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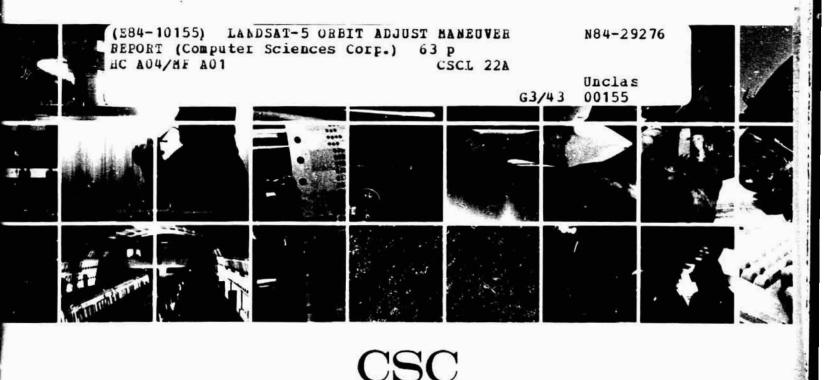
# LANDSAT-5 ORBIT ADJUST MANEUVER REPORT

Prepared for NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Goddard Space Flight Center Greenbelt, Maryland



CONTRACT NAS 5-27888 Task Assignment 14900

**JUNE 1984** 



COMPUTER SCIENCES CORPORATION

CSC/TM-84/6075

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## LANDSAT-5 ORBIT ADJUST

#### MANEUVER REPORT

Prepared for

#### GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-27888 Task Assignment 14900

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#### ABSTRACT

The Landsat-5 spacecraft was successfully launched from the Western Test Range by a Delta 3920 launch vehicle on March 1, 1984. This document describes the orbit adjust maneuvers performed to raise the spacecraft to mission altitude, synchronize it with the required groundtrack, and properly phase the spacecraft with Landsat-4 to provide an 8-day full Earth coverage cycle. It also describes maneuver planning and evaluation procedures, data and analysis results for all maneuvers performed to date, the frozen orbit concept, and the phasing requirement between Landsat-4 <sup>-</sup>nd Landsat-5.

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#### SECTION 1 - INTRODUCTION

The Landsat-5 spacecraft was successfully launched from the Western Test Range by a Delta 3920 launch vehicle on March 1, 1984. The launch was very near nominal and resulted in an orbit that was approximately 12 kilometers below the final mission altitude. The orbit was targeted low intentionally to ensure that no orbit lowering maneuvers would be required (this would necessitate a 180-degree yaw of the spacecraft, which is undesirable). A series of eight orbit raising maneuvers was performed between March 7 and April 4, 1984, to raise the semimajor axis the remaining 12 kilometers. The maneuvers were performed at the proper times so that both phasing with the World Reference System (WRS) groundtrack grid and an 8-day coverage cycle between The series of ma-Landsat-4 and Landsat-5 were achieved. neuvers also achieved a frozen orbit. Periodic orbit maintenance maneuvers have kept the groundtrack within the required bounds.

This document follows the format of the Landsat-4 Orbit Acjust Maneuver Report (Reference 1) prepared by R. J. McIntosh. Section 2 defines the Landsat-5 orbit requirements, discusses computer software and operational procedures used for maneuver planning and evaluation, and briefly describes the frozen orbit concept. Also discussed is the phasing requirement between Landsat-4 and Landsat-5 needed to achieve the 8-day coverage cycle. Section 3 describes the postlaunch injection error removal maneuver sequence and discusses orbit maintenance maneuvers. The appendix contains data and analysis results covering all maneuvers performed to date. It is intended that update pages will be published for insertion into the appendix as future maneuvers are performed.

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#### SECTION 2 - MANEUVER PLANNING AND EVALUATION

This section defines the Landsat-5 mission orbit and groundtrack and discusses computer software and procedures used for premaneuver planning and postmaneuver evaluation. In addition, brief descriptions of the frozen orbit concept and the phasing requirement between Landsat-4 and Landsat-5 are given.

#### 2.1 LANDSAT-5 MISSJON ORBIT REQUIREMENTS

The nature of the Landsat-5 mission requires that the spacecraft orbit have the proper altitude and inclination to maintain a Sun-synchronous node rate (mean local time at any descending node crossing is constant) and a 16-day groundtrack repeat cycle. The number of orbits in the groundtrack repeat cycle is 233; that is, after 233 orbits, the spacecraft must cross over the same longitude point on the Earth's Equator. The nominal mean semimajor axis required for this repeat cycle is approximately 7077.8 kilometers. The WRS groundtrack grid defines a series of descending node crossings equally spaced around the Earth's Equator, approximately 172 kilometers apart, with the base longitude defined as 295.4 degrees east longitude. An orbital inclination of approximately 98.2 degrees maintains the required Sun-synchronous nodal regression rate and mean local time of the descending node (between 9:30 and 10:00 a.m.). The orpit requirements are defined in Reference 2.

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#### 2.2 FROZEN ORBIT CONCEPT

Low-altitude circular orbits are subject to strong perturbations from the oblate Earth's gravitational potential. The magnitude of the effects of these perturbations depends on the initial values of certain orbital parameters, namely, semimajor axis, eccentricity, inclination, and argument of

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perigee. By targeting toward the proper values of these orbital parameters, the effects of certain perturbations can be minimized. This is the case of the frozen orbit, in which the line of apsides (the line joining apogee and perigee) is stopped or frozen. For a near-circular orbit, the changes in the average argument of perigee ( $\overline{\omega}$ ) and the average eccentricity ( $\overline{e}$ ) become zero when  $\overline{\omega}$  equals 90 aegrees and  $\overline{e}$  approaches some determinable small value. This value of  $\overline{e}$  (the frozen eccentricity) is a function of the averaged semimajor axis ( $\overline{a}$ ) and inclination ( $\overline{i}$ ). The frozen eccentricity for the Landsat-5 orbit is approximately 0.0012. For initial values of  $\overline{\omega}$  near 90 degrees and initial values of  $\overline{e}$  near the frozen eccentricity, the averaged argument of perigee and eccentricity oscillate within a small range about the frozen condition. Figure 2-1 shows the evolution of  $\overline{e}$  and  $\overline{\omega}$  with time for a near-frozen Landsat-5 orbit.

The evolution of a near-frozen orbit can be described in an eccentricity vector space, where the motion of the eccentricity and argument of perigee about the frozen point is circular. An example of a satellite with  $\overline{e}$  and  $\overline{\omega}$  near the frozen values is illustrated in Figure 2-2, using the eccentricity vector space representation ( $\overline{e} \cos \overline{\omega}$  and  $\overline{e} \sin \overline{\omega}$ ). Any set of initial conditions, such as point A in Figure 2-2, results in the cyclic evolution of the  $\overline{e} \cos \overline{\omega}$  and  $\overline{e} \sin \overline{\omega}$  parameters. The frozen orbit concept is developed in Reference 3.

The main advantage of the frozen orbit is a minimum variation in altitude above any given latitude due to a nearconstant perigee location. A near-constant altitude above a given latitude will minimize the necessary geometric corrections to the Landsat-5 images. The frozen orbit is a derived requirement for Landsat-5. The eccentricity will

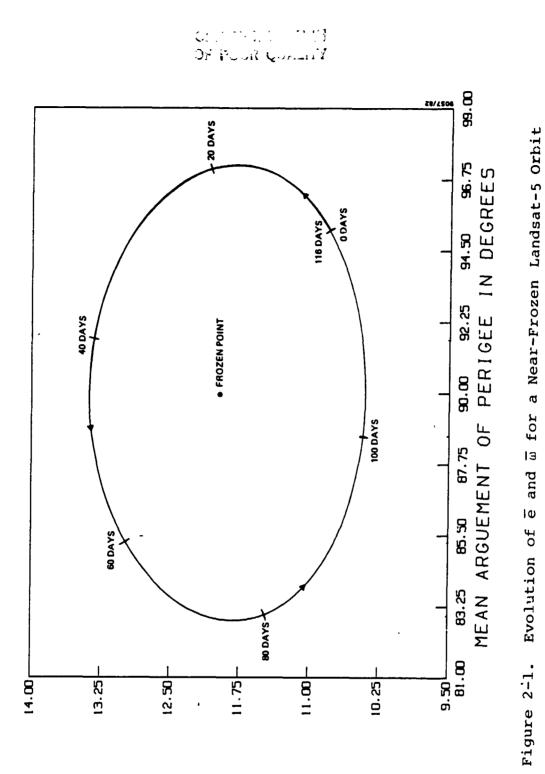
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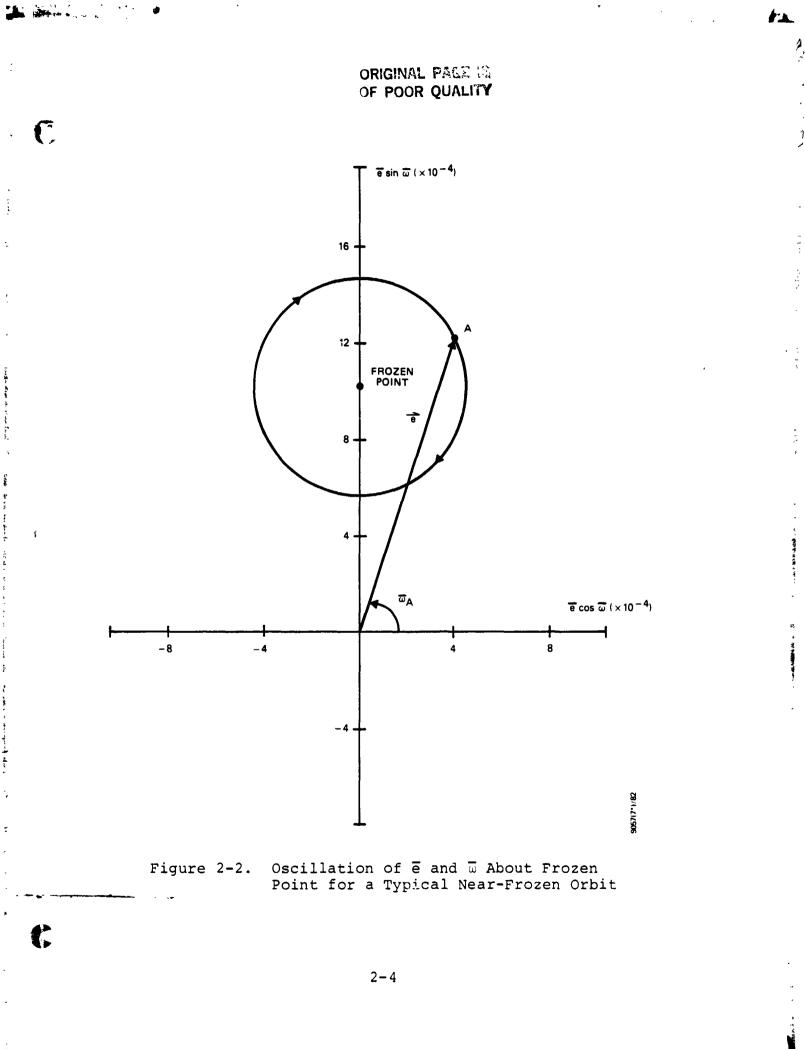
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therefore be maintained well below 0.003 for nominal image correction (Reference 2). By performing the postlaunch maneuvers (required to achieve mission orbit altitude and groundtrack phasing) at the optimum location, a near-frozen orbit can be reached. Once the initial target frozen orbit is reached,  $\overline{e}$  and  $\overline{\omega}$  can be controlled to some extent as part of the routine orbit maintenance maneuvers (which are required to counteract the effects of atmospheric drag) without additional fuel requirements. Targeting toward the frozen orbit was done during the postlaunch injection error removal maneuver sequence for Landsat-5, as discussed in Section 3.

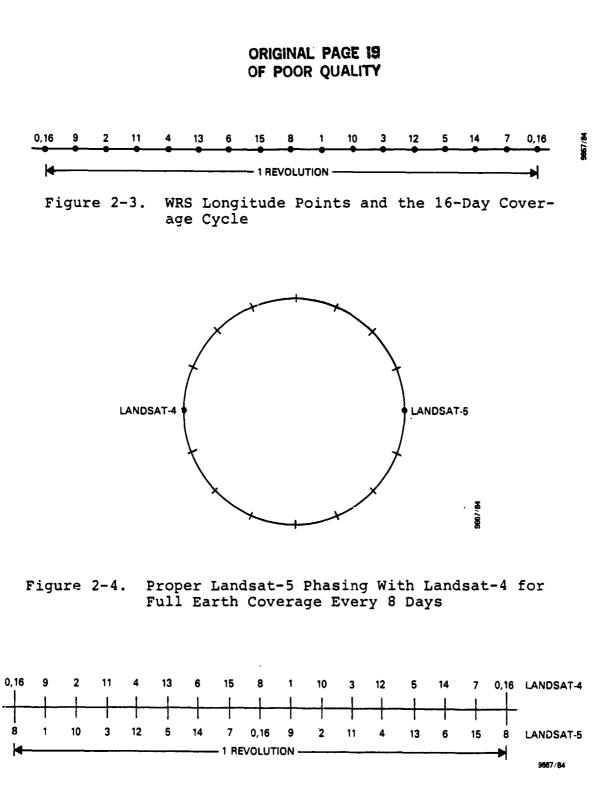
#### 2.3 PHASING WITH LANDSAT-4

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Landsat-4 and Landsat-5 both have a repeating groundtrack every 233 revolutions (16 days). Figure 2-3 represents a one-revolution segment of the Equator that contains 16 WRS intervals. Each dot on the Equator represents a WRS longitude point. The number over each WRS longitude shows the day in the 16-day repeat cycle when a Landsat spacecraft in a nominal mission orbit would cross (from north to south) the WRS point. Day 0 of the 16-day repeat cycle was arbitrarily chosen.

The nominal mission orbits of Landsat-4 and Landsat-5 are identical except for their phasing. Landsat-5 is required to be phased with Landsat-4 such that full Earth coverage is provided every 8 days. The 8-day full Earth coverage cycle is achieved when the Landsat spacecraft are 180 degrees apart when in the same orbital plane, as shown in Figure 2-4. This phasing configuration also minimizes interference between the two satellites. Figure 2-5 contrasts the days of coverage in the 16-day cycle for a segment or the Equator for Landsat-4 and Landsat-5. The figure depicts Landsat-5 as being correctly phased eight WRS intervals from Landsat-4, thus providing full coverage every 8 days.

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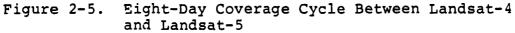
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#### 2.4 SOFTWARE FOR MANEUVER PLANNING AND EVALUATION

The software used for Landsat-5 maneuver support consists of programs to perform high-precision orbit propagation, groundtrack monitoring, maneuver targeting, propulsion system modeling, and tracking station coverage prediction. These programs are as follows:

• Goddard Mission Analysis System (GMAS) -- The GMAS Cowell propagator is used to generate high-precision ephemeris (EPHEM) files for use by the other programs. The GMAS TRACK module is used to determine groundtrack errors. Averaged orbital elements are generated by the AVECON utility module.

• General Maneuver Program (GMAN) -- GMAN performs maneuver targeting, maneuver reconstruction, and propulsion system modeling.

• Groundtrack Monitoring Program (GNDTRAK)--GNDTRAK reads a standard EPHEM file, interpolates to find descending node crossings, and compares the node crossings to the required groundtrack grid. The mean local time of each crossing is also output.

• Circular Orbit Restoration Program (RESTOR) -- RESTOR determines maneuver requirements to achieve target values of mean semimajor axis, eccentricity, and argument of perigee. RESTOR was developed for frozen orbit targeting.

• Acquisition Data Program (ACQSCAN) -- ACQSCAN determines acquisition- and loss-of-signal (AOS and LOS) times for selected ground stations, determines shadow times, generates various reports, and provides coverage schedules for several Tracking and Data Relay Satellites. ACQSCAN reads a standard EPHEM file.

• Ephemeris File Writer Program (EPHGEN) -- EPHGEN contains the same Cowell propagator as GMAS; however, EPHGEN

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executes in less than 200K bytes of core. The primary output from EPHGEN is a standard EPHEM file.

#### 2.5 PREMANEUVER PLANNING

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This subsection discusses the procedures generally followed in planning a typical orbit adjust maneuver and how the software described in the previous subsection is used. The following steps are taken in planning a maneuver:

- Obtain the latest orbit determination solution (EPHEM tape) or generate an EPHEM file using GMAS or EPHGEN and the latest vector.
- Run GNDTRAK to check the groundtrack error and determine when a maneuver is necessary to control the groundtrack evolution.
- 3. Run the GMAS AVECON utility to generate averaged orbital elements at the expected maneuver time.
- 4. Input averaged elements to RESTOR to determine maneuver location and magnitude required to control orbit semimajor axis, eccentricity, and argument of perigee to the desired values.
- 5. Run ACQSCAN to determine the best station coverage time for the maneuver (near the location defined by RESTOR).
- Obtain approval for the requested maneuver date and time.
- Obtain the latest fuel system temperatures and pressures from the Landsat-5 Control Center.
- Run GMAN using maneuver magnitude estimates from RESTOR and latest temperatures and pressures to model the maneuver and predict fuel usage.

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- 9. Run the GMAS Cowell propagator and TRACK module with several solar flux level estimates to get a groundtrack evolution prediction.
- 10. If groundtrack prediction is not satisfactory, change burn duration and repeat steps 8 and 9 as necessary.

Following this analysis, the burn start time and duration are delivered to the control center.

The greatest effect on the groundtrack evolution is from decay of the semimajor axis due to atmospheric drag. Because the solar flux level (which influences atmospheric density at a given altitude) cannot be accurately predicted, it is necessary to use several constant solar flux values (actually, atmospheric density tables) for predicting the effect of a maneuver on the groundtrack. The expected minimum and maximum solar flux levels likely to be encountered during some period following the maneuver are used to estimate bounds for the westward groundtrack drift. The objective is to determine an appropriate burn duration so that the required groundtrack error limits (±10 kilometers) will be maintained in case of sudden changes in the solar flux.

#### 2.6 POSTMANEUVER EVALUATION

Following completion of an orbit adjust maneuver, the following steps are taken to evaluate the propulsion system performance and to calibrate the thruster modeling:

 Obtain the preburn and postburn orbit determination solution EPHEM tapes; retrieve preburn and postburn state vectors at the same epoch time (burn end time).

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- Convert preburn and postburn vectors to averaged orbital elements using the GMAS AVECON utility and compute the actual change in averaged semimajor axis.
- Obtain actual temperatures, pressures, and thruster durations observed by the Landsat-5 Control Center.
- 4. Run GMAN using the observed propulsion system parameters to remodel the burn; this generates a new prediction of orbital changes.
- Convert predicted postburn osculating elements to averaged elements (AVECON) and compute predicted changes in the orbit.
- 6. Compare predicted and observed postburn semimajor axis values and compute thruster correction factor.
- 7. Perform an attitude thruster burn with GMAN using the total observed attitude thruster pulses; this is done to obtain an estimate of fuel used for attitude control.

Following the completion of this procedure, a postburn analysis report is delivered to the control center. The estimated fuel remaining and thrust correction factor are cataloged for future use.

In evaluating the maneuver with GMAN, several assumptions are made:

 The attitude is held constant at the value originally commanded by the control center (for example, roll, pitch, and yaw = 0.0 degrees). The total attitude thruster counts are used to estimate fuel usage only.

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 The burn time used is equal to the total thruster time in milliseconds divided by the number of thrusters used (2 or 4).

For example, GMAN would use a burn time of  $251.648 \div 4 = 62.912$  seconds with four thrusters firing simultaneously, if the observed values for each thruster were as follows:

Thruster	Duration (Milliseconds)
Al	51,648
Bl	65,344
Cl	67,328
Dl	67,328
Total	251,648 (or 251.648 seconds)

Modeling of the Landsat-5 propulsion system, which is identical to the Landsat-4 propulsion system, is described in Reference 4. Since that document was published, an update has been made to the equation for thrust in GMAN to model thruster warmup. The equations used for modeling thrust and specific impulse  $(I_{SP})$  are given below.

$$F = 0.197 + 0.026249P - 0.0000262P^2 \left(\frac{T}{T_S}\right)^{0.03}$$

where F = thrust (pounds)

- P = tank pressure (pounds per square inch absolute (psia))
- T = current thruster on-time (seconds)
- T<sub>S</sub> = steady state time (time for thruster to reach full output)

The last term accounts for thruster warmup. The value of  $T_S$  used in the GMAN spacecraft data file is 20 seconds. When T becomes greater than  $T_S$ , GMAN sets the expression  $T/T_S$  equal to 1.

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## $I_{SP} = 213.53 + 0.10929P - 0.0001718P^2$

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The thrust calculated by GMAN can be adjusted by adding a thrust correction factor to the program. The thrust is calculated as noted above and then adjusted as follows:

where F = thrust calculated from the polynomial equation k = thrust correction factor (nominally = 1.0) F<sub>adj</sub> = adjusted thrust level

The thrust correction factor for a maneuver is calculated as follows:

$$k_{new} = \left(\frac{\Delta \overline{a}_{obs}}{\Delta \overline{a}_{pre}}\right) k_{old}$$

where  $\Delta a_{obs}$  = observed change in averaged semimajor axis  $\Delta a_{pre}$  = change in averaged semimajor axis predicted by GMAN

> k<sub>old</sub> = thrust correction factor used by GMAN to generate the prediction

The thrust correction factors for most Landsat-5 maneuvers to date have averaged 0.97 (the observed thrust level has been 97 percent of the nominal thrust predicted by GMAN).

#### SECTION 3 - LANDSAT-5 MANEUVERS

The Landsat-5 spacecraft was successfully launched into a circular polar orbit on March 1, 1984, by a Delta 3920 launch vehicle that reached an orbit of 12 kilometers below mission iltitude. The purpose of the postlaunch maneuver sequence was to raise the semimajor axis the remaining 12 kilometers to the mission altitude, synchronize the groundtrack with the WRS grid, obtain a near-frozen orbit, and phase the spacecraft with Landsat-4 such that an 8-day coverage cycle was obtained between the two satellites. To achieve all these goals, maneuver magnitude and timing were critical. The following subsections discuss details of the postlaunch maneuver sequence and the orbit maintenance  $\pi$  - neuvers.

#### 3.1 POSTLAUNCH INJECTION ERROR REMOVAL SEQUENCE

A sequence of eight orbit adjust maneuvers raised the Landsat-5 spacecraft to operational altitude. Three short burns tested the propulsion system in the primary mode (four thrusters) and the backup mode (two thrusters). Five large maneuvers were performed to raise the orbit and synchronize the groundtrack. Details of the maneuvers are presented in Table 3-1. A brief description of the maneuvers is given below.

Number	Comments
1	A 5-second burn with two thrusters to test the backup firing modeThis burn produced a semi- major axis change of 197 meters. A large num- ber of attitude thruster firings occurred.
2	A 5-second burn with two thrusters to further test the backup firing modeA semimajor axis change of 198 meters was achieved.
3	A l6-second burn with four thrusters to test the primary firing modeThe semimajor axis increased by 1.47 kilometers.

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Maneuvers
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Table 3-1.

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			1	NUMBER	MOITAING		LOC/	LOCATION		MM	WRS TRACK		SEMIMAJOR	ORBITAL	HVDRAZINE
DAY ORBIT	=	(DAMMDD)	(HHMM88)	OF THRUSTERS					et a time	POSITION	(km/rev)	ŝ	CHANGE	CHANGE	9 <b>9</b>
								ABUINSE			BEFORE	AFTER	/manual		
~	2	200304	111703	*	15 7	8.9%	141.0"E	ARC	ORRORAL	- 69.9	8'9+	<b>9</b> .8	+ 0.187	+ 0.25	<b>R</b> . • -
	Ē		212647	~	4.898	Nº3'84	1.7.922	DBC	ALABKA	- <b>60.4</b>	+ 6.8	9.9 9.9	+ 0.196	+ 0.25	- 0.21
=	ä	840314	212003	-	11.800	N=1.61	212.1°E	080	ALASKA	+ 80.7	<b>9</b> .9 +	<b>.</b>	+ 1.473	+1.86	- 1.61
8	ŧ	RCCOM	110004	•	12.977	34.1°5	3-0.531	ASC	ORRORAL	<i>.</i>	+ 6.8	-	+ 1.101	+1.#	<b>R</b>
R	ŧ		124664	m	<b>8</b> R	38-0-S	134.B°E	ABC	ORRORAL	- 19.0	+8.1	<b>.</b>	+2.38	+2.8	- 2.62
8	Ş	9000	214403	2	40. K28	17.1•8	0.3°E	ABC	ASCENSION	+ 18.4	<b>8</b> :E +	+2.7	+ 1.863	+2.34	- 1.97
8	\$	2114044	206004	7	<b>1</b> .42	N-9'02	3-1-5	ASC	MADNID	<b>9</b> . <b>1</b>	+2.7	+1.1	+2.636	+ 3.31	- 2.7
	ŧ		203807	~~~~~	43.100	N.1.8	1.5°E	ASC	MADRID	<b>.</b>	1.1+	<b>10.0</b> +	+ 1.808	+ 2.48	- 2.01
Ĩž≶	<sup>b</sup> + = East; - = West.	TON PASS (SC	NUTH TO NOR	<sup>8</sup> ASC = ASCENDING STATION PASS (SOUTH TO NORTH); DSC = DL <sup>2</sup> "INDING STATION PASS (NORTH TO SOUTH) <sup>b</sup> + = EAST; - = WEST.	BNIGN:	ITATION PA	SS (NORTH TO	O SOUTH).				1			

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Number	Comments
4	A 13-second burn with four thrusters to begin the groundtrack phasing sequenceThis burn produced a change in semimajor axis of 1.19 kilometers and slowed the groundtrack drift rate from 5.8 kilometers per revolution to 5.1 kilometers per revolution. The D trans- lational thruster ceased firing during this maneuver, causing excessive off-pulsing. The onboard timer terminated the burn after 102 seconds elapsed. The planned burn duration for this burn was 51 seconds.
5	A 30-second burn performed one orbit after ma- neuver 4The burn was designed to complete the planned burn duration of 51 seconds started in maneuver 4. The burn used the primary firing mode, but only three thrusters fired. The semimajor axis was raised by 2.3 kilometers, and the groundtrack drift rate was slowed to 3.8 kilometers per revolution.
6	A 41-second burn with two thrustersThis burn raised the semimajor axis 1.9 kilometers and slowed the groundtrack drift rate to 2.7 kilo- meters per revolution.
7	A 58-second burn using two thrustersThis burn slowed the groundtrack drift rate to 1.1 kilo- meters per revolution and raised the semimajor axis by 2.6 kilometers.
8	A 43-second burn with two thrustersThis burn raised the orbit by 1.9 kilometers, phased the spacecraft half an orbital period ahead of Landsat-4, and positioned Landsat-5 into a fro- zen orbit. The drift rate of the groundtrack was slowed to 0.03 kilometer per revolution.
•	maneuver 8, the groundtrack position was approxi-
	kilometers west of the required WRS path (well
	±10 kilometer limits) and drifting eastward at
	ely 0.44 kilometer per day. The fuel use esti-
-	MAN for these eight burns is 12.6 pounds.
	presents the predicted and actual changes in aver- ajor axis for each maneuver and also the calcu-
-	st correction factors.
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Predicted and Actual Changes in Averaged Semimajor Axis Table 3-2.

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THRUST CORRECTION FACTOR	0.9457	0.9538	0.9969	0.9988	1.0821	0.9739	0.9686	0.9624	FOR FACH
OBSERVED Aã	0.1969	0.1981	1.4729	1.1908	2.3047	1.8626	2.6348	1.9085	
PREDICTED Aã	0.2082	0.2077	1.4494	1.1922	2.1305	1.9122	2.7199	1.9235	VEBAGES AT EPO
OBSERVED POSTBURN 7	7066.2837	7066.4864	7067.9478	7069.0816	7071.3814	7073.2318	7075.8673	7077.7722	IT NI MERICAL A
PREDICTED POSTBURN B	7066.2950	7066.4960	7067.9243	7069.0830	7071.2072	7073.2814	7075.9524	7077.7872	<sup>a</sup> both prerien and postrien values are one orright nimerical averages at epoch of ribnolit for each
PREBURN 3 <sup>8</sup>	7066.0868	7066.2883	7066.4749	7067.8908	7069.0767	7071.3692	7073.2325	7075.8637	AND POSTBILIBN V
MANEUVER	1	7	m	4	ى م	ω	7	8	<sup>a</sup> BOTH PRERIIRN

BOTH PREBURN AND POSTBURN VALUES ARE ONE-ORBIT MANEUVER. ALL VALUES ARE IN KILOMETERS.

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The evolution of the Landsat-5 groundtrack through the postlaunch injection error removal period is illustrated in Figure 3-1. The groundtrack grid comprises 233 equatorial crossings that are 172 kilometers apart. At each descending node crossing, the groundtrack is compared to the nearest grid line. The maximum groundtrack error is then half the distance between lines, or 86 kilometers. The initial drift rate in the groundtrack following launch was 100 kilometers per day. The apparently instantaneous changes from positive to negative in the plot of Figure 3-1 indicate that the halfway point between two adjacent grid lines has been crossed and the groundtrack error is then being checked against the next longitude. As maneuvers are performed to raise the semimajor axis, the drift rate decreases. The final burn was performed when the groundtrack error was within the ±10 kilometer bounds.

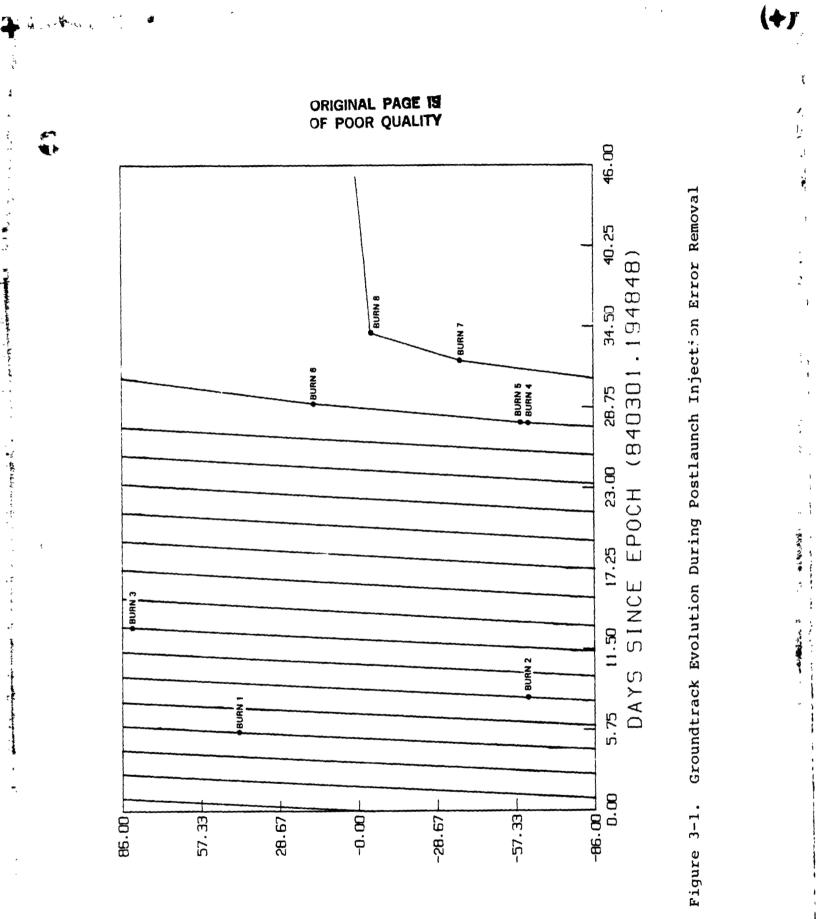
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Figure 3-2 illustrates the evolution of the frozen orbit in terms of e cos  $\omega$  and e sin  $\omega$ . The effect of each maneuver on the eccentricity vector can be seen. The appendix contains more details on each maneuver.

Landsat-5 was phased approximately half an orbital period (180 degrees) behind Landsat-4 following separation. The injection orbit of Landsat-5 was 12 kilometers lower in the semimajor axis than that of the Landsat-4 mission orbit. This caused Landsat-5 to gradually catch up to Landsat-4 and then pass it, until Landsat-5 led Landsat-4 by half an orbital period. Orbit adjust maneuver 8 was then executed to complete the injection error removal sequence, correctly phasing Landsat-5 180 degrees from Landsat-4 to provide an 8-day full Earth coverage cycle. Figure 3-3 depicts the phasing evolution between Landsat-4 and Landsat-5 during the injection error removal sequence of Landsat-5. The phasing is measured by comparing the times of corresponding

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GROUNDTRACK ERROR IN KILOMETERS

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ORIGINAL PACE 19 OF POOR QUALITY 6.0 Э.8 POSTLAUNCH FROZEN POINT POSTBURN B <del>1</del>.5 ł → POSTBURN 7 -0.8 POSTBURN 1 0.E-PO\$TBURN 6 POSTBURN 2 -5.3 POSTBURN 5 POSTBURN 3 POSTBURN 4 -7.5 8.6-13.0r 10.5 0.5 8.0 Э.0-5.5  $(^{4}-01 \times)(\overline{\omega})$  uis  $\overline{9}$ 

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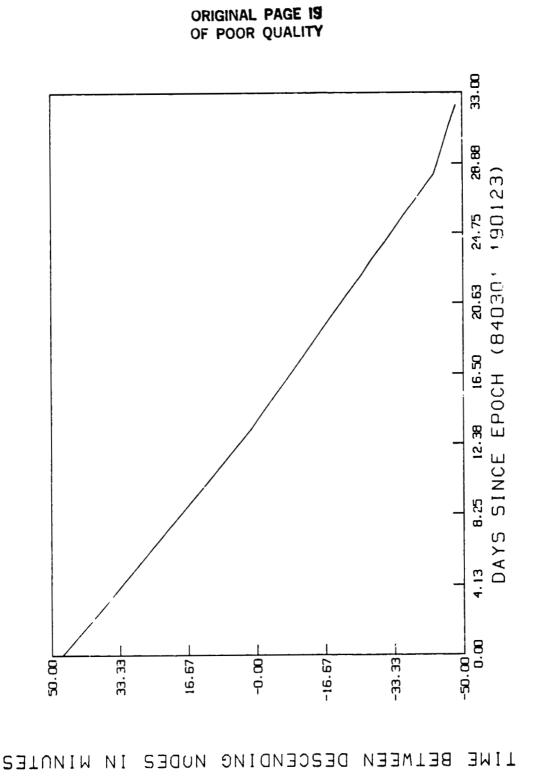
Frozen Orbit Evolution During Postlaunch Injection Error Removal Figure 3-2.

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descending nodal crossings of the two Landsat spacecraft. A positive value in the time difference indicates that Landsat-4 is leading Landsat-5. Landsat-5 leads Landsat-4 when the value is negative.

#### 3.2 ORBIT AND GROUNDTRACK MAINTENANCE MANEUVERS

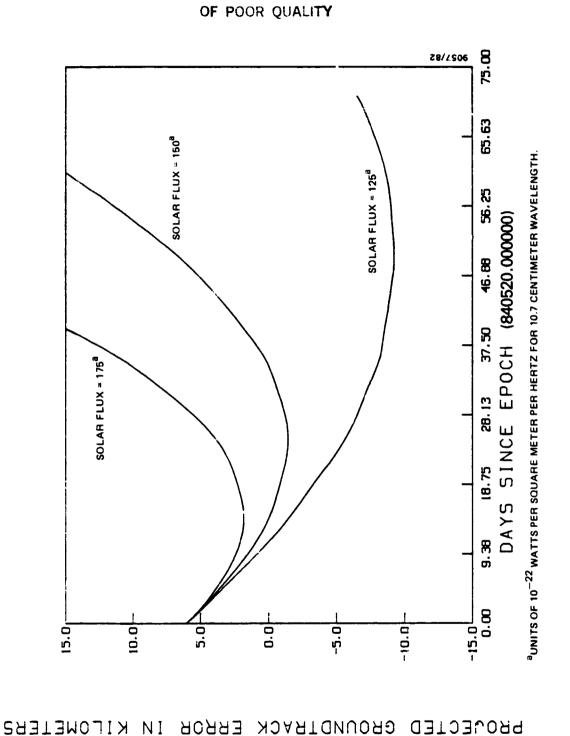
Following launch and initial groundtrack phasing maneuvers, orbit control for the Landsat-5 spacecraft entered the orbit maintenance phase. The objective of orbit maintenance is to control the spacecraft altitude within the range that will confine the groundtrack to within 10 kilometers cast or west of the required WRS path. This is accomplished by periodic adjustments to the semimajor axis on the order of 100 to 300 meters. The rate of semimajor axis decay, and thus the period between maintenance maneuvers, depends on the solar flux level. The targeted change in semimajor axis will depend on the estimated level of solar activity for several months following the maneuver.

Figure 3-4 illustrates the predicted effect of a typical maneuver on groundtrack error depending on the average solar flux level encountered (solar flux is given in units of  $10^{-22}$  watts per square meter per hertz and is for a 10.7-centimeter wavelength). Following a maneuver, the groundtrack begins drifting westward. The objective of the maneuver is to force the groundtrack to drift to the western boundary (-10 kilometers), turn around, and drift eastward. As the groundtrack reaches the eastern boundary (+10 kilometers), another maintenance burn is required to reverse the drift. If the solar flux level suddenly drops below the predicted average soon after the maneuver, the groundtrack may cross the western bour .ary. To correct at this point would require a retrograde maneuver (180-degree spacecraft yaw). Because this is undesirable from a spacecraft operational standpoint, it is necessary to be conservative in

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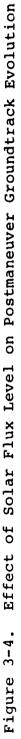
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estimating maneuver magnitude. The minimum burn length obtainable with the Landsat-5 propulsion module is 256 milliseconds with two thrusters firing simultaneously. This translates into a change in the semimajor axis of approximately 11 meters, which can make a difference of several kilometers in the westward groundtrack drift (depending on solar activity). The lower the solar flux encountered, the greater the difference in westward drift produced by two burns differing by one 256-millisecond pulse. Therefore, in planning the maneuver, the lowest expected average solar flux is used to define an upper limit for the burn time. Initial estimates of future solar activity are taken from predictions made by the Marshall Space Flight Center. The maintenance burns will be inserted in the appendix as they occur, beginning with maneuver 9.

In addition to controlling the groundtrack, the mean local time of the descending node must be maintained between 9:30 and 10:00 a.m. The local time is affected by the nodal regression rate, which is determined by the inclination of the orbit. Because the inclination changes slowly in time due to the gravitational effects of the Sun and Moon, the nodal rate will change causing a change in local ti. Inclination change maneuvers are required to restore the Sun-synchronous node rate. The inclination produced by the Delta 3920 launch vehicle was biased in such a way as to allow a relatively long time from launch to the first inclination change maneuver. It is expected that this maneuver will be required approximately 18 months after launch. During the life of the mission, detailed analysis will be performed to determine the exact date. Additional maneuvers may be required at 8-month intervals thereafter. The change in inclination for each burn is expected to be on the order of 0.05 degree. The mean local time of the descending node at injection was at 9:38 a.m.

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#### APPENDIX - LANDSAT-5 ORBIT ADJUST MANEUVER DATA

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This appendix contains data and analysis results for all maneuvers performed to date. It is intended that new tables and figures will be produced as additional maneuvers are performed. For each maneuver, the following two tables and two figures are provided:

- Table of orbit parameters for the given maneuver
- Table of spacecraft propulsion system parameters
- Plot of observed groundtrack since the previous maneuver
- Plot of observed mean local time of the descending node since the previous maneuver

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Orbit Parameters for Maneuver 1 Table A-1.

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BURN START TIME (GMT) 111703										CHANGE (OBSERVED - PREBURN)	0.1969	- 0.0000133	0.0000250	0.0001	15.49209	15.49125			0.25						
BURN START TI	OBSERVED POSTBURN	7069.5100	0.0005561	98.2528714	129.90768	205.90883	119.34712	840307	111707.608	OBSERVED POSTBURN	7066.2837	0.0000841	98.2549567	129.90259	206.12131	119.18734	840307	111707.608	5911.50	687.5494	688.7380	- 0.0000755	- 0.0000370	Ē	Ē
DATE 840307	PREDICTED POSTBURN	7069.6209	0.0006632	98.2529614	129.90766	205.96180	119.29310	840307	111707.608	PREDICTED POSTBURN	7066.2950	0.0000811	98.2549465	129.90257	206.5258	118.78501	840307	111707.608	5911.51	687.5819	688.7281	0.0000726	0.0000362	<sup>8</sup> a = SEMIMAJOR AXIS (km)	ti it
ORBIT 83	PREBURN	7069.3127	0.0005666	98.2528466	129.90767	203.27405	121.98106	<b>B403C</b> .*	111707.608	PREBURN	7066.0868	0.0000974	98.2549317	129.90258	190.62922	134.67859	840307	111707.608	5911.25	687.2586	688.6350	- 0.000957	- 0.000180	6.14	033808
MANEUVER 1	OSCULATING ELEMENTS <sup>8</sup>	19	Ð		α	3	Σ	EPOCH (YYMMDD)	(SSMMHH)	AVERAGED ELEMENTS <sup>b</sup>	D.	10	I	IQ	13	ı۶	EPOCH (YYMMDD)	(HHMMSS)	PERIOD (sec)	PERIGEE ALTITUDE <sup>C</sup>	APOGEE ALTITUDE <sup>C</sup>	e cos a	el SiN El	GROUNDTRACK ERROR (km) <sup>d</sup>	MEAN LOCAL TIME OF DESCENDING NODE

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dDISTANCE EAST (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PAIL

bNUMERICALLY AVERAGED OVER ONE ORBIT

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Q = RIGHT ASCENSION OF ASCENDING NODE (deg)

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ω = Argument of Perigee (deg) M = Mean Anomaly (deg) Times are gmt

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MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
1	83	840307	111703
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRES	SURE (PSIA)	297.48	296.94
TANK TEMPERATUR	ES (°C)		
TANK 1		17.11	17.11
TANK 2		- 16.61	16.61
TANK 3		18.18	13, 18
TANK 4 <sup>8</sup>		16.24	16.24
HYDRAZINE REMAIN	ING (POUNDS)		
TANK 1		55.67	55.61
TANK 2		55.67	55.61
TANK 3		55.67	55.61
TANK 4		343.50	343.36
TOTAL FUEL		510.51	510.1 <del>9</del>
TOTAL SPACED	RAFT WEIGHT	4284.78	4284.46
THRUSTERS			
ORBIT ADJUST THR	USTERS USED		B1, D1
TOTAL ORBIT ADJU	ST THRUSTER DURATIO	N (sec) <sup>b</sup>	9.216
TOTAL ATTITUDE TH	IRUSTER DURATION (see	2)	102.080
SPACECRAFT ATTIT	UDE (deg) <sup>C</sup>		
РІТСН			0.0
YAW			0.0
ROLL			0.0
MANEUVER CALIBRA	TION		
SEMIMAJOR A	(IS CHANGE (km)		
PREDICTED			0.2082
OBSERVED			0.1969
INCLINATION C	HANGE (deg)		
PREDICTED			N/A
OBSERVED			N/A
THRUST CORRI	ECTION FACTOR		
USED FOR F	LANNING		1.0000
RECALIBRA	redd		0.9457

# Table A-2. Spacecraft Parameters for Maneuver 1

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aTANK 4 IS THE AUXILLIARY TANK KIT (ATK)

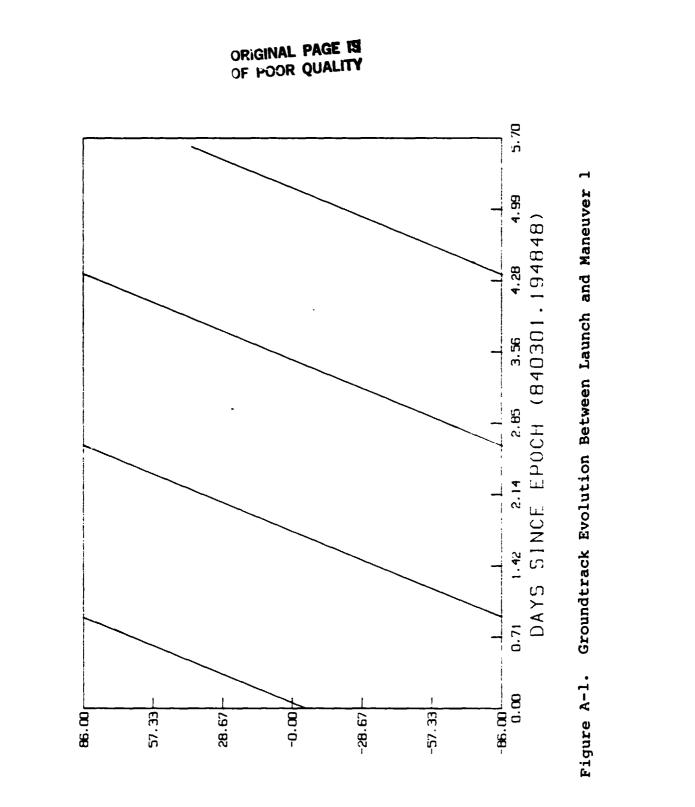
<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION - NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

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<sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING

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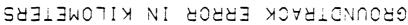
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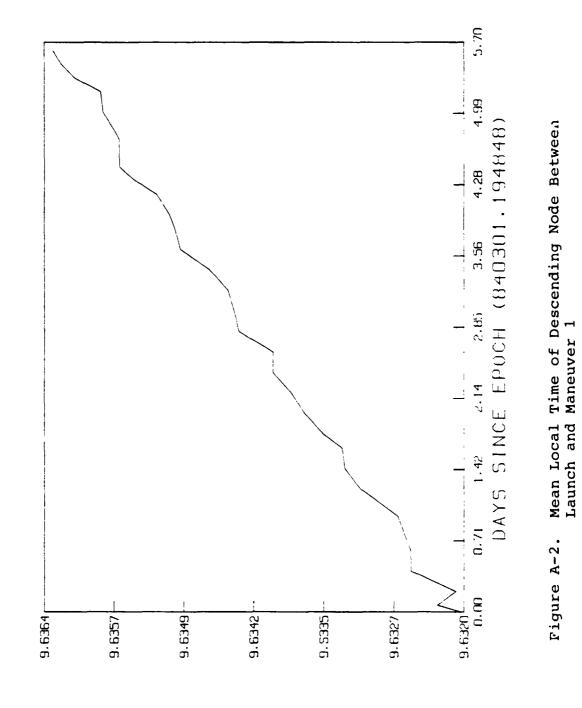
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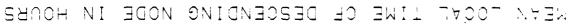
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Table A-3. Orbit Parameters for Maneuver 2

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DATE 840309 BURN START TIME (GMT) 212647	PREDICTED POSTBURN OBSERVED POSTBURN	7057.9918 7057.9823	0.0015451 0.0015466	96.2598594 98.2599719	132.31970 132.31973	277.30452 277.25790 .	183.67437 183.72113	840309 840309	212651.608 212651.608	PREDICTED POSTBURN OBSERVED POSTBURN (OBSERVED - PREBURN)	7066.4960 7066.4864 0.1981	0.0002649 0.0002658 0.000055	98.2548689 98.2549813 0.0001091	132.31769 132.31773 0.00006	175.2C228 175.C268 – 5.97928	285.73644 285.37219 5.97923	840309 840309	212651.608 212651.608	5911.76 5911.75 0.25	686.4841 686.4681	690.2279 690.2247	0.00026400.0002650	0.000219 0.0000203	a = SEMIMA IOR AXIS (tm)	II N	ω = RIGHT ASCENSION OF ASCENDING NODE (deg) ω = ARGUMENT OF PERIGEE (deg)
ORBIT 119	PREBURN	7057.7848	0.0015745	98.2599628	132.31968	277.30691	183.67218	840309	212651.608	PREBURN	7066.2883	0.0002603	98.2548722	132.31767	181.60596	279.39296	840309	212651.608	5911.50	686.3089	689.3877	0.0002602	0.000073	- 60.4	093817	
MANEUVER 2	OSCULATING ELEMENTS <sup>3</sup>	Ø	Ð		a	3	Σ	EPOCH (YYMMDD)	(HHMMSS)	AVERAGED ELEMENTS <sup>b</sup>	10	10	I	IX	13	ıž	EPOCH (YYMMDD)	(SSMMHH)	PERIOD (sec)	PERIGEE ALTITUDE <sup>C</sup>	APOGEE ALTITUDE <sup>C</sup>	e cos a		GROUNDTRACK ERROR (km) <sup>d</sup>	MEAN LOCAL TIME OF DESCENDING NODE (HHMMSS)	

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<sup>d</sup>DISTANCE EAST (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PATH

<sup>C</sup>EQUATORIAL REFERENCE

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# Table A-4. Spacecraft Parameters for Maneuver 2

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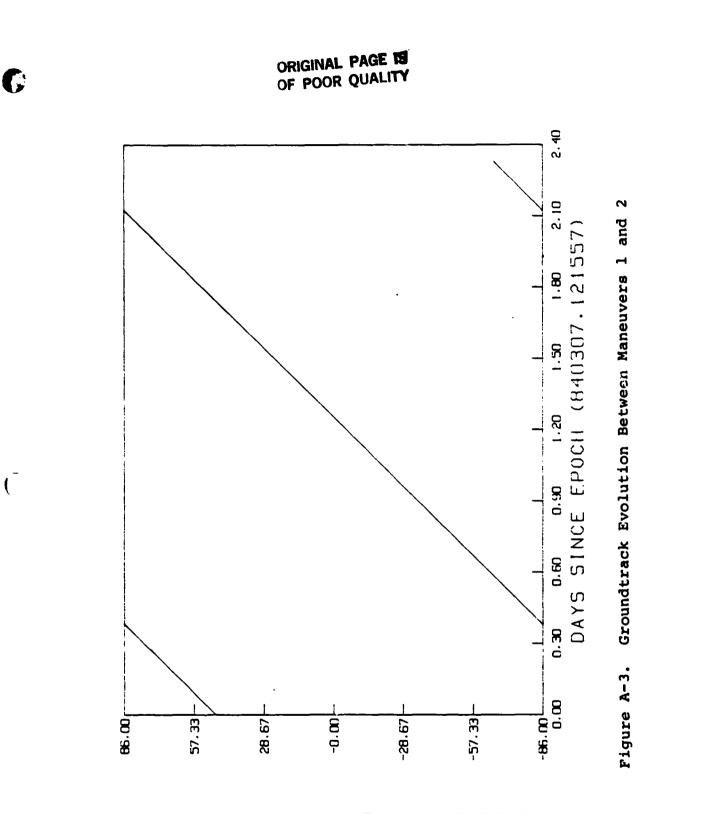
MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
2	119	840309	212647
SPACECRAFT PARAMETERS		PREBURN	POSTBURN
FUEL SYSTEM PRESSURE (PSIA)		296.97	296.61
TANK TEMPERATURE	ES (°C)		
TANK 1		17.47	17.47
TANK 2		17.11	17.11
TANK 3		18.71	18.71
TANK 4 <sup>a</sup>		16.23	16.23
HYDRAZINE REMAINI	ING (POUNDS)		
TANK 1		55.61	55.57
TANK 2		55.61	55.57
TANK 3		55.61	55.57
TANK 4		343.36	343.26
TOTAL FUEL		510.19	509.97
TOTAL SPACECRAFT WEIGHT		4284.46	4284.24
THRUSTERS		T	
ORBIT ADJUST THRUSTERS USED			B1, D1
TOTAL ORBIT ADJUST THRUSTER DURATION (sec) <sup>b</sup>			9.216
TOTAL ATTITUDE TH	RUSTER DURATION (sec	c)	7.840
SPACECRAFT ATTITU	JDE (deg) <sup>C</sup>		
РІТСН			0.0
YAW			0.0
ROLL		4	0.0
MANEUVER CALIBRA	TION		
SEMIMAJOR AX	(IS CHANGE (km)		
PREDICTED			0.2077
OBSERVED			0.1981
INC_INATION C	HANGE (deg)	}	
PREDICTED			N/A
OBSERVED		l l	N/A
THRUST CORRE			
USED FOR P			1.0000
RECALIBRAT		1	0.9538

<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION - NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

dRECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING

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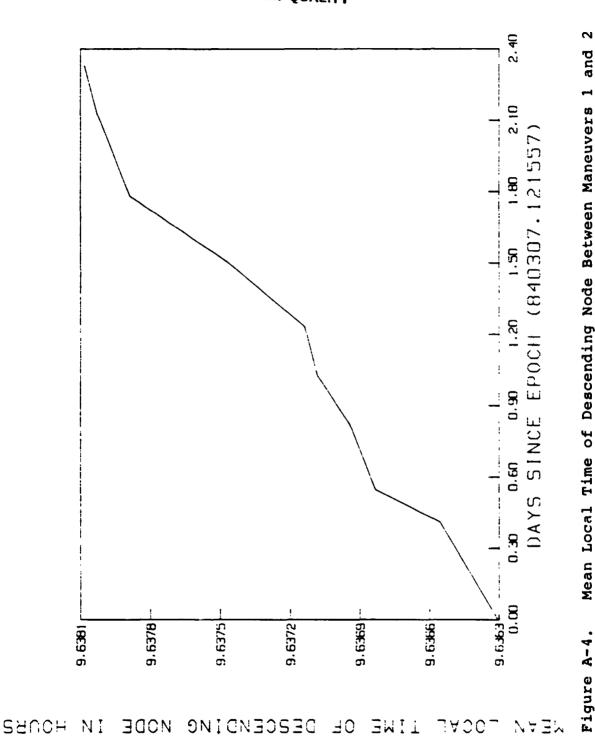
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Orbit Parameters for Maneuver 3 Table A-5.

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MANEUVER 3	ORBIT 192	DATE 840314	BURN START TI	BURN START TIME (GMT) 212903
OSCULATING ELEMENTS <sup>a</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	
~5	7058.5342	7059.9786	7060.0020	
9	0.0013113	0.0011094	0.0011060	
	98.2595169	98.2594774	98.2595338	
a	137.30470	137.30485	137.30499	
3	271.67404	269.91821	269.90158	
¥	193.41979	195.17410	195.19068	
EPOCH (YYMMDD)	840314	840314	840314	
(SSMMHH)	212918.888	212918.888	212918.888	
averaged elements <sup>b</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	CHANGE (OBSERVED-PREBURN)
ło	7066.4749	7067.9243	7067.9478	1.4729
10	0.0005825	0.006916	0.0006335	0.0001110
1	98.2548668	98.25/8279	98.2548843	0.0000175
101	137.30203	137.30218	137.30232	0.00029
13	167.2951E	151.55642	151.32066	- 15.97449
IΣ	297.82554	313.56275	313.79847	15.97293
EPOCH (YYMMDD)	840314	840314	840314	
(HHMMSS)	212918.888	212918.888	212918.888	
PERIOD (sec)	5911.74	5913.56	5913.59	1.85
PERIGEE ALTITUDE <sup>C</sup>	684.2187	684.8961	684.9062	
APOGEE ALTITUDE <sup>C</sup>	692.4511	694.6725	694.7094	
e cos a	- 0.0005682	- 0.0006081	- 0.0006084	
el Sin El	0.0001281	0.0003294	0.0003328	
GROUNDTRACK ERROR (km) <sup>d</sup>	80.7	<sup>a</sup> a = SEMIMAJOR AXIS (km)	(m	
MEAN LOCAL TIME OF DESCFNDING NODE (HHMMSS)	053830	19 11	ECCENTRICITY INCLINATION (deg)	

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$$\label{eq:constraint} \begin{split} \Omega &= \text{RIGHT} \ \text{ASCENSION OF ASCENDING NODE (deg)} \\ \omega &= \text{ARGUMENT OF PERIGEE (deg)} \end{split}$$

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M = MEAN ANOMALY (deg) TIMES ARE GMT

bNUMERICALLY AVERAGED OL \_R ONE ORBIT

CEQUATORIAL REFERENCE

<sup>d</sup>DISTANCE EAST (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PATH

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### Table A-6. Spacecraft Parameters for Maneuver 3

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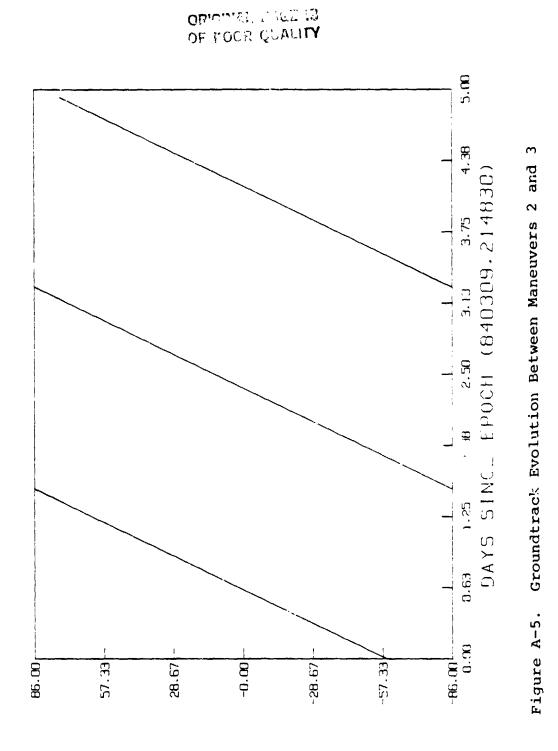
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MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
3	192	840314	212903
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRES	SURE (PSIA)	295.12	292.49
TANK TEMPERATURI	ES (°C)		
TANK 1		17.28	17.28
TANK 2		16.74	16.74
TANK 3		18.52	18.52
TANK 4 <sup>a</sup>		15.58	15.58
HYDRAZINE REMAIN	ING (POUNDS)		
TANK 1		55.57	55.30
TANK 2		55.57	55.30
TANK 3		55.57	55.30
TANK 4		343.26	342.57
TOTAL F .EL		509.97	508.47
TOTAL SPACEC		4284.24	4282.74
THRUSTERS			
ORBIT ADJUST THRU	JSTERS USED	}	A1, B1, C1, D1
TOTAL ORBIT ADJUS	ST THRUSTER DURATION	V (sec) <sup>b</sup>	63.552
TOTAL ATTITUDE TH	RUSTER DURATION (sec	:)	17.080
SPACECRAFT ATTIT	JDE (dea) <sup>C</sup>		
PITCH		1	0.0
YAW		1	0.0
ROLL			0.0
MANEUVER CALIBRA			
	(IS CHANGE (km)		
PREDICTED			1,4494
OBSERVED			1.4729
	HANGE (den)	ł	
PREDICTED	10081		N/A
OBSERVED			N/A
			17.0
THRUST CORRE	CTION FACTOR		
USED FOR P	LANNING		0.9800
RECALIBRAT	EDq		0.9959

aTANK 4 IS THE AUXILLIARY TANK KIT (ATK)

<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION + NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER\_MODELING <sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING



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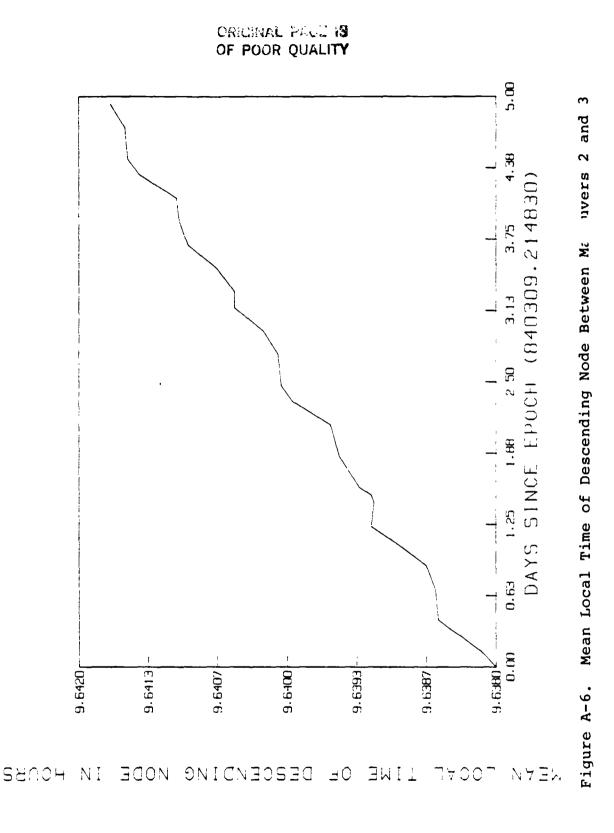
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Table A-7. Orbit Parameters for Maneuver 4

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MANEUVER 4	ORBIT 404	DATE 840329	BURN START TI	BURN START TIME (GMT) 110934
OSCULATING ELEMENTS <sup>a</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	
	7071.3944	7072.5863	7072.5850	
	0.0016011	0.0014342	0.0014319	
	98.2493759	98.2494846	98.2497870	
α	151.81186	151.81179	151.81153	
3	151.24106	152.27330	152.10650	
	174.97705	173.94356	174.11100	
EPOCH (YYMMDD)	840329	840329	<b>B4</b> 0329	
(HHMMSS)	110946.977	110946.977	110946.977	
AVERAGED ELEMENTS <sup>b</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	CHANGE (OBSERVED-PREBURN)
	7067.8908	7069.0630	7069.0816	1.1908
	0.0014209	0.0012533	0.0012524	- 0.0001685
	98.2516450	98.2517534	98.2520559	0.0004109
	151.80685	151.80678	151.80653	0.00032
	135.52514	134.59150	134.37762	- 1.14752
	190.74478	191.67715	191.89168	1.14690
EPOCH (YYMMDD)	840329	840329	840329	
(HHMMSS)	110946.977	110946.977	110946.977	
PERIOD (sec)	5913.51	5915.01	5915.01	1.50
PERIGEE ALTITUDE <sup>C</sup>	679.7080	682.3833	682.0883	
APOGEE ALTITUDE <sup>C</sup>	699.7936	699.8027	699.7949	
ច COS ជ	0.0010139	0.0008799	0.0008759	
SIN E	0.0009955	0.0008925	0.0008961	
GROUNDTRACK ERROR (km) <sup>d</sup>	- 61.7	<sup>a</sup> a = SEMIMAJOB AXIS (km)		
MEAN LOCAL TIME OF	093905	li		
DESCENDING NODE (HHMMSS)		i = INCLINATION (deg)		
	: : :	N	RIGHT ASCENSION OF ASCENDING NODE (deg)	
		<ul> <li>w = Argument of Periode (deg)</li> <li>M = MEAN ANOMALY (deg)</li> <li>TIMES ARE GMT</li> </ul>	GEE (deg) (g)	
		<sup>b</sup> NUMERICALLY AVERAGED OVER ONE ORBIT	OVER ONE ORBIT	
		<sup>C</sup> EQUATORIAL REFERENCE		

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<sup>d</sup>DISTANCE EAS <sup>r</sup> (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PATH

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### Table A-8. Spacecraft Paramer is for Maneuver 4

MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
4	404	840329	110934
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRESS		290.95	288.77
TANK TEMPERATURE	S (°C)		
TANK 1		16.97	16.97
TANK 2		16.39	16.39
TANK 3		13.00	18.00
TANK 4 <sup>8</sup>		14.26	14.26
HYDRAZINE REMAINI	NG (POUNDS)		
TANK 1		55.30	55.07
TANK 2		55.30	55.07
TANK 3		55.30	55.07
TANK 4		342.57	341.98
TOTAL FUEL		508.47	507.19
TOTAL SPACEC	RAFT WEIGHT	4282.74	4281.46
THRUSTERS			
ORBIT ADJUST THRU	STERS USED		A1, B1, C1, D1
TOTAL ORBIT ADJUS	T THRUSTER DURATION	N (sec) <sup>b</sup>	51.908
TOTAL ATTITUDE TH	RUSTER DURATION (sec	;)	73.640
SPACECRAFT ATTITU	JDE (deg) <sup>C</sup>		
PITCH	-		0.0
YAW			0.0
ROLL			0.0
MANEUVER CALIBRA	TION		
	IS CHANGE (km)		
PREDICTED			1.1922
OBSERVED			1.1908
INCLINATION C	HANGE (deg)		
PREDICTED	-		N/A
OBSERVED			N/A
THRUST CORRE	CTION FACTOR		
USED FOR P			1.0000
RECALIBRAT	FDd		0.9988

<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

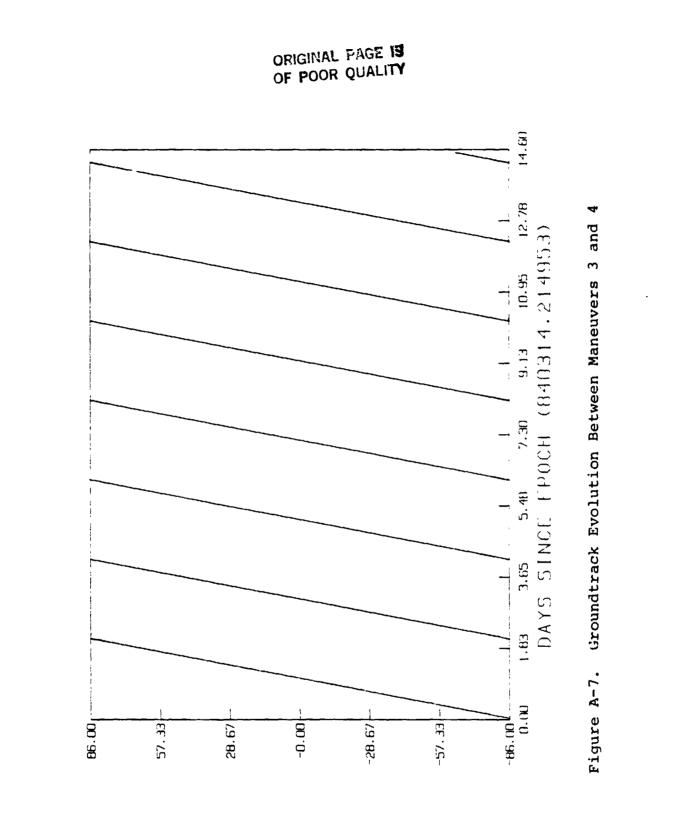
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<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION + NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING ÷

dRECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING

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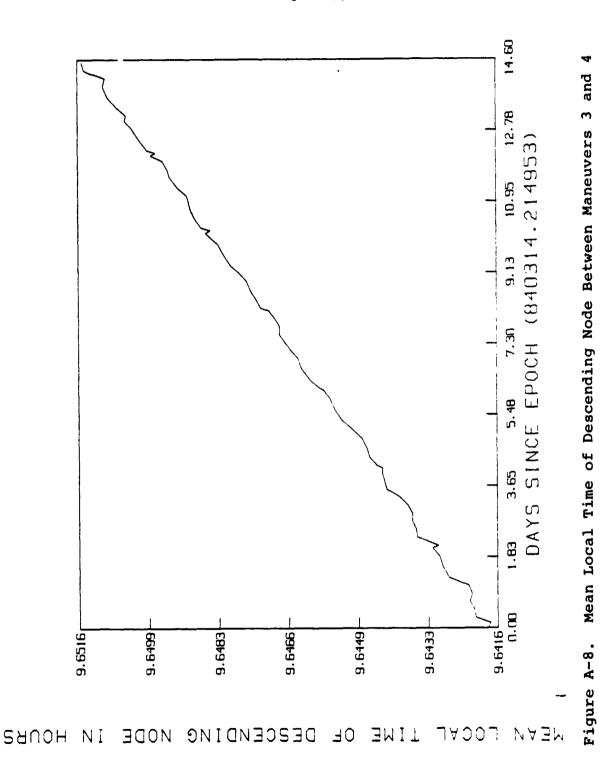
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Table A-9. Orbit Parameters for Maneuver 5

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										GE PREBURN)		73	75								<b>98</b> /1		3)/299			
AE (GMT) 124654										CHANGE (OBSERVED-PREBURN)	2.3047	-0.0003173	0.0006975	0.00036	3.52099	3.52196			2.90							
BURN START TIME (GMT) 124654	OBSERVED POSTBURN	7073.6564	0.0013046	96.2508962	151.87867	152.92971	169.35032	840329	124724.336	OBSERVED POSTBURN	7071.3814	0.0009519	98.2518617	151.87345	131.26110	191.07296	840329	124724.336	5917.90	686.5102	699.9726	0.0006278	0.0007156	1 E		RIGHT ASCENSION OF ASCENDING NODE (deg) ARGUMENT OF PERIGEE (deg)
DATE 840329	PREDICTED POSTBURN	7073.4825	0.0013346	98.2504169	151.87885	154.36411	167.91250	840329	124724.336	PREDICTED POSTBURN	7071.2072	0.000680	98.2513924	151.87363	133.74731	188.58334	840329	124724.336	5917.68	686.2223	699.9121	- 0,0006694	0.0006993	<sup>a</sup> a = Semima.ior axis (km)	11 11	
ORBIT 405	PREBURN	7071.3532	0.0016267	98.2501886	151.87903	151.38186	170.89719	<b>B4</b> 0329	124724.336	PREBURN	7069.0767	0.0012692	98.2511642	151.87381	134.78209	187.55100	840329	124724.336	5915.00	681.9646	8806.969	0.0008940	6006000'0	- 56.8	03305	
MANEUVER 5	OSCULATING ELEMENTS <sup>a</sup>		0		α	Э	Σ	EPOCH (YYMMDD)	(HHMMSS)	AVERAGED ELEMENTS <sup>b</sup>	0	iœ		101	13	IΣ	EPOCH (YYMMDD)	(HHMMSS)	PERIOD (sec)	PERIGEE ALTITUDE <sup>C</sup>	APOGEE ALTITUDE <sup>C</sup>	e cos a	el Sin El	GROUNDTRACK ERROR (km) <sup>d</sup>	MEAN LOCAL TIME OF DESCENDING NODE (HHMMSS)	

ddistance east (+) or west (-) of world reference system path

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## Table A-10. Spacecraft Parameters for Maneuver 5

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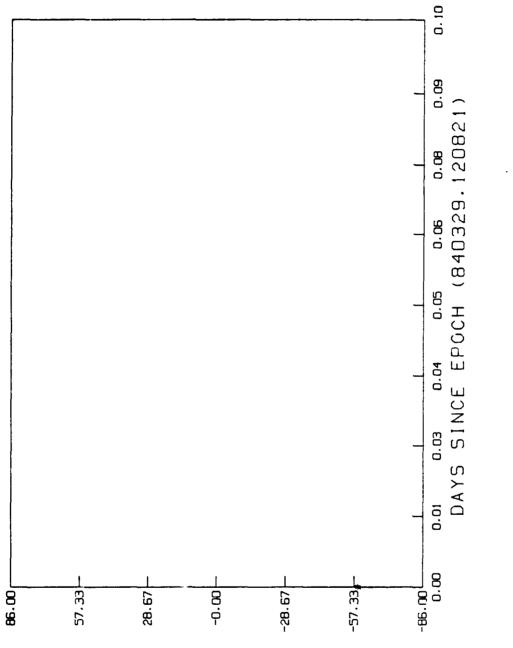
MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
5	405	840329	124654
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRES	SURE (PSIA)	288.77	284.59
TANK TEMPERATUR	ES (°C)		
TANK 1		16.97	16.97
TANK 2		16.39	16.39
TANK 3		18.00	18.00
TANK 4 <sup>a</sup>		14.26	14.26
HYDRAZINE REMAIN	IING (POUNDS)		
TANK 1		55.07	54.62
TANK 2		55.07	54.62
TANK 3		55.07	54.62
TANK 4		341.98	340.82
TOTAL FUEL		507.19	504.68
TOTAL SPACE	CRAFT WEIGHT	4281.46	4278.95
THRUSTERS			
ORBIT ADJUST THR	USTERS USED		A1, B1, C1
TOTAL ORBIT ADJU	ST THRUSTER DURATION	N (sec) <sup>b</sup>	91.008
TOTAL ATTITUDE T	HRUSTER DURATION (sec	:)	188.440
SPACECRAFT ATTIT	UDE (deg) <sup>C</sup>		
PITCH			0.0
YAW			0.0
ROLL			0.0
MANEUVER CALIBR	ATION		
SEMIMAJOR A	XIS CHANGE (km)		
PREDICTED			2.1305
OBSERVED			2.3047
INCLINATION C	HANGE (deg)		
PREDICTED			N/A
OBSERVED			N/A
THRUST CORR	ECTION FACTOR		
USED FOR I	PLANNING	l l	1.0000 1.0821
RECALIBRA	TEDd		1.0821

<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION + NUMBER OF THRUSTERS <sup>c</sup>SPACECHAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

<sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING

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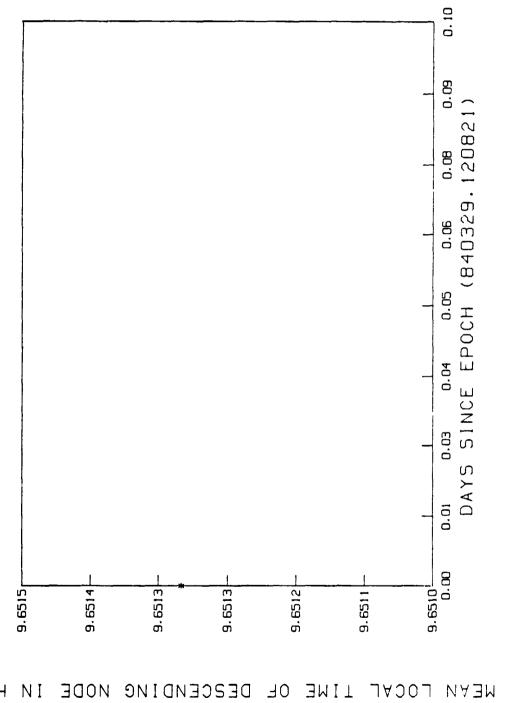


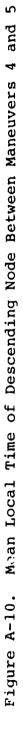
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Table A-11. Orbit Parameters for Maneuver 6

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BURN START TIME (GMT) 214803										CHANGE (OBSERVED-PREBURN)	1.8626	- 0.0002117	0.0001464	0.00005	- 9.90777	9.90606			2.34		18	/(.qı	r\$)/90			
BURN STAR	OBSERVED POSTBURN	7081.1839	0.0004362	98.2475255	153.24351	111.82824	233.45481	840330	214843.928	OBSERVED POSTBURN	7073.2318	0.0008125	98.2522172	153.24058	121.20780	224.10271	840330	214843.928	5920.22	689.3448	700.8388	- 0.0004210	0.0006949			RIGHT ASCENSION OF ASCENDING NODE (deg) ARGUMENT OF PERIGEE (deg)
DATE 840330	PREDICTED POSTBURN	7081.2337	0.0004229	98.2479092	153.24339	112.10526	233.17716	840330	214843.928	PREDICTED POSTBURN	7073.2814	0.0007998	98.2526012	153.24046	121.50841	223.80147	840330	214843.928	5920.28	689.4842	700.7986	- 0.0004180	0.0006819	<sup>a</sup> a = SEMIMA IOR AXIS (km)	1 11 11	
ORBIT 425	PREBURN	7079.3195	0.0006356	98.2476709	153.24346	130.73293	214.55183	840330	214843.928	PREBURN	7071.3692	0.0010242	98.2523636	153.24053	131.11557	214.19665	840330	214843.928	5917.88	685.9867	700.4717	0.0006735	0.0007716	18.4	806260	
MANEUVER 6	OSCULATING ELEMENTS <sup>a</sup>	6	Û	.=	a	3	Σ	EPOCH (YYMMDD)	(SSMMHH)	averaged elements <sup>b</sup>	100	10	1·	101	13	ı٤	EPOCH (YYMMDD)	(HHMMSS)	PERIOD (sec)	PERIGEE ALTITUDE <sup>C</sup>	APOGEE ALTITUDE <sup>C</sup>	e COS &	e SIN EI	GROUNDTRACK ERROR (km) <sup>d</sup>	MEAN LOCAL TIME OF DESCENDING NODE	

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<sup>d</sup>DISTANCE EAST (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PATH

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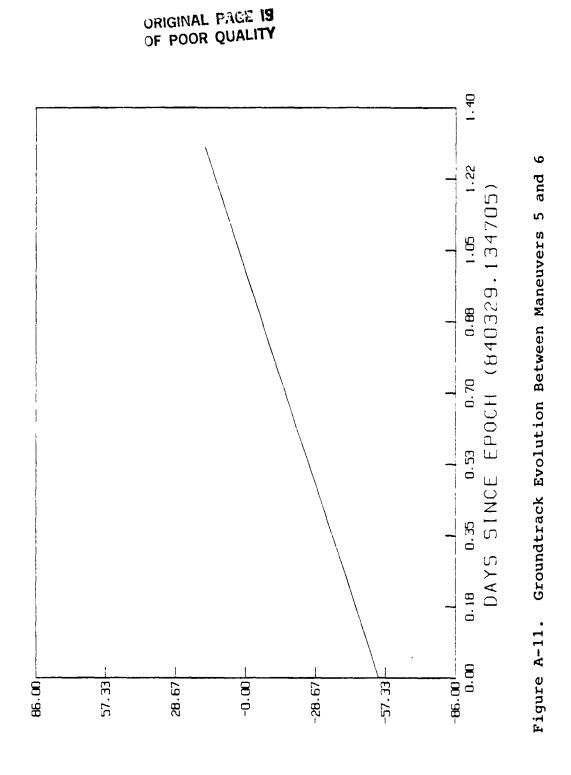
### Table A-12. Spacecraft Parameters for Maneuver 6

MANEUVER	ORBIT	DATE	BURN START TIME (GMT)			
6	425	840330	214803			
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN			
FUEL SYSTEM PRESS	SURE (PSIA)	284.24	281.06			
TANK TEMPERATURE	S (°C)					
TANK 1		17.11	17.11			
TANK 2		16.40	16.40			
TANK 3		18.06	18.06			
TANK 4 <sup>a</sup>		13.95	13.95			
HYDRAZINE REMAINI	NG (POUNDS)					
TANK 1		54.62	54.26			
TANK 2		54.62	54.26			
TANK 3		54.62	54.26			
TANK 4		340.82	339.92			
TOTAL FUEL		504.68	502.70			
TOTAL SPACEC	RAFT WEIGHT	4278.95	4276.97			
THRUSTERS						
ORBIT ADJUST THRU	JSTERS USED		A1, C1			
TOTAL ORBIT ADJUS	T THRUSTER DURATION	N (sec) <sup>b</sup>	81.856			
TOTAL ATTITUDE TH	RUSTER DURATION (see	:)	87.360			
SPACECRAFT ATTITU	JDE (deg) <sup>C</sup>					
PITCH	-		0.0			
YAW			0.0			
ROLL			0.0			
MANEUVER CALIBRA	TION					
SEMIMAJOR AX	IS CHANGE (km)					
PREDICTED			1.9123			
OBSERVED			1.8626			
INCLINATION CH	HANGE (dea)					
PREDICTED	·g.		N/A			
OBSERVED			N/A			
			N/A			
THRUST CORPO	CTION FACTOR		4 0000			
THRUST CORRE USED FOR P			1.0000			

<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION + NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

<sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING



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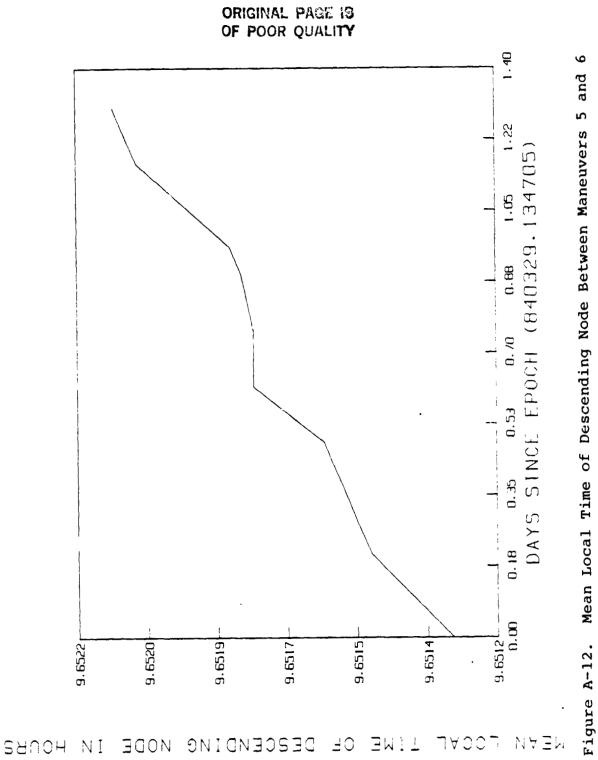
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> Orbit Parameters for Maneuver 7 Table A-13.

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MANEUVER 7	ORBIT 469	DATE 840402	BURN START TI	BURN START TIME (GMT) 205004
OSCULATING ELEMENTS <sup>a</sup>	PfiEBURN	PREDICTED POSTBURN	OBSERVED POSTBURK	
	7075.6386	7078.3570	7078.2720	
ť	0.0013429	0.0012923	0.0012989	
	98.2492276	98.2495193	98.2499165	
a	156.17316	156.17337	156.17369	
3	138.31083	121.66387	122.18392	
Σ	259.32621	275.96968	275.45000	
EPOCH (YYMMDD)	840402	840402	840402	
(SSMMHH)	205102.432	205102.432	205102.432	
AVERAGED ELEMENTS <sup>b</sup>	PREBURN	PREDICTED POS TBURN	OBSERVED POSTBURN	CHANGE (OBSERVED - PREBLIRN)
141	7073.2325	7075.9524	175.8673	2.6348
ļo	0.0009096	0.0009865	0.0009882	0.0000786
1	98.2505715	98.2508630	98.2512603	0.0006888
101	156.17840	156.17861	156.17894	0.00054
13	122.67551	99.73043	100.50609	- 22. : 6942
ı۶	274.90897	297.85057	297 07528	22.16631
EPOCH (YYMMDD)	840402	840402	840402	
(SIMMH)	205102.432	205102.432	205102.432	
PERIOD (sec)	5920.22	5923.63	5923.53	3.31
PERIGEE ALTITUDE <sup>C</sup>	688.6587	690.8320	690.7349	
APOGEE ALTITUDE <sup>C</sup>	701.5263	704.7928	704.7197	
e COS 🖬	0.0004911	- 0.0001667	-0.0001802	
e Sin E	0.0007656	0.0009723	0.0009716	
GROUNDTRACK ERROR (km) <sup>d</sup>	38.0	<sup>a</sup> a = SEMIMAJOR AXIS (km)		
MEAN I SCAL TIME OF DESC eNDING NODE (HHIGIMSS)	093913	H H	E	

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Q = RIGHT ASCENSION OF ASCENDING NODE (deg)

ω = ARGUMENT OF PERIGEE (deg)

M = MEAN ANOMALY (deg) TIMES ARE GMT

<sup>b</sup>NUMERICALLY AVERAGED OVER ONE ORBIT

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<sup>d</sup>DISTANCE EAST (+) OR WEST (-) OF WORLD REFERENCE SYSTEM PATH

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### Table A-14. Spacecraft Parameters for Maneuver 7

MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
7	469	840402	205004
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRES	SURE (PSIA)	280.89	276.54
TANK TEMPERATUR	ES (°C)		
TANK 1		16.94	16.94
TANK 2		16. <b>39</b>	16.39
TANK 3		17. <b>87</b>	17.87
TANK 4 <sup>a</sup>		13.94	13.94
HYDRAZINE REMAIN	ING (POUNDS)		
TANK 1		54.26	53.77
TANK 2		54.26	53.77
TANK 3		54.26	53.77
TANK 4		339.92	338.64
TOTAL FUEL		502.70	499.95
TOTAL SPACEO	RAFT WEIGHT	4276.97	4274.22
THRUSTERS			
ORBIT ADJUST THR	USTERS USED		A1, C1
TOTAL ORBIT ADJU	ST THRUSTER DURATION	l (sec) <sup>b</sup>	116.864
TOTAL ATTITUDE TH	IRUSTER DURATION (sec	)	111.160
SPACECRAFT ATTIT	UDE (deg) <sup>C</sup>		
PITCH	•		0.0
YAW			0.0
ROLL			0.0
MANEUVER CALIBRA	TION		
SEMIMAJOR A	(IS CHANGE (km)		
PREDICTED			2.7199
OBSERVED			2.6348
INCLINATION C	HANGE (deg)		
PREDICTED	0		N/A
OBSERVED			N/A
THRUST CORRI	ECTION FACTOR		
USED FOR P	LANNING		1.0000
RECALIBRAT	rend		0.9686

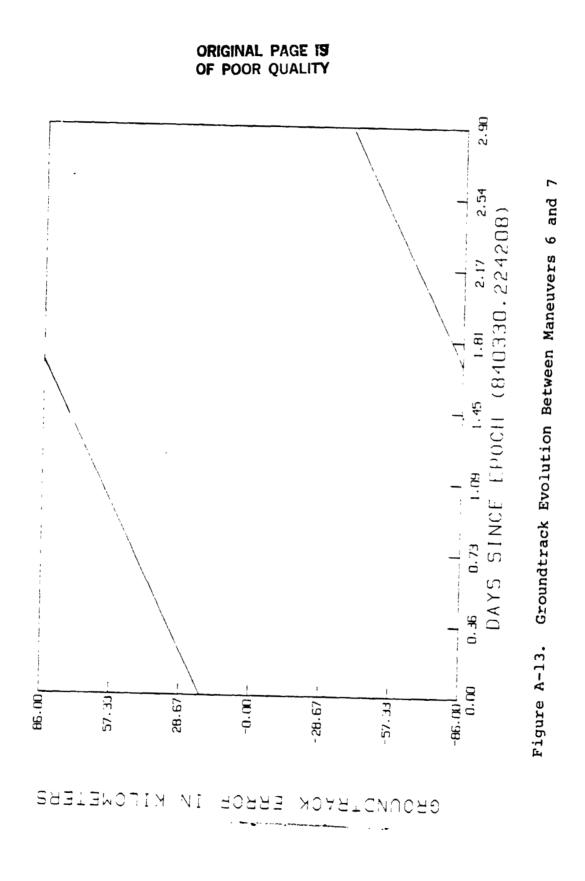
<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

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<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = TOTAL DURATION - NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

<sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING



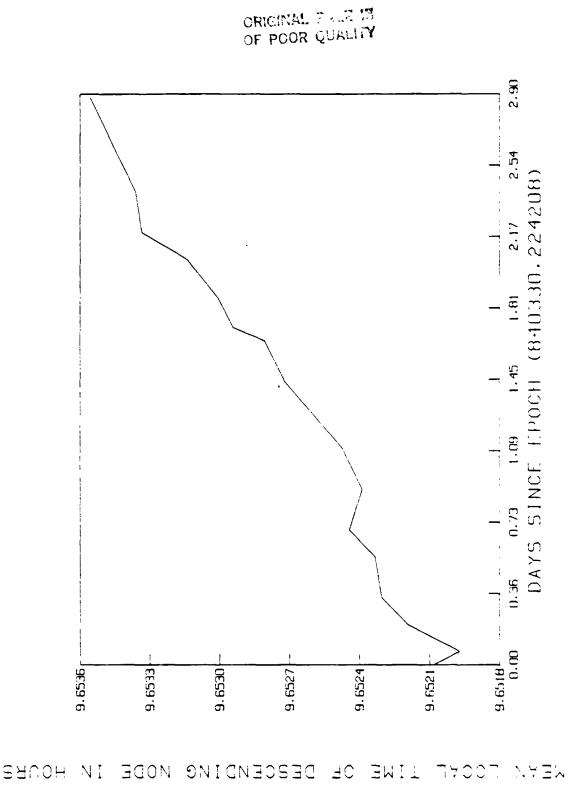
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Orbit Parameters for Maneuver 8 Table A-15. **-.** .

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OSCULATING ELEMENTS <sup>3</sup> PREBURIN         REBURIN         REBURIN         REBURIN         REBURIN         ROSTBURIN	MANEUVER 8	ORBIT 498	DATE 840404	BURN START TH	BURN START TIME (GMT) 203807
7078.787         7078.7104         7078.704         7078.664           0.0012836         0.0013032         96.2496010         96.249605         96.249605           96.2466010         96.249605         96.249605         96.249605         96.249605           131.72728         131.72728         138.14807         138.3421         158.14807           131.72728         2016.1750         96.246607         158.14807         158.3421           131.72728         200404         84.0404         84.0404         84.0404           20050.168         20050.168         20050.168         200360.168         200360.168           AGED ELEMENTSD         PREULIN         PREDICTED POSTBURN         0.86.0404         84.0404           AGED ELEMENTSD         PREUL         7077.7722         0.0011669         203860.168           20010066         98.2604517         28.15649         158.15549         158.15549           198.1523         188.15249         158.15549         158.15549         9.200156           198.15249         188.15549         158.15549         9.200156         9.20056           198.15249         188.15549         158.15549         9.20056         9.20056           198.15249         188.15549         15	OSCULATING ELE:MENTS <sup>a</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	
0.0013028         0.0013022         0.0013079           98.2496010         98.249662         98.260620           158.14790         158.1407         158.1407           158.14790         158.1407         158.1407           158.14750         158.1407         158.1487           131.7228         270.5515         282.6456         282.2665           200560.168         203660.168         203660.168         203660.168           200560.168         200566.168         203660.168         20077.722           200561         PREBURN         PREDICTED POSTBURN         0.001569           200561         2000166         0.0011642         0.0011669           2000006         0.0011642         0.0011642         0.0011669           2000010066         98.40040         88.260516         98.2606117           2000011642         98.40040         88.26056         98.40040           20010066         99.40040         88.26668         98.40040           20011642         98.40040         88.26668         98.40040           201117025         158.11590         98.40040         88.4380           201111026         10.011642         20.0011540         20.0011569           20111016	5	7076.7987	7078.7104	7078.6954	
98.2466010         98.2466020         98.2466020         115.1467         115.1466		0.0012938	0.0013032	0.0013079	
168.14790         158.14807         158.14807         158.14817           131.72228         119.71375         119.71375         119.82421           131.7228         200.63163         222.64287         222.5256           200.63163         20360.168         200404         840404           201.6101         840404         840404         840404           20360.168         20360.168         20366.168         20366.168           20360.168         20366.168         20366.168         20366.168           2010.01006         0.0011642         0.0011642         0.0011643           2010.01066         0.0011642         96.2604817         96.260485           20360.168         168.15324         168.15324         168.15326           188.1532         168.1532         168.1532         168.15326           199.1642         0.0011642         96.260665         96.2606485           20360.168         20366.168         20366.168         20366.168           20360.168         86.35066         96.2606485         196.1539           19.11400         10161482         96.260665         96.2606485           20360.168         82.3000         89.40040         89.40040           190.11400		98.2498010	98.2499952	98.2500920	
131.7278         119.71375         119.85421           707.053163         220.64287         222.64287         222.655           700560.168         200404         840404         840404           AGED ELEMENTS <sup>D</sup> PREDIRN         282.64287         232.655           AGED ELEMENTS <sup>D</sup> PREDIRN         0.05560.168         203650.168           203650.168         203650.168         203650.168         203650.168           7077.7722         0.0010696         96.2604517         0.0011642           80.4604         98.360516         98.2604517         0.0011643           98.260451         158.15349         158.15349         158.15349           158.15349         158.15349         158.15349         158.15369           101<61489	a	158.14790	158.14807	158.14817	
TVMMDD         270.63163         222.64287         222.5265           IHHMMSSI         200404         840404         840404         840404           IHHMMSSI         202860.168         203860.168         203860.168         203860.168           AGED ELEMENTS <sup>D</sup> PREBURN         PREDICTED POSTBURN         08644         840404           AGED ELEMENTS <sup>D</sup> PREBURN         PREDICTED POSTBURN         085680.168         203860.168           AGED ELEMENTS <sup>D</sup> 7077.787         7077.787         7077.772         7077.7722           7077.782         0.0011542         0.0011542         96.266465           88.260575         168.15349         168.15349         168.15369           88.260617         88.40040         89.25664617         98.2566465           168.1532         168.15349         168.15369         168.15369           168.1532         168.1539         88.40040         89.4004           84.0404         840404         840404         840404           84064         203860.168         203860.168         525.52           641.1170E <sup>C</sup> 681.4780         681.4780         681.4439           642.433         707.787         7077.812         707.826 <t< td=""><td>-</td><td>131.72728</td><td>119.71375</td><td>119.83421</td><td></td></t<>	-	131.72728	119.71375	119.83421	
(YYMMDD)         840404         840404         840404           (HHMMSS)         203650.168         203650.168         203650.168         203650.168           AGED ELEMENTS <sup>b</sup> PREBURN         PREDICTED POSTBURN         OBSERVED POSTBURN         203650.168           AGED ELEMENTS <sup>b</sup> PREBURN         PREDICTED POSTBURN         OBSERVED POSTBURN         203650.168           AGED ELEMENTS <sup>b</sup> 7077.7872         7077.7872         7077.7872         7077.7722           YNDD         88.2602575         98.2604517         98.250458         98.2506485           158.15322         158.15322         158.1532         98.260451         98.2506485           YNMDD         98.260451         98.260451         98.2506485         98.2506485           YNMDD         98.40040         89.40040         89.6667         98.40040           Reci         300.68983         312.90205         98.250468         312.66682           YNMDD         840404         840404         89.40040         86.1438           YNMDD         840404         840404         99.40404         99.40404           ALTITUDE <sup>C</sup> 680.5660         680.5660         681.4730         707.8168           ALTITUDE <sup>C</sup> 680.5600	5	270.63163	282.64287	282.52265	
IHHMMSS         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         203860.168         2037.7722         7077.7722         98.266465         7727.722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         777722         98.266465         7777226         98.26665         98.266665	EPOCH (YYMMDD)	840404	B40404	840404	
AGED ELEMENTS <sup>b</sup> PREBURN         PREDICTED POSTBURN         OBSERVED POSTBURN           AGED ELEMENTS <sup>b</sup> 7075.8837         7077.382         7077.372           7075.8637         7077.382         7077.382         7077.372           70066         0.0011642         0.0011642         0.0011648           88.2602575         168.15349         98.2604617         98.260465           158.1532         158.15349         89.40040         89.260465           158.1532         158.15349         89.40040         89.260465           158.1532         158.15349         89.40040         89.260465           158.1532         158.15349         89.40040         89.260465           11HIMMSS         203660.168         203660.168         203660.168           4eet         690.5670         691.4780         691.4339           14HIMMSS         5925.94         5925.92         691.4339           14et         690.5670         691.4780         691.4339           14et         203660.168         5925.92         691.4339           14et         203660.168         5925.92         691.4339           14et         203660.168         5925.92         691.4339           14et	(HHMMSS)	203850.168	203850.168	203850.168	
707.172         707.772         707.772           0.001066         0.0011642         0.0011663           98.2604575         98.2604617         98.260485           98.260467         98.2604617         98.260485           158.1532         158.15349         158.15359           158.1532         158.15349         158.15359           101.61480         89.40040         89.506485           300.68963         300.68963         312.90205           301.2626         158.15349         158.15359           101.61480         840404         840404           840.404         840404         840404           1HIMMSS)         203860.168         203860.168           203860.168         203860.168         203860.168           4eci         691.4780         691.4780           4eci         691.4780         691.4439           20.000973         0.000121         0.0011569           0.0001541         0.0011561         0.0011569           0.0001550         0.0011561         0.0011569           0.0011561         0.0011561         0.0011569           0.0011561         0.0011561         0.0011569           0.0011561         0.0011561         0.	AVERAGED ELEMENTS <sup>b</sup>	PREBURN	PREDICTED POSTBURN	OBSERVED POSTBURN	CHANGE (OBSERVED-PREBURN)
0.001006         0.0011642         0.001169           98.2602515         98.2604517         98.2604517         98.2604517           158.15332         158.15332         158.15349         158.15369           101 61489         89.40040         98.260566         98.260566           101 61489         732.90205         98.55046         158.15369           101 61489         89.40040         89.40040         89.63668           101 61489         840404         89.40040         89.63668           300 68983         312.90205         89.63668         312.66562           840404         840404         840404         840404           Eaci         691.4790         89.63668         312.66562           4aci         203860.168         203860.168         203860.168           4aci         203860.168         203860.168         203660.168           4aci         691.4790         691.4790         691.4439           4aci         707.8106         691.4439         707.8206           50.0011541         0.0011541         0.0011541         0.0011569           611AACK ERHOR (km) <sup>d</sup> -4.9         a         5926.92           0.000121         0.0011541         0.0011569		7075.8637	7077.7872	7077.7722	1.9005
96.260575         96.260457         96.260457         96.260457         96.260455           158.15322         158.1532         158.15359         158.15359         158.15359           178.1532         158.15349         158.15359         158.15359         158.15359           170.1010         300.68963         312.90205         89.40040         89.506688           1111100         300.68963         312.90205         840404         840404           1111100         840.404         840.404         840.404         840.404           1111100         5423.52         5935.94         5925.92         5925.92           14111100         690.5870         691.4780         691.4439         707.8205           1111100         -0.0002031         0.000121         0.000123         0.000123           1111100         -0.0002031         0.0001241         0.0001369         707.8205           111100         -0.0002031         0.0001241         0.0001369         707.8205           111100         -4.9         -4.9         0.0001241         0.0001369           111100         -4.9         -4.9         0.0001241         0.0001369           111100         -4.9         -4.9         0.0001541 <t< td=""><td></td><td>0.0010006</td><td>0.0011542</td><td>0.0011569</td><td>0.0001483</td></t<>		0.0010006	0.0011542	0.0011569	0.0001483
158.15332         158.15349         158.15359         158.15359         158.15359           101 61489         89.40040         89.63668         89.40040         89.63668           101 61489         83.40040         89.63668         312.66682         312.66682           300 68983         312.90205         312.66682         312.66682         312.66682           300 68983         312.90205         312.66682         312.66682         312.66682           6ec)         840404         840404         840404         840404           (HHMMSS)         5925.94         5925.94         5925.92         5925.92           (acc)         680.5670         691.4780         691.4780         691.439         707.8206           a LTITUDEC         704.8604         707.8164         707.8206         707.8206           707.810         0.0011541         0.0011541         0.0011569         0.0011569           DTRACK ERROR (km) <sup>d</sup> -4.9         a         SEMIMAJOR AXIS (km)         0.0011569           OCAL TIME OF         0.93315         e         E         ECCENTRICITY         0.0011569           DING NODE         i         =         INCLINATION (deg)         i         INCLINATION (deg)		98.2502575	98.2504517	98.2505485	0.0002910
101 61489         R9.40040         89.63688         89.63682         89.63688         89.63688         89.63682         89.63688         89.63688         89.63682         89.6443         99.6443		158.16332	158.15349	158.16359	0.00027
TYYMMD)         300 68963         312.90205         312.66682           TYYMMD)         840404         840404         840404           RHHMMSS)         203660.168         203660.168         312.66682           CHITUDE <sup>C</sup> 5925.94         840404           (HHMMSS)         203660.168         203860.168         203860.168           (HHMMSS)         203660.168         203860.168         203860.168           (HHMMSS)         5925.94         840404           (Eacl)         691.4780         691.433           (ALTITUDE <sup>C</sup> 707.8104         707.8104           -0.0002031         0.0011541         707.8205           0.000124         0.0011541         0.0011569           DTRACK ERHOR (km) <sup>d</sup> -4.9 <sup>a</sup> DCAL TIME OF         0.0011641         0.0011569           DCAL TIME OF         0.33915         e           SS)         i         = INCLINATION (deg)		101 61489	R9.40040	889.63688	- 11.97801
IVVMMDD)         840404         707.8205         925.92         825.92         8205.92         84033         9.00011541         9.00011541         9.000073         9.000073         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.00011569         9.000011569         9.00011569         9.000011569 <td></td> <td>300 66963</td> <td>312.90205</td> <td>312.66582</td> <td>11.97599</td>		300 66963	312.90205	312.66582	11.97599
(HHMMSS)         20386.0.168         20.00116.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.	EPOCH (YYMMDD)	840404	840404	840404	
(sec)         5923.5.2         5925.94         5925.92           ALTITUDE <sup>C</sup> 690.5870         691.4780         691.439           ALTITUDE <sup>C</sup> 704.8604         707.8164         707.8205           D         -0.0002031         0.000121         0.000073           0         0.0001641         0.0011641         0.0011569           DTRACK ERHOR (km) <sup>d</sup> -4.9         a         SEMIMAJOR AXIS (km)           OCAL TIME OF         033915         e         E.CCENTRICITY           SS)         0.001         i <tn (deg)<="" condition="" td="">         0.0011569</tn>	(HHMMSS)	203850.168	203850.168	203850.168	
E ALTITUDE <sup>C</sup> 690.6870         691.4780           E ALTITUDE <sup>C</sup> 704.8604         707.8164           0.0002031         0.000121         0.000121           0         0.0002031         0.000121           0         0.000979         0.0011641           0         0.0011641         0.0011641           0         0.0011541         0.0011641           0         0.0011541         0.0011541           0         0.0011541         0.0011541           0         0.0011541         0.0011541           0         0.0011541         0.0011541           0         0.0011541         0.0011541           0         -4.9         a         = SEMIMAJOR AXIS (km)           0         0.0011541         0.0011541         0.0011541           0         0.0011541         1         1           0         0.0011541         1         1           0         0.0011541         1         1           0         0.0011541         1         1           0         0.0011541         1         1           0         0.0011541         1         1           0         0.0011541	PERIOD (sec)	<b>5923.52</b>	5925.94	5925.92	2.40
ALTITUDE <sup>C</sup> 704.8604         707.81C4           0         -0.0002031         0.000121           0         0.000121         0.000121           0         0.000159         0.0011541           0         0.001541         0.0011541           0         0.0011541         0.0011541           0         0.0011541         0.0011541           0         -4.9         a           0         -4.9         a           0         0.0011541           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.9           0         -1.1           0         -1.1           0         -1.1           0         -1.1           0         -1.1           0         -1.1           0         -1.1           0         -1.1           0	PERIGEE ALTITUDE <sup>C</sup>	690.5870	691.4780	691.4439	
-0.002031         0.000121           0.001541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541           0.0011541         0.0011541	APOGEE ALTITUDE <sup>C</sup>	704.8604	707.8164	707.8205	
0.0009879         0.0011541           DTRACK ERROR (km) <sup>d</sup> -4.9         8a         = SEMIMAJOR AXIS (km)           OCAL TIME OF         093915         e         = CCCENTRICITY           DING NODE         i         = INCLINATION (deg)	5 COS 2	- 0.0002031	0.0000121	0.000073	
A (km) <sup>d</sup> - 4.9 a = a = a = 0.03315 e = i = i = i = i = i = i = i = i = i =	SIN E	0.0009879	0.0011541	0.0011569	
093315	GROUNDTRACK ERROR (km) <sup>d</sup>	- 4.9	n	Ē	
	MEAN LOCAL TIME OF DESCENDING NODE HHMMSS)	093915	11 11		

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CEQUATORIAL REFERENCE

bNUMERICALLY AVERAGED OVER UNE ORBIT

ω = ARGUMENT OF PERIGEE (deg)

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M - MEAN ANOMALY (deg) TIMES ARE GMT

<sup>d</sup>DISTANCE EAST (+) OR WEST (+) OF WORLD REFERENCE SYSTEM PATH

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MANEUVER	ORBIT	DATE	BURN START TIME (GMT)
8	498	840404	203907
SPACECRAFT	PARAMETERS	PREBURN	POSTBURN
FUEL SYSTEM PRESS	URE (PSIA)	275.21	272.16
TANK TEMPERATURE	S (°C)		
TANK 1		16.78	16.78
TANK 2		16.39	16.39
TANK 3		17.82	17.82
TANK 4ª		13.77	13.77
HYDRAZINE REMAINI	NG (POUNDS)		
TANK 1		53.77	53.40
TANK 2		53.77	53.40
TANK 3		53.77	53.40
TANK 4		338.64	337.72
TOTAL FUEL		499.95	497.92
TOTAL SPACEC	RAFT WEIGHT	4274.22	4272.19
THRUSTERS			
ORBIT ADJUST THRU	ISTERS USED		A1, C1
TOTAL ORBIT ADJUS	T THRUSTER DURATIO	N (sec) <sup>b</sup>	86.336
TOTAL ATTITUDE TH	RUSTER DURATION (see	c)	83.440
SPACECRAFT ATTITU	IDE (deg) <sup>C</sup>		
PITCH			0.0
YAW			0.0
ROLL			0.0
MANEUVER CALIBRA	TION		
SEMIMAJOR AX	IS CHANGE (km)		
PREDICTED			1.9235
OBSERVED		(	1.9085
INCLINATION CH	ANGE (deg)		
PREDICTED			N/A
OBSERVED			N/A
THRUST CORRE	CTION FACTOR		
USED FOR PI	LANNING		0.9700
RECALIBRAT	EDd		0.9624

### Table A-16. Spacecraft Parameters for Maneuver 8

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<sup>a</sup>TANK 4 IS THE AUXILLIARY TANK KIT (ATK)

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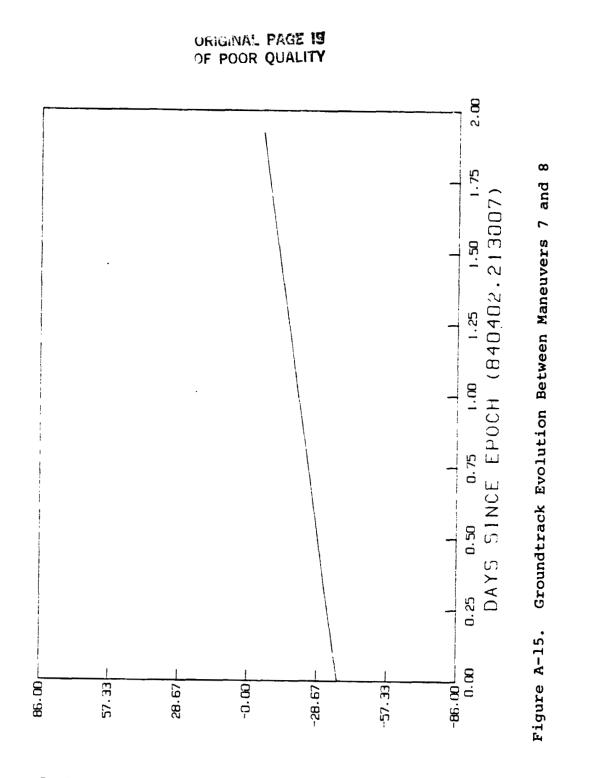
<sup>b</sup>BURN TIME INPUT TO GENERAL MANEUVER PROGRAM (GMAN) = FOTAL DURATION + NUMBER OF THRUSTERS <sup>c</sup>SPACECRAFT ATTITUDE AS INPUT TO GMAN FOR MANEUVER MODELING

1993 1993 B. A. 28 B. 12 A.

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<sup>d</sup>RECALIBRATED THRUST CORRECTION FACTOR = (OBSERVED + PREDICTED) × FACTOR USED FOR PLANNING

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# GROUNDTRACK ERROR IN KILOMETERS

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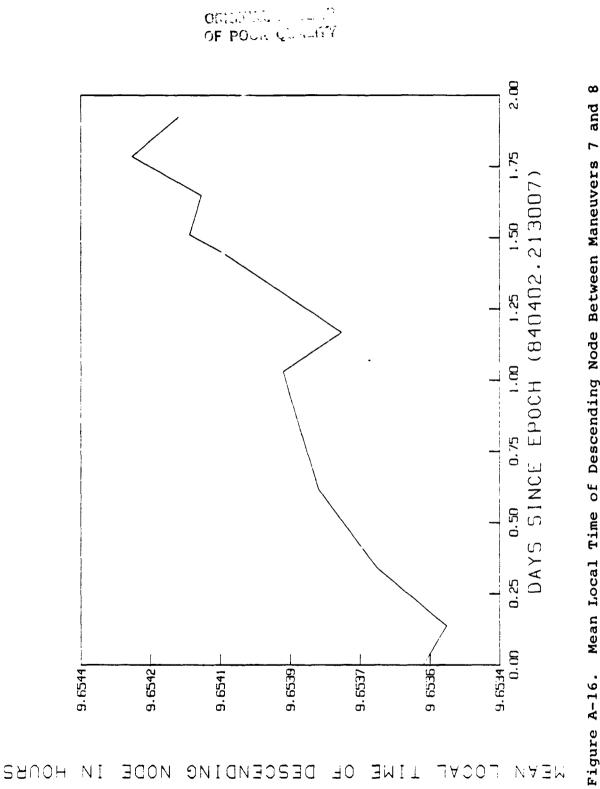
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