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COMPARISON OF NAVIGATION SYSTEMS IN EARTH ORBIT

By Michael J. Oles, USAF

Mathematical Physics Branch

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CONTENTS

Section	Page
SUMMARY	1
INTRODUCTION	1
The S-IVB IU Navigation System	2
The CM Navigation System	2
Ground Navigation System	3
ANALYSIS	3
RESULTS	4
CONCLUSIONS	5
APPENDIX A - EARTH PARKING ORBIT PROCEDURES	17
APPENDIX B - TRANSLUNAR INJECTION MANEUVER PROCEDURES	39
APPENDIX C - TRANSLUNAR PHASE PROCEDURE	61
REFERENCES	65

COMPARISON OF NAVIGATION SYSTEMS

IN EARTH ORBIT

By Michael J. Oles, USAF

SUMMARY

Three procedures have been studied to determine which best utilizes the capabilities of the S-IVB instrumentation unit (S-IVB IU), command module (CM), and ground navigation systems during the earth parking orbit (EPO). The procedures are (1) using the S-IVB IU alone, (2) combining the IU and ground, and (3) combining the CM system and ground. The systems were evaluated by determining the velocity required (i.e., ΔV cost) for the first translunar midcourse correction (MCC) using existing error analysis programs.

The results of the study show that it is desirable, but not necessary, to update the S-IVB IU estimate of position and velocity in the EPO. If the CM navigation system is prime for navigating through the TLI maneuver, it is desirable to perform an inertial platform alignment in EPO. The S-IVB IU platform drift in EPO appears to contribute greatly to the ΔV cost of the first MCC.

The study indicates that, for the first 10 hours after translunar insertion (TLI), the time the first MCC is performed does not significantly influence the size of the correction. The ΔV cost does not seem to differ for various launch azimuths, lunar declinations at pericynthion, and the constraints they cause on the tracking profiles.

The ΔV costs presented in this report should not be considered as being actual; rather, they should be considered as criteria for comparing the three navigation systems.

INTRODUCTION

In the earth orbit phase of the Apollo lunar landing mission there are three navigation systems operating - the S-IVB IU, the CM guidance and navigation equipment, and the ground tracking complex. For convenience, the S-IVB navigation system, hardware, and software will be referred to as the IU in this report. To determine the navigation procedure which best utilizes these capabilities, estimates of the uncertainty in position and velocity were computed and evaluated in terms of the first midcourse correction for three navigation procedures - IU

alone, IU and ground, and CM and ground. In studying the procedures the following areas were investigated:

1. Whether to update the IU estimate of position and velocity with the ground estimate.

2. The use of CM instead of IU navigation to execute the TLI maneuver.

3. The effects of platform misalignment and other hardware errors on the first MCC ΔV cost.

4. How the time of the first MCC affects ΔV cost.

5. The influence of launch azimuth and lunar declination at pericynthion on the first MCC ΔV cost.

The S-IVB IU Navigation System

The IU contains a navigation system which can maintain an estimate of position and velocity (R and V) throughout the launch phase, earth parking orbit (EPO) phase, and TLI maneuver. During the EPO phase, the IU integrator includes the effects of an atmospheric model, a venting model, and four zonal harmonics, but no accelerometer readings.

During the launch phase and the TLI maneuver, the IU accelerometers, which are attached to an inertially oriented platform, measure vehicle accelerations due to thrust. These acceleration measurements are passed to a predictor which integrates thrust acceleration as well as the gravitational accelerations (including the effects of two zonal harmonics) to obtain R and V.

A ground-computed R and V may be transmitted during EPO to replace the IU-computed R and V. Replacement of the onboard-computed vector by a ground-computed vector is called an update.

Although it may drift from its inertial orientation, the inertial platform within the IU cannot be realigned after the launch phase has begun.

The CM Navigation System

The CM contains a navigation system which is capable of maintaining an estimate of R and V during the entire lunar landing mission. Because its free-flight integrator does not consider atmospheric or venting accelerations, the CM estimate of position and velocity during EPO will be updated prior to TLI. During EPO, the CM inertial platform may be realigned. The thrust accelerations during powered flight are measured

by accelerometers attached to an inertial platform within the CM. These readouts are passed to its predictor which integrates the gravitational and thrust accelerations.

Ground Navigation System

The ground navigation system can determine an estimate of the vehicle's position and velocity during all mission phases. The following sources of information can be used to obtain this estimate:

1. A global network which includes unified S-band (USBS) and C-band tracking facilities.

2. IU- or CM-computed R and V vectors telemetered to the Real-Time Computer Complex (RTCC).

3. Vehicle vectors computed by RTCC free- and powered-flight integrators.

The information obtained from these three sources can be combined at the RTCC to obtain a ground-estimated vector.

During EPO, the RTCC free-flight Encke integrator includes a gravitational model with one tesseral and three zonal harmonics, the perturbative effects of the sun and moon, and venting and atmospheric models. At insertion into earth parking orbit, the IU estimate of R and V may be used by the ground navigation system as its initial estimate. After the TLI maneuver the ground navigation system determines the position and velocity of the vehicle.

ANALYSIS

The three navigation systems were compared in the following manner.

The statistical deviation of the estimated from the actual R and V(covariance matrix) at the start of TLI was computed for the three procedures using various launch azimuths and injection opportunitites (appendix A). These deviations were then propagated through the TLI maneuver considering, as applicable, either IU or CM navigation errors during the maneuver (appendix B). The covariance matrix at the end of TLI represents the deviation of the IU or CM estimate from the actual R and V. This study assumes that if this deviation were zero, the vehicle would pass through the desired TLI target position near the moon; i.e., the estimated and desired R and V were assumed equal at TLI cutoff. The covariance matrices at TLI cutoff, considered to represent deviations of the actual from the desired R and V, were then propagated to the time of the first MCC. The ΔV cost of the correction

was computed as a function of the covariance matrix at the time of the first MCC (appendix C).

RESULTS

Table I concisely presents first MCC ΔV costs for each of the three combinations of navigation systems. The first MCC was assumed to occur either 5 or 10 hours after TLI. The following discussion refers to the first MCC when made 5 hours after TLI. A comparison of the IU alone against the ground and IU navigation systems combined is presented for a 72.6° launch azimuth and -27.5° lunar declination in table I. These conditions offer a TLI opportunity at 86.0 minutes after EPO insertion (EPOI). If a vector update of the IU occurs 50 minutes after EPOI (see appendix A for the various tracking profiles), the ΔV cost of the first MCC is 3.35 fps. If the same conditions exist and no update is made, the ΔV cost of the first MCC is 4.93 fps.

A second TLI opportunity having a 72.6° launch azimuth and -27.5° lunar declination occurs 260.5 minutes after EPOI; this is probably the longest time expected for the earth parking orbit phase. If an update of the IU estimate is made 228 minutes after EPOI with this TLI opportunity, the midcourse ΔV cost is 8.62 fps. When no update of the IU is made, the ΔV cost of the first MCC is 12.75 fps.

When the TLI opportunity is close to the time of insertion (86 minutes), the difference between the first MCC ΔV cost using both the ground and IU and using the IU navigation alone is about 1.5 fps. When the TLI opportunity is far from insertion (260.5 minutes), the difference is about 4.1 fps.

If the IU inertial platform is considered to drift in the EPO and if the IU is updated 50 minutes in the EPO with an injection opportunity 86.0 minutes in the EPO, the ΔV cost is 3.35 fps. It would be 2.09 fps if the platform did not drift in EPO. The ΔV cost due to platform drift is therefore 1.26 fps.

If the IU is not updated and the TLI opportunity occurs at 260.5 minutes after EPOI, the ΔV cost due to platform drift in earth orbit is 2.77 fps.

A comparison of all three navigation system combinations (IU alone, IU and ground, CM and ground) is also presented in table I. Based on a 90° launch azimuth and a -27.5° lunar declination, a TLI opportunity occurs 176.0 minutes after EPOI. If a vector update of the IU occurs 135 minutes after EPOI, the ΔV cost for first MCC is 5.88 fps; with no update, the ΔV cost is 8.24 fps. If the CM vector is updated, the ΔV cost is 12.6 fps if the CM platform is not realigned in EPO and 8.51 fps if it is realigned.

Table II presents the results in more detail. The table presents the difference between IU and ground combined and the IU alone and the difference between the IU and ground combined and the CM and ground combined. Table III details the ΔV cost at the first MCC as a function of individual error sources. The results in table II and table III are graphed in figures 1 through 4.

CONCLUSIONS

From the results of this study (tables I and II and fig. 1 through 4), the following conclusions are drawn.

1. In view of the small ΔV saving which occurs when the S-IVB IU estimate of position and velocity is updated in EPO, it appears to be desirable, but not necessary, to perform the update.

2. From figure 3 it appears that, up until two revolutions in the EPO phase, the IU performs the TLI maneuver with no update better than the CM can with a platform alignment in EPO and a ground-computed vector update used as the spacecraft's position and velocity vector at the start of TLI. When a ground update of the CM vector has been made as explained in the appendices, but no platform alignment is effected, the ΔV cost of the first MCC always appears to be worse than if the S-IVB IU navigated through the maneuver but had no ground update in EPO.

3. IU platform misalignment appears to be the major contributor to the ΔV cost as portrayed in figures 1 through 3. Figure 3 indicates that it is quite desirable to align the CM inertial platform in EPO.

4. This study indicates that the time the first MCC is performed does not significantly influence the size of the corrections for the first 10 hours after TLI.

5. The ΔV cost of the first MCC did not seem to differ significantly for various launch azimuths, lunar declinations, and the constraints they cause on the tracking profiles, when similar times of TLI opportunities were compared.

TABLE I.- A SUMMARY OF THE ΔV COST OF THE FIRST MCC

(a) IU and ground

Launch azimuth, deg	Lunar declination, deg	Time of TLI in minutes after EPOI	Approximate time of vector update (if applicable), in minutes after EPOI (a)	Navigation systems considered	ΔV cost of the 1st MCC: IU platform drift in EPO considered		No IU platform drift in EPO considered	
					1st MCC 5 hours after TLI	1st MCC 10 hours after TLI	1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
72.6	-27.5	86.0	--	IU	4.93	5.66	4.17	5.03
72.6	-27.5	86.0	50.	IU and ground	3.35	3.47	2.09	2.31
72.6	-27.5	260.5	--	IU	12.75	13.35	9.98	10.82
72.6	-27.5	260.5	228.	IU and ground	8.62	8.75	3.35	3.91
90.0	-27.5	176.0	--	IU	8.24	8.83	6.26	7.08
90.0	-27.5	176.0	135.	IU and ground	5.88	5:94	2.39	2.70

(b) CM

Launch azimuth, deg	Lunar declination, deg	Time of TLI in minutes after EPOI	Approximate time of vector update in minutes after EPOI	Navigation systems considered	ΔV cost of the 1st MCC: CM inertial platform realigned approximately 1/2 hour prior to TLI		No CM inertial platform alignment during EPO	
					1st MCC 5 hours after TLI	1st MCC 10 hours after TLI	1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
90.0	-27.5	176.0	[b]135.	CM and ground	8.51	11.0	12.6	14.4

[a]See Appendix A for ground track profile.

[b]The update was uplinked to the CM at this time, but the values were those predicted by the ground navigation system to the start of TLI.

TABLE II.- ΔV COST OF THE FIRST MCC

(a) IU and Ground

Launch azimuth, deg	Lunar declination, deg	Time of TLI in minutes after EPOI	Approximate time of vector update (if applicable) in minutes after EPOI (a)	Navigation systems considered	ΔV cost of the 1st MCC			
					IU platform drift in EPO considered		No IU platform drift in EPO considered	
					1st MCC 5 hours after TLI	1st MCC 10 hours after TLI	1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
72.6	+27.5	131.0	--	IU	5.28	5.45	3.45	3.78
72.6	+27.5	145.0	--		5.90	6.12	3.92	4.30
72.6	+27.5	218.5	--		9.45	9.67	6.70	7.11
72.6	+27.5	232.5	--		10.17	10.42	7.29	7.74
72.6	+27.5	131.0	90.	IU and Ground	4.34	4.33	1.68	1.80
72.6	+27.5	145.0	90.		4.89	4.94	2.10	2.33
72.6	+27.5	218.5	180.		6.87	6.79	1.67	1.75
72.6	+27.5	232.5	180.		7.28	7.20	1.69	1.75
72.6	-27.5	86.0	--	IU	4.93	5.66	4.17	5.03
72.6	-27.5	101.0	--		5.60	6.32	4.68	5.54
72.6	-27.5	173.0	--		8.27	8.89	6.37	7.21
72.6	-27.5	188.5	--		9.19	9.82	7.17	8.03
72.6	-27.5	260.5	--		12.75	13.35	9.98	10.82
72.6	-27.5	86.0	50.	IU and Ground	3.35	3.47	2.09	2.31
72.6	-27.5	101.0	50.		4.41	4.76	3.15	3.67
72.6	-27.5	173.0	136.		6.10	6.26	3.06	3.49
72.6	-27.5	188.5	136.		6.53	6.60	3.10	3.41
72.6	-27.5	260.5	228.		8.62	8.75	3.35	3.91
90.0	-27.5	168.0	--	IU	7.49	7.92	5.46	6.10
90.0	-27.5	176.0	--		8.24	8.83	6.26	7.08
90.0	-27.5	256.0	--		11.99	12.45	9.09	9.79
90.0	-27.5	168.0	135.	IU and Ground	5.56	5.60	2.16	2.42
90.0	-27.5	176.0	135.		5.88	5.94	2.39	2.70
90.0	-27.5	256.0	197.		8.34	8.37	2.95	3.31

[a]See Appendix A for ground track profile.

TABLE II.- ΔV COST OF THE FIRST MCC - Concluded

(a) IU and Ground - Concluded

Launch azimuth, deg	Lunar declination, deg	Time of TLI in minutes after EPOI	Approximate time of vector update (if applicable) in minutes after EPOI (a)	Navigation systems considered	ΔV cost of the 1st MCC			
					IU platform drift in EPO considered		No IU platform drift in EPO considered	
					1st MCC 5 hours after TLI	1st MCC 10 hours after TLI	1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
108.0	-27.5	85.0	--	IU	4.80	5.50	4.04	4.87
108.0	-27.5	157.5	--		6.67	6.91	4.63	5.04
108.0	-27.5	172.5	--		8.20	8.79	6.29	7.11
108.0	-27.5	244.5	--		11.05	11.35	8.16	8.66
108.0	-27.5	85.0	55.	IU and Ground	3.14	3.20	1.77	1.93
108.0	-27.5	157.5	83.		5.56	5.68	2.80	3.14
108.0	-27.5	172.5	147.		6.00	6.08	2.90	3.19
108.0	-27.5	244.5	172.		9.22	9.49	5.43	6.02

(b) CM and Ground

Launch azimuth, deg	Lunar declination, deg	Time of TLI in minutes after EPOI	Approximate time of vector update in minutes after EPOI.	Navigation systems considered	ΔV cost of the 1st MCC			
					CM inertial platform realigned approximately 1/2 hour prior to TLI		No CM inertial platform alignment during EPO	
					1st MCC 5 hours after TLI	1st MCC 10 hours after TLI	1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
90.0	-27.5	168.0	[b]135.	CM and Ground	8.44	10.9	12.4	14.2
90.0	-27.5	176.0	[b]135.		8.51	11.0	12.6	14.4
90.0	-27.5	256.0	[b]197.		8.68	11.2	14.1	15.7

[a]See Appendix A for ground track profile.

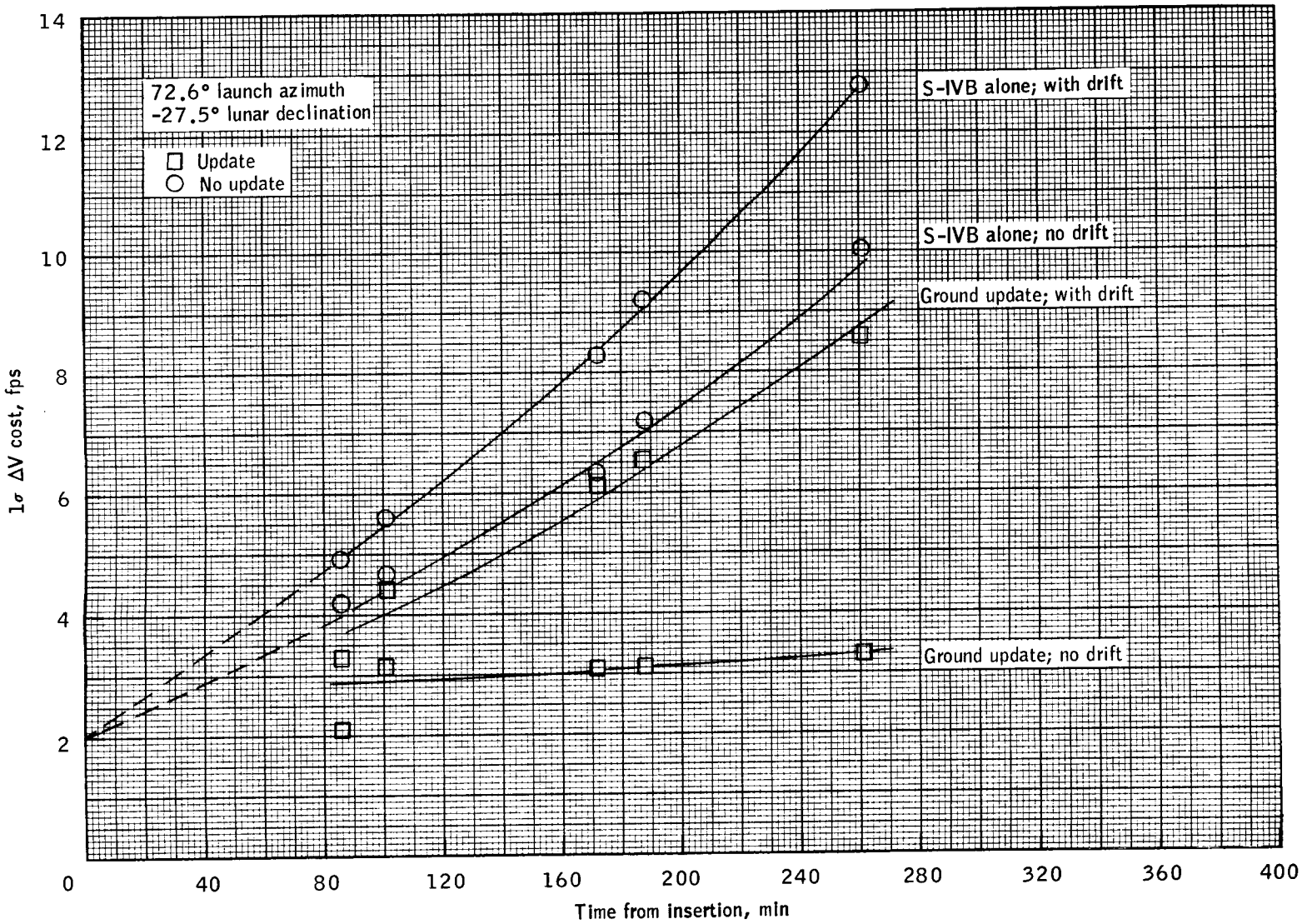
[b]The update was uplinked to the CM at this time, but the values were those predicted by the ground navigation system to the start of TLI.

TABLE III.- EFFECT OF INDIVIDUAL ERROR SOURCES ON THE FIRST MCC

Time of TLI, minutes after EPOI	Approximate time of vector update (if applicable), minutes after EPOI	Individual error sources of the ground and IU.	ΔV cost of the 1st MCC	
			1st MCC 5 hours after TLI	1st MCC 10 hours after TLI
Anytime	Anytime[a]	IU scale factor and bias during TLI. Other IU navigation hardware and software perfect.	0.45	0.60
Launch azimuth and lunar declination not applicable				
86.0	[a]86.0	IU launch pad misalignment and drift to TLI. Other IU navigation hardware and software perfect	2.92	2.88
101.0	[a]101.0		3.34	3.29
173 0	[a]173.0		5.43	5.35
188.5	[a]188.5		5.89	5.80
260.5	[a]260.5		8.04	7.92
72.6° Launch azimuth; -27.5° lunar declination				
86.0	--	IU estimate of position and velocity at the start of TLI in error due to IU navigation errors during the launch and earth orbit phases. Perfect IU navigation during the TLI maneuver.	3.94	4.84
101.0	--		4.48	5.36
173.0	--		6.23	7.07
188.5	--		7.04	7.90
260.5	--		9.88	10.7
72.6° Launch azimuth; -27.5° lunar declination				
86.0	[b]50.0	IU estimate of position and velocity at the start of TLI in error due to ground navigation error and IU earth orbit navigation error from the time of the update to the start of TLI. Perfect IU navigation during the TLI maneuver.	1.58	1.84
101.0	[b]50.0		2.84	3.38
173.0	[b]136.0		2.74	3.19
188.5	[b]136.0		2.78	3.09
260.5	[b]228.0		3.07	3.67

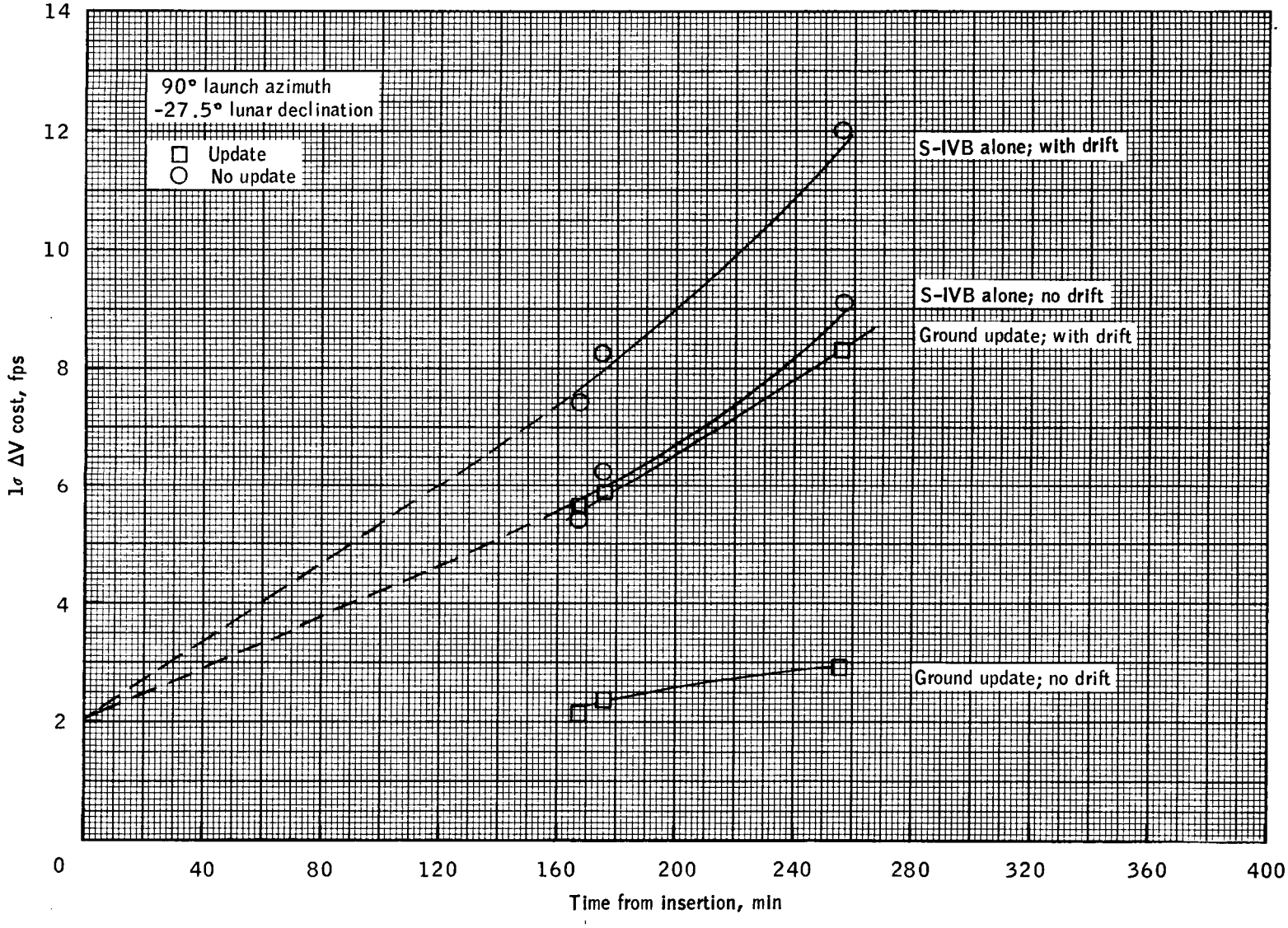
[a]Perfect update uplinked to IU.

[b]See Appendix A for ground track profile.



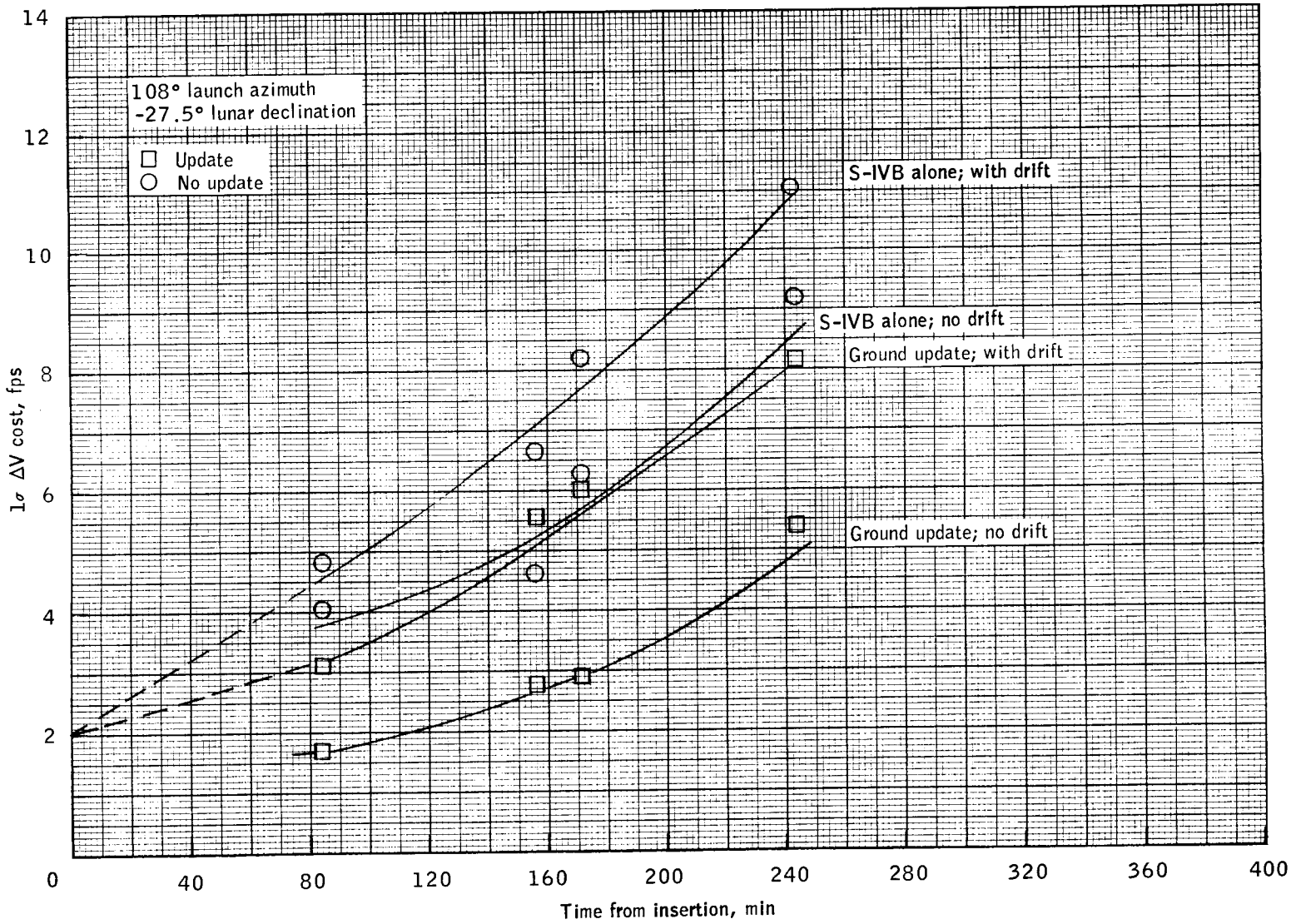
(a) 72.6° launch azimuth; -27.5° lunar declination.

Figure 1.- ΔV cost with and without ground update and platform drift for a midcourse correction 5 hours from translunar injection.



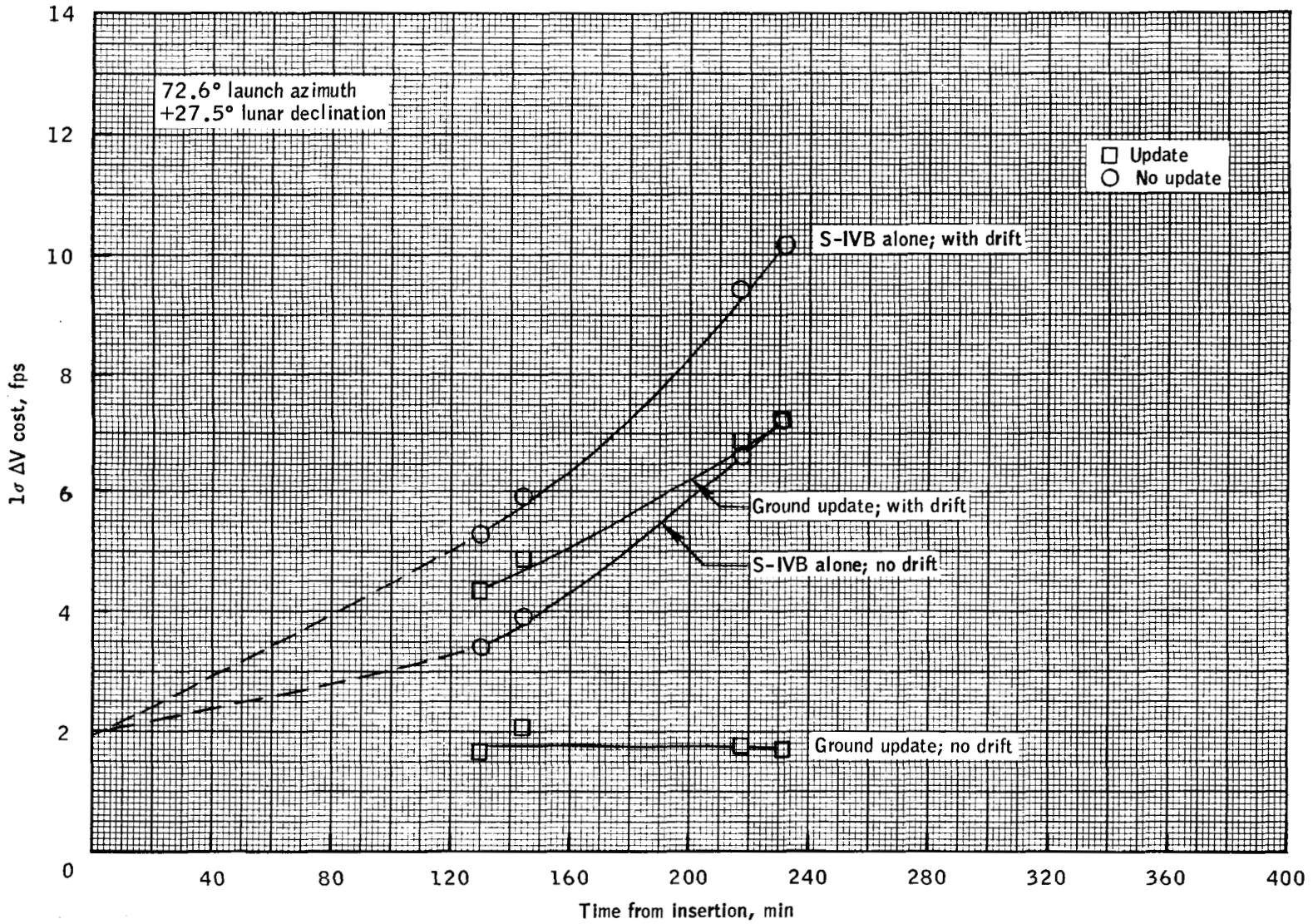
(b) 90° launch azimuth; -27.5° lunar declination.

Figure 1.- Continued.



(c) 108° launch azimuth; -27.5° lunar declination.

Figure 1.- Continued.



(d) 72.6° launch azimuth; +27.5° lunar declination.

Figure 1.- Concluded.

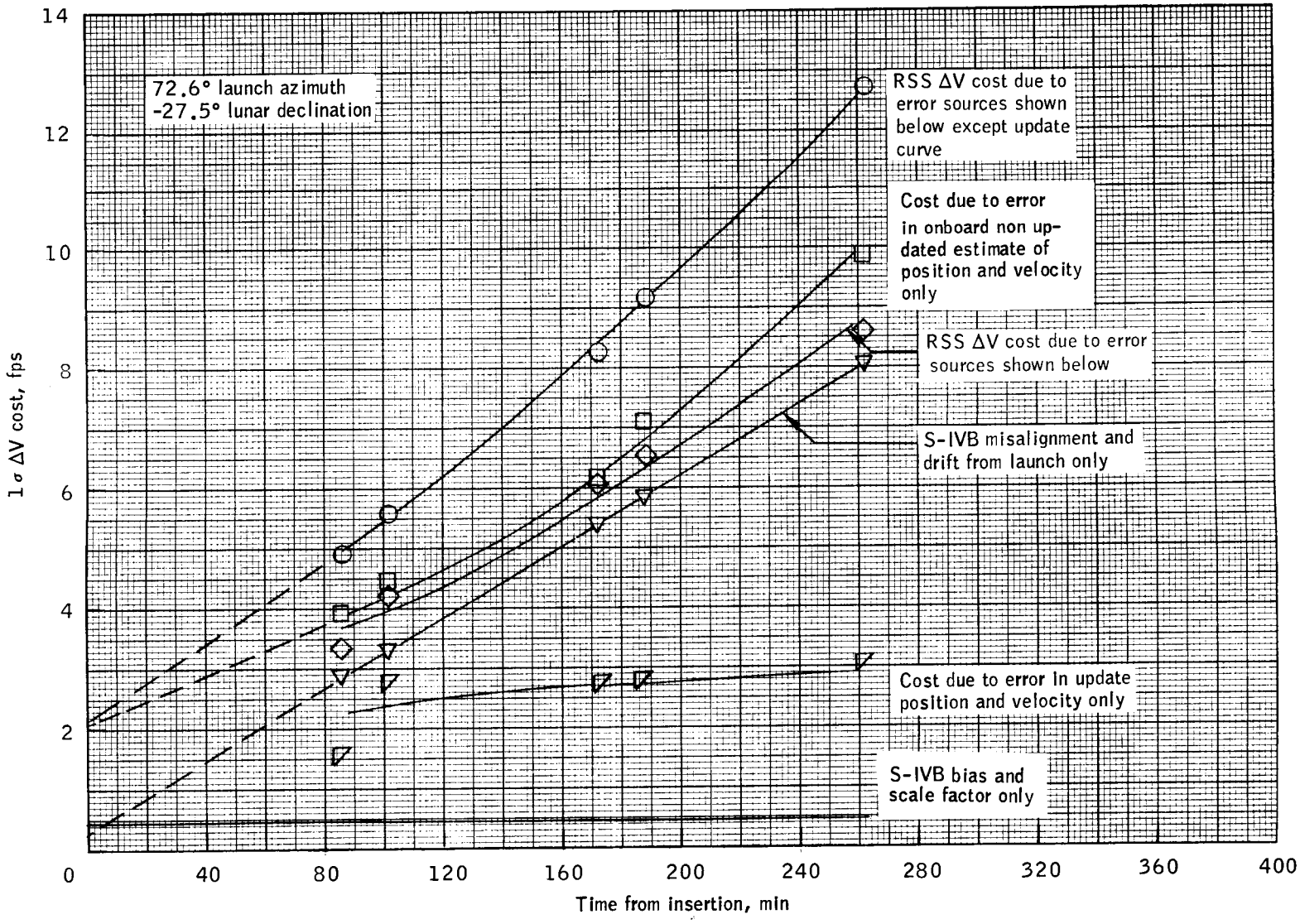


Figure 2.- ΔV cost due to individual error sources for a midcourse correction five hours from translunar injection.

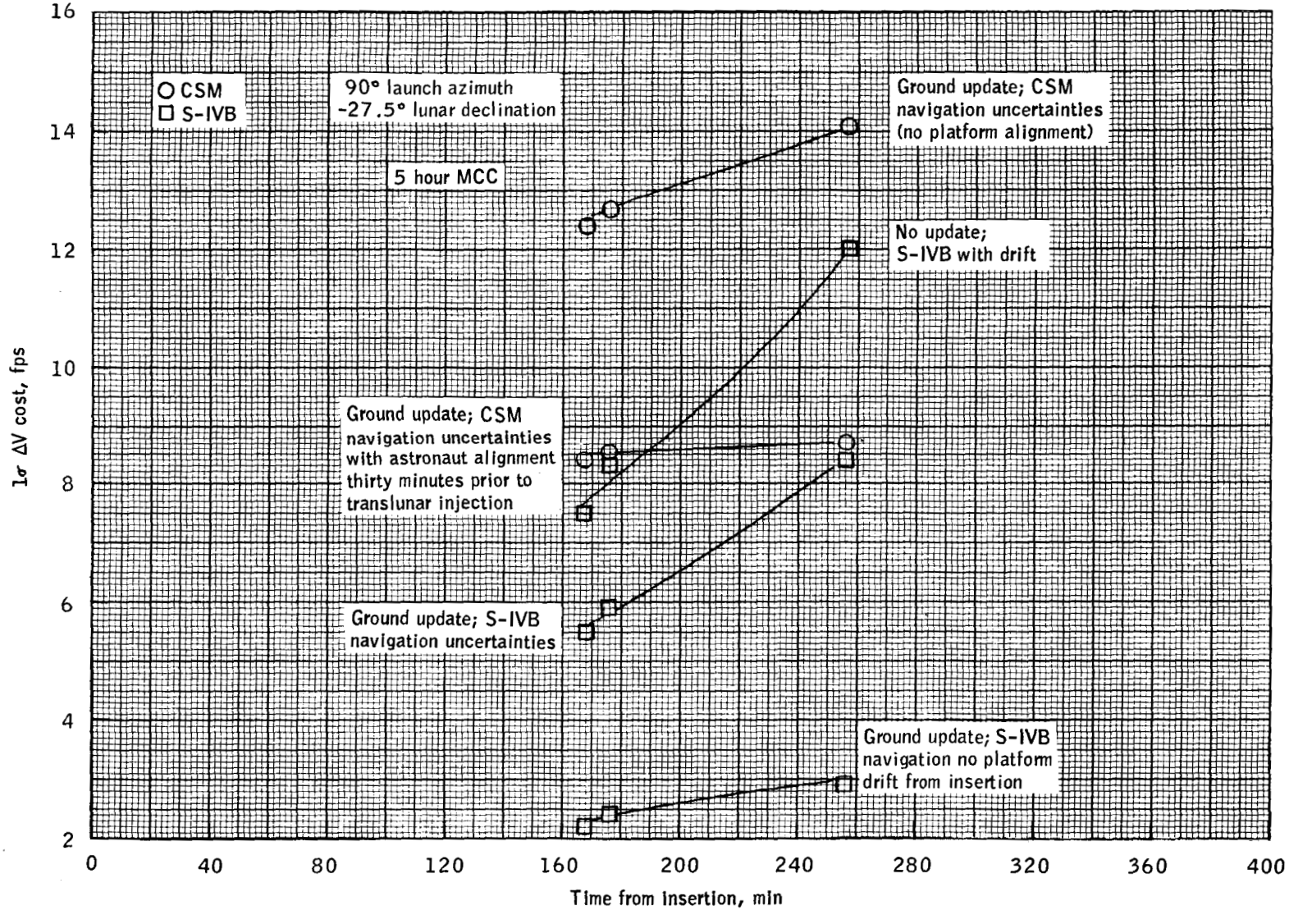


Figure 3.- Comparison of S-IVB and spacecraft maneuver navigation.

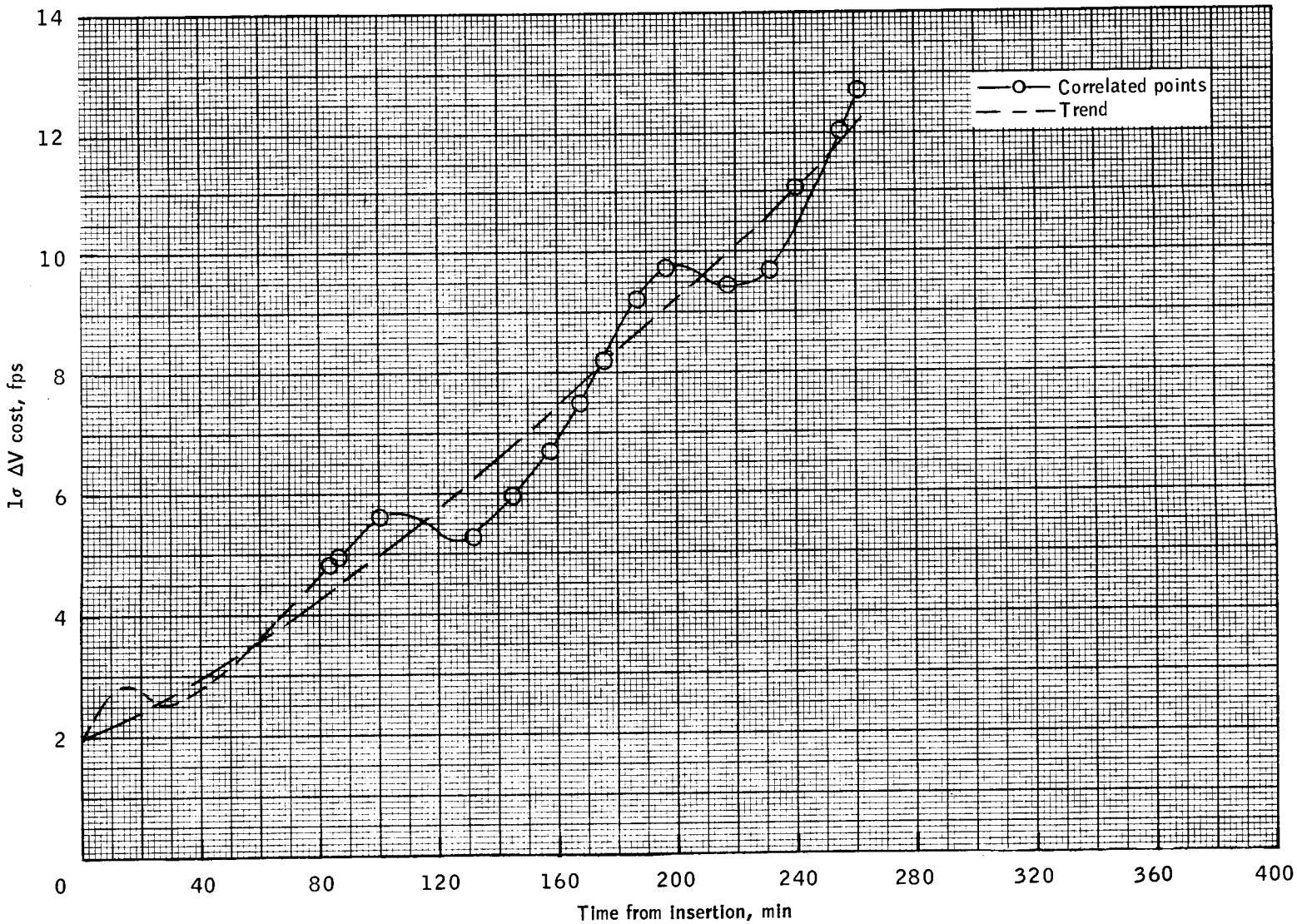


Figure 4.- ΔV cost based on S-IVB navigation, no update, and a midcourse correction five hours from translunar injection.

APPENDIX A

EARTH PARKING ORBIT PROCEDURES

APPENDIX A

EARTH PARKING ORBIT PROCEDURES

This appendix presents the procedures used in the EPO to generate covariance matrices expressing deviations of the onboard estimate of position and velocity from the actual position and velocity at the start of the TLI maneuver.

The matrices were computed under a separate task (ref. 1), using the Bissett-Berman Orbit Error Analysis Program (BBOEAP). A detailed discussion on the program is found in reference 2.

The TLI injection opportunities depend on the launch azimuth, lunar declination at pericynthion, and constraints in the updating procedures. The injection points are given in table A-I.

Table A-I was obtained by determining the latitude and longitude of the vehicle at TLI and the time of TLI with the Bissett-Berman Visibility and Ground Track Program (BBVGTP) - (ref. 3).

The BBVGTP was also used to determine the C- and S-band stations capable of observing the vehicle for various earth parking orbit insertion conditions. Table A-II was formed considering only C-band tracking in EPO with the possibility of a C-band or S-band station updating the onboard vector. It includes the preliminary mission constraint that the update, if it occurs, must be made 30-90 minutes prior to TLI. Observations of range and azimuth and elevation angles taken by the C-band stations occurred at 6-second intervals.

The covariance matrices expressing the deviation of the estimated from the actual values were propagated in EPO to the start of TLI. This study assumes the ground navigation system has no knowledge of the vehicle's position and velocity at insertion into earth parking orbit. During periods of no tracking, the covariance matrices of the ground-computed estimates were propagated considering errors in the venting, gravitational, and drag accelerations. During tracking intervals, errors in the observables were considered in the covariance matrices. Table A-III includes the ground track error model assumed for the ground navigation system.

If the IU estimate is updated in earth orbit, its estimate at the start of TLI deviates from the actual because of the error in the update and error in the IU prediction model after the time of the update. If

the IU estimate is not updated in earth orbit, the error at the start of TLI is due to the error in the IU earth orbit insertion conditions and the error in the IU prediction model in earth orbit. This study assumed the ground and IU navigation systems had the same free-flight prediction model. The errors in both, during free flight and periods of no tracking were modeled as gravitational, venting, and drag acceleration uncertainties shown in the footnote to table III.

The error in the IU estimate of position and velocity at insertion into an earth parking orbit was obtained in the following manner:

Reference 4 describes the deviation of the actual from the IU estimate of the position and velocity of the vehicle at insertion due to 3σ navigation errors. The dispersions are 3σ based on 3σ perturbations of the navigation parameters. Although the covariance of the onboard uncertainty was not explicitly given at insertion, it was built in the following manner. Let

$$\frac{1}{3}\begin{bmatrix} \frac{3\Delta x_1}{\sigma_{P_1}} & \frac{3\Delta x_2}{\sigma_{P_2}} & \frac{3\Delta x_3}{\sigma_{P_3}} & \cdots & \frac{3\Delta x_{30}}{\sigma_{P_{30}}} \\ \frac{3\Delta y_1}{\sigma_{P_1}} & \frac{3\Delta y_2}{\sigma_{P_2}} & \frac{3\Delta y_3}{\sigma_{P_3}} & \cdots & \frac{3\Delta y_{30}}{\sigma_{P_{30}}} \\ \vdots & & & & \\ \frac{3\Delta \dot{z}_1}{\sigma_{P_1}} & \frac{3\Delta \dot{z}_2}{\sigma_{P_2}} & \frac{3\Delta \dot{z}_3}{\sigma_{P_3}} & \cdots & \frac{3\Delta \dot{z}_{30}}{\sigma_{P_{30}}} \end{bmatrix}_{6 \times 30} = \Omega$$

and $P = \text{diagonal}\,(\sigma^2_{P_1}, \sigma^2_{P_2}, \sigma^2_{P_3}, \ldots, \sigma^2_{P_{30}})_{30 \times 30}$

where $(3\,\Delta S_i)$, $i = 1, 30$; $S = x, y, z, \dot{x}, \dot{y}, \dot{z}$ are the 3σ dispersions of the state at insertion and σ_{P_i}, $i = 1, 30$ corresponding to the navigation uncertainties.

Then $\Omega_{6 \times 30} P_{30 \times 30} \Omega^T_{30 \times 6}$ = (covariance of state at insertion)$_{6\times6}$

obtained by

$$\sigma^2_{ij} = \frac{1}{9} \sum_{k=1}^{30} (3\Delta\, i_k)\,(3\Delta\, j_k) \quad i, j = x, y, z, \dot{x}, \dot{y}, \dot{z}$$

where k is the navigation parameter causing the particular dispersion. Thus,

$$\sigma^2_{xx} = \frac{1}{9}\,(3\Delta\, x_1)\,(3\Delta\, x_1) + \frac{1}{9}\,(3\Delta\, x_2)\,(3\Delta\, x_2) + \ldots + \frac{1}{9}\,(3\Delta\, x_{30})\,(3\Delta\, x_{30})$$

and

$$\sigma^2_{yz} = \frac{1}{9}\,(3\Delta\, y_1)\,(3\Delta\, z_1) + \frac{1}{9}\,(3\Delta\, y_2)\,(3\Delta\, z_2) + \ldots + \frac{1}{9}\,(3\Delta\, y_{30})\,(3\Delta\, z_{30})$$

etc.

The covariance matrix obtained at insertion was expressed in a plumbline system defined at lift-off as follows:

The Y-axis parallel to and positive to the vehicle radius vector at lift-off.

The X-axis in the plane of the vehicle's motion, positive downrange, perpendicular to y.

The Z-axis completes a right-handed orthogonal system.

It was rotated to the local vertical system to be used in the BBOEAP. The local vertical system is defined as follows:

The X-axis parallel to and positive in the direction of the vehicle radius vector at the time of interest.

The Y-axis is in the plane of the vehicle's motion positive downrange, perpendicular to X.

The Z-axis forms the right-handed orthogonal system.

The rotation was accomplished in two steps. The first was to rotate the matrix into the local vertical system defined at lift-off.

Denoting the local vertical system by primes,

$$\begin{bmatrix} \Delta x' \\ \Delta y' \\ \Delta z' \\ \Delta \dot{x}' \\ \Delta \dot{y}' \\ \Delta \dot{z}' \end{bmatrix} = \left[\begin{array}{ccc|ccc} 0 & 1 & 0 & & & \\ 1 & 0 & 0 & & \bar{0} & \\ 0 & 0 & -1 & & & \\ \hline & & & 0 & 1 & 0 \\ & \bar{0} & & 1 & 0 & 0 \\ & & & 0 & 0 & -1 \end{array}\right] \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \\ \Delta \dot{x} \\ \Delta \dot{y} \\ \Delta \dot{z} \end{bmatrix} = R \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \\ \Delta \dot{x} \\ \Delta \dot{y} \\ \Delta \dot{z} \end{bmatrix}$$

where $\bar{0}$ denotes the null matrix.

Taking the expectation of both sides, $P' = R\ P\ R^T$, where P is the covariance of the state in the plumbline system and P' is the covariance of the state in the local vertical at time of launch. P' was then rotated through the central angle between the launch pad and insertion vector by an in-plane rotation about the z' axis. This central angle is dependent on the launch azimuth (see ref. 3).

Launch azimuth, deg	Central angle, deg
72.6	27.848
90.	25.546
108.	27.654

Table A-IV presents the covariance matrices associated with these three launch azimuths at EPOI.

All of the covariance matrices presented in this report are in units of feet and feet per second expressed in a local vertical system defined at the time of interest.

The form of the covariance matrices is

$$\begin{pmatrix} \sigma_{xx} & \sigma_{xy} & \cdots & \cdots\cdots & \cdots\cdots \\ \cdot & \sigma_{yy} & \cdots & \cdots\cdots & \cdots\cdots \\ \cdot & \cdot & \sigma_{zz} & \cdots & \cdots\cdots \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \end{pmatrix}$$

The covariance matrices at EPOI (table A-IV) express the deviation of the S-IVB estimate from the actual in the local vertical system defined at EPOI for the three launch azimuths.

Table A-V presents the format of the covariance matrices at the start of TLI (table A-VI) considering update or no update of the IU estimate in earth orbit.

TABLE A-I.- TLI OPPORTUNITIES

Launch azimuth, deg	Lunar declination, deg	Injection opportunities, minutes after EPOI
72.6	+27.5	131. 145. 218.5 232.5
72.6	-27.5	86. 101. 173. 188.5 260.5
90.	-27.5	168. 176. 256.
108.	-27.5	85. 157.5 172.5 244.5

TABLE A-II.- TRACKING VISIBILITY PROFILE

Injection opportunity	Station	Tracking interval, minutes past earth parking orbit insertion	Injection, minutes past earth parking orbit insertion
(a) -27.5° Lunar declination, 72.6° launch azimuth			
1st Atlantic injection[a]	---	---	---
1st Pacific injection	CYI CRO CNB[b,c]	6.5 - 10.6 42.3 - 44.1 49.1 - 52.7	86.0
2nd Atlantic injection	Same as for 1st Pacific injection	Same as for 1st Pacific injection	101.0
2nd Pacific injection (same tracking as for 1st Pacific injection plus the adjacent)	WHS EGL CNV BDA CYI CRO[b]	80.1 - 82.2 82.9 - 87.1 84.3 - 88.2 88.3 - 91.9 98.9 - 102.4 135.6 - 136.2	173.0
3rd Atlantic injection	Same as for 2nd Pacific injection	Same as for 2nd Pacific injection	188.5
3rd Pacific injection (same tracking as for 2nd Pacific injection plus the adjacent)	CAL WHS EGL CNV BDA PRE CRO[b,c]	169.2 - 171.5 171.1 - 175.2 175.3 - 179.3 177.0 - 180.4 180.0 - 184.1 207.8 - 210.4 226.5 - 230.1	260.5

[a]Injection opportunity does not meet the 30 - 90 minute update criteria.

[b]Update occurred over the station.

[c]No C-band tracking.

TABLE A-II.- TRACKING VISIBILITY PROFILE - Continued

Injection opportunity	Station	Tracking interval, minutes past earth parking orbit insertion	Injection, minutes past earth parking orbit insertion
(b) -27.5° Lunar declination, 90° launch azimuth			
1st Atlantic injection[a]	---	---	---
1st Pacific injection[a]	---	---	---
2nd Atlantic injection[a]	---	---	---
2nd Pacific injection	CRO	41.5 - 45.7	168.0
	HAW	66.9 - 69.7	
	CAL	76.6 - 78.6	
	WHS	78.7 - 82.5	
	EGL	83.0 - 86.9	
	CNV	84.3 - 88.4	
	ANT	89.6 - 93.3	
	ASC	103.4 - 106.8	
	PRE	114.5 - 118.5	
	CRO[b]	134.3 - 137.4	
3rd Atlantic injection	Same as for 2nd Pacific injection	Same as for 2nd Pacific injection	176.0
3rd Pacific injection (same tracking as for 2nd Pacific injection plus the adjacent)	HAW	158.5 - 162.7	256.0
	CAL	168.3 - 171.1	
	WHS	171.2 - 174.4	
	EGL	176.3 - 177.8	
	CNV	177.8 - 179.2	
	GBI	178.0 - 180.4	
	GTI	179.5 - 183.0	
	ANT	182.1 - 185.5	
	ASC[b]	196.0 - 198.9	

[a]Injection opportunity does not meet the 30 - 90 minute update criteria.

[b]Update occurred over the station.

TABLE A-II.- TRACKING VISIBILITY PROFILE - Continued

Injection opportunity	Station	Tracking interval, minutes past earth parking orbit insertion	Injection, minutes past earth parking orbit insertion
(c) +27.5° Lunar declination, 72.6° launch azimuth			
1st Atlantic injection[a]	---	---	---
1st Pacific injection[a]	---	---	---
2nd Atlantic injection	CYI CRO WHS EGL CNV BDA[b]	6.5 - 10.6 42.3 - 44.1 80.1 - 82.2 82.9 - 87.1 84.3 - 88.2 87.8 - 91.9	131.0
2nd Pacific injection	Same as for 2nd Atlantic injection	Same as for 2nd Atlantic injection	145.0
3rd Atlantic injection (same tracking as for 2nd Atlantic injection plus the adjacent	CYI CRO CAL WHS EGL CNV BDA[b]	98.9 - 102.4 135.6 - 136.2 169.2 - 171.5 171.1 - 175.2 175.3 - 179.3 177.0 - 180.4 180.0 - 184.1	218.5
3rd Pacific injection	Same as for 3rd Atlantic injection	Same as for 3rd Atlantic injection	232.5

[a]Injection opportunity does not meet the 30 - 90 minute update criteria.

[b]Update occurred over the station.

TABLE A-II.- TRACKING VISIBILITY PROFILE - Concluded

Injection opportunity	Station	Tracking interval, minutes past earth parking orbit insertion	Injection, minutes past earth parking orbit insertion
(d) -27.5 Lunar declination, 108° launch azimuth			
1st Atlantic injection[a]	---	---	---
1st Pacific injection[a]	---	---	---
2nd Atlantic injection	ANT ASC PRE CRO GUA[b,c]	0.0 - 1.1 10.7 - 14.7 22.3 - 25.9 42.4 - 44.1 54.4 - 56.0	85.0
2nd Pacific injection (same tracking as for 2nd Atlantic injection plus the adjacent	CAL WHS TEX[b,c]	75.2 - 79.2 78.3 - 82.2 81.0 - 84.5	157.5
3rd Atlantic injection (same tracking as for 2nd Pacific injection plus the adjacent)	EGL GTI PRE GUA[b,c]	84.0 - 84.5 87.8 - 89.5 115.6 - 117.5 145.4 - 149.0	172.5
3rd Pacific injection (same tracking as for 3rd Atlantic injection plus the adjacent)	CAL GYM[b,c]	168.4 - 169.8 170.1 - 173.4	244.5

[a]Injection opportunity does not meet the 30 - 90 minute update criteria.

[b]Update occurred over the station.

[c]No C-band tracking.

TABLE A-III.- ERROR MODEL ASSUMED FOR THE GROUND NAVIGATION SYSTEM[a]

Radar	Type	Bias			Noise			Station location uncertainties		
		Azimuth angle, m. rad	Elevation angle, m. rad	Range, ft	Azimuth angle, m. rad	Elevation angle, m. rad	Range, ft	σ_x, ft	σ_y, ft	σ_z, ft
CYI	MPS-26	1.0	1.0	60	2.0	2.0	120	105	458	466
CRO	FPQ-6	0.15	0.15	20	0.3	0.3	40	216	202	192
WHS	FPS-16	0.2	0.2	30	0.4	0.4	60	131	103	101
EGL	FPS-16	0.2	0.2	30	0.4	0.4	60	131	105	101
CNV	FPS-16	0.2	0.2	30	0.4	0.4	60	131	107	101
GBI	FPS-16	0.2	0.2	30	0.4	0.4	60	134	109	101
BDA	FPQ-6	0.15	0.15	20	0.3	0.3	40	141	120	122
CAL	FPS-16	0.2	0.2	30	0.4	0.4	60	131	100	101
HAW	FPS-16	0.2	0.2	30	0.4	0.4	60	141	150	142
ANT	FPQ-6	0.15	0.15	20	0.3	0.3	40	138	116	112
ASC	FPS-16	0.2	0.2	30	0.4	0.4	60	105	352	345
PRE	MPS-25	1.0	1.0	60	2.0	2.0	120	141	137	142
GTI	TPQ-18	0.2	0.2	30	0.4	0.4	60	138	113	101

[a]Uncertainty in gravitational constant of earth = 1.06×10^{11} ft^3/sec^2

Uncertainty in acceleration due to venting = 1.1428×10^{-4} ft/sec^2

Uncertainty in drag = 10 percent of total drag = 1.465×10^{-6} ft/sec^2

TABLE A-IV.- COVARIANCE MATRICES OF IU ESTIMATE AT EPOI FOR VARIOUS LAUNCH AZIMUTHS

72.6° Launch azimuth

0.244434E 06	-0.186499E 06	-0.790528E 03	0.983913E 03	-0.515144E 03	-0.377653E 01
-0.186499E 06	0.185955E 06	0.373498E 03	-0.780784E 03	0.490326E 03	0.223698E 01
-0.790528E 03	0.373498E 03	0.295004E 06	-0.459138E 01	0.134469E 01	0.874968E 03
0.983913E 03	-0.780784E 03	-0.459138E 01	0.404943E 01	-0.216422E 01	-0.192262E-01
-0.515144E 03	0.490326E 03	0.134469E 01	-0.216422E 01	0.132271E 01	0.709504E-02
-0.377653E 01	0.223698E 01	0.874968E 03	-0.192262E-01	0.709504E-02	0.275595E 01

90° Launch azimuth

0.259309E 06	-0.183551E 06	-0.804892E 03	0.103513E 04	-0.493244E 03	-0.386334E 01
-0.183551E 06	0.171079E 06	0.341444E 03	-0.758883E 03	0.439111E 03	0.208348E 01
-0.804892E 03	0.341444E 03	0.295004E 06	-0.464169E 01	0.115918E 01	0.874968E 03
0.103513E 04	-0.758883E 03	-0.464169E 01	0.421875E 01	-0.204780E 01	-0.194956E-01
-0.493244E 03	0.439111E 03	0.115918E 01	-0.204780E 01	0.115339E 01	0.631706E-02
-0.386334E 01	0.208348E 01	0.874968E 03	-0.194956E-01	0.631706E-02	0.275595E 01

108° Launch azimuth

0.245696E 06	-0.186297E 06	-0.791788E 03	0.988295E 03	-0.513458E 03	-0.378409E 01
-0.186297E 06	0.184692E 06	0.370819E 03	-0.779098E 03	0.485944E 03	0.222418E 01
-0.791788E 03	0.370819E 03	0.295004E 06	-0.459591E 01	0.132913E 01	0.874968E 03
0.988295E 03	-0.779098E 03	-0.459591E 01	0.406406E 01	-0.215494E 01	-0.192501E-01
-0.513458E 03	0.485944E 03	0.132913E 01	-0.215494E 01	0.130808E 01	0.702990E-02
-0.378409E 01	0.222418E 01	0.874968E 03	-0.192501E-01	0.702990E-02	0.275595E 01

TABLE A-V.- FORMAT OF THE COVARIANCE MATRICES AT THE START OF THE TLI MANEUVER

Time of TLI, minutes after EPOI	Approximate time of vector update (if applicable), minutes after EPOI (a, b)	Navigation system considered and covariance matrix number	
		IU	Ground and IU or Ground and CM (b)
72.6° Launch azimuth; +27.5° lunar declination			
131.0	90.0	1	17
145.0	90.0	2	18
218.5	180.0	3	19
232.5	180.0	4	20
72.6° Launch azimuth; -27.5° lunar declination			
86.0	50.0	5	21
101.0	50.0	6	22
173.0	136.0	7	23
188.5	136.0	8	24
260.5	228.0	9	25
90° Launch azimuth; -27.5° lunar declination			
168.0	135.0	10	26
176.0	135.0	11	27
256.0	197.0	12	28
108° Launch azimuth; -27.5° lunar declination			
85.0	55.0	13	29
157.5	83.0	14	30
172.5	147.0	15	31
244.5	172.0	16	32

[a]See table A-II for ground track profile.

[b]The update was uplinked to the CM at this time, but the values were those predicted by the ground navigation system to the start of TLI.

TABLE A-VI. - COVARIANCE MATRIX AT THE START OF TLI [a]

Number	Covariance Matrix
1	(1,1) 0.8518440OE 07 (1,2)-0.44523000E 08 (1,3)-0.19418400E 04 (1,4) 0.56904300E 05 (1,5)-0.76497100E 04 (1,6)-0.12221700E 02 (2,1)-0.44523000E 08 (2,2) 0.26544100E 09 (2,3)-0.48992800E 04 (2,4)-0.32882900E 06 (2,5) 0.36525000E 05 (2,6) 0.28705900E 01 (3,1)-0.19418400E 04 (3,2)-0.48992800E 04 (3,3) 0.27619100E 06 (3,4) 0.18821800E 01 (3,5) 0.19552100E 01 (3,6) 0.84921700E 03 (4,1) 0.56904300E 05 (4,2)-0.32882900E 06 (4,3) 0.18821800E 01 (4,4) 0.40955100E 03 (4,5)-0.47012100E 02 (4,6)-0.20173500E-01 (5,1)-0.76497100E 04 (5,2) 0.36525000E 05 (5,3) 0.19552100E 01 (5,4)-0.47012100E 02 (5,5) 0.67790900E 01 (5,6) 0.12055500E-01 (6,1)-0.12221700E 02 (6,2) 0.28705900E 01 (6,3) 0.84921700E 03 (6,4)-0.20173500E-01 (6,5) 0.12055500E-01 (6,6) 0.27829200E 01
2	(1,1) 0.11100200E 08 (1,2)-0.64043800E 08 (1,3)-0.16568700E 05 (1,4) 0.75149500E 05 (1,5)-0.97844300E 04 (1,6)-0.67108600E 01 (2,1)-0.64043800E 08 (2,2) 0.45549200E 09 (2,3) 0.25928400E 05 (2,4)-0.53270400E 06 (2,5) 0.53188600E 05 (2,6) 0.17750400E 02 (3,1)-0.16568700E 05 (3,2) 0.25928400E 05 (3,3) 0.21051399E 07 (3,4)-0.32147000E 02 (3,5) 0.17822500E 02 (3,6) 0.53900900E 03 (4,1) 0.75149500E 05 (4,2)-0.53270400E 06 (4,3)-0.32147000E 02 (4,4) 0.62366800E 03 (4,5)-0.62149300E 02 (4,6)-0.20963500E-01 (5,1)-0.97844300E 04 (5,2) 0.53188600E 05 (5,3) 0.17822500E 02 (5,4)-0.62149300E 02 (5,5) 0.89449500E 01 (5,6) 0.70291600E-02 (6,1)-0.67108600E 01 (6,2) 0.17750400E 02 (6,3) 0.53900900E 03 (6,4)-0.20963500E-01 (6,5) 0.70291600E-02 (6,6) 0.16054900E 00
3	PO (1,1) 0.12946000E 08 (1,2)-0.12895000E 09 (1,3)-0.19861200E 04 (1,4) 0.15837300E 06 (1,5)-0.10067700E 05 (1,6)-0.12259600E 02 (2,1)-0.12895000E 09 (2,2) 0.13702900E 10 (2,3) 0.10553600E 04 (2,4)-0.16696300E 07 (2,5) 0.96425700E 05 (2,6) 0.43537000E 02 (3,1)-0.19861200E 04 (3,2) 0.10553600E 04 (3,3) 0.28083800E 06 (3,4)-0.52883300E 01 (3,5) 0.20012100E 01 (3,6) 0.85570600E 03 (4,1) 0.15837300E 06 (4,2)-0.16696300E 07 (4,3)-0.52883300E 01 (4,4) 0.20363900E 04 (4,5)-0.11896200E 03 (4,6)-0.68821500E-01 (5,1)-0.10067700E 05 (5,2) 0.96425700E 05 (5,3) 0.20012100E 01 (5,4)-0.11896200E 03 (5,5) 0.82344000E 01 (5,6) 0.12102300E-01 (6,1)-0.12259600E 02 (6,2) 0.43537000E 02 (6,3) 0.85570600E 03 (6,4)-0.68821500E-01 (6,5) 0.12102300E-01 (6,6) 0.27762600E 01
4	(1,1) 0.15692600E 08 (1,2)-0.16118000E 09 (1,3)-0.16589900E 05 (1,4) 0.19174000E 06 (1,5)-0.12608200E 05 (1,6)-0.66452400E 01 (2,1)-0.16118000E 09 (2,2) 0.18575500E 10 (2,3) 0.57876300E 05 (2,4)-0.22077000E 07 (2,5) 0.12256100E 06 (2,6) 0.33410400E 02 (3,1)-0.16589900E 05 (3,2) 0.57876300E 05 (3,3) 0.21080600E 07 (3,4)-0.70349600E 02 (3,5) 0.17845100E 02 (3,6) 0.53120700E 03 (4,1) 0.19174000E 06 (4,2)-0.22077000E 07 (4,3)-0.70349600E 02 (4,4) 0.26247200E 04 (4,5)-0.14537700E 03 (4,6)-0.39691300E-01 (5,1)-0.12608200E 05 (5,2) 0.12256100E 06 (5,3) 0.17845100E 02 (5,4)-0.14537700E 03 (5,5) 0.10677900E 02 (5,6) 0.69584700E-02 (6,1)-0.66452400E 01 (6,2) 0.33410400E 02 (6,3) 0.53120700E 03 (6,4)-0.39691300E-01 (6,5) 0.69584700E-02 (6,6) 0.15636600E 00
5	(1,1) 0.11288900E 07 (1,2)-0.21551700E 07 (1,3)-0.21969300E 03 (1,4) 0.31710600E 04 (1,5)-0.92021200E 03 (1,6)-0.23311000E 01 (2,1)-0.21551700E 07 (2,2) 0.12798100E 09 (2,3)-0.26133600E 04 (2,4)-0.14131400E 06 (2,5)-0.68401100E 04 (2,6)-0.39668700E 02 (3,1)-0.21969300E 03 (3,2)-0.26133600E 04 (3,3) 0.16109500E 06 (3,4) 0.37096100E 00 (3,5) 0.43484200E 00 (3,6) 0.65379800E 03 (4,1) 0.31710600E 04 (4,2)-0.14131400E 06 (4,3) 0.37096100E 00 (4,4) 0.15784500E 03 (4,5) 0.67019300E 01 (4,6) 0.29592100E-01 (5,1)-0.92021200E 03 (5,2)-0.68401100E 04 (5,3) 0.43484200E 00 (5,4) 0.67019300E 01 (5,5) 0.13724500E 01 (5,6) 0.53999300E-02 (6,1)-0.23311000E 01 (6,2)-0.39668700E 02 (6,3) 0.65379800E 03 (6,4) 0.29592100E-01 (6,5) 0.53999300E-02 (6,6) 0.29479500E 01
6	(1,1) 0.22694800E 07 (1,2)-0.46958700E 07 (1,3)-0.97530799E 04 (1,4) 0.57050800E 04 (1,5)-0.22717200E 04 (1,6)-0.35817500E 01 (2,1)-0.46958700E 07 (2,2) 0.11751700E 09 (2,3)-0.13993200E 05 (2,4)-0.14941800E 06 (2,5)-0.42958000E 04 (2,6)-0.93329099E 01 (3,1)-0.97530799E 04 (3,2)-0.13993200E 05 (3,3) 0.20867400E 07 (3,4) 0.15343900E 02 (3,5) 0.13678800E 02 (3,6) 0.58534500E 03 (4,1) 0.57050800E 04 (4,2)-0.14941800E 06 (4,3) 0.15343900E 02 (4,4) 0.19022300E 03 (4,5) 0.56752300E 01 (4,6) 0.11315500E-01 (5,1)-0.22717200E 04 (5,2)-0.42958000E 04 (5,3) 0.13678800E 02 (5,4) 0.56752300E 01 (5,5) 0.31056400E 01 (5,6) 0.53425300E-02 (6,1)-0.35817500E 01 (6,2)-0.93329099E 01 (6,3) 0.58534500E 03 (6,4) 0.11315500E-01 (6,5) 0.53425300E-02 (6,6) 0.18693000E 00

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

TABLE A-VI. - Continued [a]

Number	Covariance Matrix
7	(1,1) 0.41087200E 07 (1,2)-0.32745700E 08 (1,3)-0.93975200E 02 (1,4) 0.39735700E 05 (1,5)-0.26800800E 04 (1,6)-0.18438500E 01 (2,1)-0.32745700E 08 (2,2) 0.78266000E 09 (2,3)-0.31239900E 04 (2,4)-0.91175900E 06 (2,5) 0.36266400E 04 (2,6)-0.81106100E 02 (3,1)-0.93975200E 02 (3,2)-0.31239900E 04 (3,3) 0.12747700E 06 (3,4) 0.14607500E 01 (3,5) 0.21307800E 00 (3,6) 0.57835400E 03 (4,1) 0.39735700E 05 (4,2)-0.91175900E 06 (4,3) 0.14607500E 01 (4,4) 0.10643999E 04 (4,5)-0.57862000E 01 (4,6) 0.78859200E-01 (5,1)-0.26800800E 04 (5,2) 0.36266400E 04 (5,3) 0.21307800E 00 (5,4)-0.57862000E 01 (5,5) 0.23747100E 01 (5,6) 0.48218200E-02 (6,1)-0.18438500E 01 (6,2)-0.81106100E 02 (6,3) 0.57835400E 03 (6,4) 0.78859200E-01 (6,5) 0.48218200E-02 (6,6) 0.29[illegible]E 01
8	(1,1) 0.53276300E 07 (1,2)-0.38592500E 08 (1,3)-0.97665699E 04 (1,4) 0.46374299E 05 (1,5)-0.40212000E 04 (1,6)-0.35431900E 01 (2,1)-0.38592500E 08 (2,2) 0.85365800E 09 (2,3)-0.45482900E 05 (2,4)-0.10416400E 07 (2,5) 0.54699900E 04 (2,6)-0.25715800E 02 (3,1)-0.97665699E 04 (3,2)-0.45482900E 05 (3,3) 0.20899100E 07 (3,4) 0.53102000E 02 (3,5) 0.13697800E 02 (3,6) 0.57768600E 03 (4,1) 0.46374299E 05 (4,2)-0.10416400E 07 (4,3) 0.53102000E 02 (4,4) 0.12714600E 04 (4,5)-0.60604700E 01 (4,6) 0.30958900E-01 (5,1)-0.40212000E 04 (5,2) 0.54699900E 04 (5,3) 0.13697800E 02 (5,4)-0.60604700E 01 (5,5) 0.41024700E 01 (5,6) 0.52885300E-02 (6,1)-0.35431900E 01 (6,2)-0.25715800E 02 (6,3) 0.57768600E 03 (6,4) 0.30958900E-01 (6,5) 0.52885300E-02 (6,6) 0.18230500E 00
9	(1,1) 0.91299600E 07 (1,2)-0.11934000E 09 (1,3)-0.10535000E 03 (1,4) 0.14343300E 06 (1,5)-0.57007100E 04 (1,6)-0.18931900E 01 (2,1)-0.11934000E 09 (2,2) 0.27549200E 10 (2,3)-0.50391100E 04 (2,4)-0.32606800E 07 (2,5) 0.47466800E 05 (2,6)-0.12221600E 03 (3,1)-0.10535000E 03 (3,2)-0.50391100E 04 (3,3) 0.13065100E 06 (3,4) 0.37053000E 01 (3,5) 0.23382400E 00 (3,6) 0.58601100E 03 (4,1) 0.14343300E 06 (4,2)-0.32606800E 07 (4,3) 0.37053000E 01 (4,4) 0.38618200E 04 (4,5)-0.58287300E 02 (4,6) 0.12811900E 00 (5,1)-0.57007100E 04 (5,2) 0.47466800E 05 (5,3) 0.23382400E 00 (5,4)-0.58287300E 02 (5,5) 0.41954600E 01 (5,6) 0.48804900E-02 (6,1)-0.18931900E 01 (6,2)-0.12221600E 03 (6,3) 0.58601100E 03 (6,4) 0.12811900E 00 (6,5) 0.48804900E-02 (6,6) 0.29[illegible]E 01
10	(1,1) 0.40868000E 07 (1,2)-0.38777200E 08 (1,3)-0.58118700E 03 (1,4) 0.45889400E 05 (1,5)-0.24631000E 04 (1,6) 0.38373000E 01 (2,1)-0.38777200E 08 (2,2) 0.65710400E 09 (2,3) 0.15588300E 05 (2,4)-0.75831800E 06 (2,5) 0.15612700E 05 (2,6)-0.49023300E 02 (3,1)-0.58118700E 03 (3,2) 0.15588300E 05 (3,3) 0.52054300E 05 (3,4)-0.15043100E 02 (3,5) 0.19515200E 00 (3,6)-0.33785300E 03 (4,1) 0.45889400E 05 (4,2)-0.75831800E 06 (4,3)-0.15043100E 02 (4,4) 0.87826700E 03 (4,5)-0.18929600E 02 (4,6) 0.39712700E-01 (5,1)-0.24631000E 04 (5,2) 0.15612700E 05 (5,3) 0.19515200E 00 (5,4)-0.18929600E 02 (5,5) 0.17107400E 01 (5,6)-0.29965000E-02 (6,1) 0.38373000E 01 (6,2)-0.49023300E 02 (6,3)-0.33785300E 03 (6,4) 0.39712700E-01 (6,5)-0.29965000E-02 (6,6) 0.31042900E 01
11	(1,1) 0.43869000E 07 (1,2)-0.31782300E 08 (1,3)-0.13988200E 04 (1,4) 0.38975100E 05 (1,5)-0.30505500E 04 (1,6)-0.48381200E 01 (2,1)-0.31782300E 08 (2,2) 0.70583500E 09 (2,3)-0.89246000E 04 (2,4)-0.83102300E 06 (2,5) 0.44247700E 04 (2,6)-0.49669600E 02 (3,1)-0.13988200E 04 (3,2)-0.89246000E 04 (3,3) 0.41904600E 06 (3,4) 0.55181300E 01 (3,5) 0.19803200E 01 (3,6) 0.10163099E 04 (4,1) 0.38975100E 05 (4,2)-0.83102300E 06 (4,3) 0.55181300E 01 (4,4) 0.98045600E 03 (4,5)-0.68702200E 01 (4,6) 0.43589500E-01 (5,1)-0.30505500E 04 (5,2) 0.44247700E 04 (5,3) 0.19803200E 01 (5,4)-0.68702200E 01 (5,5) 0.28168000E 01 (5,6) 0.74607800E-02 (6,1)-0.48381200E 01 (6,2)-0.49669600E 02 (6,3) 0.10163099E 04 (6,4) 0.43589500E-01 (6,5) 0.74607800E-02 (6,6) 0.25780900E 01
12	(1,1) 0.90692500E 07 (1,2)-0.12598200E 09 (1,3)-0.35731500E 03 (1,4) 0.15047100E 06 (1,5)-0.54893700E 04 (1,6) 0.32343900E 01 (2,1)-0.12598200E 09 (2,2) 0.24335500E 10 (2,3) 0.21043300E 05 (2,4)-0.28723800E 07 (2,5) 0.63668000E 05 (2,6)-0.75453500E 02 (3,1)-0.35731500E 03 (3,2) 0.21043300E 05 (3,3) 0.33206800E 05 (3,4)-0.22215200E 02 (3,5)-0.20238900E-01 (3,6)-0.23776900E 03 (4,1) 0.15047100E 06 (4,2)-0.28723800E 07 (4,3)-0.22215200E 02 (4,4) 0.33939200E 04 (4,5)-0.76634300E 02 (4,6) 0.71165900E-01 (5,1)-0.54893700E 04 (5,2) 0.63668000E 05 (5,3)-0.20238900E-01 (5,4)-0.76634300E 02 (5,5) 0.35713600E 01 (5,6)-0.22522900E-02 (6,1) 0.32343900E 01 (6,2)-0.75453500E 02 (6,3)-0.23776900E 03 (6,4) 0.71165900E-01 (6,5)-0.22522900E-02 (6,6) 0.31313200E 01

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

TABLE A-VI.- Continued [a]

Covariance Matrix

Number						
13	(1,1) 0.10674000E 07	(1,2)-0.28036700E 07	(1,3) 0.21448800E 02	(1,4) 0.37938300E 04	(1,5)-0.80281300E 03	(1,6)-0.12453100E 01
	(2,1)-0.28036700E 07	(2,2) 0.12628900E 09	(2,3)-0.14016600E 03	(2,4)-0.13820600E 06	(2,5)-0.58785100E 04	(2,6)-0.39003699E 02
	(3,1) 0.21448800E 02	(3,2)-0.14016600E 03	(3,3) 0.92672900E 05	(3,4)-0.15142400E 01	(3,5)-0.16661600E-01	(3,6) 0.48460300E 03
	(4,1) 0.37938300E 04	(4,2)-0.13820600E 06	(4,3)-0.15142400E 01	(4,4) 0.15316000E 03	(4,5) 0.56741300E 01	(4,6) 0.28060000E-01
	(5,1)-0.80281300E 03	(5,2)-0.58785100E 04	(5,3)-0.16661600E-01	(5,4) 0.56741300E 01	(5,5) 0.11676400E 01	(5,6) 0.40312100E-02
	(6,1)-0.12453100E 01	(6,2)-0.39003699E 02	(6,3) 0.48460300E 03	(6,4) 0.28060000E-01	(6,5) 0.40312100E-02	(6,6) 0.30460500E 01
14	(1,1) 0.66246100E 07	(1,2)-0.57699800E 08	(1,3)-0.10653000E 05	(1,4) 0.65871000E 05	(1,5)-0.48754400E 04	(1,6) 0.86156400E 01
	(2,1)-0.57699800E 08	(2,2) 0.63511600E 09	(2,3) 0.48677200E 05	(2,4)-0.72402800E 06	(2,5) 0.39811000E 05	(2,6)-0.29901300E 02
	(3,1)-0.10653000E 05	(3,2) 0.48677200E 05	(3,3) 0.13246500E 07	(3,4)-0.47902000E 02	(3,5) 0.10895100E 02	(3,6)-0.12835900E 04
	(4,1) 0.65871000E 05	(4,2)-0.72402800E 06	(4,3)-0.47902000E 02	(4,4) 0.82773300E 03	(4,5)-0.44947000E 02	(4,6) 0.27987500E-01
	(5,1)-0.48754400E 04	(5,2) 0.39811000E 05	(5,3) 0.10895100E 02	(5,4)-0.44947000E 02	(5,5) 0.37750900E 01	(5,6)-0.90973401E-02
	(6,1) 0.86156400E 01	(6,2)-0.29901300E 02	(6,3)-0.12835900E 04	(6,4) 0.27987500E-01	(6,5)-0.90973401E-02	(6,6) 0.12796200E 01
15	(1,1) 0.40789100E 07	(1,2)-0.33348700E 08	(1,3) 0.13330299E 02	(1,4) 0.40379700E 05	(1,5)-0.26259200E 04	(1,6)-0.12961600E 01
	(2,1)-0.33348700E 08	(2,2) 0.77147300E 09	(2,3)-0.49756100E 03	(2,4)-0.89755900E 06	(2,5) 0.47924000E 04	(2,6)-0.78972000E 02
	(3,1) 0.13330299E 02	(3,2)-0.49756100E 03	(3,3) 0.95336599E 05	(3,4)-0.11370600E 01	(3,5)-0.16312100E-04	(3,6) 0.49253400E 03
	(4,1) 0.40379700E 05	(4,2)-0.89755900E 06	(4,3)-0.11370600E 01	(4,4) 0.10466000E 04	(4,5)-0.71112900E 01	(4,6) 0.75947100E-01
	(5,1)-0.26259200E 04	(5,2) 0.47924000E 04	(5,3)-0.16312100E-04	(5,4)-0.71112900E 01	(5,5) 0.22694100E 01	(5,6) 0.40920500E-02
	(6,1)-0.12961600E 01	(6,2)-0.78972000E 02	(6,3) 0.49253400E 03	(6,4) 0.75947100E-01	(6,5) 0.40920500E-02	(6,6) 0.30422300E 01
16	(1,1) 0.11716500E 08	(1,2)-0.15301700E 09	(1,3)-0.11167000E 05	(1,4) 0.18008400E 06	(1,5)-0.80957800E 04	(1,6) 0.83931600E 01
	(2,1)-0.15301700E 09	(2,2) 0.22825000E 10	(2,3) 0.78600800E 05	(2,4)-0.26798500E 07	(2,5) 0.10201500E 06	(2,6)-0.45508300E 02
	(3,1)-0.11167000E 05	(3,2) 0.78600800E 05	(3,3) 0.13941599E 07	(3,4)-0.83832900E 02	(3,5) 0.11478400E 02	(3,6)-0.12639700E 04
	(4,1) 0.18008400E 06	(4,2)-0.26798500E 07	(4,3)-0.83832900E 02	(4,4) 0.31494600E 04	(4,5)-0.11942799E 03	(4,6) 0.47335300E-01
	(5,1)-0.80957800E 04	(5,2) 0.10201500E 06	(5,3) 0.11478400E 02	(5,4)-0.11942799E 03	(5,5) 0.58332900E 01	(5,6)-0.89043400E-02
	(6,1) 0.83931600E 01	(6,2)-0.45508300E 02	(6,3)-0.12639700E 04	(6,4) 0.47335300E-01	(6,5)-0.89043400E-02	(6,6) 0.11799600E 01
17	(1,1) 0.15416700E 07	(1,2)-0.49015500E 07	(1,3) 0.11543100E 05	(1,4) 0.57918200E 04	(1,5)-0.11596100E 04	(1,6)-0.20289700E 03
	(2,1)-0.49015500E 07	(2,2) 0.16166100E 08	(2,3)-0.68239900E 05	(2,4)-0.19059100E 05	(2,5) 0.36772000E 04	(2,6) 0.60466600E 03
	(3,1) 0.11543100E 05	(3,2)-0.68239900E 05	(3,3) 0.20009400E 05	(3,4) 0.79241600E 02	(3,5)-0.33744800E 01	(3,6) 0.45866900E 02
	(4,1) 0.57918200E 04	(4,2)-0.19059100E 05	(4,3) 0.79241600E 02	(4,4) 0.22478800E 02	(4,5)-0.43456000E 01	(4,6)-0.71319200E 00
	(5,1)-0.11596100E 04	(5,2) 0.36772000E 04	(5,3)-0.33744800E 01	(5,4)-0.43456000E 01	(5,5) 0.88430000E 00	(5,6) 0.16525700E 00
	(6,1)-0.20289700E 03	(6,2) 0.60466600E 03	(6,3) 0.45866900E 02	(6,4)-0.71319200E 00	(6,5) 0.16525700E 00	(6,6) 0.26623100E 00
18	(1,1) 0.12310900E 07	(1,2)-0.64042900E 07	(1,3)-0.48940700E 05	(1,4) 0.73286200E 04	(1,5)-0.75876900E 03	(1,6)-0.88928000E 02
	(2,1)-0.64042900E 07	(2,2) 0.33892400E 08	(2,3) 0.24575200E 06	(2,4)-0.38782299E 05	(2,5) 0.39476900E 04	(2,6) 0.47770700E 03
	(3,1)-0.48940700E 05	(3,2) 0.24575200E 06	(3,3) 0.13165500E 06	(3,4)-0.26877500E 03	(3,5) 0.40056800E 02	(3,6) 0.54646200E 02
	(4,1) 0.73286200E 04	(4,2)-0.38782299E 05	(4,3)-0.26877500E 03	(4,4) 0.44390700E 02	(4,5)-0.45171200E 01	(4,6)-0.54378600E 00
	(5,1)-0.75876900E 03	(5,2) 0.39476900E 04	(5,3) 0.40056800E 02	(5,4)-0.45171200E 01	(5,5) 0.47796900E 00	(5,6) 0.56258600E-01
	(6,1)-0.88928000E 02	(6,2) 0.47770700E 03	(6,3) 0.54646200E 02	(6,4)-0.54378600E 00	(6,5) 0.56258600E-01	(6,6) 0.42583800E-01

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

TABLE A-VI.- Continued [a]

Covariance Matrix

Number						
19	(1,1) 0.23476899E 07	(1,2)-0.30080800E 07	(1,3)-0.12424900E 06	(1,4) 0.51065100E 04	(1,5)-0.17837100E 04	(1,6)-0.21845800E 02
	(2,1)-0.30080800E 07	(2,2) 0.39426700E 07	(2,3) 0.15569200E 06	(2,4)-0.66388800E 04	(2,5) 0.22915300E 04	(2,6) 0.34683000E 02
	(3,1)-0.12424900E 06	(3,2) 0.15569200E 06	(3,3) 0.13654400E 05	(3,4)-0.26719200E 03	(3,5) 0.96315400E 02	(3,6) 0.78470800E 01
	(4,1) 0.51065100E 04	(4,2)-0.66388800E 04	(4,3)-0.26719200E 03	(4,4) 0.11223000E 02	(4,5)-0.38893200E 01	(4,6)-0.51312400E-01
	(5,1)-0.17837100E 04	(5,2) 0.22915300E 04	(5,3) 0.96315400E 02	(5,4)-0.38893200E 01	(5,5) 0.13657200E 01	(5,6) 0.21526100E-01
	(6,1)-0.21845800E 02	(6,2) 0.34683000E 02	(6,3) 0.78470800E 01	(6,4)-0.51312400E-01	(6,5) 0.21526100E-01	(6,6) 0.82627600E-01
20	(1,1) 0.42330100E 07	(1,2)-0.10448200E 08	(1,3)-0.10680400E 06	(1,4) 0.12910000E 05	(1,5)-0.34936100E 04	(1,6) 0.15578800E 03
	(2,1)-0.10448200E 08	(2,2) 0.25925700E 08	(2,3) 0.27558600E 06	(2,4)-0.32013300E 05	(2,5) 0.86304000E 04	(2,6)-0.37319300E 03
	(3,1)-0.10680400E 06	(3,2) 0.27558600E 06	(3,3) 0.50950200E 05	(3,4)-0.33569700E 03	(3,5) 0.91546500E 02	(3,6) 0.20461500E 02
	(4,1) 0.12910000E 05	(4,2)-0.32013300E 05	(4,3)-0.33569700E 03	(4,4) 0.39544500E 02	(4,5)-0.10665900E 02	(4,6) 0.46393600E 00
	(5,1)-0.34936100E 04	(5,2) 0.86304000E 04	(5,3) 0.91546500E 02	(5,4)-0.10665900E 02	(5,5) 0.28948700E 01	(5,6)-0.12872399E 00
	(6,1) 0.15578800E 03	(6,2)-0.37319300E 03	(6,3) 0.20461500E 02	(6,4) 0.46393600E 00	(6,5)-0.12872399E 00	(6,6) 0.29152500E-01
21	(1,1) 0.27585800E 07	(1,2)-0.12272700E 08	(1,3)-0.10193399E 06	(1,4) 0.13517400E 05	(1,5)-0.21708500E 04	(1,6)-0.11002600E 04
	(2,1)-0.12272700E 08	(2,2) 0.71354900E 08	(2,3) 0.10919900E 07	(2,4)-0.76601700E 05	(2,5) 0.92416800E 04	(2,6) 0.41749300E 04
	(3,1)-0.10193399E 06	(3,2) 0.10919900E 07	(3,3) 0.85848400E 05	(3,4)-0.11541100E 04	(3,5) 0.48992500E 02	(3,6)-0.15590400E 03
	(4,1) 0.13517400E 05	(4,2)-0.76601700E 05	(4,3)-0.11541100E 04	(4,4) 0.82512800E 02	(4,5)-0.10180900E 02	(4,6)-0.44584200E 01
	(5,1)-0.21708500E 04	(5,2) 0.92416800E 04	(5,3) 0.48992500E 02	(5,4)-0.10180900E 02	(5,5) 0.17595700E 01	(5,6) 0.99122600E 00
	(6,1)-0.11002600E 04	(6,2) 0.41749300E 04	(6,3)-0.15590400E 03	(6,4)-0.44584200E 01	(6,5) 0.99122600E 00	(6,6) 0.19853200E 01
22	(1,1) 0.12476100E 07	(1,2)-0.65732400E 07	(1,3)-0.29667300E 06	(1,4) 0.74887700E 04	(1,5)-0.78603300E 03	(1,6)-0.19093900E 03
	(2,1)-0.65732400E 07	(2,2) 0.10153600E 09	(2,3) 0.46180600E 07	(2,4)-0.11281200E 06	(2,5) 0.71715800E 03	(2,6) 0.14508700E 04
	(3,1)-0.29667300E 06	(3,2) 0.46180600E 07	(3,3) 0.98502000E 06	(3,4)-0.48745200E 04	(3,5) 0.86443400E 02	(3,6) 0.73451600E 03
	(4,1) 0.74887700E 04	(4,2)-0.11281200E 06	(4,3)-0.48745200E 04	(4,4) 0.12562500E 03	(4,5)-0.90296200E 00	(4,6)-0.13842800E 01
	(5,1)-0.78603300E 03	(5,2) 0.71715800E 03	(5,3) 0.86443400E 02	(5,4)-0.90296200E 00	(5,5) 0.70002100E 00	(5,6) 0.15593699E 00
	(6,1)-0.19093900E 03	(6,2) 0.14508700E 04	(6,3) 0.73451600E 03	(6,4)-0.13842800E 01	(6,5) 0.15593699E 00	(6,6) 0.69607100E 00
23	(1,1) 0.95732700E 06	(1,2)-0.80925700E 07	(1,3)-0.41879100E 05	(1,4) 0.10019000E 05	(1,5)-0.33862800E 03	(1,6) 0.13670400E 03
	(2,1)-0.80925700E 07	(2,2) 0.69672000E 08	(2,3) 0.33707800E 06	(2,4)-0.86261300E 05	(2,5) 0.27804600E 04	(2,6)-0.13187100E 04
	(3,1)-0.41879100E 05	(3,2) 0.33707800E 06	(3,3) 0.12434100E 05	(3,4)-0.41791800E 03	(3,5) 0.14933800E 02	(3,6)-0.24232600E 01
	(4,1) 0.10019000E 05	(4,2)-0.86261300E 05	(4,3)-0.41791800E 03	(4,4) 0.10680500E 03	(4,5)-0.34428200E 01	(4,6) 0.16394200E 01
	(5,1)-0.33862800E 03	(5,2) 0.27804600E 04	(5,3) 0.14933800E 02	(5,4)-0.34428200E 01	(5,5) 0.14054700E 00	(5,6)-0.36024400E-01
	(6,1) 0.13670400E 03	(6,2)-0.13187100E 04	(6,3)-0.24232600E 01	(6,4) 0.16394200E 01	(6,5)-0.36024400E-01	(6,6) 0.26120700E 00
24	(1,1) 0.22269700E 07	(1,2)-0.15211000E 08	(1,3) 0.14622300E 06	(1,4) 0.19252700E 05	(1,5)-0.12692500E 04	(1,6) 0.16913600E 03
	(2,1)-0.15211000E 08	(2,2) 0.10414300E 09	(2,3)-0.10081600E 07	(2,4)-0.13182500E 06	(2,5) 0.86875000E 04	(2,6)-0.11491799E 04
	(3,1) 0.14622300E 06	(3,2)-0.10081600E 07	(3,3) 0.14749700E 06	(3,4) 0.12920600E 04	(3,5)-0.84357200E 02	(3,6) 0.81986500E 02
	(4,1) 0.19252700E 05	(4,2)-0.13182500E 06	(4,3) 0.12920600E 04	(4,4) 0.16688500E 03	(4,5)-0.10989800E 02	(4,6) 0.14612800E 01
	(5,1)-0.12692500E 04	(5,2) 0.86875000E 04	(5,3)-0.84357200E 02	(5,4)-0.10989800E 02	(5,5) 0.73636700E 00	(5,6)-0.96383900E-01
	(6,1) 0.16913600E 03	(6,2)-0.11491799E 04	(6,3) 0.81986500E 02	(6,4) 0.14612800E 01	(6,5)-0.96383900E-01	(6,6) 0.67552700E-01

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

TABLE A-VI. - Continued [a]

Covariance Matrix

Number						
25	(1,1) 0.13150800E 07	(1,2)-0.12001099E 08	(1,3) 0.10424400E 06	(1,4) 0.13529100E 05	(1,5)-0.49333200E 03	(1,6)-0.67181700E 02
	(2,1)-0.12001099E 08	(2,2) 0.11040200E 09	(2,3)-0.96315200E 06	(2,4)-0.12446400E 06	(2,5) 0.44607600E 04	(2,6) 0.60357700E 03
	(3,1) 0.10424400E 06	(3,2)-0.96315200E 06	(3,3) 0.14169500E 05	(3,4) 0.10854700E 04	(3,5)-0.39259400E 02	(3,6)-0.63120800E 01
	(4,1) 0.13529100E 05	(4,2)-0.12446400E 06	(4,3) 0.10854700E 04	(4,4) 0.14032100E 03	(4,5)-0.50281400E 01	(4,6)-0.67919000E 00
	(5,1)-0.49333200E 03	(5,2) 0.44607600E 04	(5,3)-0.39259400E 02	(5,4)-0.50281400E 01	(5,5) 0.20157199E 00	(5,6) 0.25012700E-01
	(6,1)-0.67181700E 02	(6,2) 0.60357700E 03	(6,3)-0.63120800E 01	(6,4)-0.67919000E 00	(6,5) 0.25012700E-01	(6,6) 0.53170900E-01
26	(1,1) 0.96609400E 06	(1,2)-0.51331100E 07	(1,3) 0.28416100E 05	(1,4) 0.60947900E 04	(1,5)-0.53241800E 03	(1,6)-0.20869300E 02
	(2,1)-0.51331100E 07	(2,2) 0.27955900E 08	(2,3)-0.14335700E 06	(2,4)-0.33197700E 05	(2,5) 0.28189600E 04	(2,6) 0.10517400E 03
	(3,1) 0.28416100E 05	(3,2)-0.14335700E 06	(3,3) 0.62207400E 04	(3,4) 0.17043600E 03	(3,5)-0.15331600E 02	(3,6)-0.54380800E 01
	(4,1) 0.60947900E 04	(4,2)-0.33197700E 05	(4,3) 0.17043600E 03	(4,4) 0.39426000E 02	(4,5)-0.33474200E 01	(4,6)-0.12435300E 00
	(5,1)-0.53241800E 03	(5,2) 0.28189600E 04	(5,3)-0.15331600E 02	(5,4)-0.33474200E 01	(5,5) 0.30459800E 00	(5,6) 0.92567800E-02
	(6,1)-0.20869300E 02	(6,2) 0.10517400E 03	(6,3)-0.54380800E 01	(6,4)-0.12435300E 00	(6,5) 0.92567800E-02	(6,6) 0.33866300E-01
27	(1,1) 0.95139900E 06	(1,2)-0.58868300E 07	(1,3) 0.14356200E 05	(1,4) 0.70813000E 04	(1,5)-0.46596500E 03	(1,6)-0.35481600E 02
	(2,1)-0.58868300E 07	(2,2) 0.36992600E 08	(2,3)-0.84765800E 05	(2,4)-0.44532600E 05	(2,5) 0.28833300E 04	(2,6) 0.20994600E 03
	(3,1) 0.14356200E 05	(3,2)-0.84765800E 05	(3,3) 0.72183700E 04	(3,4) 0.10188000E 03	(3,5)-0.78636900E 01	(3,6) 0.72824200E 01
	(4,1) 0.70813000E 04	(4,2)-0.44532600E 05	(4,3) 0.10188000E 03	(4,4) 0.53615500E 02	(4,5)-0.34669700E 01	(4,6)-0.25172099E 00
	(5,1)-0.46596500E 03	(5,2) 0.28833300E 04	(5,3)-0.78636900E 01	(5,4)-0.34669700E 01	(5,5) 0.23887600E 00	(5,6) 0.15244700E-01
	(6,1)-0.35481400E 02	(6,2) 0.20994600E 03	(6,3) 0.72824200E 01	(6,4)-0.25172099E 00	(6,5) 0.15244700E-01	(6,6) 0.32435900E-01
28	(1,1) 0.24761200E 07	(1,2)-0.16778800E 08	(1,3)-0.19481700E 04	(1,4) 0.19506800E 05	(1,5)-0.14778200E 04	(1,6) 0.32979100E 03
	(2,1)-0.16778800E 08	(2,2) 0.11399400E 09	(2,3) 0.20440300E 05	(2,4)-0.13252800E 06	(2,5) 0.10036700E 05	(2,6)-0.22368599E 04
	(3,1)-0.19481700E 04	(3,2) 0.20440300E 05	(3,3) 0.49634400E 04	(3,4)-0.23842600E 02	(3,5) 0.20204700E 01	(3,6)-0.39920400E 01
	(4,1) 0.19506800E 05	(4,2)-0.13252800E 06	(4,3)-0.23842600E 02	(4,4) 0.15408000E 03	(4,5)-0.11668500E 02	(4,6) 0.26010000E 01
	(5,1)-0.14778200E 04	(5,2) 0.10036700E 05	(5,3) 0.20204700E 01	(5,4)-0.11668500E 02	(5,5) 0.89236900E 00	(5,6)-0.19758900E 00
	(6,1) 0.32979100E 03	(6,2)-0.22368599E 04	(6,3)-0.39920400E 01	(6,4) 0.26010000E 01	(6,5)-0.19758900E 00	(6,6) 0.58295500E-01
29	(1,1) 0.11056399E 07	(1,2)-0.43040500E 07	(1,3) 0.50158300E 05	(1,4) 0.49865500E 04	(1,5)-0.77756500E 03	(1,6) 0.13948600E 02
	(2,1)-0.43040500E 07	(2,2) 0.23818200E 08	(2,3)-0.29055900E 06	(2,4)-0.26115000E 05	(2,5) 0.29949000E 04	(2,6)-0.31271500E 03
	(3,1) 0.50158300E 05	(3,2)-0.29055900E 06	(3,3) 0.39768100E 05	(3,4) 0.31463900E 03	(3,5)-0.34615900E 02	(3,6)-0.35709900E 01
	(4,1) 0.49865500E 04	(4,2)-0.26115000E 05	(4,3) 0.31463900E 03	(4,4) 0.29874400E 02	(4,5)-0.34728900E 01	(4,6) 0.32092700E 00
	(5,1)-0.77756500E 03	(5,2) 0.29949000E 04	(5,3)-0.34615900E 02	(5,4)-0.34728900E 01	(5,5) 0.56147400E 00	(5,6) 0.33493200E-02
	(6,1) 0.13948600E 02	(6,2)-0.31271500E 03	(6,3)-0.35709900E 01	(6,4) 0.32092700E 00	(6,5) 0.33493200E-02	(6,6) 0.11792700E 00
30	(1,1) 0.13683900E 07	(1,2)-0.91745200E 07	(1,3) 0.14942200E 06	(1,4) 0.11529500E 05	(1,5)-0.68362200E 03	(1,6) 0.20751400E 02
	(2,1)-0.91745200E 07	(2,2) 0.62403000E 08	(2,3)-0.95704900E 06	(2,4)-0.78309000E 05	(2,5) 0.45433500E 04	(2,6)-0.12870000E 03
	(3,1) 0.14942200E 06	(3,2)-0.95704900E 06	(3,3) 0.52839900E 05	(3,4) 0.12108500E 04	(3,5)-0.79814800E 02	(3,6)-0.25904000E 02
	(4,1) 0.11529500E 05	(4,2)-0.78309000E 05	(4,3) 0.12108500E 04	(4,4) 0.98292900E 02	(4,5)-0.57209700E 01	(4,6) 0.15776300E 00
	(5,1)-0.68362200E 03	(5,2) 0.45433500E 04	(5,3)-0.79814800E 02	(5,4)-0.57209700E 01	(5,5) 0.35716600E 00	(5,6)-0.72232700E-02
	(6,1) 0.20751400E 02	(6,2)-0.12870000E 03	(6,3)-0.25904000E 02	(6,4) 0.15776300E 00	(6,5)-0.72232700E-02	(6,6) 0.52363700E-01

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

TABLE A-VI. - Concluded[a]

Covariance Matrix

Number						
31	(1,1) 0.22774100E 07	(1,2)-0.14470000E 08	(1,3) 0.13370500E 06	(1,4) 0.18075600E 05	(1,5)-0.13730800E 04	(1,6) 0.11545200E 02
	(2,1)-0.14470000E 08	(2,2) 0.92578300E 08	(2,3)-0.82514300E 06	(2,4)-0.11567800E 06	(2,5) 0.86935500E 04	(2,6)-0.97400300E 02
	(3,1) 0.13370500E 06	(3,2)-0.82514300E 06	(3,3) 0.17696400E 05	(3,4) 0.10277200E 04	(3,5)-0.81412700E 02	(3,6) 0.72505600E 01
	(4,1) 0.18075600E 05	(4,2)-0.11567800E 06	(4,3) 0.10277200E 04	(4,4) 0.14454800E 03	(4,5)-0.10855600E 02	(4,6) 0.12421200E 00
	(5,1)-0.13730800E 04	(5,2) 0.86935500E 04	(5,3)-0.81412700E 02	(5,4)-0.10855600E 02	(5,5) 0.84549800E 00	(5,6)-0.17135400E-02
	(6,1) 0.11545200E 02	(6,2)-0.97400300E 02	(6,3) 0.72505600E 01	(6,4) 0.12421200E 00	(6,5)-0.17135400E-02	(6,6) 0.59806500E-01
32	(1,1) 0.30785300E 07	(1,2)-0.40101500E 08	(1,3) 0.28627400E 05	(1,4) 0.48259400E 05	(1,5)-0.13534200E 04	(1,6) 0.23004700E 03
	(2,1)-0.40101500E 08	(2,2) 0.52469900E 09	(2,3)-0.32314200E 06	(2,4)-0.63130200E 06	(2,5) 0.17589800E 05	(2,6)-0.29464500E 04
	(3,1) 0.28627400E 05	(3,2)-0.32314200E 06	(3,3) 0.31313100E 05	(3,4) 0.39468800E 03	(3,5)-0.16046900E 02	(3,6)-0.17663300E 02
	(4,1) 0.48259400E 05	(4,2)-0.63130200E 06	(4,3) 0.39468800E 03	(4,4) 0.75958200E 03	(4,5)-0.21176800E 02	(4,6) 0.35465700E 01
	(5,1)-0.13534200E 04	(5,2) 0.17589800E 05	(5,3)-0.16046900E 02	(5,4)-0.21176800E 02	(5,5) 0.60874400E 00	(5,6)-0.10101400E 00
	(6,1) 0.23004700E 03	(6,2)-0.29464500E 04	(6,3)-0.17663300E 02	(6,4) 0.35465700E 01	(6,5)-0.10101400E 00	(6,6) 0.45497300E-01

[a] Locate the covariance matrix number on table A-V for a description of the events preceding TLI.

APPENDIX B

TRANSLUNAR INJECTION MANEUVER PROCEDURES

APPENDIX B

TRANSLUNAR INJECTION MANEUVER PROCEDURES

Reference 5 describes a program which propagates a covariance matrix through powered-flight maneuvers. The following are the main inputs to the program:

1. An ephemeris of the maneuver containing time, position and velocity, thrust angles with respect to the local vertical and fuel used at 5-second intervals throughout the maneuver.

2. Initial covariance matrix of position and velocity.

3. Variances in scale factor error, platform misalignment and drift and accelerometer bias.

The ephemeris of the maneuver was generated by the Apollo Reference Mission Program (ARMP). The navigation uncertainties were taken from references 4 and 6.

The covariance matrices (appendix A) at TLI are in the local vertical system. They were rotated to the inertial system of the ephemeris by the following transformation (ref. 7).

$$P_o' = C_o \, P_o \, C_o^T$$

Where:

P_o is the state covariance matrix in the local vertical system.

P_o' is the covariance matrix in the inertial system of the ephemeris of the TLI maneuver.

$$C_{o\ 6 \times 6} = \left[\begin{array}{c|c} D_o & \bar{0} \\ \hline \bar{0} & D_o \end{array}\right]$$

$\bar{0}$ is 3×3 null matrix.

$$D_o = \left[\frac{R_o}{|R_o|}, \quad \frac{(R_o \times V_o) \times R_o}{|(R_o \times V_o) \times R_o|}, \quad \frac{R_o \times V_o}{|R_o \times V_o|}\right]_{3 \times 3}$$

R_o and V_o expressed in the inertial system at the start of the maneuver.

The covariance matrix at the end of TLI is based only upon dispersions in the estimated state (actual - estimated) at the start of TLI and dispersions in the navigation parameters. The engine uncertainties do not affect the onboard estimate since the accelerometers integrate the thrust acceleration during the maneuver and correct for non-nominal variations occurring in engine parameters.

This study assumes that the tailoff thrust profile is built into the guidance package, and that there is no deviation from nominal cutoff conditions if the navigation system is error free and perfect knowledge of the vehicle's position and velocity at the start of TLI is assumed. The S-IVB IU or CM estimate of position and velocity at the end of the TLI maneuver was assumed to be the desired vector.

Table B-I and table B-II present formats of the covariance matrices at the end of the TLI maneuver (table B-III) in the local vertical coordinate system defined at that time.

TABLE B-I.- FORMAT OF THE COVARIANCE MATRICES AT THE END OF THE TLI MANEUVER

Time of TLI, minutes after EPOI	Approximate time of vector update (if applicable) minutes after EPOI (a)	Navigation system considered and covariance matrix number					
		IU		Ground and IU		Ground and CM[b]	
		No Drift	Drift	No Drift	Drift	No platform alignment	Platform alignment
72.6° Launch azimuth; +27.5° lunar declination							
131.0	90.	33	49	65	81	--	--
145.0	90.	34	50	66	82	--	--
218.5	180.	35	51	67	83	--	--
232.5	180.	36	52	68	84	--	--
72.6° Launch azimuth; -27.5° lunar declination							
86.0	50.	37	53	69	85	--	--
101.0	50.	38	54	70	86	--	--
173.0	136.	39	55	71	87	--	--
188.5	136.	40	56	72	88	--	--
260.5	228.	41	57	73	89	--	--
90° Launch azimuth; -27.5° lunar declination							
168.0	135.	42	58	74	90	113[b]	116[b]
176.0	135.	43	59	75	91	114[b]	117[b]
256.0	197.	44	60	76	92	115[b]	118[b]
108° Launch azimuth; -27.5° lunar declination							
85.0	55.	45	61	77	93	--	--
157.5	83.	46	62	78	94	--	--
172.5	147.	47	63	79	95	--	--
244.5	172.	48	64	80	96	--	--

[a]See table A-II for ground track profile.

[b]The update was uplinked to the CM, but the values were those predicted by the ground navigation system to the start of TLI.

TABLE B-II.- FORMAT OF THE COVARIANCE MATRICES AT THE END OF THE TLI MANEUVER

Time of TLI, minutes after EPOI	Approximate time of vector update (if applicable) in minutes after EPOI (a)	Individual error sources of the ground and IU	Covariance matrix number
Anytime	Anytime[b]	IU scale factor and bias during TLI. Other IU navigation hardware and software perfect.	97
86.0 101.0 173.0 188.5 260.5	[b]86. [b]101. [b]173. [b]188.5 [b]260.5	IU launch pad misalignment and drift to TLI. Other IU navigation hardware and software perfect.	98 99 100 101 102
72.6° Launch azimuth; -27.5° lunar declination			
86.0 101.0 173.0 188.5 260.5	-- -- -- -- --	IU estimate of position and velocity at the start of TLI in error due to S-IVB IU navigation errors during the launch and earth orbit phases. Perfect IU navigation during the TLI maneuver.	103 104 105 106 107
Launch azimuth; -27.5° lunar declination			
86.0 101.0 173.0 188.5 260.5	50. 50. 136. 136. 228.	IU estimate of position and velocity at the start of TLI in error due to ground navigation error and IU earth orbit navigation error from the time of the update to the start of TLI. Perfect IU navigation during the TLI maneuver.	108 109 110 111 112

[a]See table A-II for ground track profile.

[b]Perfect update uplinked to S-IVB.

TABLE B-III.- COVARIANCE MATRICES AT THE END OF THE TLI MANEUVER [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.56088663E 07	-0.33623785E 08	-0.24691031E 05	0.41764404E 05	-0.98082423E 04	-0.13684825E 02
	-0.33623784E 08	0.33435434E 09	0.16793155E 06	-0.38877596E 06	0.71762414E 05	-0.54797974E 01
	-0.24691750E 05	0.16793300E 06	0.12297656E 07	-0.20195899E 03	0.42562927E 02	0.30069039E 04
33	0.41764406E 05	-0.38877596E 06	-0.20195927E 03	0.46446150E 03	-0.87221120E 02	-0.85933805E-02
	-0.98082417E 04	0.71762416E 05	0.42561390E 02	-0.87221118E 02	0.18638923E 02	0.54516792E-02
	-0.13686035E 02	-0.54765625E 01	0.30069024E 04	-0.85964203E-02	0.54526329E-02	0.13920197E 02
	LAT3 MATRIX					
	0.38210284E 07	-0.31942382E 08	-0.30456039E 05	0.36676492E 05	-0.76238446E 04	0.18277207E 01
	-0.31942378E 08	0.54507272E 09	0.31721718E 06	-0.60455087E 06	0.93446165E 05	-0.34366630E 02
	-0.30454750E 05	0.31721850E 06	0.23860683E 07	-0.34861231E 03	0.66692505E 02	0.12916462E 04
34	0.36676489E 05	-0.60455087E 06	-0.34861395E 03	0.68353576E 03	-0.10565614E 03	0.33351064E-01
	-0.76238396E 04	0.93446165E 05	0.66688242E 02	-0.10565613E 03	0.18619803E 02	-0.13615251E-01
	0.18314209E 01	-0.34371094E 02	0.12916450E 04	0.33355713E-01	-0.13611317E-01	0.12224064E 02
	LAT3 MATRIX					
	0.32446835E 07	-0.50078495E 08	-0.32436883E 05	0.60971621E 05	-0.97059953E 04	-0.85272674E 01
	-0.50078498E 08	0.15552636E 10	0.81118970E 06	-0.18161866E 07	0.23594723E 06	-0.91250721E 02
	-0.32439437E 05	0.81115400E 06	0.12372231E 07	-0.95404102E 03	0.12850073E 03	0.30078396E 04
35	0.60971622E 05	-0.18161866E 07	-0.95404767E 03	0.21332686E 04	-0.27916285E 03	0.91639757E-01
	-0.97059840E 04	0.23594723E 06	0.12849673E 03	-0.27916285E 03	0.38795770E 02	-0.90577006E-02
	-0.85272535E 01	-0.91234375E 02	0.30078470E 04	0.91629028E-01	-0.90475082E-02	0.13910076E 02
	LAT3 MATRIX					
	0.23545695E 07	-0.35613246E 08	-0.30412141E 05	0.42079391E 05	-0.67964223E 04	0.32774734E 01
	-0.35613247E 08	0.20741616E 10	0.11370853E 07	-0.23706065E 07	0.28273022E 06	-0.19137836E 03
	-0.30406281E 05	0.11370760E 07	0.23841557E 07	-0.12958867E 04	0.16690820E 03	0.12834530E 04
36	0.42079401E 05	-0.23706066E 07	-0.12958843E 04	0.27229209E 04	-0.32505829E 03	0.21411985E 00
	-0.67964312E 04	0.28273023E 06	0.16690699E 03	-0.32505826E 03	0.41013257E 02	-0.33889636E-01
	0.32714844E 01	-0.19138281E 03	0.12834523E 04	0.21409607E 00	-0.33878326E-01	0.12227211E 02
	LAT3 MATRIX					
	0.22647077E 07	0.69529604E 07	-0.34393359E 03	-0.56260544E 04	-0.20889525E 04	-0.11251389E 02
	0.69529599E 07	0.12362084E 09	0.51266879E 05	-0.14125884E 06	0.11940800E 04	-0.54191456E 02
	-0.34392187E 03	0.51267000E 05	0.10333428E 07	-0.65227295E 02	0.27294006E 01	0.29566836E 04
37	-0.56260533E 04	-0.14125884E 06	-0.65227447E 02	0.17399126E 03	-0.50460611E 01	0.45259058E-01
	-0.20889527E 04	0.11940814E 04	0.27284050E 01	-0.50460610E 01	0.26479668E 01	0.24478137E-03
	-0.11251679E 02	-0.54191406E 02	0.29566839E 04	0.45259476E-01	0.24494529E-03	0.14199220E 02
	LAT3 MATRIX					
	0.17352481E 07	-0.23246446E 07	-0.11400508E 05	0.32812463E 04	-0.23508519E 04	-0.64781952E 00
	-0.23246438E 07	0.12297394E 09	0.54430629E 05	-0.15622236E 06	0.12283127E 05	-0.21344024E 02
	-0.11401156E 05	0.54431250E 05	0.23991309E 07	-0.65552978E 02	0.17609474E 02	0.13407039E 04
38	0.32812459E 04	-0.15622236E 06	-0.65552139E 02	0.21126556E 03	-0.16895430E 02	0.22547185E-01
	-0.23508512E 04	0.12283124E 05	0.17608822E 02	-0.16895429E 02	0.40426783E 01	-0.90993643E-02
	-0.64718628E 00	-0.21344238E 02	0.13407047E 04	0.22546768E-01	-0.90984106E-02	0.12206491E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III. - Continued [a]

Number	Covariance Matrix					
39	LAT3 MATRIX					
	0.42206273E 07	0.19834787E 08	0.60679453E 04	-0.20476351E 05	-0.22991477E 04	-0.15763031E 02
	0.19834794E 08	0.80899337E 09	0.39181710E 06	-0.93400352E 06	0.63547327E 05	-0.17617323E 03
	0.60668750E 04	0.39182400E 06	0.96560081E 06	-0.45879297E 03	0.33175232E 02	0.29284503E 04
	-0.20476349E 05	-0.93400352E 06	-0.45879784E 03	0.10909477E 04	-0.77108665E 02	0.18624985E 00
	-0.22991443E 04	0.63547315E 05	0.33172138E 02	-0.77108663E 02	0.91628578E 01	-0.10190755E-01
	-0.15772095E 02	-0.17616407E 03	0.29284520E 04	0.18625259E 00	-0.10188580E-01	0.14295449E 02
40	LAT3 MATRIX					
	0.28297093E 07	0.49490520E 07	-0.96027031E 04	-0.62974043E 04	-0.24830087E 04	-0.22492676E 01
	0.49490851E 07	0.89898178E 09	0.41990016E 06	-0.10781360E 07	0.91840531E 05	-0.11612120E 03
	-0.96020312E 04	0.41989700E 06	0.23972118E 07	-0.50040039E 03	0.55652832E 02	0.13324458E 04
	-0.62974043E 04	-0.10781360E 07	-0.50040187E 03	0.13063115E 04	-0.11099842E 03	0.13530648E 00
	-0.24830134E 04	0.91840538E 05	0.55653118E 02	-0.11099843E 03	0.12801894E 02	-0.18393084E-01
	-0.22465515E 01	-0.11612890E 03	0.13324481E 04	0.13530731E 00	-0.18389702E-01	0.12209270E 02
41	LAT3 MATRIX					
	0.66016521E 07	0.60322828E 08	0.26259953E 05	-0.67529609E 05	0.54811206E 03	-0.23598846E 02
	0.60322831E 08	0.28816038E 10	0.14482633E 07	-0.33447945E 07	0.27196406E 06	-0.45757326E 03
	0.26239875E 05	0.14482800E 07	0.97285623E 06	-0.16875078E 04	0.13953858E 03	0.29313688E 04
	-0.67529581E 05	-0.33447944E 07	-0.16875119E 04	0.38950411E 04	-0.31947025E 03	0.51397455E 00
	0.54810748E 03	0.27196408E 06	0.13955748E 03	-0.31947022E 03	0.31015402E 02	-0.37235022E-01
	-0.23580567E 02	-0.45757813E 03	0.29313559E 04	0.51396179E 00	-0.37199020E-01	0.14285997E 02
42	LAT3 MATRIX					
	0.28639456E 07	0.91155130E 07	0.47473731E 04	-0.75219092E 04	-0.19628966E 04	-0.84258957E 01
	0.91155189E 07	0.69459264E 09	0.35713481E 06	-0.78978079E 06	0.62499725E 05	-0.13704935E 03
	0.47484062E 04	0.35714000E 06	0.38368952E 06	-0.40918652E 03	0.30790222E 02	0.23157219E 04
	-0.75219108E 04	-0.78978080E 06	-0.40918879E 03	0.91178532E 03	-0.75193113E 02	0.13298762E 00
	-0.19628985E 04	0.62499719E 05	0.30792507E 02	-0.75193121E 02	0.86234190E 01	-0.14213949E-01
	-0.84245911E 01	-0.13704297E 03	0.23157201E 04	0.13299179E 00	-0.14211893E-01	0.15110006E 02
43	LAT3 MATRIX					
	0.40275301E 07	0.12653053E 08	0.68078125E 02	-0.12629389E 05	-0.29590898E 04	-0.14091964E 02
	0.12653053E 08	0.73508926E 09	0.35881539E 06	-0.85636671E 06	0.63082742E 05	-0.13201194E 03
	0.66562500E 02	0.35881500E 06	0.14301836E 07	-0.42565723E 03	0.36293335E 02	0.30136204E 04
	-0.12629393E 05	-0.85636673E 06	-0.42565711E 03	0.10100472E 04	-0.76960171E 02	0.13945460E 00
	-0.29590848E 04	0.63082751E 05	0.36290725E 02	-0.76960160E 02	0.99070737E 01	-0.65986961E-02
	-0.14091064E 02	-0.13201172E 03	0.30136200E 04	0.13945770E 00	-0.65898895E-02	0.13634386E 02
44	LAT3 MATRIX					
	0.43481296E 07	0.37708474E 08	0.19305239E 05	-0.40372207E 05	0.29053955E 02	-0.14490921E 02
	0.37708469E 08	0.25743925E 10	0.13242589E 07	-0.29714639E 07	0.25855211E 06	-0.37998491E 03
	0.19317750E 05	0.13242600E 07	0.42797220E 06	-0.15320898E 04	0.13183935E 03	0.24045560E 04
	-0.40372194E 05	-0.29714639E 07	-0.15321059E 04	0.34435331E 04	-0.30284407E 03	0.41552776E 00
	0.29029785E 02	0.25855206E 06	0.13186904E 03	-0.30284412E 03	0.29872302E 02	-0.37816912E-01
	-0.14484619E 02	-0.38000000E 03	0.24045588E 04	0.41552734E 00	-0.37829399E-01	0.15049865E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.21375735E 07	0.67397859E 07	0.40728906E 03	-0.52547249E 04	-0.19503166E 04	-0.10679123E 02
	0.67397856E 07	0.12268404E 09	0.52743792E 05	-0.13870535E 06	0.13660083E 04	-0.54680088E 02
45	0.40817187E 03	0.52742000E 05	0.88612030E 06	-0.65863770E 02	0.19743729E 01	0.28878334E 04
	-0.52547249E 04	-0.13870535E 06	-0.65863617E 02	0.16955767E 03	-0.52744220E 01	0.44078887E-01
	-0.19503164E 04	0.13660098E 04	0.19733887E 01	-0.52744236E 01	0.24910032E 01	-0.54231286E-03
	-0.10678375E 02	-0.54678223E 02	0.28878331E 04	0.44078827E-01	-0.54261088E-03	0.14407586E 02
	LAT3 MATRIX					
	0.17419973E 07	-0.61452120E 07	-0.52674726E 04	0.89194150E 04	-0.23428004E 04	0.43154011E 01
	-0.61452093E 07	0.70200180E 09	0.39982422E 06	-0.77683536E 06	0.81309587E 05	-0.12787835E 03
46	-0.52707549E 04	0.39982800E 06	0.76850274E 06	-0.43612793E 03	0.47813965E 02	0.58525404E 03
	0.89194114E 04	-0.77683536E 06	-0.43612235E 03	0.87405412E 03	-0.93027256E 02	0.12407100E 00
	-0.23428017E 04	0.81309582E 05	0.47813308E 02	-0.93027266E 02	0.11174820E 02	-0.27691633E-01
	0.43161621E 01	-0.12786719E 03	0.58525225E 03	0.12407303E 00	-0.27696609E-01	0.14514838E 02
	LAT3 MATRIX					
	0.41044757E 07	0.18992069E 08	0.61737383E 04	-0.19388849E 05	-0.22629810E 04	-0.15298462E 02
	0.18992087E 08	0.79875907E 09	0.38927652E 06	-0.92062073E 06	0.63305273E 05	-0.17372236E 03
47	0.61737500E 04	0.38928100E 06	0.89279461E 06	-0.45491406E 03	0.32769836E 02	0.28914414E 04
	-0.19388842E 05	-0.92062073E 06	-0.45491405E 03	0.10737797E 04	-0.76781629E 02	0.18239754E 00
	-0.22629770E 04	0.63305276E 05	0.32769455E 02	-0.76781627E 02	0.90902578E 01	-0.10472566E-01
	-0.15301514E 02	-0.17372266E 03	0.28914392E 04	0.18239594E 00	-0.10472059E-01	0.14398420E 02
	LAT3 MATRIX					
	0.21034750E 07	0.94966040E 07	0.37623945E 04	-0.81990918E 04	-0.83620923E 03	0.11033974E 01
	0.94966199E 07	0.24672192E 10	0.13326267E 07	-0.28127410E 07	0.27869795E 06	-0.34917096E 03
48	0.37633750E 04	0.13326280E 07	0.83099759E 06	-0.15119101E 04	0.15191553E 03	0.54306061E 03
	-0.81990929E 04	-0.28127411E 07	-0.15119138E 04	0.32217053E 04	-0.32112458E 03	0.38004755E 00
	-0.83623387E 03	0.27869793E 06	0.15193421E 03	-0.32112460E 03	0.33443716E 02	-0.51909775E-01
	0.11220093E 01	-0.34918750E 03	0.54305674E 03	0.38006592E 00	-0.51916122E-01	0.14425248E 02
	LAT3 MATRIX					
	0.78248415E 07	-0.34286757E 08	-0.25440761E 05	0.58289151E 05	-0.13653311E 05	-0.17970581E 02
	-0.34286793E 08	0.33455272E 09	0.16548955E 06	-0.39371972E 06	0.72912815E 05	-0.23261933E 02
	-0.25441547E 05	0.16549175E 06	0.35047571E 07	-0.20506982E 03	0.32972290E 02	0.19279180E 05
49	0.58289150E 05	-0.39371972E 06	-0.20506879E 03	0.58771497E 03	-0.11589694E 03	-0.26257992E-01
	-0.13653310E 05	0.72912820E 05	0.32970306E 02	-0.11589693E 03	0.25311060E 02	-0.64419270E-01
	-0.17971680E 02	-0.23257812E 02	0.19279179E 05	-0.26260376E-01	-0.64420700E-01	0.13074816E 03
	LAT3 MATRIX					
	0.65337254E 07	-0.32754329E 08	-0.31376219E 05	0.56911181E 05	-0.12332381E 05	-0.34244385E 01
	-0.32754328E 08	0.54531566E 09	0.31422941E 06	-0.61060480E 06	0.94854954E 05	-0.56134888E 02
50	-0.31374891E 05	0.31422950E 06	0.51720426E 07	-0.35241845E 03	0.54949097E 02	0.21217108E 05
	0.56911181E 05	-0.61060479E 06	-0.35242065E 03	0.83444257E 03	-0.14076807E 03	0.11711121E-01
	-0.12332377E 05	0.94854959E 05	0.54945892E 02	-0.14076806E 03	0.26789916E 02	-0.99185705E-01
	-0.34213867E 01	-0.56136719E 02	0.21217107E 05	0.11714935E-01	-0.99185467E-01	0.15526173E 03

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
51	LAT3 MATRIX					
	0.94055729E 07	-0.51922032E 08	-0.34524812E 05	0.10690175E 06	-0.20394949E 05	-0.20450195E 02
	-0.51922028E 08	0.15558152E 10	0.80440339E 06	-0.18299297E 07	0.23914563E 06	-0.14067444E 03
	-0.34527344E 05	0.80440800E 06	0.75622914E 07	-0.96268945E 03	0.10183057E 03	0.48235513E 05
	0.10690174E 06	-0.18299297E 07	-0.96268945E 03	0.24757044E 04	-0.35885181E 03	0.42501450E-01
	-0.20394939E 05	0.23914562E 06	0.10182599E 03	-0.35885180E 03	0.57340939E 02	-0.20333815E 00
	-0.20460538E 02	-0.14065625E 03	0.48235513E 05	0.42495728E-01	-0.20332718E 00	0.33847796E 03
52	LAT3 MATRIX					
	0.93289616E 07	-0.37700194E 08	-0.32770563E 05	0.94072447E 05	-0.18896488E 05	-0.10218018E 02
	-0.37700180E 08	0.20747861E 10	0.11293979E 07	-0.23861639E 07	0.28635090E 06	-0.24733538E 03
	-0.32765703E 05	0.11293920E 07	0.95442901E 07	-0.13056679E 04	0.13671362E 03	0.52481310E 05
	0.94072473E 05	-0.23861639E 07	-0.13056719E 04	0.31105490E 04	-0.41526540E 03	0.15847397E 00
	-0.18896454E 05	0.28635095E 06	0.13671264E 03	-0.41526536E 03	0.62006465E 02	-0.25382710E 00
	-0.10230957E 02	-0.24733594E 03	0.52481313E 05	0.15846252E 00	-0.25381851E 00	0.37962811E 03
53	LAT3 MATRIX					
	0.32212635E 07	0.66668209E 07	-0.66750781E 03	0.15112020E 04	-0.37491508E 04	-0.13101562E 02
	0.66668219E 07	0.12370644E 09	0.50213166E 05	-0.14339345E 06	0.14906674E 04	-0.61868713E 02
	-0.66768750E 03	0.50214000E 05	0.20153715E 07	-0.66568603E 02	-0.14081726E 01	0.99851250E 04
	0.15112027E 04	-0.14339345E 06	-0.66568970E 02	0.22727212E 03	-0.17436237E 02	0.37634134E-01
	-0.37491510E 04	0.14906682E 04	-0.14090118E 01	-0.17436239E 02	0.55297105E 01	-0.29912829E-01
	-0.13101671E 02	-0.61868652E 02	0.99851252E 04	0.37636757E-01	-0.29913247E-01	0.64707455E 02
54	LAT3 MATRIX					
	0.30535740E 07	-0.27190411E 07	-0.11846719E 05	0.13115077E 05	-0.46386576E 04	-0.31982422E 01
	-0.27190393E 07	0.12309193E 09	0.52979230E 05	-0.15916390E 06	0.12967524E 05	-0.31923905E 02
	-0.11847414E 05	0.52979875E 05	0.37525656E 07	-0.67401855E 02	0.11905130E 02	0.11024456E 05
	0.13115076E 05	-0.15916390E 06	-0.67401184E 02	0.28464620E 03	-0.33963688E 02	0.12037754E-01
	-0.46386577E 04	0.12967522E 05	0.11904327E 02	-0.33563687E 02	0.80132202E 01	-0.50666094E-01
	-0.31981201E 01	-0.31923828E 02	0.11024457E 05	0.12036324E-01	-0.50663710E-01	0.81765201E 02
55	LAT3 MATRIX					
	0.80816041E 07	0.18679520E 08	0.47615625E 04	0.83099551E 04	-0.89980237E 04	-0.23229004E 02
	0.18679527E 08	0.80933906E 09	0.38756322E 06	-0.94261648E 06	0.65551669E 05	-0.20715649E 03
	0.47619375E 04	0.38756600E 06	0.49294065E 07	-0.46420899E 03	0.16462647E 02	0.31274656E 05
	0.83099555E 04	-0.94261649E 06	-0.46421521E 03	0.13055967E 04	-0.12705622E 03	0.15546036E 00
	-0.89980207E 04	0.65551655E 05	0.16459838E 02	-0.12705622E 03	0.20785538E 02	-0.13194919E 00
	-0.23242279E 02	-0.20714453E 03	0.31274659E 05	0.15545654E 00	-0.13194370E 00	0.21774767E 03
56	LAT3 MATRIX					
	0.74142417E 07	0.35773020E 07	-0.11153500E 05	0.27882106E 05	-0.10437090E 05	-0.11116088E 02
	0.35773002E 07	0.89939226E 09	0.41484823E 06	-0.10883628E 07	0.94220531E 05	-0.15291443E 03
	-0.11153812E 05	0.41484500E 06	0.71038389E 07	-0.50683008E 03	0.35807007E 02	0.34989328E 05
	0.27882105E 05	-0.10883628E 07	-0.50683020E 03	0.15611604E 04	-0.17030215E 03	0.98741531E-01
	-0.10437091E 05	0.94220550E 05	0.35807129E 02	-0.17030215E 03	0.26602525E 02	-0.16297340E 00
	-0.11119873E 02	-0.15291406E 03	0.34989331E 05	0.98747253E-01	-0.16296864E 00	0.25376280E 03

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.15155838E 08	0.57703310E 08	0.23298625E 05	-0.22701992E 04	-0.14639619E 05	-0.40532715E 02
	0.57703300E 08	0.28823876E 10	0.14386201E 07	-0.33643217E 07	0.27650872E 06	-0.52780872E 03
	0.23277875E 05	0.14386440E 07	0.99601990E 07	-0.16997890E 04	0.10165259E 03	0.67192549E 05
57	-0.22701836E 04	-0.33643217E 07	-0.16997905E 04	0.43815539E 04	-0.43269216E 03	0.44417191E 00
	-0.14639633E 05	0.27650874E 06	0.10166601E 03	-0.43269213E 03	0.57365192E 02	-0.31327724E 00
	-0.40516723E 02	-0.52782812E 03	0.67192542E 05	0.44412231E 00	-0.31324196E 00	0.47540950E 03
	LAT3 MATRIX					
	0.65072519E 07	0.80253860E 07	0.35147813E 04	0.19641888E 05	-0.82841313E 04	-0.15471924E 02
	0.80253901E 07	0.69491884E 09	0.35311881E 06	-0.79790821E 06	0.64391112E 05	-0.16628488E 03
	0.35160625E 04	0.35312100E 06	0.41240252E 07	-0.41429883E 03	0.15020569E 02	0.29064252E 05
58	0.19641888E 05	-0.79790822E 06	-0.41430127E 03	0.11143404E 04	-0.12232582E 03	0.10393715E 00
	-0.82841324E 04	0.64391104E 05	0.15022736E 02	-0.12232583E 03	0.19591296E 02	-0.12909842E 00
	-0.15474975E 02	-0.16628125E 03	0.29064252E 05	0.10393143E 00	-0.12909603E 00	0.20709964E 03
	LAT3 MATRIX					
	0.80252489E 07	0.11456871E 08	-0.12846875E 04	0.17176118E 05	-0.98951687E 04	-0.21825195E 02
	0.11456871E 08	0.73544718E 09	0.35440976E 06	-0.86528463E 06	0.65158119E 05	-0.16409192E 03
	-0.12871250E 04	0.35440900E 06	0.55343703E 07	-0.43126563E 03	0.18991089E 02	0.32363445E 05
59	0.17176114E 05	-0.86528464E 06	-0.43126502E 03	0.12322932E 04	-0.12867580E 03	0.10757256E 00
	-0.98951651E 04	0.65158131E 05	0.18988603E 02	-0.12867580E 03	0.21941605E 02	-0.13265753E 00
	-0.21821899E 02	-0.16408594E 03	0.32363444E 05	0.10757446E 00	-0.13264751E 00	0.22428697E 03
	LAT3 MATRIX					
	0.12804081E 08	0.35178200E 08	0.16446937E 05	0.22664152E 05	-0.14641262E 05	-0.30841797E 02
	0.35178181E 08	0.25751496E 10	0.13149413E 07	-0.29903260E 07	0.26294192E 06	-0.44784253E 03
	0.16458499E 05	0.13149480E 07	0.91091223E 07	-0.15439727E 04	0.95232178E 02	0.64476683E 05
60	0.22664140E 05	-0.29903259E 07	-0.15439790E 04	0.39134754E 04	-0.41220927E 03	0.34807777E 00
	-0.14641287E 05	0.26294188E 06	0.95263916E 02	-0.41220931E 03	0.55324479E 02	-0.30445766E 00
	-0.30840637E 02	-0.44784375E 03	0.64476688E 05	0.34808350E 00	-0.30446625E 00	0.46046795E 03
	LAT3 MATRIX					
	0.30720506E 07	0.64602552E 07	0.91343750E 02	0.17179657E 04	-0.35722132E 04	-0.12486633E 02
	0.64602544E 07	0.12276766E 09	0.51714316E 05	-0.14079071E 06	0.18511334E 04	-0.62179855E 02
	0.92031250E 02	0.51712750E 05	0.18454827E 07	-0.67173828E 02	-0.20673065E 01	0.97542270E 04
61	0.17179657E 04	-0.14079071E 06	-0.67174072E 02	0.22161188E 03	-0.17379102E 02	0.36630392E-01
	-0.35722129E 04	0.18511350E 04	-0.20683899E 01	-0.17379104E 02	0.53063000E 01	-0.30004978E-01
	-0.12485832E 02	-0.62178711E 02	0.97542267E 04	0.36629677E-01	-0.30004978E-01	0.63753210E 02
	LAT3 MATRIX					
	0.49437409E 07	-0.71032100E 07	-0.63512344E 04	0.32791890E 05	-0.78980024E 04	-0.18796387E 01
	-0.71032057E 07	0.70228845E 09	0.39629642E 06	-0.78397787E 06	0.82971744E 05	-0.15356784E 03
	-0.63540625E 04	0.39630100E 06	0.40555162E 07	-0.44062012E 03	0.33956421E 02	0.24092827E 05
62	0.32791897E 05	-0.78397787E 06	-0.44061511E 03	0.10520763E 04	-0.13445009E 03	0.98542213E-01
	-0.78980031E 04	0.82971736E 05	0.33957520E 02	-0.13445010E 03	0.20813763E 02	-0.12864923E 00
	-0.18791504E 01	-0.15356641E 03	0.24092825E 05	0.98541260E-01	-0.12865734E 00	0.18325229E 03

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
63	LAT3 MATRIX					
	0.79453261E 07	0.17842829E 08	0.48740625E 04	0.92473789E 04	-0.89269093E 04	-0.22729858E 02
	0.17842845E 08	0.79910294E 09	0.38504565E 06	-0.92918876E 06	0.65299206E 05	-0.20454553E 03
	0.48733750E 04	0.38505300E 06	0.48359312E 07	-0.46030371E 03	0.16142822E 02	0.31089871E 05
	0.92473865E 04	-0.92918877E 06	-0.46030371E 03	0.12873100E 04	-0.12646874E 03	0.15176392E 00
	-0.89269067E 04	0.65299205E 05	0.16142395E 02	-0.12646874E 03	0.20652663E 02	-0.13159204E 00
	-0.22733978E 02	-0.20453516E 03	0.31089871E 05	0.15176392E 00	-0.13158989E 00	0.21679036E 03
64	LAT3 MATRIX					
	0.98157397E 07	0.71888640E 07	0.11471562E 04	0.49293939E 05	-0.14216359E 05	-0.13812500E 02
	0.71888762E 07	0.24679097E 10	0.13241298E 07	-0.28299442E 07	0.28270170E 06	-0.41104834E 03
	0.11505625E 04	0.13241280E 07	0.87486630E 07	-0.15227226E 04	0.11852783E 03	0.57156725E 05
	0.49293959E 05	-0.28299442E 07	-0.15227387E 04	0.36503291E 04	-0.42087318E 03	0.31854057E 00
	-0.14216387E 05	0.28270168E 06	0.11854621E 03	-0.42087318E 03	0.56657671E 02	-0.29511452E 00
	-0.13803222E 02	-0.41104687E 03	0.57156726E 05	0.31857300E 00	-0.29512024E 00	0.42068176E 03
65	LAT3 MATRIX					
	0.1[illegible]E 07	-0.4[illegible]E 07	-0.4194[illegible]E 05	0.64[illegible]E 04	-0.15051510E 04	-0.14217661E 02
	-0.43[illegible]E 07	0.[illegible]E 08	0.17121347E 06	-0.26[illegible]E 05	0.59666538E 04	0.72148043E 03
	-0.41[illegible]E 05	0.17121[illegible]E 06	0.30578529E 06	-0.1[illegible]E 03	0.57538467E 02	0.17934682E 04
	0.64[illegible]E 04	-0.[illegible]E 05	-0.18[illegible]E 03	0.40774233E 02	-0.93772625E 01	-0.79592318E 00
	-0.15051511E 04	0.59666540E 04	0.57538443E 02	-0.93772625E 01	0.22120201E 01	0.18894324E 00
	-0.14217[illegible]E 03	0.72148[illegible]E 03	0.17934683E 04	-0.79592312E 00	0.18894312E 00	0.12326500E 02
66	LAT3 MATRIX					
	0.61471243E 06	-0.3[illegible]E 07	-0.37961006E 05	0.60576[illegible]E 04	-0.10407284E 04	-0.34657150E 02
	-0.39023[illegible]E 07	0.41[illegible]E 08	0.44099529E 06	-0.46784424E 05	0.68557021E 04	0.37113215E 03
	-0.37[illegible]E 05	0.44[illegible]E 06	0.38651051E 06	-0.46983631E 03	0.73491638E 02	0.16906393E 04
	0.60576044E 04	-0.46784424E 05	-0.46983633E 03	0.63963476E 02	-0.10417468E 02	-0.42044008E 00
	-0.10407227E 04	0.68557022E 04	0.73491638E 02	-0.10417468E 02	0.18058799E 01	0.49977645E-01
	-0.34657370E 02	0.37113257E 03	0.16906392E 04	-0.42044020E 00	0.49977601E-01	0.12145373E 02
67	LAT3 MATRIX					
	0.28347072E 07	-0.5[illegible]E 07	-0.13074933E 06	0.83830528E 04	-0.31944232E 04	0.35778206E 02
	-0.5[illegible]E 07	0.[illegible]E 07	0.25208405E 06	-0.13512533E 05	0.55410792E 04	-0.59713909E 02
	-0.13074932E 06	0.25208406E 06	0.26096092E 06	-0.33352621E 03	0.14232285E 03	0.17147807E 04
	0.83830530E 04	-0.13512533E 05	-0.33352620E 03	0.30007801E 02	-0.10153887E 02	0.81405759E-01
	-0.31944232E 04	0.55410793E 04	0.14232284E 03	-0.10153887E 02	0.37223487E 01	-0.42255461E-01
	0.35778[illegible]E 02	-0.59713867E 02	0.17147807E 04	0.81405647E-01	-0.42255580E-01	0.12196[illegible]E 02
68	LAT3 MATRIX					
	0.29[illegible]E 07	-0.1[illegible]E 08	-0.4[illegible]E 05	0.13635[illegible]E 05	-0.39843[illegible]E 04	0.15362248E 03
	-0.10[illegible]E 08	0.42625197E 08	0.19741215E 06	-0.47466[illegible]E 05	0.14206334E 05	-0.60149692E 03
	-0.43926[illegible]E 05	0.19741234E 06	0.29538936E 06	-0.21283906E 03	0.61286514E 02	0.16934473E 04
	0.13635[illegible]E 05	-0.47466[illegible]E 05	-0.21283916E 03	0.64556222E 02	-0.19499767E 02	0.65640229E 00
	-0.39843[illegible]E 04	0.14206334E 05	0.61286545E 02	-0.19499767E 02	0.53827824E 01	-0.20882758E 00
	0.15362[illegible]E 03	-0.60149[illegible]E 03	0.16934473E 04	0.65640235E 00	-0.20882785E 00	0.12146213E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
69	LAT3 MATRIX					
	0.12327[illegible]	-0.[illegible]E 07	-0.17373462E 06	0.75894461E 04	-0.13739009E 04	-0.56052417E 03
	-0.[illegible]	0.[illegible]	0.[illegible]	-0.[illegible]E 05	0.12051441E 05	0.45579986E 04
	-0.17373[illegible]	0.[illegible]	0.41326433E 07	-0.26455631E 04	0.40443362E 03	0.21155527E 04
	0.75894461E 04	-0.[illegible]E 05	-0.26455631E 04	0.15423009E 03	-0.16421035E 02	-0.40050523E 01
	-0.13739009E 04	0.12051441E 05	0.40443362E 03	-0.16421035E 02	0.32592228E 01	0.95484711E 00
	-0.56052417E 03	0.[illegible]	0.21155527E 04	-0.40050523E 01	0.95484711E 00	0.19966433E 02
70	LAT3 MATRIX					
	0.11326[illegible]	0.14732844E 07	0.17571603E 06	-0.45665918E 01	-0.10772142E 04	-0.63781288E 02
	0.14732844E 07	0.[illegible]	0.48900751E 07	-0.11836017E 06	0.67430153E 04	-0.50802114E 03
	0.17571603E 06	0.48900751E 07	0.15833752E 07	-0.51065896E 04	0.22955621E 03	0.20367508E 04
	-0.45665918E 01	-0.11836017E 06	-0.51065896E 04	0.14416933E 03	-0.12200224E 02	0.30375326E 00
	-0.10772142E 04	0.67430153E 04	0.22955621E 03	-0.12200224E 02	0.19414485E 01	0.16732037E-01
	-0.63781288E 02	-0.50802114E 03	0.20367508E 04	0.30375326E 00	0.16732037E-01	0.12326083E 02
71	LAT3 MATRIX					
	0.55363374E 06	-0.[illegible]E 07	-0.20031864E 04	0.77336608E 04	-0.13981444E 04	0.90466782E 02
	-0.[illegible]E 07	0.[illegible]	-0.54070752E 05	-0.[illegible]E 05	0.11[illegible]E 05	-0.14706207E 04
	-0.20031864E 04	-0.[illegible]E 05	0.27073472E 06	0.69802093E 02	-0.35476080E 01	0.17584335E 04
	0.77336608E 04	-0.[illegible]E 05	0.69802093E 02	0.17901349E 03	-0.16163575E 02	0.17901669E 01
	-0.13981444E 04	0.11[illegible]E 05	-0.35476080E 01	-0.16163574E 02	0.22175386E 01	-0.19807754E 00
	0.90466782E 02	-0.[illegible]	0.17584335E 04	0.17901669E 01	-0.19807754E 00	0.12359756E 02
72	LAT3 MATRIX					
	0.12812[illegible]	-0.11[illegible]E 08	0.12801754E 06	0.15611487E 05	-0.24603227E 04	0.65664352E 02
	-0.11[illegible]	0.[illegible]	-0.13603131E 07	-0.15203248E 06	0.22756686E 05	-0.71450085E 03
	0.12801754E 06	-0.[illegible]E 07	0.41451585E 06	0.16625427E 04	-0.35280340E 03	0.17112053E 04
	0.15611487E 05	-0.15203248E 06	0.16625624E 04	0.15765740E 03	-0.30308968E 02	0.86017430E 00
	-0.24603227E 04	0.22756686E 05	-0.35280317E 03	-0.30308967E 02	0.47860102E 01	-0.13581535E 00
	0.65664352E 02	-0.71450085E 03	0.17112053E 04	0.86017430E 00	-0.13581535E 00	0.12148280E 02
73	LAT3 MATRIX					
	0.31126055E 06	-0.[illegible]E 07	0.15[illegible]E 05	0.5[illegible]E 04	-0.[illegible]E 03	-0.25[illegible]E 02
	-0.[illegible]	0.[illegible]	0.[illegible]	-0.[illegible]	0.[illegible]	0.[illegible]
	0.15[illegible]	-0.[illegible]	0.24[illegible]	0.76[illegible]	-0.65[illegible]	0.[illegible]
	0.50[illegible]	-0.[illegible]	0.76[illegible]	0.16[illegible]	-0.15[illegible]	-0.[illegible]
	-0.69[illegible]	0.[illegible]	-0.[illegible]	-0.15[illegible]	0.17[illegible]	0.97360397E-01
	-0.75[illegible]	0.[illegible]	0.[illegible]	-0.[illegible]	0.97[illegible]	0.12[illegible]
74	LAT3 MATRIX					
	0.61129[illegible]	-0.[illegible]E 07	0.11[illegible]E 05	0.57[illegible]E 04	-0.[illegible]E 03	-0.2[illegible]E 02
	-0.[illegible]	0.[illegible]	-0.[illegible]	-0.[illegible]	0.[illegible]	0.[illegible]
	0.11[illegible]	-0.[illegible]	0.24[illegible]	0.10[illegible]	-0.18[illegible]	0.16[illegible]
	0.57[illegible]	-0.[illegible]	0.10[illegible]	0.[illegible]	-0.[illegible]	-0.[illegible]
	-0.[illegible]	0.[illegible]	-0.18[illegible]	-0.[illegible]	0.16[illegible]	0.20[illegible]E-01
	-0.[illegible]	0.[illegible]	0.[illegible]	-0.[illegible]	0.20[illegible]E-01	0.12[illegible]

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
75	LATA MATRIX					
	[illegible]	[illegible]	[illegible]	0.626659855E 04	-0.999223195E 03	-0.247461248E 02
	-0.398767653E 07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-0.891668705E 01	-0.134967316E 01	0.170259416E 04
	[illegible]	[illegible]	-0.831689147E 01	0.735407554E 02	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-0.109461885E 02	0.176354625E 01	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
76	LATA MATRIX					
	[illegible]	[illegible]	0.435665437E 05	0.114414725E 05	-0.165211705E 04	0.146163238E 03
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.435445225E 05	[illegible]	0.243376111E 06	0.746148325E 03	-0.972658545E 02	0.170143205E 04
	0.114414725E 05	[illegible]	[illegible]	0.183475335E 03	-0.249670085E 02	0.257376785E 01
	-0.165211705E 04	[illegible]	-0.472667615E 02	-0.249670085E 02	0.354891705E 01	-0.340316335E 00
	0.146163238E 03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
77	LATA MATRIX					
	[illegible]	[illegible]	0.108832025E 05	0.448534955E 04	-0.112004195E 04	-0.280486155E 02
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.108832025E 05	[illegible]	0.279774145E 06	0.394835515E 03	-0.405271295E 02	0.170605495E 04
	0.448534955E 04	[illegible]	[illegible]	0.455952525E 02	[illegible]	[illegible]
	-0.112004195E 04	[illegible]	-0.405272795E 02	-0.905296745E 01	0.174164695E 01	0.004130015E-02
	-0.280486155E 02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
78	LATA MATRIX					
	[illegible]	[illegible]	0.991145175E 05	0.906503925E 04	-0.156800495E 04	-0.325574955E 02
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.991144495E 05	[illegible]	0.271390535E 06	0.120017935E 04	-0.177965365E 03	0.166578915E 04
	0.906503925E 04	[illegible]	0.120017935E 04	0.122565875E 03	-0.182592405E 02	-0.388675215E 00
	-0.156800495E 04	[illegible]	-0.177965365E 03	-0.182592405E 02	0.286966225E 01	0.539305045E-01
	-0.325574955E 02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
79	LATA MATRIX					
	[illegible]	[illegible]	0.904473315E 05	0.144790195E 05	-0.234626865E 04	-0.327980115E 02
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.904473315E 05	[illegible]	0.262266365E 06	0.984766165E 03	-0.151521765E 03	0.170634885E 04
	0.144790195E 05	[illegible]	0.984766165E 03	[illegible]	-0.274964455E 02	[illegible]
	-0.234626865E 04	[illegible]	-0.151521765E 03	-0.274964455E 02	0.445733765E 01	0.501446085E-01
	-0.327980115E 02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	LATA MATRIX					
	[illegible]	[illegible]	[illegible]	0.117330735E 05	-0.140134115E 04	0.433768775E 02
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.207225875E 05	[illegible]	0.256675325E 06	0.115638775E 04	-0.121468025E 03	0.167695535E 04
	0.117330735E 05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	-0.140134115E 04	[illegible]	-0.121468025E 03	-0.810396955E 02	0.943131585E 01	-0.330539095E 00
	0.433768775E 02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III. - Continued [a]

Covariance Matrix

Number						
81	LAT3 MATRIX					
	0.32731729E 07	-0.50021905E 07	-0.42689922E 05	0.22924983E 05	-0.53502197E 04	-0.14646331E 03
	-0.50021906E 07	0.23493298E 08	0.16877208E 06	-0.30968339E 05	0.71170560E 04	0.70369843E 03
	-0.42689860E 05	0.16877197E 06	0.25807764E 07	-0.18320124E 03	0.47948349E 02	0.18065745E 05
	0.22924582E 05	-0.30968338E 05	-0.18320135E 03	0.16402771E 03	-0.38053075E 02	-0.80359221E 00
	-0.53502199E 04	0.71170561E 04	0.47948364E 02	-0.38053076E 02	0.88941582E 01	0.11906743E 00
	-0.14646362E 03	0.70369849E 03	0.18065745E 05	-0.80359268E 00	0.11906707E 00	0.12915446E 03
82	LAT3 MATRIX					
	0.33304137E 07	-0.48043497E 07	-0.38879344E 05	0.26292303E 05	-0.57492630E 04	-0.39906494E 02
	-0.48043500E 07	0.42123209E 08	0.43800530E 06	-0.52838356E 05	0.82644928E 04	0.34935629E 03
	-0.38879305E 05	0.43800522E 06	0.31724834E 07	-0.47364477E 03	0.61746612E 02	0.21616100E 05
	0.26292304E 05	-0.52838356E 05	-0.47364477E 03	0.21487029E 03	-0.45529399E 02	-0.44208145E 00
	-0.57492630E 04	0.82644931E 04	0.61746521E 02	-0.45529400E 02	0.99759917E 01	-0.35595655E-01
	-0.39906494E 02	0.34935571E 03	0.21616100E 05	-0.44208050E 00	-0.35595894E-01	0.15518304E 03
83	LAT3 MATRIX					
	0.89956914E 07	-0.69379647E 07	-0.13283434E 06	0.54313166E 05	-0.13883382E 05	0.23859619E 02
	-0.69379648E 07	0.10402944E 08	0.24629632E 06	-0.27255642E 05	0.87394907E 04	-0.10914782E 03
	-0.13283438E 06	0.24629630E 06	0.65860288E 07	-0.34217432E 03	0.11565356E 03	0.46942453E 05
	0.54313166E 05	-0.27255643E 05	-0.34217407E 03	0.37244365E 03	-0.89842836E 02	0.32266617E-01
	-0.13883382E 05	0.87394908E 04	0.11565369E 03	-0.89842836E 02	0.22267520E 02	-0.23654366E 00
	0.23859619E 02	-0.10914807E 03	0.46942453E 05	0.32264709E-01	-0.23654413E 00	0.33676390E 03
84	LAT3 MATRIX					
	0.99648640E 07	-0.12963586E 08	-0.46286469E 05	0.65628147E 05	-0.16084461E 05	0.14013037E 03
	-0.12963587E 08	0.43249671E 08	0.18972703E 06	-0.63023794E 05	0.17827017E 05	-0.65745648E 03
	-0.46286468E 05	0.18972719E 06	0.74555244E 07	-0.22262842E 03	0.31096130E 02	0.52891304E 05
	0.65628148E 05	-0.63023795E 05	-0.22262914E 03	0.45218420E 03	-0.10870689E 03	0.60077667E 00
	-0.16084462E 05	0.17827017E 05	0.31096009E 02	-0.10870690E 03	0.26376000E 02	-0.42876768E 00
	0.14013037E 03	-0.65745630E 03	0.52891304E 05	0.60077858E 00	-0.42876959E 00	0.37954709E 03
85	AT3 MATRIX					
	0.22392982E 07	-0.58460087E 07	-0.17405791E 06	0.14726702E 05	-0.35310887E 04	-0.56237384E 03
	-0.58460088E 07	0.86444435E 08	0.26022062E 07	-0.91980154E 05	0.13488228E 05	0.40502606E 04
	-0.17405853E 06	0.26022066E 07	0.13952948E 07	-0.26469048E 04	0.40228586E 03	0.91439941E 04
	0.14726702E 05	-0.91990154E 05	-0.26469043E 04	0.15870394E 03	-0.28811211E 02	-0.40135782E 01
	-0.35310885E 04	0.13488229E 05	0.40228558E 03	-0.28811212E 02	0.61409669E 01	0.92468917E 00
	-0.56237366E 03	0.40502612E 04	0.91439941E 04	-0.40135770E 01	0.92468798E 00	0.64504666E 02
86	LAT3 MATRIX					
	0.24220083E 07	0.10788891E 07	0.17526992E 06	0.98293246E 04	-0.33650230E 04	-0.66331360E 02
	0.10788903E 07	0.10609700E 09	0.48885232E 07	-0.12130171E 06	0.74274122E 04	-0.60950134E 03
	0.17526960E 06	0.48885233E 07	0.29373100E 07	-0.51084388E 04	0.22385251E 03	0.11720543E 05
	0.98293238E 04	-0.12130171E 06	-0.51084387E 04	0.21754996E 03	-0.27367481E 02	0.79324198E 00
	-0.33650230E 04	0.74274137E 04	0.22385237E 03	-0.27367483E 02	0.58119908E 01	-0.24835587E-01
	-0.66330871E 02	-0.60950244E 03	0.11720542E 05	0.79324245E 00	-0.24835925E-01	0.81885693E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.44157850E 07	-0.61899612E 07	-0.43049844E 04	0.36528595E 05	-0.77890571E 04	0.72996582E 02
	-0.61899609E 07	0.80042318E 08	-0.59235578E 05	-0.10572075E 06	0.13015515E 05	-0.15016121E 04
87	-0.43050791E 04	-0.59235750E 05	0.42357450E 07	0.64379303E 02	-0.20264603E 02	0.30113227E 05
	0.36528596E 05	-0.10572075E 06	0.64380005E 02	0.34462741E 03	-0.66126164E 02	0.17593985E 01
	-0.77890576E 04	0.13015516E 05	-0.20264160E 02	-0.66126166E 02	0.13844061E 02	-0.31986594E 00
	0.72997192E 02	-0.15016103E 04	0.30113226E 05	0.17593994E 01	-0.31986809E 00	0.21587350E 03
	LAT3 MATRIX					
	0.58655387E 07	-0.12897369E 08	0.12646606E 06	0.49791002E 05	-0.10414394E 05	0.56796387E 02
	-0.12897369E 08	0.12619312E 09	-0.13658648E 07	-0.16315931E 06	0.25130697E 05	-0.75138562E 03
88	0.12646643E 06	-0.13658653E 07	0.51231432E 07	0.16561280E 04	-0.27274759E 03	0.35368090E 05
	0.49791001E 05	-0.16315931E 06	0.16561279E 04	0.45240641E 03	-0.89702700E 02	0.82361317E 00
	-0.10414393E 05	0.25130696E 05	-0.27274781E 03	-0.89702695E 02	0.18586631E 02	-0.28038788E 00
	0.56796875E 02	-0.75138574E 03	0.35368090E 05	0.82361031E 00	-0.28038740E 00	0.25370179E 03
	LAT3 MATRIX					
	0.90655535E 07	-0.56462758E 07	0.12539719E 05	0.70282656E 05	-0.15869025E 05	-0.42928223E 02
	-0.56462751E 07	0.12276370E 09	-0.69362914E 06	-0.15635205E 06	0.16073080E 05	0.94150623E 03
89	0.12539062E 05	-0.69362800E 06	0.92368457E 07	0.75101111E 03	-0.10289691E 03	0.65957451E 05
	0.70282655E 05	-0.15635205E 06	0.75101147E 03	0.65167765E 03	-0.12893738E 03	-0.12047882E 01
	-0.15869025E 05	0.16073083E 05	-0.10289697E 03	-0.12893738E 03	0.28140081E 02	-0.18870735E 00
	-0.42928711E 02	0.94150439E 03	0.65957450E 05	-0.12047844E 01	-0.18870783E 00	0.47330512E 03
	LAT3 MATRIX					
	0.42545966E 07	-0.46912201E 07	0.98106719E 04	0.32937664E 05	-0.73144499E 04	-0.27983154E 02
	-0.46912194E 07	0.34819411E 08	-0.10021686E 06	-0.48241671E 05	0.77123379E 04	0.14437979E 03
90	0.98106094E 04	-0.10021653E 06	0.39822381E 07	0.10445978E 03	-0.33815414E 02	0.28442546E 05
	0.32937663E 05	-0.48241671E 05	0.10446008E 03	0.26085600E 03	-0.56648842E 02	-0.23510742E 00
	-0.73144497E 04	0.77123384E 04	-0.33815521E 02	-0.56648841E 02	0.12632565E 02	-0.94201565E-01
	-0.27982910E 02	0.14438013E 03	0.28442545E 05	-0.23510551E 00	-0.94202280E-01	0.20415247E 03
	LAT3 MATRIX					
	0.45795960E 07	-0.51538602E 07	-0.20449906E 04	0.36072118E 05	-0.79352983E 04	-0.32479370E 02
	-0.51538603E 07	0.44732616E 08	0.16588594E 04	-0.61334377E 05	0.90138913E 04	0.21735376E 03
91	-0.20450781E 04	0.16589375E 04	0.43542306E 07	-0.14527100E 02	-0.18653442E 02	0.31052418E 05
	0.36072119E 05	-0.61334378E 05	-0.14527344E 02	0.29579572E 03	-0.62661805E 02	-0.32957268E 00
	-0.79352983E 04	0.90138916E 04	-0.18653320E 02	-0.62661807E 02	0.13798075E 02	-0.95673561E-01
	-0.32478882E 02	0.21735400E 03	0.31052418E 05	-0.32957363E 00	-0.95673800E-01	0.22280413E 03
	AT3 MATRIX					
	0.92469955E 07	-0.11231657E 08	0.40704438E 05	0.74477802E 05	-0.16322428E 05	0.12980689E 03
	-0.11231657E 08	0.13539273E 09	-0.67228803E 06	-0.17094811E 06	0.24044921E 05	-0.23585449E 04
92	0.40704531E 05	-0.67228775E 06	0.89245267E 07	0.73427917E 03	-0.13387030E 03	0.63773552E 05
	0.74477802E 05	-0.17094811E 06	0.73427881E 03	0.65341773E 03	-0.13433223E 03	0.25063286E 01
	-0.16322426E 05	0.24044923E 05	-0.13387183E 03	-0.13433223E 03	0.29001080E 02	-0.60698032E 00
	0.12980542E 03	-0.23585449E 04	0.63773552E 05	0.25063210E 01	-0.60697794E 00	0.45760120E 03

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.17821609E 07	-0.27411694E 07	0.10573160E 05	0.11458059E 05	-0.27509382E 04	-0.29855957E 02
	-0.27411692E 07	0.29305357E 08	-0.37910293E 06	-0.33633319E 05	0.52141344E 04	-0.16443244E 03
93	0.10573028E 05	-0.37910272E 06	0.12391386E 07	0.39352510E 03	-0.44569099E 02	0.85724486E 04
	0.11458060E 05	-0.33633319E 05	0.39352527E 03	0.97979459E 02	-0.20157549E 02	0.15023232E 00
	-0.27509381E 04	0.52141346E 04	-0.44569275E 02	-0.20157550E 02	0.45569432E 01	-0.19519925E-01
	-0.29855835E 02	-0.16443262E 03	0.85724486E 04	0.15023184E 00	-0.19519925E-01	0.61586399E 02
	LAT3 MATRIX					
	0.40750081E 07	-0.78268022E 07	0.98031015E 05	0.33837515E 05	-0.71232068E 04	-0.38750122E 02
	-0.78268021E 07	0.75129804E 08	-0.99275731E 06	-0.98285284E 05	0.14396578E 05	0.28863788E 03
94	0.98031164E 05	-0.99275712E 06	0.35584039E 07	0.11956860E 04	-0.19182709E 03	0.25173361E 05
	0.33837516E 05	-0.98285285E 05	0.11956859E 04	0.30060803E 03	-0.59682074E 02	-0.41420841E 00
	-0.71232073E 04	0.14396578E 05	-0.19182669E 03	-0.59682075E 02	0.12507602E 02	-0.47033072E-01
	-0.38750855E 02	0.28863867E 03	0.25173361E 05	-0.41421032E 00	-0.47033548E-01	0.18094136E 03
	AT3 MATRIX					
	0.50930579E 07	-0.11904705E 08	0.79147172E 05	0.43115251E 05	-0.90122006E 04	-0.38228516E 02
	-0.11904704E 08	0.11326761E 09	-0.83097238E 06	-0.14394425E 06	0.22647816E 05	0.25444143E 03
95	0.79147359E 05	-0.83097225E 06	0.42040041E 07	0.97937372E 03	-0.16814613E 03	0.29904781E 05
	0.43115251E 05	-0.14394425E 06	0.97937354E 03	0.38744772E 03	-0.77173580E 02	-0.36870003E 00
	-0.90122007E 04	0.22647814E 05	-0.16814563E 03	-0.77173581E 02	0.16019743E 02	-0.70971966E-01
	-0.38228760E 02	0.25444238E 03	0.29904781E 05	-0.36870003E 00	-0.70971251E-01	0.21456927E 03
	AT3 MATRIX					
	0.80885394E 07	-0.10884756E 08	0.18110063E 05	0.69224025E 05	-0.14781489E 05	0.28458252E 02
	-0.10884753E 08	0.57329942E 09	-0.98537003E 06	-0.69095727E 06	0.70513538E 05	-0.28540506E 04
96	0.18111781E 05	-0.98537000E 06	0.81743362E 07	0.11395625E 04	-0.15485523E 03	0.58290621E 05
	0.69224020E 05	-0.69095729E 06	0.11395652E 04	0.12330201E 04	-0.18078731E 03	0.32160416E 01
	-0.14781496E 05	0.70513539E 05	-0.15485132E 03	-0.18078731E 03	0.31645267E 02	-0.57374620E 00
	0.28462158E 02	-0.28540547E 04	0.58290620E 05	0.32160416E 01	-0.57374859E 00	0.41844452E 03
	AT3 MATRIX					
	0.36264555E 03	-0.16502512E 02	-0.28761588E 02	0.23998947E 01	-0.14778484E 00	-0.20111781E 00
	-0.16502513E 02	0.36456633E 03	-0.72903705E 01	-0.14966862E 00	0.23902818E 01	-0.42691432E-01
	-0.28761589E 02	-0.72903709E 01	0.30739792E 03	-0.20631645E 00	-0.42475780E-01	0.19406751E 01
97	0.23998947E 01	-0.14966860E 00	-0.20631644E 00	0.15923717E-01	-0.12883915E-02	-0.14441583E-02
	-0.14778484E 00	0.23902818E 01	-0.42475786E-01	-0.12883914E-02	0.15775420E-01	-0.23626526E-03
	-0.20111781E 00	-0.42691423E-01	0.19406751E 01	-0.14441582E-02	-0.23626523E-03	0.12260072E-01
	AT3 MATRIX					
	0.11666322E 07	-0.35496655E 06	-0.40139062E 03	0.88522089E 04	-0.20593408E 04	-0.22952576E 01
	-0.35498696E 06	0.10620333E 06	-0.13071406E 04	-0.26477982E 04	0.61602938E 03	-0.95234833E 01
	-0.40139453E 03	-0.13071367E 04	0.12182333E 07	-0.16643676E 01	-0.51336212E 01	0.87171510E 04
98	0.88522087E 04	-0.26477982E 04	-0.16643066E 01	0.66063799E 02	-0.15365316E 02	-0.94599724E-02
	-0.20593407E 04	0.61602937E 03	-0.51336365E 01	-0.15365316E 02	0.35741912E 01	-0.37413955E-01
	-0.22952271E 01	-0.95234985E 01	0.87171511E 04	-0.94599724E-02	-0.37413895E-01	0.62623848E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued [a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.15484033E 07	-0.46324441E 06	-0.52384375E 03	0.11548783E 05	-0.26869493E 04	-0.29951782E 01
	-0.46324440E 06	0.13859914E 06	-0.17058027E 04	-0.34547299E 04	0.80383902E 03	-0.12426025E 02
	-0.52383594E 03	-0.17058047E 04	0.15896394E 07	-0.21722412E 01	-0.66998596E 01	0.11372461E 05
99	0.11548784E 05	-0.34547300E 04	-0.21722412E 01	0.86163577E 02	-0.20043397E 02	-0.12345791E-01
	-0.26869493E 04	0.80383900E 03	-0.66998749E 01	-0.20043398E 02	0.46629908E 01	-0.48822641E-01
	-0.29951172E 01	-0.12426117E 02	0.11372461E 05	-0.12345791E-01	-0.48823178E-01	0.81674325E 02
	LAT3 MATRIX					
	0.40522270E 07	-0.12244660E 07	-0.13848125E 04	0.30509978E 05	-0.71000332E 04	-0.79161377E 01
	-0.12244660E 07	0.36639294E 06	-0.45090156E 04	-0.91287389E 04	0.21244380E 04	-0.32835754E 02
	-0.13847969E 04	-0.45090000E 04	0.42012132E 07	-0.57431641E 01	-0.17712768E 02	0.30043503E 05
100	0.30509978E 05	-0.91287394E 04	-0.57430420E 01	0.22749687E 03	-0.52937732E 02	-0.32634735E-01
	-0.71000330E 04	0.21244380E 04	-0.17712707E 02	-0.52937733E 02	0.12318968E 02	-0.12904477E 00
	-0.79157715E 01	-0.32835663E 02	0.30043503E 05	-0.32634735E-01	-0.12904549E 00	0.21562936E 03
	AT3 MATRIX					
	0.48146070E 07	-0.14406332E 07	-0.16293437E 04	0.35894466E 05	-0.83532347E 04	-0.93135986E 01
	-0.14406332E 07	0.43108058E 06	-0.53050469E 04	-0.10740011E 05	0.24994541E 04	-0.38632019E 02
	-0.16293750E 04	-0.53050469E 04	0.49428325E 07	-0.67575684E 01	-0.20840332E 02	0.35345595E 05
101	0.35894466E 05	-0.10740010E 05	-0.67576904E 01	0.26763187E 03	-0.62278871E 02	-0.38394928E-01
	-0.83532346E 04	0.24994543E 04	-0.20840454E 02	-0.62278871E 02	0.14493069E 02	-0.15182734E 00
	-0.93134766E 01	-0.38632263E 02	0.35345595E 05	-0.38394928E-01	-0.15182710E 00	0.25366913E 03
	AT3 MATRIX					
	0.89842699E 07	-0.26883757E 07	-0.30406875E 04	0.66974368E 05	-0.15586862E 05	-0.17379639E 02
	-0.26883757E 07	0.80446485E 06	-0.98999375E 04	-0.20040460E 05	0.46640906E 04	-0.72086304E 02
	-0.30406875E 04	-0.98999062E 04	0.92235467E 07	-0.12610107E 02	-0.38891906E 02	0.65949898E 05
102	0.66974368E 05	-0.20040460E 05	-0.12610352E 02	0.49929582E 03	-0.11619703E 03	-0.71653366E-01
	-0.15586861E 05	0.46640907E 04	-0.38891845E 02	-0.11619703E 03	0.27042231E 02	-0.28332138E 00
	-0.17379639E 02	-0.72086121E 02	0.65949898E 05	-0.71653366E-01	-0.28332281E 00	0.47323913E 03
	AT3 MATRIX					
	0.20342650E 07	0.70218246E 07	-0.23757422E 03	-0.73434071E 04	-0.16896620E 04	-0.10605293E 02
	0.70218250E 07	0.12359987E 09	0.51527964E 05	-0.14074551E 06	0.10722471E 04	-0.52302059E 02
	-0.23757813E 03	0.51528250E 05	0.75683074E 06	-0.64697510E 02	0.37679749E 01	0.12660335E 04
103	-0.73434058E 04	-0.14074551E 06	-0.64698311E 02	0.16119239E 03	-0.20696326E 01	0.48538700E-01
	-0.16856620E 04	0.10722482E 04	0.37670765E 01	-0.20696327E 01	0.19397435E 01	0.77374279E-02
	-0.10605011E 02	-0.52303223E 02	0.12660336E 04	0.48538208E-01	0.77371150E-02	0.20713467E 01
	LAT3 MATRIX					
	0.15048086E 07	-0.22557759E 07	-0.11293922E 05	0.15638942E 04	-0.19515615E 04	-0.14953613E-02
	-0.22557786E 07	0.12295297E 09	0.54691553E 05	-0.15570902E 06	0.12161294E 05	-0.19455666E 02
	-0.11294613E 05	0.54692250E 05	0.21626186E 07	-0.65023682E 02	0.18647926E 02	-0.34994580E 03
104	0.15638935E 04	-0.15570903E 06	-0.65022887E 02	0.19846670E 03	-0.13919002E 02	0.25826932E-01
	-0.19515614E 04	0.12161293E 05	0.18647095E 02	-0.13919000E 02	0.33344555E 01	-0.16072113E-02
	-0.10414124E-02	-0.19455567E 02	-0.34994524E 03	0.25825500E-01	-0.16053915E-02	0.78616319E-01

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued[a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.39501828E 07	0.19903659E 08	0.61765547E 04	-0.22193705E 05	-0.18998578E 04	-0.15115346E 02
	0.19903664E 08	0.80897242E 09	0.39207677E 06	-0.93349020E 06	0.63425497E 05	-0.17428613E 03
105	0.61760625E 04	0.39207900E 06	0.72908676E 06	-0.45826172E 03	0.34214233E 02	0.12377986E 04
	-0.22193701E 05	-0.93349020E 06	-0.45826686E 03	0.10781489E 04	-0.74132240E 02	0.18953157E 00
	-0.18998550E 04	0.63425484E 05	0.34210535E 02	-0.74132241E 02	0.84546356E 01	-0.26994865E-02
	-0.15128174E 02	-0.17427735E 03	0.12378017E 04	0.18953705E 00	-0.26977062E-02	0.21675735E 01
	LAT3 MATRIX					
	0.25552698E 07	0.50179520E 07	-0.94958828E 04	-0.80147549E 04	-0.20837215E 04	-0.16038494E 01
	0.50179494E 07	0.69856083E 09	0.42015985E 06	-0.10776226E 07	0.91718697E 05	-0.11423123E 03
106	-0.94948750E 04	0.42015800E 06	0.21606992E 07	-0.49987110E 03	0.56693359E 02	-0.35820286E 03
	-0.80147543E 04	-0.10776226E 07	-0.49987129E 03	0.12935126E 04	-0.10802199E 03	0.13858545E 00
	-0.20837241E 04	0.91718716E 05	0.56694406E 02	-0.10802200E 03	0.12093680E 02	-0.10906282E-01
	-0.16057739E 01	-0.11423437E 03	-0.35820015E 03	0.13858795E 00	-0.10905743E-01	0.81401739E-01
	LAT3 MATRIX					
	0.61712159E 07	0.60391706E 08	0.26364938E 05	-0.69246953E 05	0.94739478E 03	-0.22951721E 02
	0.60391687E 08	0.28815829E 10	0.14485182E 07	-0.33442811E 07	0.27184224E 06	-0.45569564E 03
107	0.26344750E 05	0.14485399E 07	0.73634644E 06	-0.16869883E 04	0.14058447E 03	0.12407193E 04
	-0.69246933E 05	-0.33442811E 07	-0.16869873E 04	0.38822423E 04	-0.31649382E 03	0.51726479E 00
	0.94739337E 03	0.27184227E 06	0.14059778E 03	-0.31649380E 03	0.30307193E 02	-0.29737350E-01
	-0.22933594E 02	-0.45570313E 03	0.12407078E 04	0.51725769E 00	-0.29701233E-01	0.21581237E 01
	LAT3 MATRIX					
	0.10523032E 07	-0.54910059E 07	-0.17362778E 05	0.58720938E 04	-0.14716001E 04	-0.55987759E 03
	-0.54910057E 07	0.86337869E 08	0.26033208E 07	-0.89332207E 05	0.12869809E 05	0.40598269E 04
108	-0.17362844E 06	0.26033215E 07	0.17675403E 06	-0.26450341E 04	0.40746193E 03	0.42490258E 03
	0.58720938E 04	-0.89332208E 05	-0.26450333E 04	0.92524221E 02	-0.13444606E 02	-0.40026737E 01
	-0.14716000E 04	0.12869808E 05	0.40746164E 03	-0.13444606E 02	0.25509996E 01	0.96233915E 00
	-0.55987755E 03	0.40598276E 04	0.42490267E 03	-0.40026741E 01	0.96233815E 00	0.18085595E 01
	LAT3 MATRIX					
	0.87324287E 06	0.15421488E 07	0.17582248E 05	-0.17218594E 04	-0.67792549E 03	-0.63134906E 02
	0.15421508E 07	0.13595533E 09	0.43902362E 07	-0.11784684E 06	0.66211822E 04	-0.59703215E 03
109	0.17582219E 06	0.43902369E 07	0.13473631E 07	-0.51060604E 04	0.23059467E 03	0.34614078E 03
	-0.17218595E 04	-0.11784684E 06	-0.51060602E 04	0.13137046E 03	-0.73227954E 01	0.80703177E 00
	-0.67792564E 03	0.66211826E 04	0.23059469E 03	-0.73227963E 01	0.11332252E 01	0.24224508E-01
	-0.63134705E 02	-0.59703320E 03	0.34614034E 03	0.80703211E 00	0.24224639E-01	0.19910970E 00
	LAT3 MATRIX					
	0.32319607E 06	-0.49654801E 07	-0.28915605E 04	0.60162180E 04	-0.68887595E 03	0.81113033E 02
	-0.49654801E 07	0.79675365E 08	-0.54718873E 05	-0.96591862E 05	0.10888686E 05	-0.14687323E 04
110	-0.28916875E 04	-0.54719000E 05	0.34224508E 05	0.70329102E 02	-0.25091248E 01	0.67783544E 02
	0.60162187E 04	-0.96591862E 05	0.70323597E 02	0.11711462E 03	-0.13187147E 02	0.17934761E 01
	-0.68887634E 03	0.10888686E 05	-0.25087810E 01	-0.13187145E 02	0.15093152E 01	-0.19058573E 00
	0.81113373E 02	-0.14687314E 04	0.67782994E 02	0.17934736E 01	-0.19058567E 00	0.23188161E 00

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Continued[a]

Covariance Matrix

Number

111

AT3 MATRIX

0.10555592E 07	-0.11455719E 08	0.12812410E 06	0.13894135E 05	-0.20610123E 04	0.66310471E 02
-0.11456720E 08	0.12576167E 09	-0.13605523E 07	-0.15241915E 06	0.22628854E 05	-0.71271100E 03
0.12812449E 06	-0.13605525E 07	0.18000316E 06	0.16530918E 04	-0.25186478E 03	0.20555328E 02
0.13894134E 05	-0.15241915E 06	0.16530916E 04	0.18475862E 03	-0.27422539E 02	0.86345305E 00
-0.20610117E 04	0.22628552E 05	-0.25186480E 03	-0.27422539E 02	0.40777870E 01	-0.12832370E 00
0.66310913E 02	-0.71271191E 03	0.20555554E 02	0.86345196E 00	-0.12832284E 00	0.20406056E-01

112

AT3 MATRIX

0.80921174E 05	-0.29578840E 07	0.15608902E 05	0.33058867E 04	-0.28201593E 03	-0.25347144E 02
-0.29578831E 07	0.12195887E 09	-0.68372172E 06	-0.13631144E 06	0.11426599E 05	0.10136326E 04
0.15608387E 05	-0.68372075E 06	0.12991534E 05	0.76382886E 03	-0.63962707E 02	0.56123199E 01
0.33058869E 04	-0.13631143E 06	0.76382917E 03	0.15236591E 03	-0.12739069E 02	-0.11316902E 01
-0.28201586E 03	0.11426501E 05	-0.63962427E 02	-0.12739070E 02	0.10820710E 01	0.94852683E-01
-0.25347137E 02	0.10136313E 04	0.56120415E 01	-0.11316910E 01	0.94852149E-01	0.53722214E-01

113

LAT3 MATRIX

0.12572949E 08	-0.71458910E 07	0.31980000E 04	0.94816764E 05	-0.21552052E 05	-0.70680176E 02
-0.71458903E 07	0.35674931E 08	-0.11021814E 06	-0.66540067E 05	0.12742513E 05	0.72955078E 02
0.31980000E 04	-0.11021784E 06	0.12506557E 08	0.65414551E 02	-0.74955200E 02	0.89278942E 05
0.94816764E 05	-0.66540069E 05	0.65414062E 02	0.72125251E 03	-0.16278172E 03	-0.49325562E 00
-0.21552052E 05	0.12742513E 05	-0.74955688E 02	-0.16278171E 03	0.42259104E 02	-0.38409996E 00
-0.70680176E 02	0.72954590E 02	0.89278941E 05	-0.49325562E 00	-0.38410187E 00	0.63989883E 03

114

LAT3 MATRIX

0.12950240E 08	-0.76241794E 07	-0.86753750E 04	0.98340980E 05	-0.22263615E 05	-0.75277832E 02
-0.76241795E 07	0.45592820E 08	-0.83998750E 04	-0.79749408E 05	0.14071212E 05	0.14550952E 03
-0.86755625E 04	-0.83997812E 04	0.12932233E 08	-0.53646728E 02	-0.60019836E 02	0.92272612E 05
0.98340979E 05	-0.79749408E 05	-0.53645996E 02	0.75909744E 03	-0.16947084E 03	-0.58813858E 00
-0.22263616E 05	0.14071213E 05	-0.60019897E 02	-0.16947085E 03	0.43581987E 02	-0.38722229E 00
-0.75277832E 02	0.14550879E 03	0.92272613E 05	-0.58814240E 00	-0.38722134E 00	0.66130405E 03

115

LAT3 MATRIX

0.18175402E 08	-0.13868884E 08	0.33885250E 05	0.14090412E 06	-0.31618364E 05	0.85930176E 02
-0.13868883E 08	0.13630288E 09	-0.68296103E 06	-0.19060723E 06	0.29391800E 05	-0.24348667E 04
0.33885125E 05	-0.68296087E 06	0.18075147E 08	0.69437744E 03	-0.17765149E 03	0.12908759E 06
0.14090412E 06	-0.19060724E 06	0.69437695E 03	0.11477084E 04	-0.24835374E 03	0.22433204E 01
-0.31618363E 05	0.29391801E 05	-0.17765284E 03	-0.24835374E 03	0.60463659E 02	-0.91611671E 00
0.85928711E 02	-0.24348682E 04	0.12908759E 06	0.22433167E 01	-0.91610909E 00	0.92547232E 03

116

LAT3 MATRIX

0.71081039E 06	-0.35962290E 07	0.72128886E 04	0.63985564E 04	-0.97334186E 03	-0.47733658E 02
-0.35962283E 07	0.34612703E 08	-0.97146274E 05	-0.40081521E 05	0.65844081E 04	0.16812902E 03
0.72128555E 04	-0.97146031E 05	0.32849218E 06	0.82066681E 02	-0.23600868E 02	0.22137506E 04
0.63985558E 04	-0.40081521E 05	0.82066765E 02	0.62199251E 02	-0.93916985E 01	-0.39863509E 00
-0.97334206E 03	0.65844083E 04	-0.23600903E 02	-0.93916986E 01	0.65584056E 01	-0.10011286E-01
-0.47733826E 02	0.16812927E 03	0.22137505E 04	-0.39863539E 00	-0.10011107E-01	0.15251238E 02

[a]Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

TABLE B-III.- Concluded[a]

Covariance Matrix

Number						
	LAT3 MATRIX					
	0.68139877E 06	-0.39528138E 07	-0.45226582E 04	0.68912912E 04	-0.97934898E 03	-0.51543915E 02
	-0.39528141E 07	0.44494172E 08	0.51197651E 04	-0.52383710E 05	0.77019725E 04	0.24394702E 03
117	-0.45228593E 04	0.51198750E 04	0.33663409E 06	-0.36422912E 02	-0.69044266E 01	0.22223292E 04
	0.68912909E 04	-0.52383710E 05	-0.36422936E 02	0.77448072E 02	-0.10821747E 02	-0.49027514E 00
	-0.97934922E 03	0.77019728E 04	-0.69043274E 01	-0.10821747E 02	0.66572667E 01	-0.30618906E-03
	-0.51543640E 02	0.24394702E 03	0.22223292E 04	-0.49027586E 00	-0.30633807E-03	0.15239966E 02
	LAT3 MATRIX					
	0.89057070E 06	-0.86965182E 07	0.39735682E 05	0.12066164E 05	-0.16322434E 04	0.11936532E 03
	-0.86965175E 07	0.13475506E 09	-0.66391370E 06	-0.15205335E 06	0.20418562E 05	-0.22961823E 04
118	0.39735625E 05	-0.66391350E 06	0.32996587E 06	0.71864258E 03	-0.10282044E 03	0.22211670E 04
	0.12066164E 05	-0.15205335E 06	0.71864235E 03	0.18737365E 03	-0.24842567E 02	0.23811847E 01
	-0.16322420E 04	0.20418562E 05	-0.10282184E 03	-0.24842566E 02	0.84426391E 01	-0.37101486E 00
	0.11936432E 03	-0.22961816E 04	0.22211671E 04	0.23811846E 01	-0.37101376E 00	0.15271519E 02

[a] Locate the covariance matrix number on either table B-I or B-II for a description of the events preceding TLI.

APPENDIX C

TRANSLUNAR PHASE PROCEDURE

APPENDIX C

TRANSLUNAR PHASE PROCEDURE

The ΔV cost of the first midcourse correction is computed from the following formulation taken directly from reference 8. Given the particular position and velocity of a vehicle, the ΔV required for the midcourse can be computed. The procedure for computing midcourse ΔV is based on a simple guidance scheme and, for the present, on the assumption that the post injection orbit is well known compared to the expected deviation of the actual orbit from the nominal.

The deviations in position and velocity at midcourse correction time (t_M) and at some target time t are approximately related by the following linear expression

$$\begin{vmatrix} \delta X \\ \delta \dot{X} \end{vmatrix}_t = \begin{vmatrix} A & B \\ C & D \end{vmatrix} \begin{vmatrix} \delta X \\ \delta \dot{X} \end{vmatrix}_{t_M}$$

The deviation in position is just

$$\delta X_t = A\delta X_M + B\delta \dot{X}_M$$

where X is a three element position vector and A and B are 3 X 3 matrices. The guidance law assumed is simply that a change in velocity is made at t_M to achieve the proper position at a target time t. That is,

$\delta X_t = A\delta X_M + B\,(\delta \dot{X}_M + \Delta V)$, where ΔV is the amount to be added to make $\delta X_t = 0$. This expression can be written for ΔV.

$$B\,(\delta \dot{X}_M + \Delta V) = \delta X_t - A\delta X_M$$

$$\Delta V = B^{-1}(\delta X_t - A\delta X_M) - \delta \dot{X}_M$$

Since δV is taken to make $\delta X_t = 0$, this becomes

$$\Delta V = -B^{-1} A\ \delta X_M - \delta \dot{X}_M$$

or

$$\Delta V = -\left[B^{-1} A,\ I\right]\ \delta \begin{pmatrix} X_M \\ \dot{X}_M \end{pmatrix}$$

The expected value of ΔV then becomes

$$E(\Delta V, \Delta V^T) = E \left[(B^{-1}A, I) \, \delta \begin{pmatrix} X_M \\ \dot{X}_M \end{pmatrix} \delta (X_M^T, \dot{X}_M^T) \begin{pmatrix} [B^{-1} A]^T \\ I \end{pmatrix} \right]$$

$$= (B^{-1}A, I) \; E \left[\delta \begin{pmatrix} X_M \\ \dot{X}_M \end{pmatrix} \delta (X_M^T, \dot{X}_M^T) \right] \begin{pmatrix} [B^{-1} A]^T \\ I \end{pmatrix} = L \, P_M \, L^T$$

where $L = (B^{-1}A, I)$ and P_M is the covariance matrix of the position and velocity at t_M. The target time will be the time of lunar sphere of influence. What is desired is not the expected value of $\overline{\Delta V}$ but the scalar Δv. This is given by

$$\Delta v = \left[\frac{2}{\pi} (\sigma^2_{\Delta V_x} + \sigma^2_{\Delta V_y} + \sigma^2_{\Delta V_z}) \right]^{\frac{1}{2}}$$

The $\frac{2}{\pi}$ factor is the first term in a series expression developed by Breakwell (ref. 9).

The target time used for this study was 51.5 hours after the TLI maneuver. No drag or venting was considered outside earth orbit. The covariance matrix of position and velocity at the time of the midcourse correction is generated by propagating the covariance at the end of TLI with two-body partials. The ground-computed estimate of position and velocity was assumed to be the actual vector at the time of the first MCC.

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