER OF VECTORS STORED IN EPHEMERIS TABLE

MAX. TURNING RATE EXCEEDED FOR GUIDED MANEUVERS

M50 VELOCITY-TO-BE-GAINED VECTOR = ZERO

NO CONVERGENCE, MAX. ITERATIONS EXCEEDED

The remaining BMSBURN messages are the result of fatal errors from the powered flight numerical integrator. In all cases, integration is terminated, and the state vector at error condition is output as the burnout vector.

PROP. FUEL OR TOTAL VEH. WEIGHT HAS GONE TO ZERO
(Propulsion system fuel weight or total vehicle weight is zero)

IMPACTED PRIOR TO REACHING END CONDITIONS (Note 1)

TOTAL VEHICLE WEIGHT HAS GONE BELOW WEIGHT LIMIT (Note 1)

NO PHYSICAL SOLUTION (Note 2)

HYPERBOLIC TRAJECTORY (Note 2)

TIME FROM BI TO RCS OFF INPUT - BUT WRONG THRUSTER

INPUT THRUSTER UNACCEPTABLE FOR PEG GUIDANCE

INVALID PFNI THRUSTER CODE SPECIFIED (Note 3)

Note 1 - Error encountered in Runge-Kutta integration.

Note 2 - Error from linear terminal velocity constraint routine.

Note 3 - The correlation between guidance mode and allowed thruster codes are given in the following matrix:

Load module BMSBURN - Concluded

Message	Corrective action or explanation
Guidance mode(s)	Thruster codes
P4A, P4D, M50, P7, RES	PXH, MZH, OL, OR, OBP, OBC
BFI	PXH, PXL, MXL, YL, MYL, ZH, ZL MZH, MZL, M, OL, OR, OBP, OBC

Load module BMSDCC

Message	Corrective action or explanation
DC RNP MATRICES NOT LOADED	Error from RNP matrix loader (EMLOAD error return).
DC INTEGRATION ERROR	OD integration control error (see BMSTIC error messages).
DC CONVERGENCE PROCESSOR ERROR	(see convergence errors below).
DC TERMINATED BY STOP IMMEDIATE MED	S09 MED was entered with STOP parameter.
INPUT COVARIANCE INVERSION ERROR; WILL DO SS1 SOLUTION	Error in convergence initialization - warning only.
OUTPUT COVARIANCE INVERSION ERROR; PROCESSING CONTINUES	Error in DC convergence - warning only.

Convergence errors - One of the following errors was encountered by the DC convergence processor:

1. Too few vectors in the ephemeris.
2. Trajectory defined by the ephemeris cannot be handled.
3. All data were tagged negative and therefore were not used.
4. Fatal error return from generalized speed-of-light delay routine.
5. Angle value too large.

(Vector ID) VEH (N) COVI = (N) W (NN) = EDIT (NN) = ITER (N) = D2 (N) = D3 (N) = R (N) = A1 (N) = A2 EMAX = (N) DEG	Printed at end of DC solution and covergence processing.

Example:

```
PCSB002 VEH 3 COVI = + 4W 00 = EDIT 03 = ITER 24 = D2 0 = D3 25 = R 25 = A1
25 = A2 EMAX = 10 DEG
VEC = +0.354821633 -0.838758481 _____ (etc.) _____ _____
COR = -0.000026504 +0.000041764 _____ (etc.) _____ _____
DIAG = 33.736 10.692 27.691 0.388 0.077 0.589
FOM = 11.589 TRACE OUT = +1.49E-08 TRACE IN = +1.12E-07 VEH WEIGHT = 191275.6
IMODE = AVM BIASES
```

In this example, the covariance indicator (COVI) = +4, the number of edit loops (EDIT) is zero, number of iterations (ITER) is three, two-way Doppler (D2) = 24, three-way Doppler (D3) = 0, the range (R), X-angle (A1), and Y-angle (A2) each equal 25, and maximum elevation (EMAX) = 10 degrees. Also, the vector (VEC), correction (COR), covariance diagonal (DIAG), figure of merit (FOM), trace out, trace in, vehicle weight, and integration mode (IMODE) are printed. (There are no biases.)

Load module BMSINT

Message	Corrective action or explanation
INVALID PHASE FOR DC	DC processing is only valid in OPS phase.
DC SUPPRESSED	Enter S10 MED.
(Vector) NOT FOUND	Enter a valid vector ID.
DC ANCHOR VECTOR FOR VEHICLE (N) AT (GMT) ___ ___ ___ ___ ___ ___	Printed after S20 MED - specified vector is integrated to B/B DC initialization time.

Example:

DC ANCHOR VECTOR FOR VEHICLE 3 AT 079/12/33/20.00
-0.687057472 0.459298304 -0.620301882 _____ (etc.) _____

Load module BMSLPC

Message	Corrective action or explanation
BURN NI ERROR (No.) VEHICLE (No.)	A fatal error was detected from the powered flight numerical integrator. See BMSBURN errors for messages output prior to this message.
ILLEGAL REQUEST FOR BACKWARD INTEGRATION	A maneuver was encountered within backward integration. Request DC for interval that does not include a maneuver or with forward integration.

Load module BMSMED

Message	Corrective action or explanation
REQUESTED BATCH NOT FOUND	Check batch number input on the S07 MED against the vehicle's batch summary table. Request a different batch.
REPEAT BATCH NOT FOUND	The repeat batch is the batch that occurs before the batch requested on the S07 MED. Request a different batch.
ARRAY IS FULL, (batch #), NOT ACCEPTED	The SB override table is full (max. number is 30). No batches on the S15 MED after the printed batch numbers were put in the table. Use the S14 MED to delete all entries in the list.

Load module BMSPBI

Message	Corrective action or explanation
INVALID PBI COMBINATION ENTERED	Check inputs against PBI table below (notes 1, 2, and 7).
DC PBI ENTERED IN INVALID PHASE	DC PBI's are allowed in OPS phase only.
DC SUPPRESSED - PBI REJECTED	Enter a S10 MED to unsuppress DC.
DC IS NOT WAITING - PBI REJECTED	Check inputs against PBI table below (note 3).
INVALID MODE - PBI REJECTED	Check inputs against PBI table below (notes 4, 5, and 6).

PBI table

PBI number	PBI name	Note(s)
M08T0101P	Shuttle	7
M08T0102P	Payload	7
M08T0103P	BB mode	1
M08T0104P	SB mode	
M08T0105P	Accept	2,3
M08T0106P	Reject	3,4
M08T0107P to	SS1 to	3
M08T0110P	SS4	3
M08T0111P	Zero edit loops	5
M08T0112P	Normal edit loops	5
M08T0113P	K-gamma	3
M08T0114P	Alpha downweight	3,4
M08T0115P	Force	3
M08T0116P to	S1 to	6
M08T0125P	S10	6

Notes: 1. May be entered with the zero edit or normal edit loops.
2. If SB mode, must be entered with S1, S2,..., or S10.
3. A DC solution for the current mode must be waiting for a decision.
4. Valid in BB mode only.
5. Valid in BB mode only or when entered with a BB mode PBI.
6. Valid only in SB mode and when entered with an accept PBI.
7. Exactly one vehicle must be ertered.

DC PBI ENTRIES: (PBI, names) — Printed if PBI's entered
(Vector ID) ACCEPTED — with ACCEPT or REJECT.
REJECTED

Load module BMSPBI - Concluded

Message	Corrective action or explanation
Example:	
DC PBI ENTRIES: M08T0102P, M08T0105P, ORRS0001 ACCEPTED	
DC PBI ENTRIES: (PBI, names)	All other valid PBI combinations.

Load module BMSQDC

Message	Corrective action or explanation
STARTER ERROR NBR -	Error detected in starter processor. The explanation of the numbers are as follows: 1. Work area not available. 2. Not more than two observations. 3. Error from vector conversion. 6. Exceeded maximum iterations. --. Perform starter processing over a different batch.
BB AFTER EB TIME	Specify a superbatch begin batch that is prior to the end batch.
MANEUVER IN SUPERBATCH	Perform the superbatch over a different set of batches.
BBN OR EBN IS EXCLUDED	Superbatch begin batch or end batch has been excluded via the S15 MED. Enter the S14 MED with the delete option to include all excluded batches
VECTOR NOT AVAILABLE	Specify a vector that is available.
BBN NOT AVAILABLE	The begin batch for a SB is not available; specify a different begin batch on the S17 MED.
EBN NOT AVAILABLE	Superbatch end batch is not available; specify a different end batch on the S17 MED.
DATA NOT AVAILABLE	Data are not available to perform the next batch-to-batch DC; wait for a batch to EOT.
TOO MANY BATCHES IN SB	More than 80 batches have been specified for a SB; specify a different set of batches.
DC SUPPRESSED	Enter the S10 MED.
DC IS IDLE	SS1, SS2, SS3, SS4, force, K-gamma, or K-alpha PBI was entered when a DC was not waiting.

Load module BMSQDC - Concluded

Message	Corrective action or explanation
WRONG DC MODE (Example: cannot use the "reject" PBI while in super-batch mode)	Reject PBI, K-alpha PBI, or S10 start MED was entered in the wrong mode.
SS4 NOT AVAILABLE	An SS4 PBI was entered for a superbatch that was not performed with a DC vector. (SS4 is valid only with DC current solution, BB history, or SB vector table batches.)
BATCHES IN SB HAVE CHANGED	SS1, SS2, SS3, SS4, force or K-gamma PBI was entered for a SB, and at least one of the batches from the original SB has been deleted.
STARTER BATCH NOT FOUND	The batch specified for STARTER was not available; specify a different batch.
INVALID PHASE FOR DC	DC processing is only valid in OPS phase.
ERROR FROM BMSLPC	An error was encountered during propagation (see BMSLPC error messages).
FORCE NOT ALLOWED AFTER MISHAP. LT.15	The force PBI is not allowed after a DC that has encountered a catastrophic error.

Load module BMSTIC

When BMSTIC detects an error, a two part error message is printed on-line. The first part indicates the category of error and the error number within the category.

Message	Corrective action or explanation
MISC NI ERROR XX	This indicates an error from the numerical integration supervisor. The error number XX indicates one of the following: 1. Input time cannot be referenced on the Sun/Moon ephemeris. 2. MPT is being updated. 3. Error from maneuver integrator. 4. Integration stopped by P80 MED. 5. Incomplete ephemeris received. The ephemeris does not span the entire time period requested. 6. Ephemeris space filled before request satisfied. 7. Integration went below the surface of the Earth. 8. Maximum time not reached because of failsafe limits. 9. Error from preprocessor.
BACKWARD INTEGRATION ERROR XX	This indicates that an error was encountered while integrating backwards. Error number XX indicates one of the following: 1. Anchor vector below 300 000 feet. 2. Through a maneuver; when backwards integration and consideration of maneuvers are requested, NI control will read the MPT and determine if there are maneuvers (except zero ΔV) within the period of backwards integration.

Load module BMSTIC - Concluded

Message	Corrective action or explanation
VECTOR ROTATION ERROR XX	An error was received from the vector rotation routine. Error number XX indicates one of the following: 1. Input time outside Sun/Moon ephemeris. 2. Invalid reference indicator input.
NI CONTROL ERROR XX	This error code includes errors encountered in NI control logic that are not common enough to warrant separate error messages. Error number XX indicates one of the following: 1. Invalid job code received. 2. Invalid profile code received. 3. Anchor time of zero. 4. T-left not less than T-right. 5. TUP flag indicates that a trajectory update needs to be performed. 6. Anchor vector below the surface of the Earth.

Load module BMSVCTL

Message	Corrective action or explanation
)BMSVCTL(- INVALID SLOT ID.	An invalid VAT slot ID has been input to the vector control processor. Doublecheck your MED inputs. Could occur as a result of bad inputs on a variety of MED's (i.e., S82, S83, S84, S85, S86, P16, U02, etc.)
)BMSVCTL(- VECTOR ROTATION FAILED.	An invalid coordinate system conversion has been requested of vector control processing. Doublecheck any coordinate system indicators that you have put on MED's.
)BMSVCTL(- VECTOR NOT AVAILABLE	A request for a vector from a VAT slot has been made and no vector was in the slot. Double check the VAT slot ID on your MED.
)BMSVCTL(- INVALID NUMERIC IN NAME.	A vector name specified for a vector input into the VAT is incorrect. The correct format is as follows: XXXXYYY where: XXXX = one to four valid alphabetic characters YYY = 0-999 numeric
)BMSVCTL(- INTEGRATION NOT ALLOWED.	On the S85 MED, a vector fetch ID and fetch time from an ephemeris have been specified in conjunction with "I" for integrate. This is not allowed. The time parameter is assumed to be the interpolation time for (EV1-4, 1-4, E, W, S).
)BMSVCTL(- INT. ERR - TIME NOT IN SUN MOON	On an S85 integrate, an NI error was encountered. Time was not within the bounds of the Sun/Moon ephemeris.

Load module BMSVCTL - Concluded

Message	Corrective action or explanation
)BMSVCTL(- INT. ERR - MPT UPDATE BUSY.	On an S85 integrate, an NI error was encountered. The MPT was in update status.
)BMSVCTL(- INT. ERR - MNVR.INTERFERES	On an S85 integrate, an NI error was encountered. A maneuver was within the interval and a minimum number of vectors was not generated.
)BMSVCTL(- INT. ERR - STOPPED BY P80.	On an S85 integrate, an NI error was encountered. The integration was halted by the P80 MED.
)BMSVCTL(- INT.ERR-MNVR.INT.ERROR	On an S85 integrate, an NI error was encountered. A maneuver integrator error occurred.
)BMSVCTL(- INT.ERR.-IMPACTED W/DRAG.	On an S85 integrate, an NI error was encountered. The trajectory impacted on the Earth's surface while drag was being applied.
)BMSVCTL(- INT.ERR-FAILSAFE ON TMAX	On an S85 integrate, an NI error was encountered. The TMAX time was not reached due to the failsafe integration limit.
)BMSVCTL(- INT. ERR-PREPROCESSOR ERR	On an S85 integrate, an NI error was encountered. The timeline construction was in error.

Load module EIGBHA

Message	Corrective action or explanation
)EIGBHA(DELTA TIME FROM EPHEMERIS TIME TO UNIVERSAL TIME CORRECTED IS XXX SECONDS.	This message is output to show the calculated ET/UTC value as a result of the P80 processing.

Load module EMEPHEM

Message	Corrective action or explanation
)EMEPHEM(- DYNAMIC ALLOCATION OF THE SUN/MOON TAPE DRIVE HAS FAILED.	This error message is output when YES has been specified on the P80 MED and the dynamic tape drive allocation for the Sun/Moon tape has failed. This is usually due to the lack of an available tape drive. The P80/YES can be retried when the drive is available. The result of the failure is a default to NO processing. No new Sun/Moon data is read in.
)EMEPHEM(- DYNAMIC DEALLOCATION OF THE SUN/MOON TAPE DRIVE HAS FAILED	This error message is output on completion of reading new Sun/Moon data into the computer using the P80/YES processing. The deallocation failure indicates a potential tape drive error that should be brought to the attention of operations. The new launch day and Sun/Moon data have been initialized properly by the time this error occurs.

Load modules EMSAVTUP

Message	Corrective action or explanation
)EMSAVTUP(ORBIT EPHEMERIS PROFILE X CHANGED TO "STATIC or LIVE"	This message is output to notify the user of a profile status change. The status is input on the P16. The default is no change and the profiles are preinitialized to static.
)EMSAVTUP(- NO START TIME ALLOWED FOR LIVE EPH.	Using the P16 MED, a static start time was specified with a live update request. The trajectory update request was rejected. No static start time is needed.
)EMSAVTUP(- ANCHOR VECTOR FETCH FAILED.	The source ID specified on the P16 MED (first item) was an invalid vector control ID. Correct input.
)EMSAVTUP(- FETCH TIME REQUIRED FOR INTERPOLATION	On a P16 MED, a source ID was specified that requires interpolation from an existing ephemeris and no fetch time was specified (i.e., EV1-4, 1-4, E, W, S).
)EMSAVTUP(MPT TRANSFER REJECTED. FROM ID NOT A VALID MPT.	On a P16, a request to transfer MPT header values from one profile to another was indicated with the "T" option. However, the source ID was not a valid profile ID (i.e., 1-4, E, W, S).

Load module EMSEPH

Message	Corrective action or explanation
)EMSEPH(- ZERO VECTORS RETURNED FROM EMSMISS - UPDATE TERMINATED	During a trajectory update, a return from the numerical integration supervisor showed that no ephemeris was generated. The trajectory update was prematurely cancelled. Look for other on-line error messages to identify the exact cause of the failure.
)EMSEPH(EPHX AT "EI or KO" ALTITUDE GMT = HHHH/MM/SS.TH LAT = XXX LONG = XXX	This message is output when the trajectory strikes kickout (KO) or entry interface (EI) while storing ephemerides during a trajectory update. In addition to the event time, the subsatellite coordinates are displayed.
)EMSEPH(- EPHEMERIS UPDATE COMPLETED.	This message is output at the completion of the trajectory update.
Status messages	
)EMSEPH(EPHX EPHEMERIS LIMITS DDD/HH/MM/SS.TH To DDD/HH/MM/SS.TH (GMT)	This message is output at the end of a trajectory update to notify the user of the begin and end time of the new ephemeris.

Load module EMSMISS

Message	Corrective action or explanation
)EMSMISS(- ERROR RETURN FROM MANEUVER INTEGRATOR. ERROR CODE = X MANEUVER NO. = XX	This error message is output when the powered flight numerical integrator (EMPFNI) returns an error code that indicates a valid integration was not performed. The potential PFNI error codes are as follows: 5 Propulsion system fuel weight or total vehicle weight has gone to zero (second derivative routine) 6 Impacted before reaching end conditions (Runge-Kutta routine) 7 Total vehicle weight has gone below weight limit (Runge-Kutta routine) 8 No physical solution (fatal PEG error with IABORT=1) 9 Hyperbolic trajectory (fatal PEG error with IABORT=2) 10 Delta time from ignition to RCS off for OPS-1 parallel OMS/RCS maneuver is input, but wrong thruster is selected (fatal PEG error with IABORT=5) 11 Input thruster unacceptable for PEG guidance (fatal PEG error with IABORT=6) 12 Invalid PFNI thruster code specified (executive routine)

Load module EMSVCT

Message	Corrective action or explanation
)EMSVCT(- EPHEMERIS GENERATION FAILED.	The trajectory update has failed to build an ephemeris. Look for another on-line message to identify the exact cause of the failure.
)EMSVCT(- ANCHOR VECTOR MOVE FAILED - TUP CANCEL	The attempted integration of the anchor vector from the fetch time to the ephemeris begin time has failed. The trajectory update is cancelled. Look for another on-line message to identify the exact cause of the failure.
)EMSVCT(- N.I. ERROR CODE = XX	Numerical integration has failed. This explains other error messages referring to the trajectory update failure. The error codes and their meanings are as follows: 1. Integration request time was outside the limits of the available Sun/Moon data. 2. MPT update already in progress. 3. Maneuver integration error. 4. Integration using ENCKE stopped by P80 MED. 5. Maneuver prevents generation of the minimum number of vectors requested (minimum = 8 vectors). 6. Ephemeris filled prior to reaching stop time. 7. Integration reached the surface of the Earth with drag being applied. 8. Integration reached failsafe limits. 9. Preprocessor error (i.e., failure in timeline construction).

Load module EMSVCT - Concluded

Message	Corrective action or explanation
)EMSVCT(INVALID QUEUE ID. TRAJECTORY UPDATE CANCELLED.	This situation should not occur and is DRable.

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Load module EMTRAJ

Message	Corrective action or explanation
)EMTRAJ(, PROFILE ID = X/"anchor vector ID" "vehicle weight" GMT = DD/HH/MM/SS.TH X = Y = Z = CSI = 'coor. system ID' R = "rev. #" XV = YV = ZV =	This message is output at the end of a trajectory update to display the anchor vector in Cartesian format.
)EMTRAJ(- "profile #" ORBITAL ELEMENTS FOR UPDATE NO. "TUP #" A = XXX NM MEAN ANOMALY = XX DEG H (AP) = XXX NM I = XXX DEG ARG.PERIGEE = XXX DEG H (PER) = XXX NM E = XXX ARG. ASCEND.NODE = XXX DEG	This message is output at the end of a trajectory update to display the anchor vector in Keplerian elements.

Load module EMUVTIME

Message	Corrective action or explanation
)EMUVTIME(DELTA TIME FROM EPHEMERIS TIME TO UNIVERSAL TIME CORRECTED IS XXX SECONDS. THE NEW UNIVERSAL TIME CORRECTED IS XXX SECONDS.	This message is output to show the old and new values for ET/UTC as a result of a P79 (leap - second) update.

Load model EMVENTBL

Message	Corrective action or explanation
)EMVENTBL(WARNING - CHANGES MADE TO THE "VTL or VIT" ARRAY MAY NOT BE REFLECTED IN EPHEMERIS X	This message is output to notify the user that the vent timeline or vent initialization table has been modified and that an ephemeris using venting may be affected.
)EMVENTBL(XXXX ARRAY IS FILLED.	A P42 or P43 MED request to add an entry to the VTL, RVTL, or VIT has failed. The indicated table is already full. The table limits are as follows: VTL - 200 entries RVTL - 50 entries VIT - 50 entries
)EMVENTBL(AN ENTRY ALREADY EXISTS IN THE XXXX ARRAY WITH THIS VENT-ID AND TIME TAG. XXXX DDD/HH/MM/SS.TH	Using the P42 MED, an attempt to add or modify an entry in the indicated array (VTL or RVTL) has failed. No two entries can have the same vent ID and start time.
)EMVENTBL(VENT-ID XXXX ALREADY EXISTS IN THE VIT ARRAY.	Using the P43 MED, an attempt to add the indicated vent ID to the VIT has failed. The ID already exists in the table. A delete is required first.
)EMVENTBL(ENTRY NUMBER XXX DOES NOT EXIST IN THE XXXX ARRAY.	Using the P42 and P43 MED, an attempt to modify (P42 only) or delete the indicated entry has failed. No entry by that number existed in the indicated array. An add or a corrected entry number is required.
)EMVENTBL(VTL DISPLAY TIME IS GREATER THAN THE TIME OF THE LAST VENT ENTRY (DDD/HH/MM/SS.TH).	Using the P44 MED, a VTL display time was specified that was greater than the end time of the last entry in the table. The P44 time must be less than the indicated end time.

Load model EMVENTBL - Concluded

Message	Corrective action or explanation
)EMVENTBL(VENT-ID XXXX HAS NOT BEEN DEFINED IN THE VENT INITIALIZATION ARRAY.	Using the P42 MED, an attempt to add a vent entry to the VTL or RVTL has failed. The vent ID specified does not exist in the vent initialization array. The P43 MED can be used to add the vent definition to the vent initialization table (VIT).
)EMVENTBL(VENT-ID XXXX CAN NOT BE DELETED FROM VENT INITIALIZATION. VENT-ID IS IN VTL OR RVTL.	Using the P43 MED, an attempt to delete a vent ID from the VIT has been rejected. The vent ID is currently being referenced in the VTL or RVTL. It must be removed from the VTL and RVTL with a P42 MED first.
)EMVENTBL(XXXX ARRAY, ENTRY NUMBER XX, VENT START TIME (DDD/HH/MM/SS.TH) IS GREATER THAN THE VENT END TIME (DDD/HH/MM/SS.TH).	Using the P42 MED, an attempt to add or modify an entry in the VTL or RVTL has resulted in the vent start time being greater than the vent end time. The request is rejected. The begin and end times must be placed in the proper order.

Load module EMWGTABL

Message	Corrective action or explanation
)EMWGTABL(CARGO BAY DOOR STATUS ARRAY IS FILLED.	An attempt to add an entry to the cargo bay door status table with the P41 MED has failed. The table holds a maximum of 10 entries.
)EMWGTABL(CARGO BAY DOOR STATUS ARRAY GMT DDD/HH/MM/SS.TH ENTRY NOT FOUND	A P41 delete request to the cargo bay door status table has failed. No entry exists within the nearest second to the specified time.
)EMWGTABL(CARGO BAY DOOR STATUS ARRAY. AN ENTRY ALREADY EXISTS WITH THIS TIME TAG. DDD/HH/MM/SS.TH	A P41 add request to the cargo bay door status table has failed. An entry already exists at the indicated time.
)EMWGTABL(WEIGHT LOSS/GAIN ARRAY XX IS FILLED	An attempt to add a weight loss/gain entry to the indicated table has failed using the P40 MED. Each of the four weight loss/gain tables is limited to 75 entries. An existing entry must be deleted before an addition can be made.
)EMWGTABL(WEIGHT LOSS/GAIN ARRAY XX GMT DDD/HH/MM/SS.TH ENTRY NOT FOUND.	A request through the P40 MED failed to modify or delete an entry at the specified time because no entry was found with a time tag within the nearest second.
)EMWGTABL(WEIGHT LOSS/GAIN ARRAY XX AN ENTRY ALREADY EXISTS WITH THIS TIME TAG	Using the P40 MED, an add request has failed. An existing entry is within $\pm$5 seconds of the time specified. A different time or a modify is required.

ON-LINE MONITOR DISPLAY

		On-line monitor	0005 0005 A +	
Real time - GMT	Simulation time	User ID	Load module	Message
011:02:11:57.1 ER 3	116:17:36:57.1	*NV*	)BMDPLT (	ERROR NUMB
011:02:10:02.5 ER 3	116:17:35:02.5	*NV*	)BMDPLT (	ERROR NUMB
011:02:09:51.7 ER 3	116:17:34:51.7	*NV*	)BMDPLT (	ERROR NUMB
011:02:05:42.9 T DATA SET REACHED	116:17:30:42.9	*NV* 001 RT	)EMXLSTDR(	END OF INPU
011:02:02:15.5 EPTABLE	116:17:27:15.5	*DY*	)EMPAEG (	INPUT UNACC
011:02:02:15.5 EPTABLE	116:17:27:15.5	*DY*	)EMPAEG (	INPUT UNACC
011:02:02:15.5 EPTABLE	116:17:27:15.5	*DY*	)EMPAEG (	INPUT UNACC
011:02:02:15.5 EPTABLE	116:17:27:15.5	*DY*	)EMPAEG (	INPUT UNACC
011:02:02:15.5 EPTABLE	116:17:27:15.5	*DY*	)EMPAEG (	INPUT UNACC
011:02:02:12.0 EPTABLE	116:17:27:12.0	*DY*	)EMPAEG (	INPUT UNACC