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Supplemental Report 4

GEMINI 6 INERTIAL GUIDANCE SYSTEM EVALUATION AND TRAJECTORY RECONSTRUCTION

Issued as: Supplemental Report 4
To: Gemini Program Mission Report
Gemini VI-A
MSC-G-R-66-2
By: Gemini VI-A Mission Evaluation Team
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

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GEMINI 6 INERTIAL GUIDANCE SYSTEM EVALUATION AND TRAJECTORY RECONSTRUCTION(U)

30 JUNE 1966

Prepared for
MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
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GROUP 4
Downgraded at 3 year intervals; declassified after 12 years

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TRW SYSTEMS

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ABSTRACT

This report contains a detailed accuracy evaluation of the Gemini 6 inertial guidance system during the ascent and reentry phases of the mission. An analysis of the external tracking instrumentation accuracy is also included. The results of the error analyses are used to construct reference Gemini 6 ascent and reentry trajectories.

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1. INTRODUCTION AND SUMMARY

Gemini 6 was launched on 15 December 1965 from Complex 19 at Cape Kennedy, Florida. The primary objective of this flight was to perform a rendezvous with the orbiting Gemini 7 spacecraft. TRW Systems is submitting this report to the NASA Manned Spacecraft Center in response to Task MSC/TRW G-14 of the Gemini Mission Trajectory Control Program, Contract NAS 9-4810. This document presents the results obtained from analysis of the inertial guidance system (IGS) performance during the ascent and reentry flight phases and provides a reconstruction of the spacecraft trajectory during ascent and reentry.

The following is a brief summary of the analysis results:

a) The IGS performance during ascent was approximately within anticipated uncertainties. Best estimates of IGS error at insertion (SECO + 20 seconds) are as follows:

$\Delta X = +671 \pm 100$ ft	$\Delta \dot{X} = +0.2 \pm 0.5$ ft/sec
$\Delta Y = +856 \pm 200$ ft	$\Delta \dot{Y} = +10.3 \pm 3$ ft/sec
$\Delta Z = -449 \pm 100$ ft	$\Delta \dot{Z} = -2.3 \pm 1$ ft/sec

b) Major contributors to the above IGS errors were determined by regression and visual analysis to be the following:

X accelerometer bias	= 197 ± 10 ppmg
X accelerometer scale factor	= -76 ± 9 ppm
Z accelerometer misalignment towards X	= 84 ± 24 $\widehat{\text{sec}}$
Y gyro constant drift rate	= 0.34 ± 0.1 deg/hr
X gyro input axis unbalance	= -0.23 ± 0.7 deg/hr/g
Platform misalignment about Y accelerometer axis	= -40 ± 42 $\widehat{\text{sec}}$

Timing errors, both correlation and scale factor (clock rate error), were found to be significant at SECO but have not been listed as major error sources.

c) The support tracking systems, GE Mod III, MISTRAM I and MISTRAM II performed within anticipated uncertainties with the exception of a P bias in the MISTRAM I data of -1.5 feet in the 100 K baseline data and -0.1 feet in the 10 K baseline data.

d) No major IGS problems were evident from the available data during reentry. Loss of spacecraft telemetry during the "blackout" period precluded a more detailed IGS analysis. The IGS and ship indicated impact points are summarized below for comparison with respect to the target.

Source	Geodetic Latitude (deg north)	Longitude (deg west)	Miss (n mi)
Ship	23.375	67.875	14.3
IGS	23.7	67.74	7.3
Target	23.61	67.83	-

e) Coarse agreement was obtained between a reconstructed Gemini 6 to Gemini 7 relative position vector and the telemetered rendezvous radar value. However, uncertainties in the trajectory reconstructions limited the calculated vector accuracies to 1 - 3 n mi.

Section 2 of this report discusses the IGS detailed accuracy analysis. Section 3 describes the IGS performance during reentry, and Section 4 contains the external tracking system performance. The ascent and reentry trajectory reconstruction is presented in Section 5. Section 6 discusses the rendezvous radar/trajectory reconstruction comparisons. Appendix A contains a list of trajectory reconstruction, and Appendix B contains a mathematical description of the TRW error regression program (REMP). Appendix C presents the preflight calibration history plots.

2. INERTIAL GUIDANCE SYSTEM PERFORMANCE ANALYSIS

2.1 SUMMARY OF DATA USED IN ANALYSIS

Comparisons of IGS telemetered navigation quantities and external tracking data were made to evaluate the accuracy of the Gemini 6 IGS performance. The IGS evaluation was based in part on sensed velocity comparisons (Figure 1). These were generated by comparing external tracking data, adjusted for gravity, with the telemetered accelerometer accumulated count appropriately biased and scaled to engineering units. The residuals from these comparisons were attributed to inertial measurement unit (IMU) and tracking system errors.

Comparisons were also made between the telemetered total inertial position and velocity outputs from the airborne computer and external tracking data (Figures 2 and 3). These comparisons (called total inertial comparisons) include airborne computer navigation errors caused by gravity approximations, truncation errors, etc., as well as IMU and tracking system errors. The difference between the sensed and inertial comparison sets are called delta-delta comparisons (Figure 4), and provide a measure of the airborne computer computational error alone.

The sensed, inertial, and delta-delta comparisons are plotted in the IGS computer coordinate system, which is an inertial, orthogonal, right-handed system referenced to the center of the earth. The x and z axes lie in a plane parallel to the geodetic tangent plane at the launch site at platform release time, with the x axis nominally defined by the launch azimuth (actually to the misaligned azimuth), positive downrange. The y axis is positive down along the geodetic vertical, and the z axis is directed to complete the right-handed x, y, z set.

Position and velocity comparisons were also made in the external tracking measurement coordinates to isolate IMU and tracker error coefficients by performing a statistical regression analysis on the differences. External tracking data used in the evaluation included Quick Look MISTRAM I 10K and 100K, GE MOD III/Final MISTRAM, Passive MISTRAM II, and AFETR BET. An analysis of these data sources is described in Section 4.

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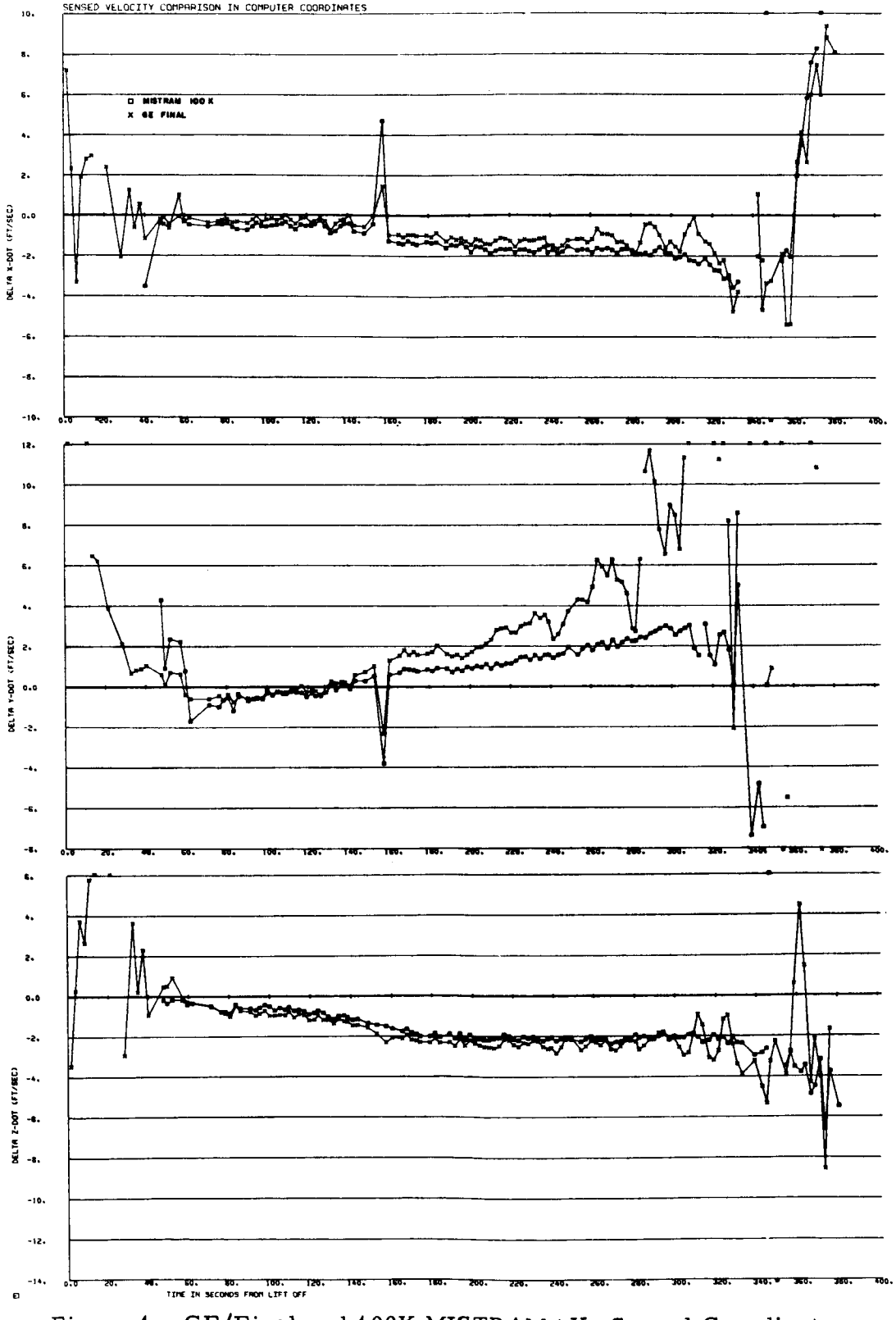

Figure 1. GE/Final and 100K MISTRAM ΔV, Sensed Coordinates

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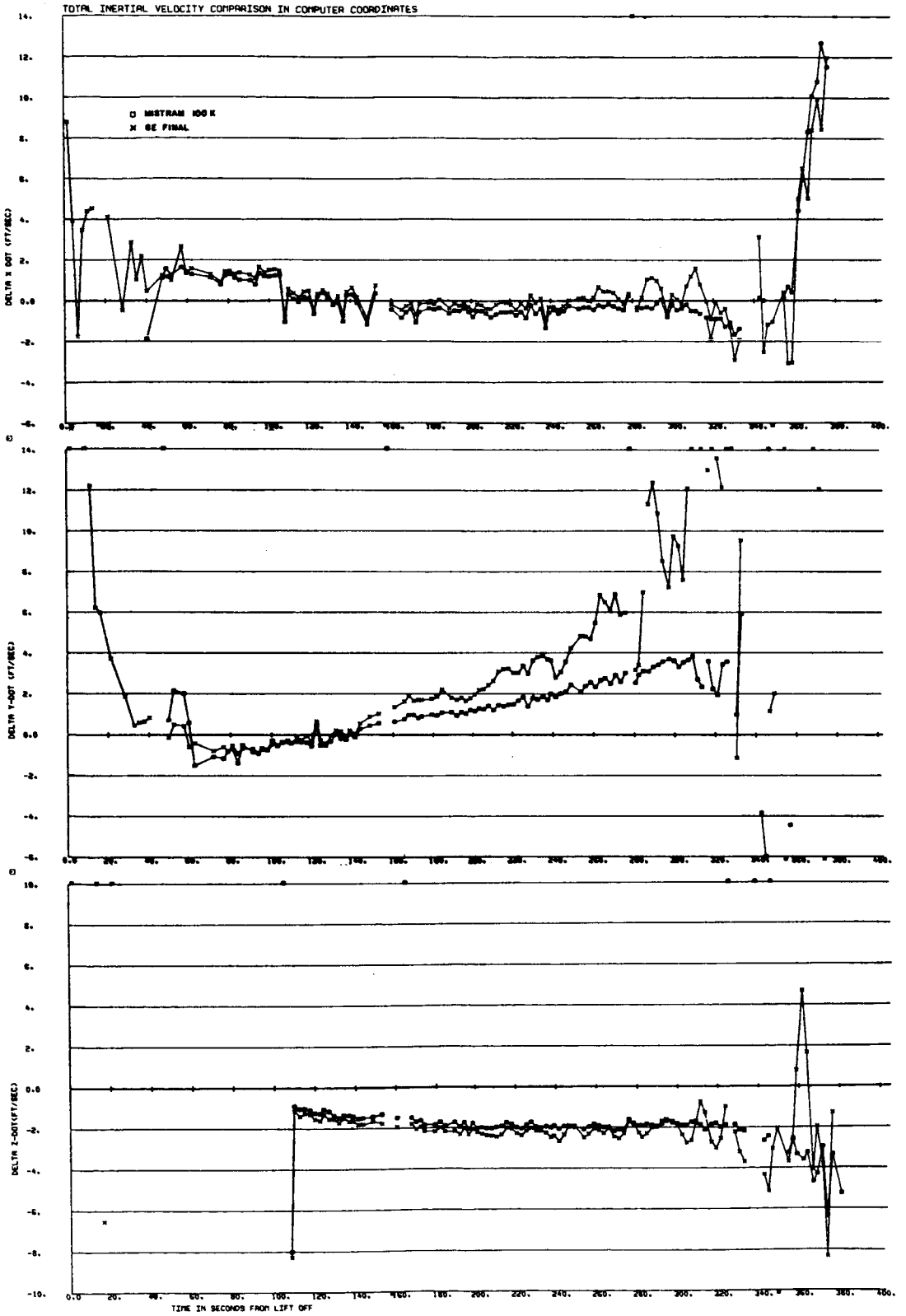

Figure 2. GE/Final and 100K MISTRAM ΔV, Guidance Inertial Coordinates

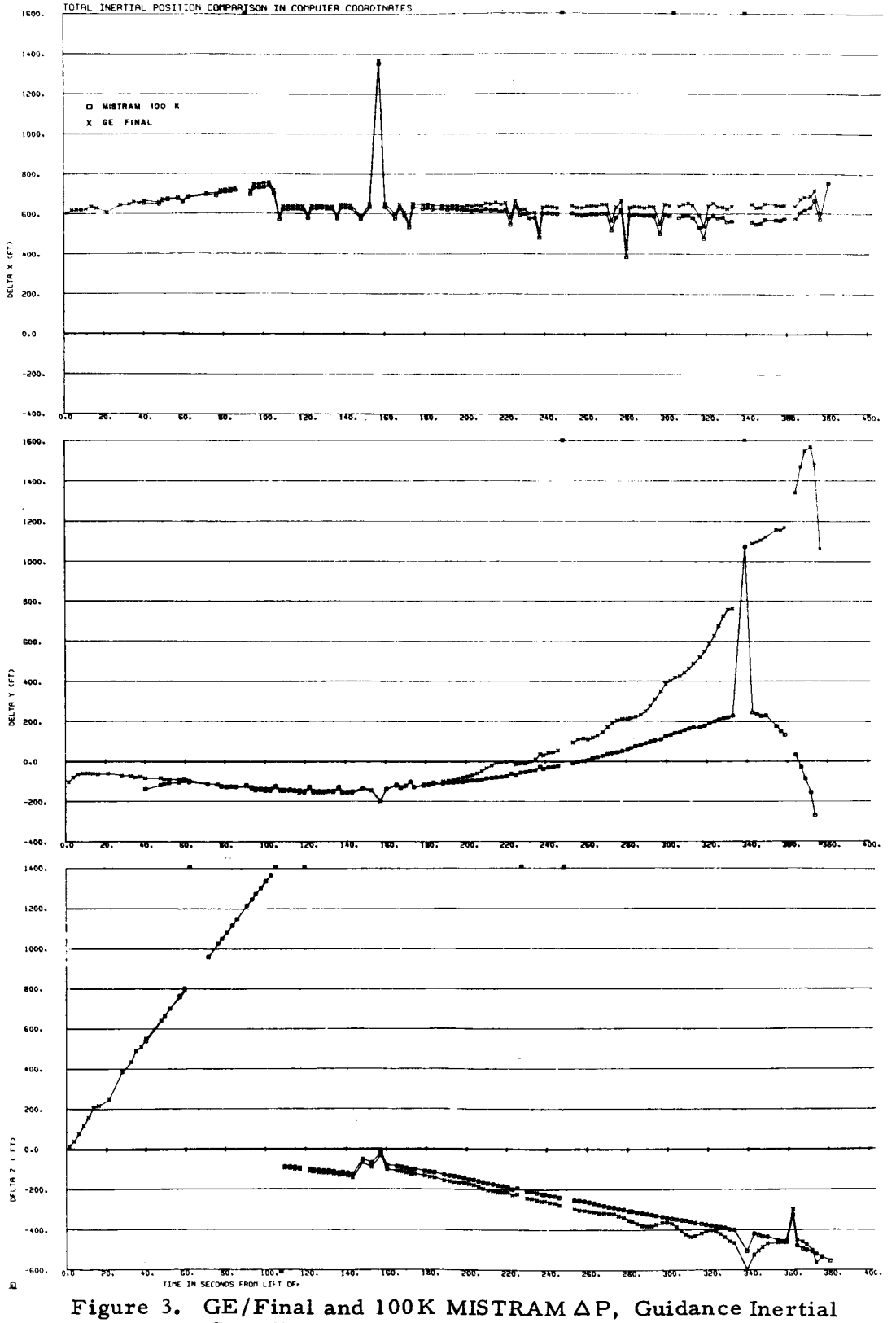

Figure 3. GE/Final and 100K MISTRAM ΔP, Guidance Inertial Coordinates

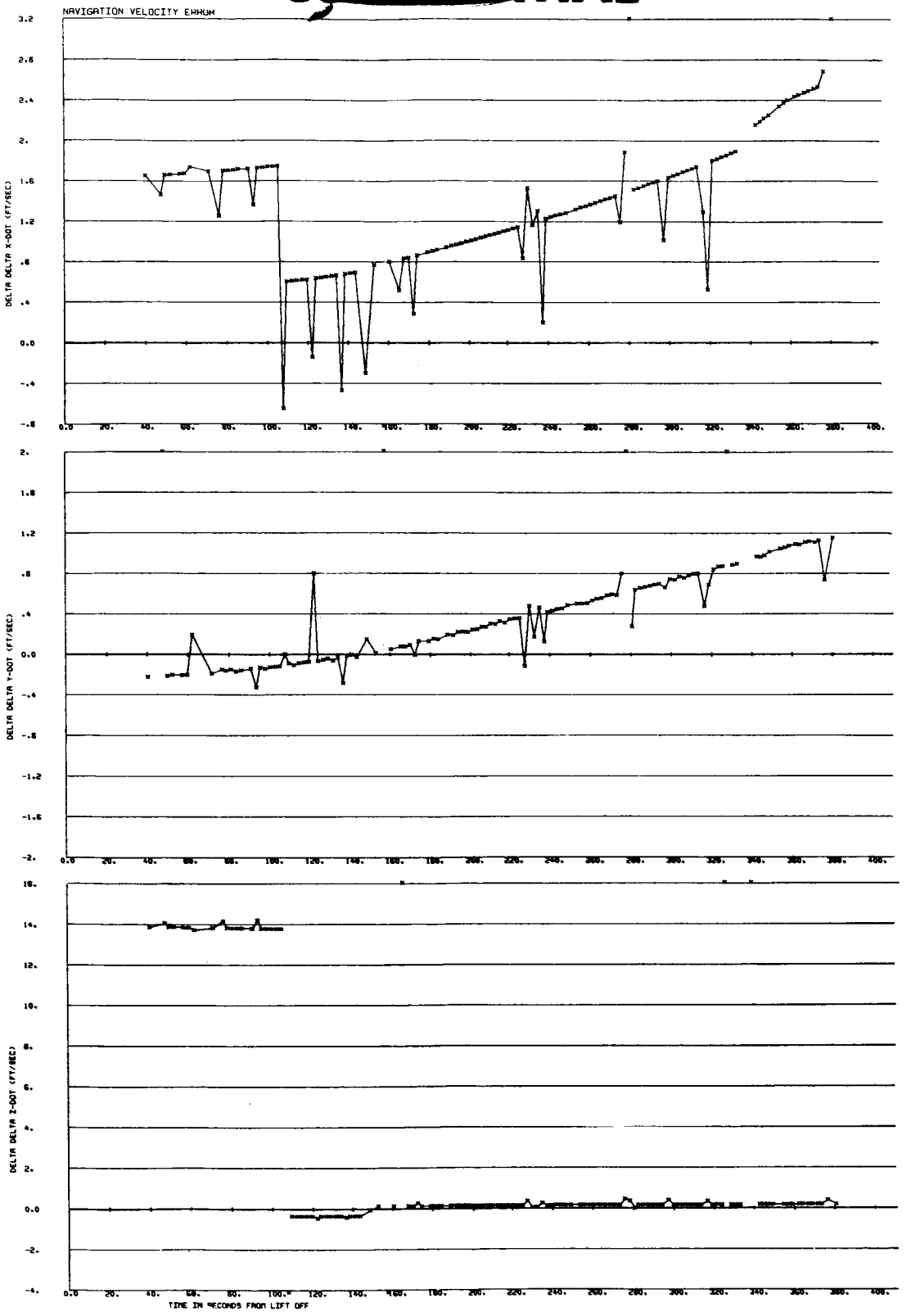

Figure 4. Navigation Velocity Error

The plots enclosed are referenced to liftoff time (13:37:26:471 GMT) which occurred 3.279 seconds after IGS "platform release."

2.2 INERTIAL GUIDANCE SYSTEM ERROR

The indicated inertial guidance system errors following the end of the powered ascent phase (SECO + 20, 359 seconds from liftoff) are contained in Table 1. These errors were obtained from an analysis of available tracking and guidance data. For purposes of presentation, Figures 2 and 3 have been included, although the regression analysis which recovers the IMU error was performed in the tracker domain. The column headed "IMU Error" represents the error contributed by the accelerometer, gyro, and initial platform alignment sources. The column headed "Navigation Equation Errors" is the contribution due to various approximations within the airborne computer as observed from the delta-delta comparisons, and the column titled "Total Guidance Errors" is the sum of the two and represents the total IGS error. These total errors result in velocity magnitude and flight path angle errors at SECO + 20 seconds of the following amounts:

$$\Delta |V| = 1.0 \text{ ft/sec}$$

$$\Delta\gamma = -0.02 \text{ deg (indicating the guidance velocity vector is pitched down)}$$

Table 1 also presents simulated navigation errors.* With the exception of the large x position error, the actual navigation errors approximate the simulation values. The major contributor to the 1048-foot x error was an IGS initial x position error of approximately 700 feet (Figure 3). This error is associated with the airborne computer's detection of platform release time and suggests that the IGS computer began navigation early by approximately 0.45 second. The remaining 400 feet of x position navigation error is due principally to the integration of the x velocity error.

*The preflight values were determined from simulation results obtained from IBM. Since no exact simulation of the Gemini 6 trajectory was available, values were obtained by interpolating from a series of simulations for similar trajectories with various launch azimuths.

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Table 1. Inertial Guidance Errors at SECO + 20 Seconds

IGS Coordinate	IMU Errors	Navigation Errors	Total Guidance Errors	Simulated Navigation Errors*	NASA Computed Total Guidance Errors**
$\Delta\dot{X}$	-1.9 ± 0.5	+2.1 ± 0.2	+0.2 ± 0.5	+1.9	+0.8 ± 1.5
$\Delta\dot{Y}$	+9.3 ± 3.0	+1.0 ± 0.1	+10.3 ± 3.0	+0.9	+11.0 ± 3.0
$\Delta\dot{Z}$	-2.5 ± 1.0	+0.2 ± 0.1	-2.3 ± 1.0	-0.15	-2.3 ± 0.5
ΔX	-415 ± 100	+1086 ± 10	+671 ± 100	+213	+570 ± 150
ΔY	+800 ± 200	+56 ± 3	+856 ± 200	+78	+235 ± 50
ΔZ	-500 ± 100	+51 ± 3	-449 ± 100	-18	-450 ± 100

*No one sigma estimate available

**NASA/MSC furnished these guidance error estimates and uncertainties

Note: The ± numbers are one sigma estimates

2.2.1 Free Flight Fix

A comparison was made between the IGS position/velocity vector after SECO and a position/velocity vector derived from a trajectory reconstruction of the free flight interval during Revolution 1. The tracking data used in this reconstruction consisted of the following radars (measuring range, azimuth, elevation):

- Grand Turk
- Bermuda
- Canarvon
- White Sands
- Eglin

An examination of the orbital fit to these station's data indicates residuals which are within the expected uncertainties and lends credence to the corrected position/velocity vector at the comparison time.

This comparison has been made to support the estimation of the IGS errors, although it is only one point in time, the leverage afforded by five radars tracking during free flight yields effectively much more than a single point comparison. Figure 5 presents the Free Flight Fix point at

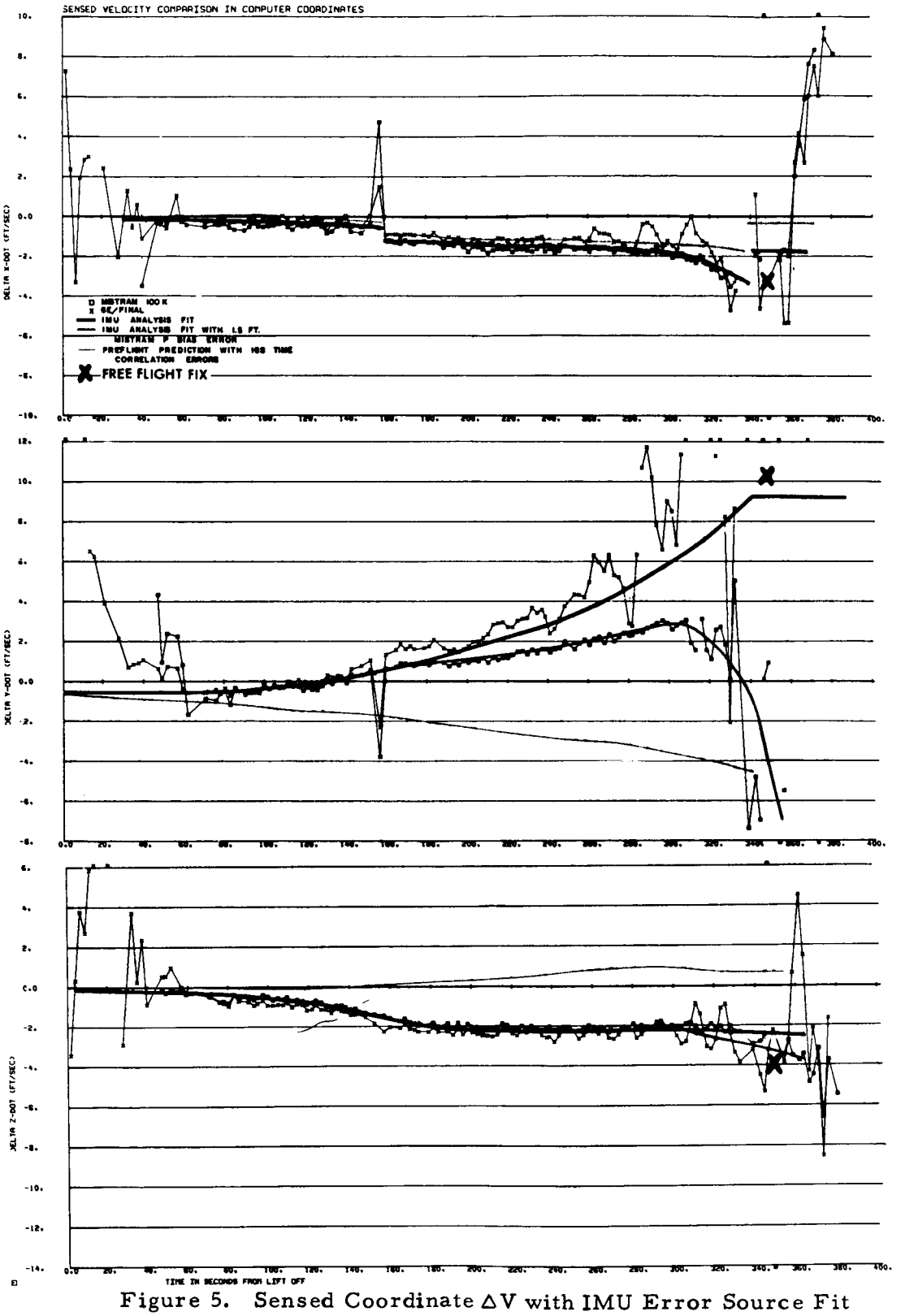

Figure 5. Sensed Coordinate ΔV with IMU Error Source Fit

349 seconds as a heavy X. The most important direction is the vertical, as evidenced by the diverging tracker comparisons (Figure 5). The accuracy of the Free Flight Fix point is assumed to be about ± 2 ft/sec in the vertical and downrange directions and about ± 5 ft/sec in crossrange. The GE and MISTRAM uncertainties (including biases) are both about ± 10 ft/sec in the vertical direction at the time of comparison.

2.3 INERTIAL MEASUREMENT UNIT ERROR ANALYSIS

2.3.1 IMU Error

Analyses to recover IMU error source coefficients were performed by using procedures and data processing programs as documented in Reference 1 with the exception that the Recursive Error Modeling Program (REMP) was used for regression analysis. The IMU error source coefficients recovered in the analysis are presented in Table 2. These were recovered as follows:

a) Errors in the accelerometer biases were recovered during orbit phases of flight, and the ascent comparisons were precompensated for their effect (Section 2.3.3).

b) IGS/tracker comparisons were made in the rate domain of the tracking systems and a regression analysis was performed in that domain.

The general effect of IMU errors on the Gemini 6 ascent flight can be seen in the IGS/GE Mod III final sensed velocity comparison (Figure 1). These show x, y, and z velocity differences that build up to -0.5, 1.0, and -1.5 ft/sec at the end of the booster stage (BECO), and -2, 10, and -2 ft/sec at SECO, respectively.

The dominant errors that contributed to the x axis residuals were a time correlation error of 0.015 second, a time scale factor (IGS clock drift) error of -63 parts per million (ppm), and an X accelerometer scale factor error of -76 ppm. The timing errors were evidenced by -0.5 and 1.5 ft/sec jumps in the x velocity residuals at BECO and SECO, respectively. The minus sign associated with the clock drift error indicates that the onboard clock is running too fast.

The recovered IGS error coefficients presented in Table 2 that account for the major portion of y axis residuals were the X accelerometer bias (which results in an initial misalignment error about the Y accelerometer),

Table 2. Recovered IGS Error Coefficients

IGS ERROR SOURCE	UNITS	TRW ANALYSIS RECOVERED COEFFICIENT	TRW ANALYSIS NO. OF SIGMAS*	TRW ANALYSIS CONTRIBUTION TO ERROR AT SECO + 20 SECONDS VELOCITY ΔẊ	TRW ANALYSIS ΔẎ	TRW ANALYSIS ΔŻ	NASA ANALYSIS RECOVERED COEFFICIENT	NASA ANALYSIS NO. OF SIGMAS*	NASA ANALYSIS CONTRIBUTION TO ERROR AT SECO + 20 SEC VELOCITY ΔẊ	NASA ANALYSIS ΔẎ	NASA ANALYSIS ΔŻ	PREFLIGHT MEASURED RECOVERED COEFFICIENT	PREFLIGHT MEASURED NO. OF SIGMAS*	ERRORS CONTRIBUTION TO ERROR AT SECO + 20 SECONDS VELOCITY ΔẊ	ERRORS ΔẎ	ERRORS ΔŻ
ACCELEROMETER																
X BIAS	PPMG	197 ± 10	2.	.94	-4.9		100.	1.	.4	-2.4		10.9	.1	.05	-.27	
Y BIAS	PPMG	- 60 ± 5	.6			.9	-160.	1.6			2.3	-12.3	.1			.18
Z BIAS	PPMG	- 29 ± 5	.3		- .33		56.	.6		.6		-106.5	1.		-1.23	
X SCALE FACTOR	PPM	- 76 ± 9	.5	-1.9			- 70.	.5	-1.7			19.8	.1	.48		
Z SCALE FACTOR	PPM	92 ±155	.75		- .62		400.	3.		-2.7		120.	1		- .63	
Z MISALIGN. TOWARDS X	SEC	84 ± 24	3.		10.		100.	3.		12.		41.	1		4.94	
TOTAL I				-.96	4.15	.9			-1.3	7.5	2.3			.53	2.81	.18
AZIMUTH AND ROLL GYRO DRIFT																
X GYRO CONST. DRIFT RATE	DEG/HR	**					.12	.5			-1.1	.12	.5		- .08	-1.18
Z GYRO CONST. DRIFT RATE	DEG/HR	**					-.05	.2			- .07	- .05	.2	-.03		- .7
X GYRO INPUT AXIS UNBALANCE	DEG/HR/G	- .23 ± .68	1.	.01	.08	2.8	-.35	1.5			4.3	- .35	1.5	.02	.12	4.27
Z GYRO INPUT AXIS UNBALANCE	DEG/HR/G	**					-.11	.5			-3.8	- .11	.5	-.18		-3.82
Z GYRO SPIN AXIS UNBALANCE	DEG/HR/G	**					-.14	.7			1.1	- .228	1.	.06		1.97
X GYRO SPIN AXIS UNBALANCE	DEG/HR/G	**					-.02	.1			.2	**				
TOTAL II				.01	.08	2.8			0	0	.63			-.13	.04	.54
PITCH GYRO DRIFT																
Y GYRO CONSTANT DRIFT RATE	DEG/HR	.34 ± .1	1.5	.32	9.15		**					-.04	.2	-.04	-1.08	
Y GYRO INPUT AXIS UNBALANCE	DEG/HR/G	.04 ± .27	.2	.14	1.12		.1	.5	.3	2.7		-.2	1.	-.7	-5.6	
TOTAL III				.46	10.27	0			.3	2.7	0			-.74	-6.68	0
OTHER																
PLATFORM MISALIGNMENT ABOUT X ACCELEROMETER AXIS	SEC	2 ±42				-.22	**					**				
PLATFORM MISALIGNMENT ABOUT Y ACCELEROMETER AXIS	SEC	-40 ±42	1.	-1.32	-4.8		**					**				
IGS AZIMUTH MISALIGNMENT	SEC	-45 ±24	1.			-5.4	-40.	1.			-4.8	**				
IGS TIME CORRELATION	SEC	.015± .002	1.5				.013	1.5				**				
IGS TIME SCALE FACTOR	PPM	-63 ± 60	1.5				-70.	1.5				**				
TOTAL IV				-1.32	-4.8	-5.62					-4.8			0	0	0
TOTAL (I - IV)				-1.81	9.7	-1.92			-1.0	10.2	- 1.97			-.34	-3.83	.72

* THIS COLUMN INDICATES HOW MANY APRIORI ONE SIGMAS ARE REPRESENTED BY THE ERROR COEFFICIENT

** DENOTES THAT EITHER THE COEFFICIENT WAS NOT USED IN THE REGRESSION ANALYSIS OR WAS NOT AVAILABLE

the Z accelerometer misalignment and scale factor, the Y gyro constant drift rate, and the platform misalignment about the accelerometer Y axis. The Y gyro drift and platform misalignment also contributed significantly to the x axis residuals.

The z axis residuals show a velocity error of approximately -1.0 ft/sec at 140 seconds. This is attributable to an azimuth misalignment of -45 arc seconds (Section 2.4 discusses the azimuth updating). The residuals then show a nearly constant -2.0 ft/sec error between 180 and 330 seconds. This trend resulted from the IGS azimuth misalignment and the partially compensating X gyro input axis unbalance drift.

Figure 5 presents the velocity comparisons between IMU and tracking data in several combinations. The very heavy line denotes the total effect of the IMU errors recovered in the regression analysis. It is observed that this heavy line fits all the curves within anticipated bounds except for the MISTRAM 100K comparison in the y direction. Analysis of the MISTRAM data revealed a P bias in that system of -1.5 feet (100K baseline) (Section 4). When the effect of this bias is accounted for, the fit improves to an acceptable level. It should be noted that since the regression analysis was accomplished in the rate domain ($\dot{R}$ $\dot{P}$ $\dot{Q}$) of the tracker any strictly DC bias (i.e., ambiguities) will not affect the regression solution.

2.3.2 Honeywell Preflight Error Coefficient Prediction

A set of predicted IGS error source coefficients was determined by Honeywell based upon a final instrument calibration. These are presented in Table 2 along with error sources recovered from both the NASA and TRW postflight analysis. The most significant observation is that the total X gyro drift rate (constant plus unbalance) determined postflight equals the summation of the predicted X gyro drifts. No attempt was made to distinguish between the types of X gyro drift in the postflight analysis because of the high correlation between their velocity propagations on the flight. Otherwise, there is little similarity between the preflight and postflight error source coefficients. Figure 5 shows a propagation of the velocity error due to the preflight estimated error coefficients on the observed residuals (combined with actual IGS timing errors). A reasonable fit to the x axis residuals was obtained, and the z axis discrepancy is for the most part attributable to the IGS azimuth update error on this flight. However, the

predicted y error is one-half the magnitude and of the opposite sign to compensate the TRW proposed flight error. Section 2.3.5 gives additional evaluation of the preflight values, and Appendix C presents calibration history plots.

2.3.3 Accelerometer Bias Updating

An inflight updating of the X accelerometer bias value was accomplished after Revolution 3 of the Gemini 6 orbit. The X bias error was determined to be approximately 198 ppm g and was corrected onboard for that amount. The bias values before and after correction are presented in Table 3. Figures 6 through 8 are plots of IGS sensed velocities during intervals of Revolutions 3, 5, and 8 when no thrusting was being applied. The slopes of the velocity plots provide an estimate of the accelerometer bias errors. Comparisons of the velocity slopes of Revolution 3 (before bias correction) with those of Revolution 5 and 6 (after bias correction) show that the X accelerometer bias error calculation was adequate. Table 4 summarizes the accelerometer bias values determined from the sensed velocity plots.

Table 3. Accelerometer Bias Constants

	Before Updating	After Updating	Difference (ppm g)
KX	1.8058311	1.870000	198
KY	-0.07332507	-0.07332507	0
KZ	0.08083010	0.08083010	0

Table 4. Accelerometer Bias Error (Determined from Sensed Velocities)

Revolution No.	Accelerometer Bias (ppm g)		
	x	y	z
3 (before update)	198	-24.5	-73
5 (after update)	-13.2	-28.7	-59.5
8	-14.5	-28.8	-60.2

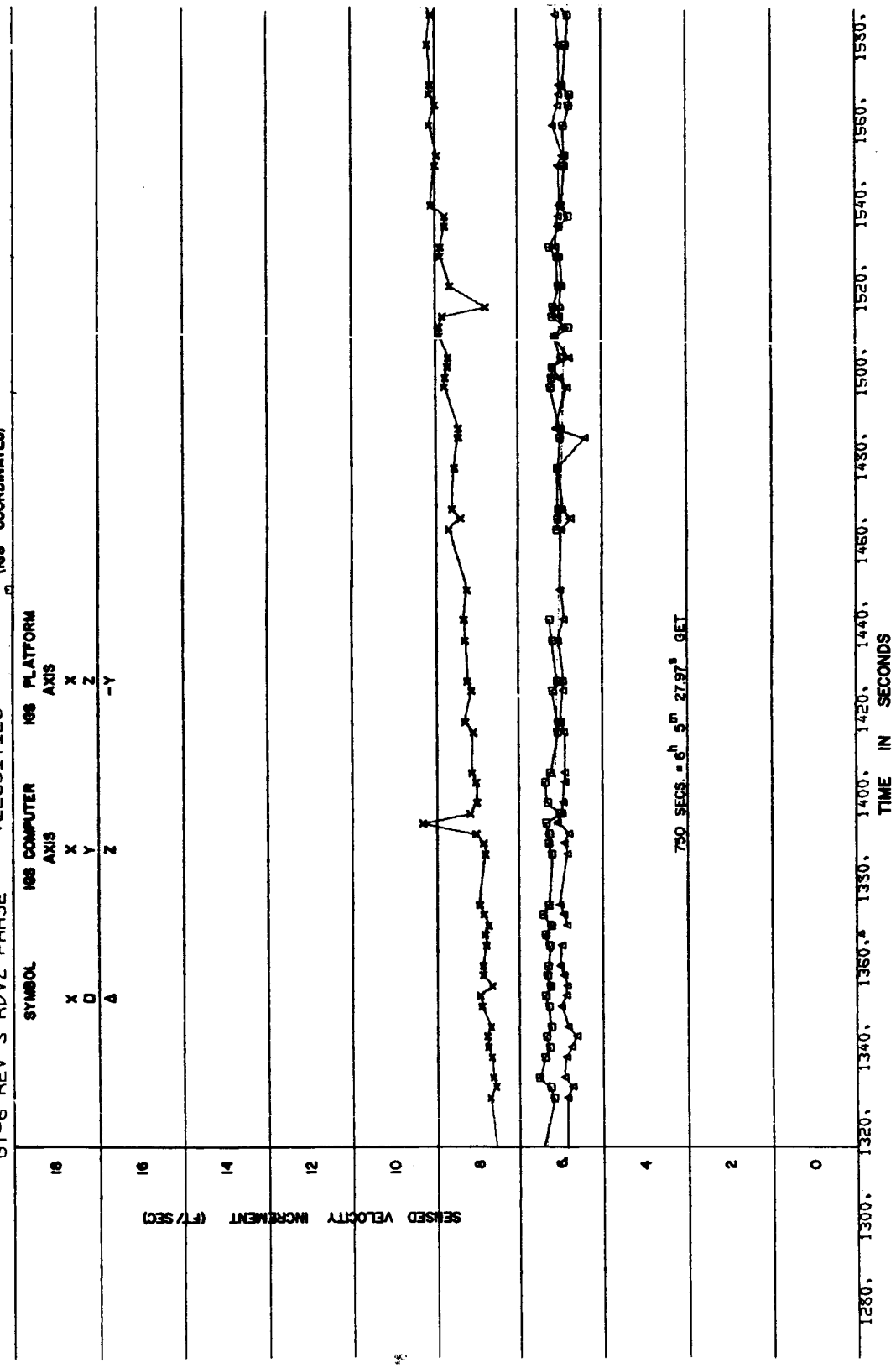

Figure 6. Sensed Velocities Revolution 3 RDVZ Phase

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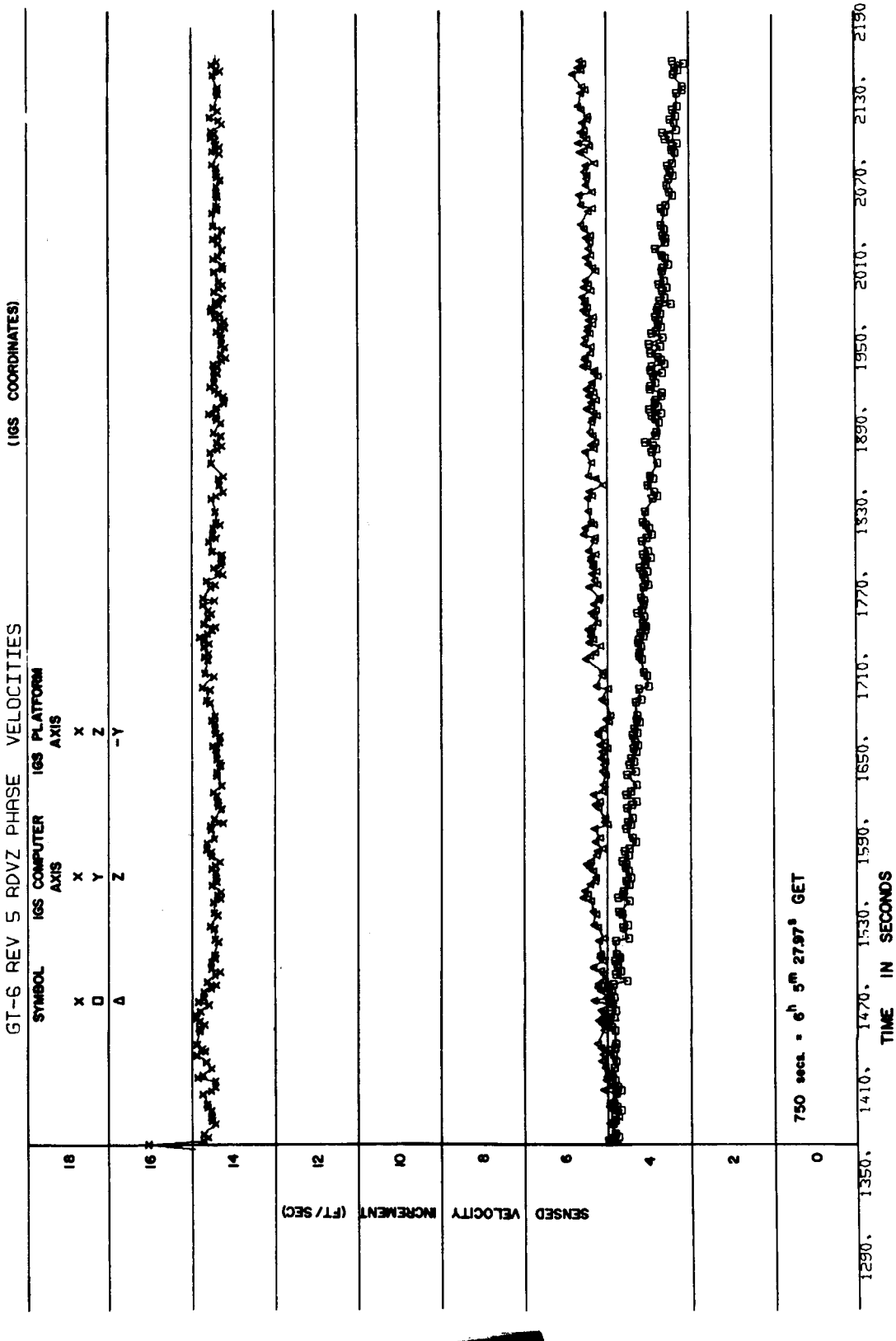

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Figure 7. Sensed Velocities Revolution 5 RDVZ Phase

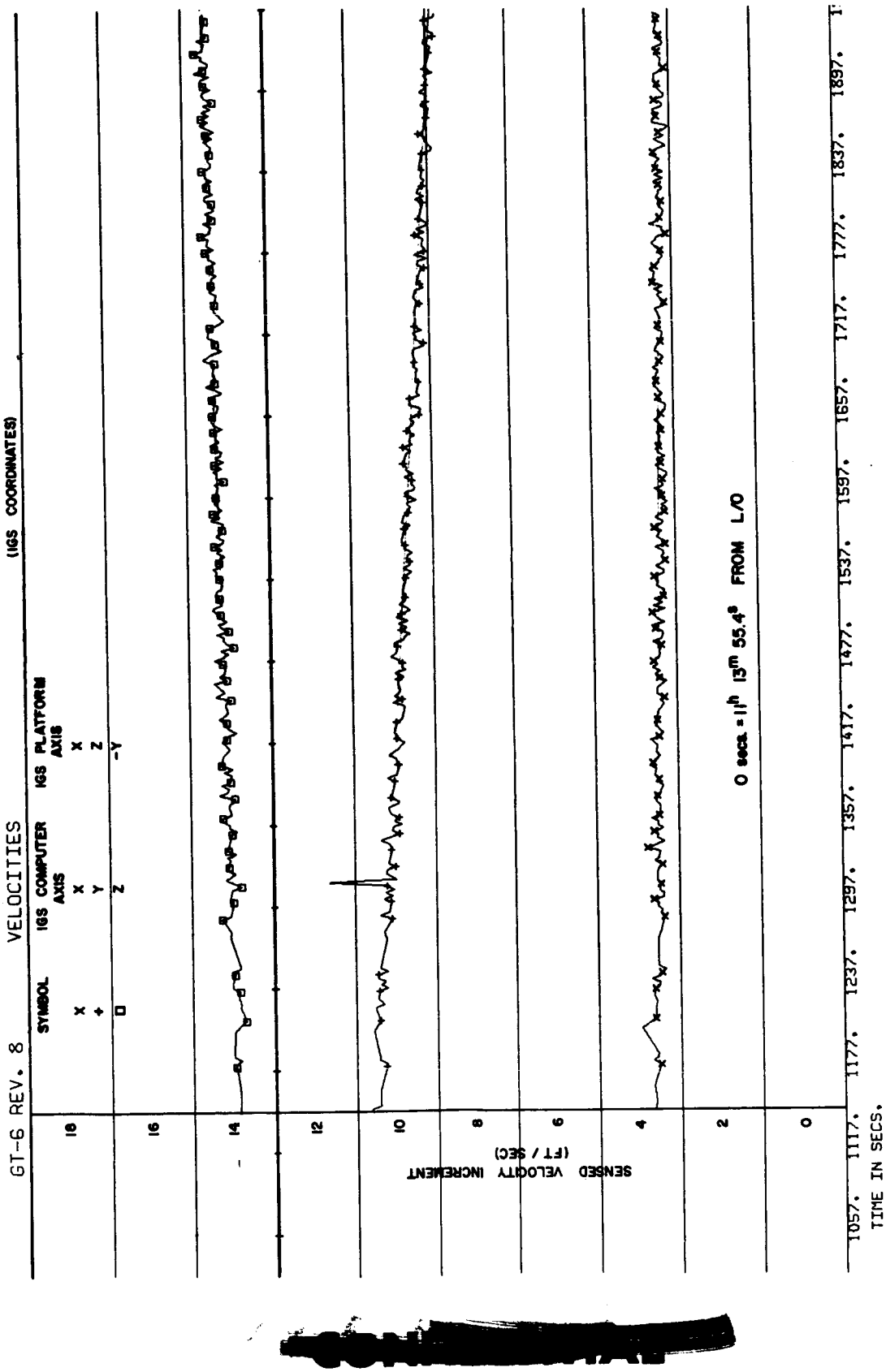

Figure 8. Sensed Velocities Revolution 8

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2.3.4 Error Coefficient Recovery

Regression analyses were performed on the residuals between the tracking data and the IGS data corrected for the free flight recovered accelerometer bias since these biases were considered to be well established. A minimization of the regression error model size is desirable due to the high correlation among many Gemini IMU error sources. Therefore, the following representative error model was chosen for the regression.

IGS Sources:

XSF = X accelerometer scale factor error
ZSF = Z accelerometer scale factor error
ZXMSL = Z accelerometer misalignment toward X
YGCDR = Y gyro constant drift rate
XGIAU = X gyro input axis unbalance
YGIAU = Y gyro input axis unbalance
PHIX = Platform misalignment about the X accelerometer axis
PHIY = Platform misalignment about the Y accelerometer axis
PHIZ = Platform misalignment about the Z accelerometer axis
POX = X computer axis position bias
POY = Y computer axis position bias
POZ = Z computer axis position bias
DT = Time correlation error
TSF = Timing scale factor.

Tracker Sources:

MISTRAM II passive range sum rate bias

The regression domain chosen was the following:

10K MISTRAM	$\dot{P}$ $\dot{Q}$ $\dot{R}$SUM
100K MISTRAM	$\dot{P}$ $\dot{Q}$
GE Final (Mod III)	$\dot{R}$ $\dot{P}$ $\dot{Q}$
Passive MISTRAM	$\dot{R}$SUM

The following eight guidance errors were omitted from the regression solution but their statistical affect is accounted for in the regression program.

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Z gyro input axis unbalance
X gyro spin axis unbalance
Y gyro spin axis unbalance
Z gyro spin axis unbalance
Z gyro constant drift rate
X velocity bias
Y velocity bias
Z velocity bias

Carrying these terms for their statistical affect means the following: More than likely, these errors are present to some degree in the system, and since many of them look alike it would be difficult to separate them from one another—this dilema usually manifests itself in the form of large (many sigma) errors which tend to compensate one another. Solving only for a representative set of errors usually avoids this phenomenon. However, the accuracy of the resulting error coefficients must reflect the fact that they are indeed only a representative set. The mathematics of this procedure is presented in Appendix B.

The results of the regression analysis have been presented, in part, in Table 2. In addition to the IMU errors, a range rate bias error of -0.18 ± 0.06 ft/sec was found in the MISTRAM II system. This error is well within the apriori uncertainty of 0.5 ft/sec. No other tracking errors were considered and none were carried statistically in the solution.

The regression results were not as good as anticipated; the normalized RMS of the residuals remaining after the regression fit was 1.9, ideally it would be 1.0. This means that either a total (3 trackers, 9 observations) effective one sigma error remains in the data or the noise estimates of the input IMU-tracker comparisons were incorrect (they would have to have been estimated too small). More than likely, a combination of these has resulted in this large RMS.

Recovery of the MISTRAM I and II and GE Mod III position bias was accomplished by compensating the IMU/tracker position domain residuals with the errors recovered in the regression analysis and estimating the bias levels from the remaining position errors (Section 4).

The IMU model used in the regression analysis was based on engineering judgement. The preflight model and coefficients did not influence the regression analysis, and, as it turns out, the preflight values are insufficient to correct the observed IMU errors. The recovered IMU coefficients are all tolerable (within specification) with the exception of the Z accelerometer misalignment toward X. This 3 sigma coefficient (84 $\widehat{sec}$) has an à posteriori uncertainty of 24 $\widehat{sec}$, which is slightly less than the specification (30 $\widehat{sec}$). This indicates that the flight test did improve the statistical knowledge of this error somewhat. The following information was obtained about this and other coefficients from examining the regression computer runs:

a) ZXMSL is not excessively correlated with other terms in the fit.

b) Along with the following terms ZXMSL did the most towards fitting the data.

XSF	(X Accelerometer Scale Factor)
XGIAU	(X Gyro Input Axis Unbalance)

c) As the regression solution (Recursive Error Modeling Program) proceeded, solving the least squares solution again with the addition of each new error term the ZXMSL coefficient remained relatively stable—its variation remaining within the a posteriori one sigma level. This tends to indicate that no serious compensational effects are occurring with all error coefficients other than G3(4), XSF, DT, TSF, PHIZ, and ZSF which were in the solution ahead of ZXMSL.

d) Error terms which change significantly when ZXMSL enters the solution change well within their one sigma uncertainty.

e) Exactly half of the other error sources had more statistical improvement from the flight test.* The following table indicates the order of statistical improvement of the recovered coefficients (best at the top left etc.)

XSF	POX	POY	YGCDR
G3(4)	POZ	PHIX	YGIAU
DT	PHIZ	PHIY	YGIAU
TSF	ZXMSL	ZSF	

*Improvement may be defined here as the ratio of the a priori to the a posteriori uncertainty.

In light of these points it is reasonable to believe that the system suffers either the indicated ZXMSL error or some very similar error produced by a combination of the omitted errors. This latter possibly being less likely than the first.

2.3.5 December 12 Gemini 6 Attempted Launch Data Analysis

The Gemini 6 mission schedule for 12 December 1965 was cancelled just prior to liftoff. However, the IGS was in the ascent mode for approximately 850 seconds, and PCM telemetry data were collected.

An analysis of the data was conducted in an effort to recover IMU error sources. The IGS sensed velocity error curves of the cancelled mission are presented in Figure 9. The x and z errors build up proportional to t^2 (time squared) indicating a platform drift rate, and the y error builds up linearly indicating an error source proportional to the integral of gravity. The IMU error sources that could have caused the velocity errors were:

x Axis	
Y gyro constant drift and/or Y gyro input axis unbalance	-0.20 deg/hr (/g) (total) (pitch down drift)
z Axis	
X gyro constant drift and/or X gyro input axis unbalance	-0.43 deg/hr (/g) (total) (z axis down drift)
y Axis	
IGS time scale factor and/or Z accelerometer bias and/or Z accelerometer scale factor	276 ppm (g) (total)

No distinction between g dependent and non g dependent drift could be made since the IMU senses a constant 1g input. The true error sources could have been combinations of the error sources or any one alone, but having

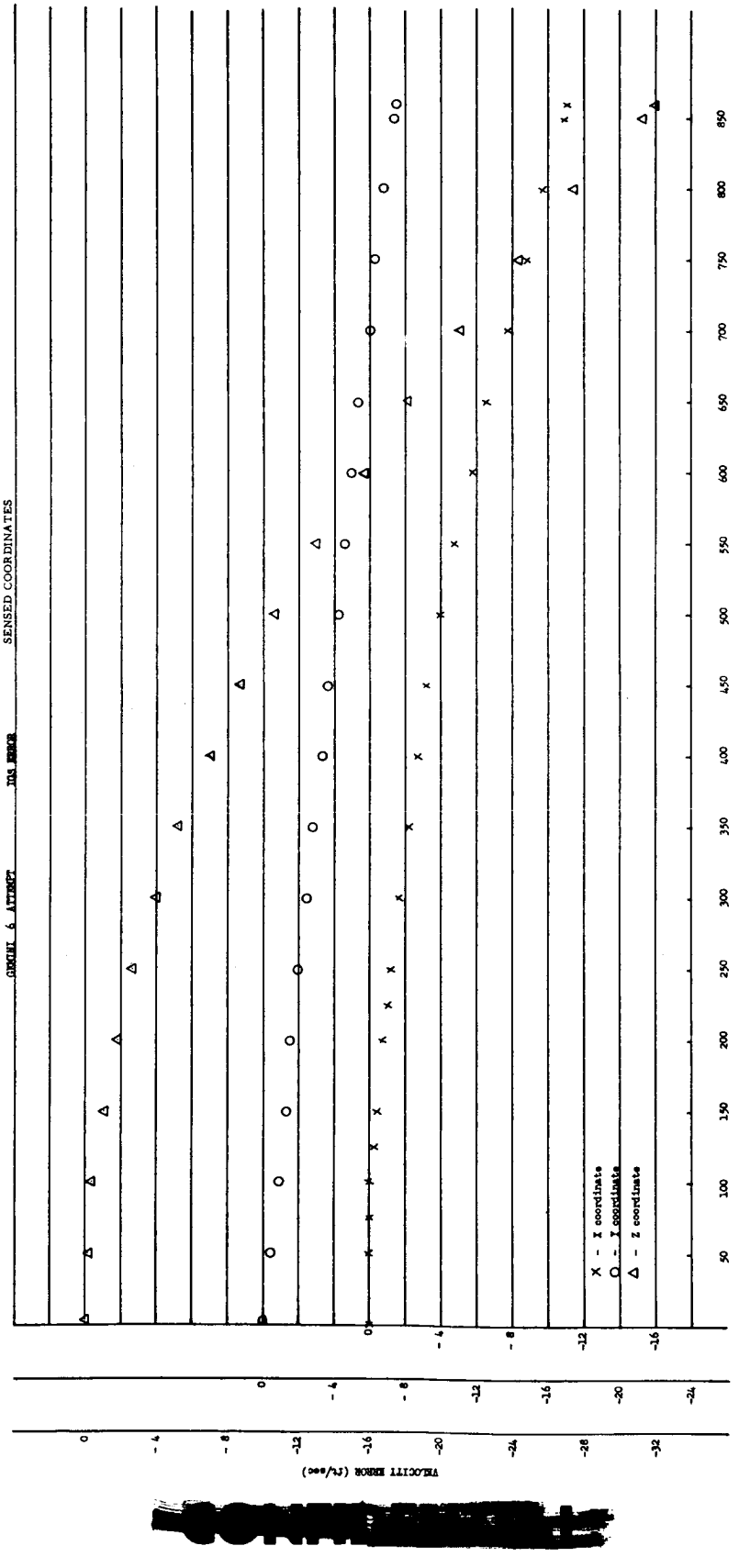

Figure 9. Gemini 6 Abort Sensed Velocity Error

coefficients which netted the indicated values. A comparison of the above error coefficients with the preflight coefficients for the same error sources is presented in Table 5.

Table 5. IGS Error Source Comparison

Error Sources	Error Value	
	Attemped Launch	Preflight
Summation of Y Gyro		
Constant Drift Rate (deg/hr) and Input Axis Unbalance (deg/hr/g)	-0.19	-0.24
Summation of X Gyro		
Constant Drift Rate (deg/hr) and Input Unbalance (deg/hr/g)	-0.43	-0.23
Summation of Z (Vertical)		
Accelerometer Bias (ppm g) and Scale Factor (ppm)	276	226*

*The sign sense is such that the Z accelerometer bias and the scale factor coefficients must be added with opposite signs for their comparison.

When the actual flight test results are considered, Table 5 becomes rather inconclusive. Both the attempted launch data and preflight data indicate a positive pitch (up) error while the postflight data indicates the opposite situation. The X gyro errors are different by one sigma specification ($\approx$0.2 deg/hr) and the postflight data supports the preflight value of -0.23 deg/hr/g.

If it is assumed that the postflight determined onboard clock drift was correct for the attempted launch, the attempted launch value for the total of Z bias and scale factor should be 339 ppm (g), not 276, indicating a difference of 100 ppm with the preflight data. Since it is not known what clock is used, (or its accuracy) in preflight testing, little can be said regarding the value of the vertical direction comparisons. In light of all these discrepancies, nothing of real value can be extracted from the attempted launch data to support or refute the postflight determined errors. It appears, in fact, that the limited and static test afforded by the cancelled launch cannot be compared to the dynamic test of the flight either due to lack of system stability or the severe change of the test environment.

2.4 AZIMUTH UPDATE

An IGS azimuth alignment correction is calculated at three separate times by the onboard computer. On the first pass through the navigation equations after platform release, the roll gimbal angle reading is compared with the desired value, and the difference is used as a correction to the intended flight azimuth. This correction is called $\Delta\eta_x$, where a positive value implies that the platform is rotated clockwise from the desired azimuth.

Additional azimuth corrections are made during flight at 100 and 140 seconds after liftoff. These are calculated by comparing the cross-range (z direction) velocity as measured by GE/Burroughs with that derived from the airborne system and attributing the residual to a platform misalignment about the vertical axis.

The calculated updates are not telemetered; however, they are obtained quite accurately from the data analysis. Table 6 summarizes the updates determined by the following methods:

a) Calculated from the telemetry data and simulation of the inflight calculations

b) Calculated from the jumps in the inertial velocity comparison or the delta-delta curve

c) Derived by IBM during their postflight simulation.

The value indicated at 100 seconds includes that at zero seconds. The value for zero seconds in the Flight Calculation Simulation column was determined from an observable jump in the IGS z velocity after platform release. This jump corresponds to the first IGS correction. The value for zero seconds in the delta-delta column is that of IBM. The consistency of results presented in Table 6 indicates that the IGS satisfactorily performed the required update calculation. However, the IGS/GE Mod III tracker comparisons of Figure 1 show a z velocity error at 140 seconds. The -0.9 ft/sec value at that time therefore indicates that the Burroughs update value telemetered to the IGS was incorrect. This error is apparently associated with the Burroughs computation of the update values for rendezvous missions since it has not existed on any of the previous flights, all of which were of the nonrendezvous type (i.e., nonvariable launch azimuths).

Table 6. Azimuth Update

Time (sec from liftoff)	Flight Calculation Simulation	Delta-Delta	IBM Postflight Simulation	Units
0	0.00120	0.00106	0.00106	rad
100	-0.00938	-0.00924	-0.00960	rad
140	0.00020	0.00008	0.00039	rad
Total	-0.00918	-0.00916	-0.00921	rad
(100 and 140)	-0.5261	-0.5261	-0.5276	deg

The total azimuth correction of -0.5261 degree has been included in all comparisons contained in this report.

The history of initial alignment error for six Gemini flights is:

Flight No.	Alignment Error (deg)
2	-0.29
3	-0.52
4	-0.12
5	-0.27
6	-0.53
7	-0.48

Mean Value = -0.37 degree
NASA/Honeywell Specification Value 0.75 degree

2.5 CONCLUSIONS

a) Digital data analysis accomplished on this flight established that the guidance system performed approximately within the anticipated uncertainties and did not malfunction in any way. Table 7 is a history of total IGS errors at SECO + 20 for Gemini flights GT-2, 3, 4, 5 and 6; a column has been included which represents anticipated IMU uncertainties due only to assumed a priori component accuracies (i.e., this column does not include the affect of navigation errors which vary from flight to flight).

b) It must be concluded at this time, that the preflight error coefficients for this flight are of little value to the postflight analysis.

c) **The inflight azimuth update was, as usual, performed correctly by the IGS computer. However, the fact that an erroneous GE/Burroughs value was commanded, results in an IGS error of 5 ft/sec crossrange.**

d) **Accelerometer bias error measurement and compensation was satisfactorily accomplished during orbital flight.**

e) **The regression analysis indicated that the presence of serious unmodeled errors is not likely and that substantial faith can be had in the significant recovered error coefficients.**

Table 7. IMU Error History*

	GT-2	GT-3	GT-4	GT-5	GT-6	Assumed 1σ IMU Specification
ΔX (ft)	N/A	N/A	-80	487	-415	800
ΔY	-1100	N/A	-700	115	+800	1340
ΔZ	-200	-1000	900	-100	-500	1180
$\Delta\dot{X}$ (ft/sec)	N/A	N/A	-1.3	0.8	-1.9	4.29
$\Delta\dot{Y}$	-11	N/A	-4.8	-0.5	+9.3	9.76
$\Delta\dot{Z}$	-6	-2.5	13.4	-3.9	-2.5	11.15

(N/A indicates "not applicable" due to system malfunction affecting these parameters)

*Ingredients for this table can be found in Reference 2.

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3. REENTRY

A detailed IGS analysis during reentry was precluded by the loss of spacecraft telemetry during the dynamic atmospheric reentry portion of flight. This loss resulted from a failure of the onboard tape recorder earlier in the mission.

Table 8 gives the state vectors at retrofire as calculated by the TRW Systems postflight trajectory reconstruction and as computed real time by the Real Time Computer Complex (RTCC) and used by the IGS.

Table 8. Reentry Initial Conditions

	IGS(RTCC)	TRW Postflight	Difference
X (ft)	11564700	11563563	1137
Y (ft)	18416400	18416701	-301
Z (ft)	2253900	2254076	-176
$\dot{X}$ (ft/sec)	-19615.2	-19616.15	0.05
$\dot{Y}$ (ft/sec)	10799.7	10798.67	1.03
$\dot{Z}$ (ft/sec)	12004.2	12004.50	-0.3

t = 12:14:53:24 from zero hour GMT day of Gemini 7 launch

The coordinate system of the above vectors is that used by the RTCC, i.e., earth-centered inertial, x through Greenwich at zero hours day of the Gemini 7 launch. This initial condition difference is much less than that of the Gemini 7 mission and is more consistent with that of previous missions.

No overlapping segment of tracking and spacecraft telemetry data were available for an explicit evaluation of the IGS accuracy performance. A straight extrapolation of the ground trace of the spacecraft, as determined by the tracking systems, lies within about 5 miles of the IGS indicated position when telemetry is recovered. This kind of extrapolation is rather crude and the result takes no account of the crossrange steering that the astronaut performs. About the most this limited analysis showed was that the IGS-indicated spacecraft position after blackout was not obviously inconsistent with previous tracking data.

Table 9 summarizes the Gemini 6 impact point determined by the IGS and by the recovery ship. The target location is also presented. It was concluded, from an analysis of the available data, that the IGS estimate of actual impact is probably the more correct of the two.

Table 9. Gemini 6 Reentry Impact Location

Source	Geodetic Latitude (deg North)	Longitude (deg West)	Target Miss (n mi)
Ship	23.375	67.875	14.3
IGS	23.70	67.74	7.3
Target	23.61	67.83	---

3.1 REENTRY SIMULATION RESULTS

MSC/MPAD generated a reentry trajectory using a simulation that had the following boundary conditions:

a) Spacecraft initial conditions were obtained from the White Sands radar (WHS-16) vector during the free flight portion of reentry.

b) The end point was taken as the ship indicated pickup position (23.375°N, 67.875°W).

c) In the absence of IGS telemetry of gimbal angles, spacecraft bank angles were assumed so as to give the ship impact.

The simulation showed reasonably good agreement with the TRW postflight trajectory above 300,000 feet. Figure 10 is a comparison of the simulation with the merge of radar tracking data during the high acceleration atmospheric reentry interval of flight. There are fairly large errors in the flight path direction (Δx and Δy); however, the most interesting error is the very large negative trend in the crossrange z direction. The error curve indicates that the simulation has placed the spacecraft 4 n mi south of the radar estimate.

This comparison lends weight to the argument that the ship-indicated pickup point is considerably south of the true impact, since at 182,000 feet a trajectory consistent with the ship value is already 4 miles in error to the south.

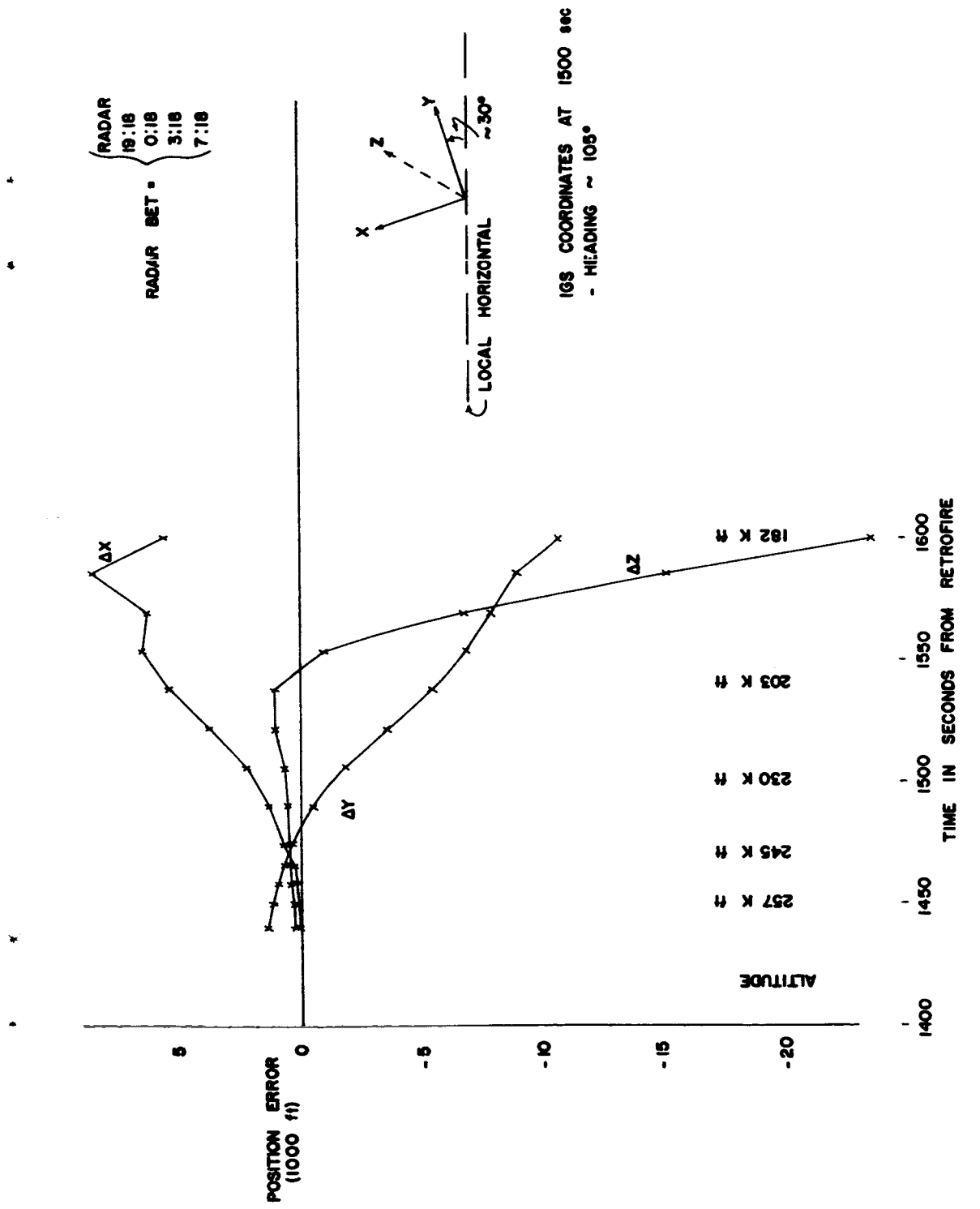

Figure 10. Gemini 6 MSC Reentry Simulation Minus Radar BET (IGS Coordinates)

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4. TRACKING SYSTEM PERFORMANCE

Tracking data available for analysis of the Gemini 6 IGS performance during ascent included the following:

a) GE Mod III/Burroughs

b) GE Mod III/Final

c) MISTRAM I Quick Look 10K and 100K

d) Passive MISTRAM II

e) MISTRAM Final (GLAD)

f) Air Force Eastern Test Range (AFETR) BET

Each of the above sets were used for position and velocity comparisons as decribed in Section 2. The GE Mod III/Burroughs data were used for quick look analyses; however, detailed analyses were subsequently accomplished with the remaining sources.

An ensemble IMU/tracking system analysis was performed on this flight and is discussed in Section 2. The tracker error sources recovered by the analysis are presented in Table 9. Also presented are error sources obtained by the AFETR, GLAD, and BET programs. Comparisons show that there was generally good agreement among the recovered coefficients for the various error source extractions.

The most significant of the recovered error sources were MISTRAM I P_{10K} and P_{100K} biases of -0.1 and -1.5 feet, respectively. The affects of the P_{100K} bias on IGS coordinate comparisons is discussed in Section 2 and is indicated in Figure 5.

The following sections provide a brief discussion of the tracking data. To clearly show the tracking data quality, each set of data are compared with the TRW Systems BET, which is IGS output corrected for the analyzed error sources (Figures 11 through 24).

4.1 GE MOD III

The GE Mod III tracking system consists of a monopulse radar tracker that measures position and a doppler, interferometer rate system that measures range rate, and two lateral rates. The data from this system are available from two data extraction systems: 1) the Burroughs, where the data are extracted at a 2 per second rate, and 2) the GE Flight Data Recording (FDR) unit, where the data are sampled at a 10 per second rate.

The Burroughs data consist of raw counts recorded on punched paper tape. The data were transferred to magnetic tape at TRW Systems and processed in the data reduction programs. The Mod III final data were processed by GE/Syracuse from the 10 per second FDR output. The data were available unsmoothed in measurement coordinates and in smoothed Cartesian coordinates. The final measurement coordinate ($\dot{R}$, $\dot{P}$, $\dot{Q}$) data were used in the computer regression analyses discussed in Section 2.

The quality of the Mod III data was relatively good, and the bias errors were negligible (see Table 10). The GE final data are compared with the IGS data before IMU error compensation in Figure 1 and after compensations in Figures 13 and 14. Comparisons of the Burroughs and compensated IGS data are presented in Figures 11. There was what appears to be an elevation type error between the GE final data and the TRW processed Burroughs data, which results in a 5 ft/sec difference in $\dot{y}$ at the end of flight. This error has been observed on previous flights and is thought to be an error in the TRW/Burroughs reduction. The problem is being investigated. There is good agreement between the TRW and GE/Syracuse reductions in the x and z directions except for a 5-millisecond timing difference.

4.2 MISTRAM DATA

4.2.1 MISTRAM I Quick Look Data

The MISTRAM I quick look data received are corrected but unsmoothed and in the system's measurement coordinates. This consists of R, P_{10K}, P_{100K}, Q_{10K}, and Q_{100K} position data, where R is a range sum measurement, P_{10K} and Q_{10K} are range difference measurements from the 10,000-foot baselines, and P_{100K} and Q_{100K} are range difference measurements

Table 10. Tracking Data Bias Errors*

System Error		Units	TRW Systems Analysis		MISTRAM Final (GLAD) *		AFETR BET *	
			Error Coefficient	1 Sigma Uncertainty	Error Coefficient	1 Sigma Uncertainty	Error Coefficient	1 Sigma Uncertainty
MISTRAM I	R	ft	---	---	8.7	1.6	-0.15	0.94
	P10K	ft	-0.1	0.05	-0.12	0.01	-0.082	0.008
	Q10K	ft	0.02	0.05	-0.027	0.01	0.006	0.010
	P100K	ft	-1.5	0.5	-1.8	0.11	-1.4	0.082
	Q100K	ft	0.2	0.1	-0.079	0.13	0.22	0.094
MISTRAM II	R	ft	-21	5	-26.6	1.2	-24.9	1.0
	P	ft	-1.8	0.5	-2.17	0.18	-1.56	0.146
	Q	ft	-2.8	0.5	-1.29	0.06	-1.59	0.045
	$\dot{R}$	ft/sec	0.065	0.02	---	---	---	---
GE MOD III	R	ft	-20	25	---	---	---	---
	A	mili rad	-0.03	0.05	---	---	---	---
	E	mili rad	-0.01	0.05	---	---	---	---

*1) MISTRAM final (GLAD) results obtained from Reference 3.

2) AFETR (BET) results obtained from Reference 4.

3) No attempt was made to recover error sources left blank.

from the 100,000-foot baselines. The two sets of range difference measurements along with the range sum measurement were processed to give essentially two redundant sets of tracking data.

The MISTRAM I data were of good quality, but had P_{100K} and P_{10K} biases of approximately -1.5 and -0.1 feet, respectively. The effect of the P bias was to cause the MISTRAM/IGS y velocity residuals to droop starting near BECO and continue somewhat exponentially until termination of the data. Figure 5, which presents comparisons of the best estimate of actual IGS error with that indicated by MISTRAM 100K residuals, shows that the apparent y velocity error resulting from the P bias is -8 and -16 ft/sec at SECO and separation, respectively. Table 10 presents other MISTRAM I errors recovered from analyses. The overall quality of the MISTRAM I data is indicated in Figures 15 through 18, which compare the MISTRAM I and compensated IGS data.

4.2.2 MISTRAM II (Passive Mode)

MISTRAM II/compensated IGS comparisons are shown in Figures 19 and 20. The analysis results show an approximate 0.13 ft/sec range sum rate bias and range sum bias of -21 feet. The results also indicate P and Q biases of -1.8 and -2.8 feet, respectively.

4.2.3 MISTRAM Final

The MISTRAM final is a best estimate trajectory based upon the available MISTRAM data (both active and passive). The tracking errors recovered by the GLAD BET program, which was used by AFETR for the generations of MISTRAM final, are listed in Table 10. The recovered error source coefficients compare favorably with the TRW analysis values and those derived from the range BET analysis, which are also presented. Comparisons of MISTRAM final and compensated IGS data are presented in Figures 21 and 22. These show little residual x and z velocity differences, but a y velocity error of approximately 3 ft/sec at SECO. This residual difference resulted from an apparent 0.3-foot P bias excess correction applied to the MISTRAM 100K data used in the MISTRAM final. A correction of 1.8 feet was used in the MISTRAM final reduction, but the TRW analysis and AFETR BET indicated that 1.5 and 1.4-foot corrections, respectively, were necessary (see Table 10).

4.3 RANGE BET

Figures 23 and 24 show comparisons between compensated IGS and the AFETR Best Estimate of Trajectory (BET). This BET combined the measurements from MISTRAM I, 10K and 100K, MISTRAM II, GLOTRAC (using the MISTRAM signal in a passive mode), GE Mod III (rate only), and C-band FRQ-6 radars Number 19:18 (Merritt Island), 7:18 (Grand Turk), 3:18 (GBI), and 0L18 (Patrick AFB). The program is a least squares adjustment in which a constant bias error model for each observation is specified. The recovered bias magnitudes, Table 10, and the AFETR BET/compensated IGS (TRW BET) residuals, Figure 23 and 24, indicate very good agreement between the TRW and AFETR analyses.

4.4 DISCUSSION OF TRACKING DATA EVALUATIONS

The judgement that Mod III data are good is relative to expected performance. Though the system appears to be relatively free of bias, in actual fact the elevation angle data becomes very noisy under 10 degrees elevation angle, and no precision angle information is available near the end of flight where the elevation angle is 5 degrees. MISTRAM data, which could, because of the ambiguities on biases, be judged as poor, is in fact generally much superior to the Mod III data for postflight IGS analysis purposes. This is because the problem with MISTRAM is uncorrected bias error though the data are relatively noise free for IGS analysis purposes. At least ideally, the MISTRAM bias error can be extracted in the postflight analysis; however, there is no way to obtain information from the very noisy Mod III angular data at the lower elevation angles, and usually this data is discarded from the analysis.

To carry the discussion one step further and show the scheme of the analysis procedure, it is found that at elevation angles below 5 to 7 degrees the refraction correction becomes uncertain. This uncertainty affects all ground tracking systems. At this point, trajectory accuracy depends on the IGS, for though it is potentially the most biased of all the systems, it has low noise throughout, and is not ordinarily subject to abrupt level changes. It is insensitive to low elevation angles, and the majority of its systematic errors are well defined and removable.

In summary, the higher elevation GE Mod III tracking establishes confidence in the MISTRAM angle measurements (P and Q). The bias-corrected high precision MISTRAM allows detailed evaluation of the IGS bias errors before the tracker angle data becomes uncertain at the very end of flight. The corrected IGS output provides detailed trajectory reconstruction over the unfavorable segments of the trajectory with respect to the tracking systems, i.e., very early and very late in flight. The evaluations of the tracking systems should be related to how each fits into the analysis being attempted on Gemini. On this particular flight the above procedure was implicit in the engineering analysis of the IMU and tracking error sources. The tracking systems operated as well as they ordinarily do and afforded considerable insight into the guidance system errors. Fortunately, no large or unusual tracking errors were present or at least detectable to any disturbing degree.

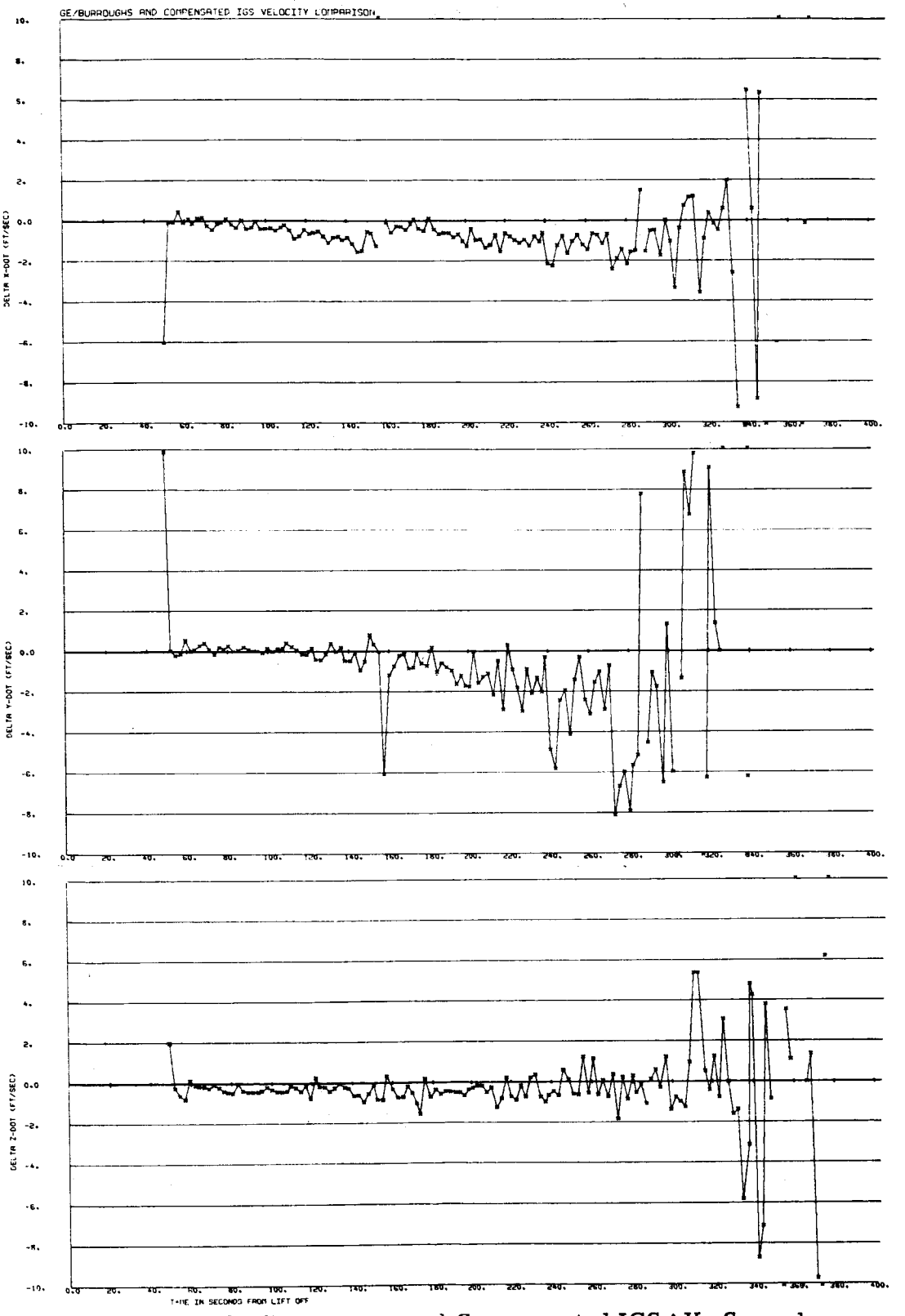

Figure 11. GE/Burroughs and Compensated IGS ΔV, Sensed Coordinates

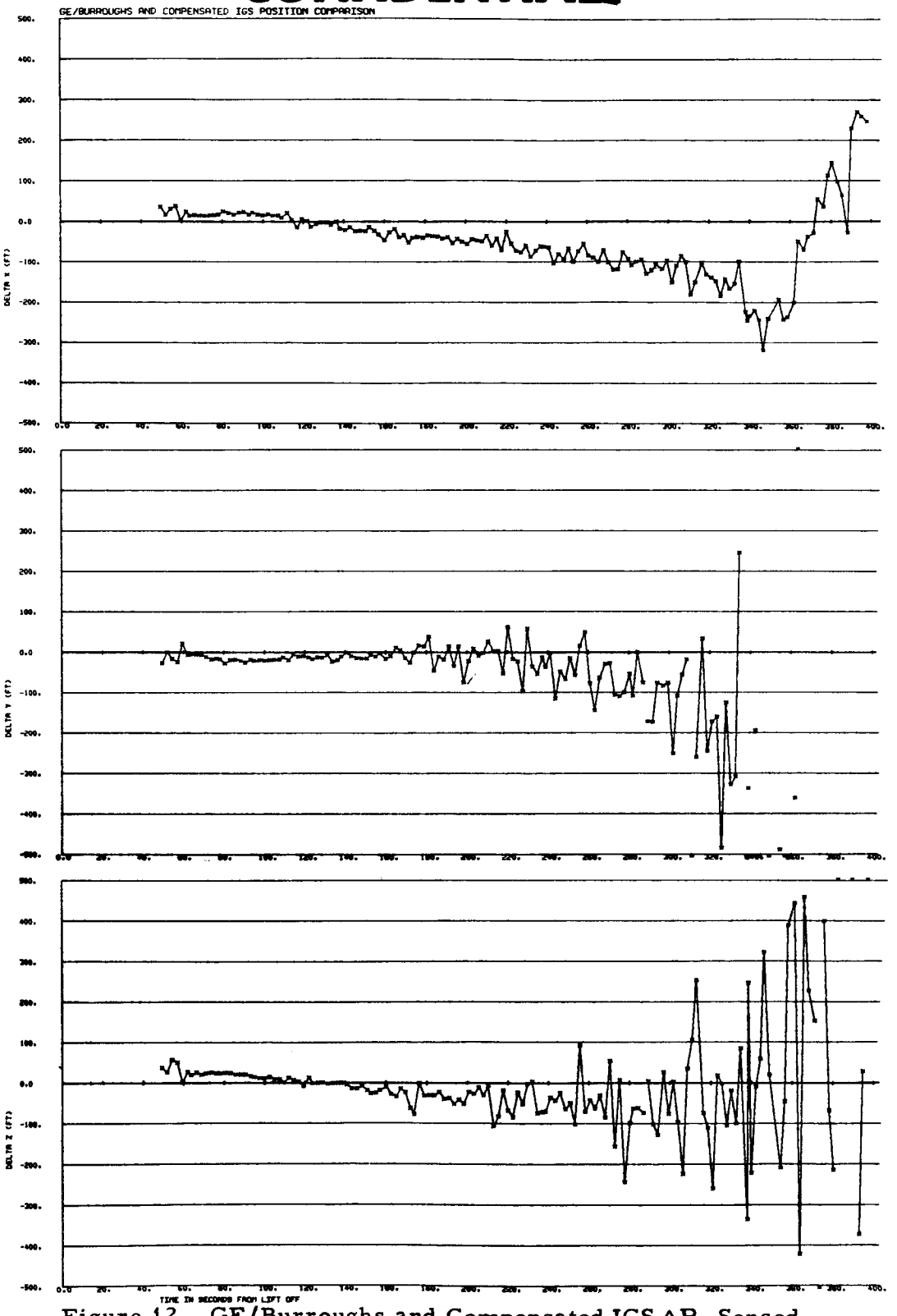

Figure 12. GE/Burroughs and Compensated IGS ΔP, Sensed Coordinates

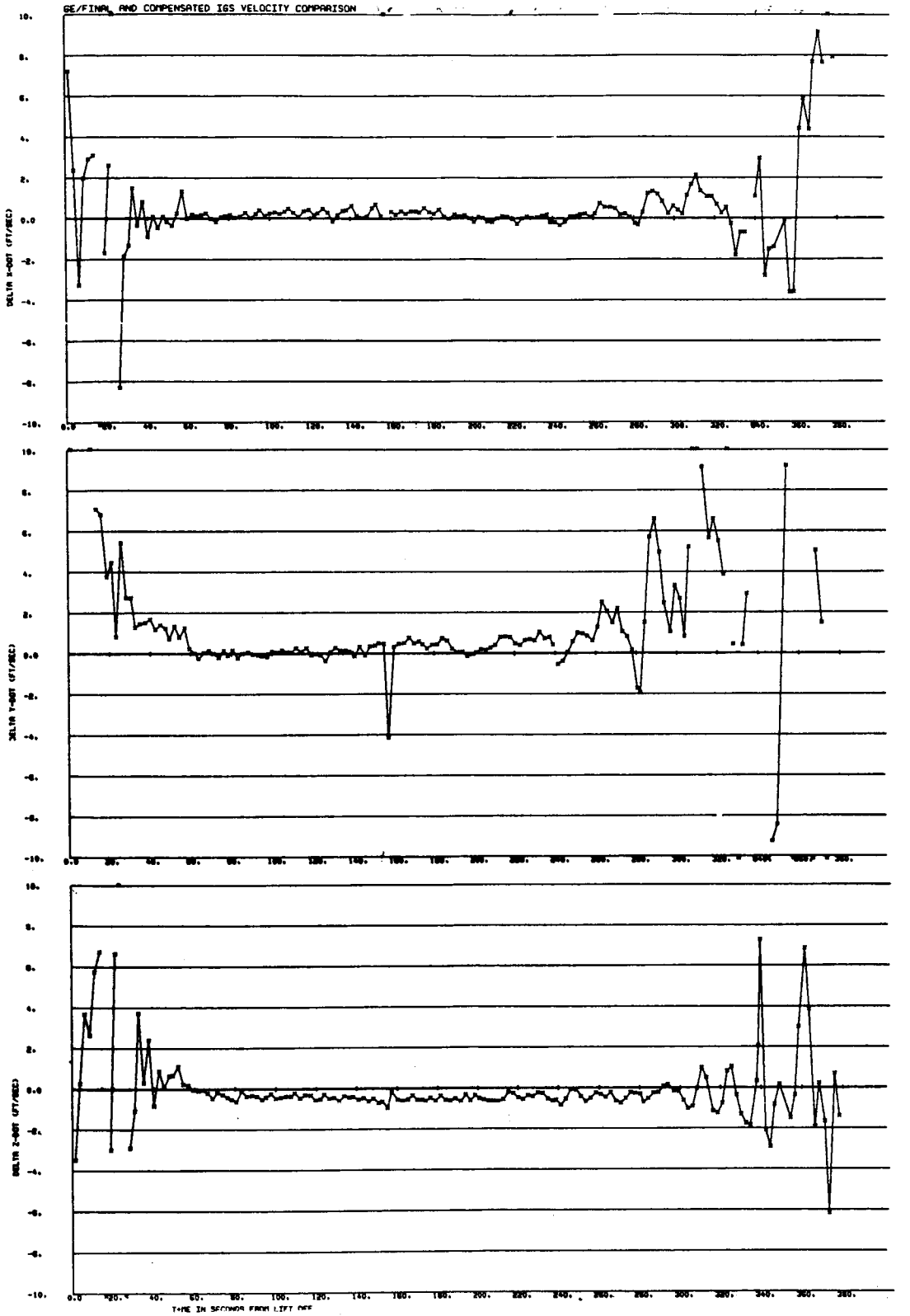

Figure 13. GE/Final and Compensated IGS ΔV, Sensed Coordinates

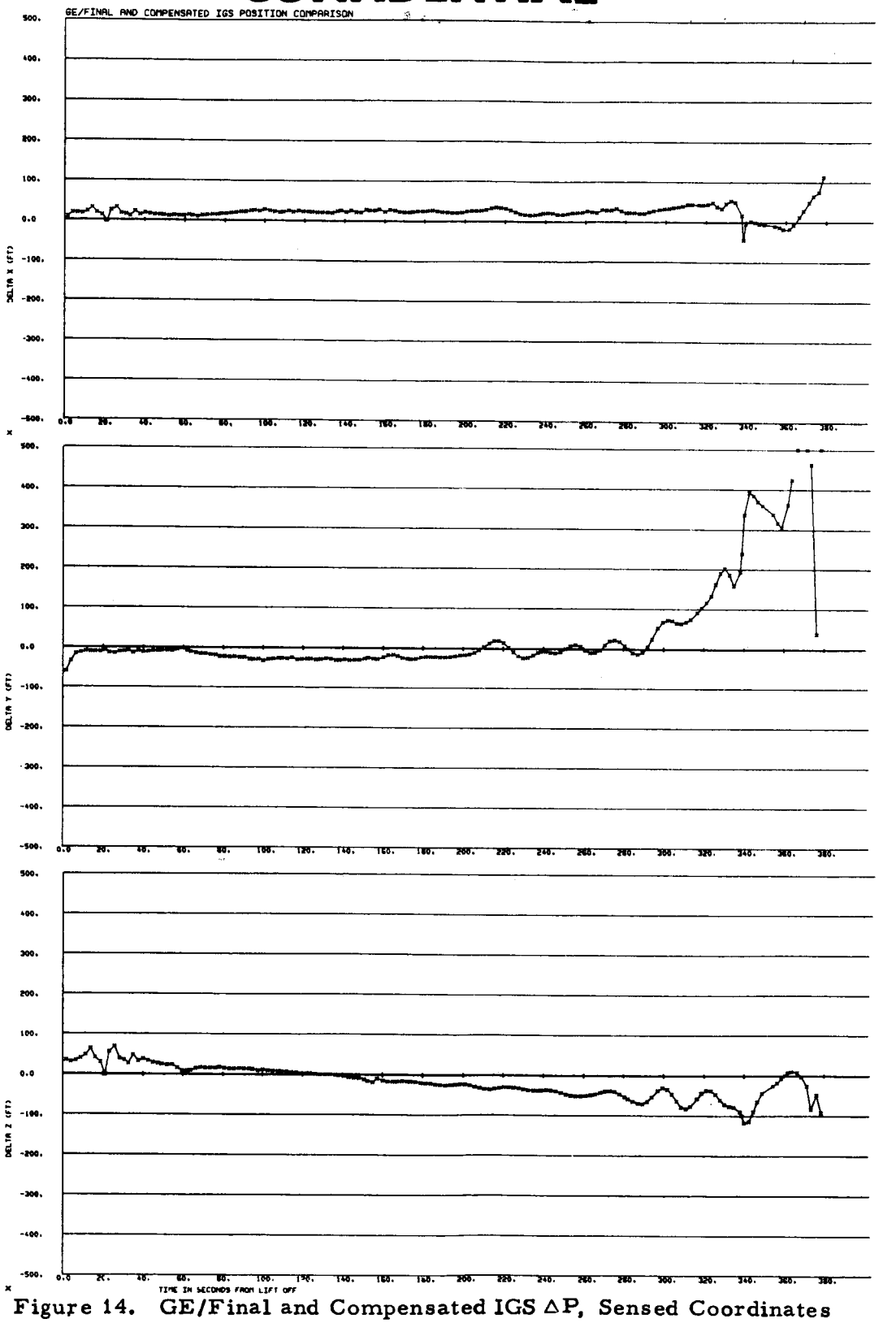

Figure 14. GE/Final and Compensated IGS ΔP, Sensed Coordinates

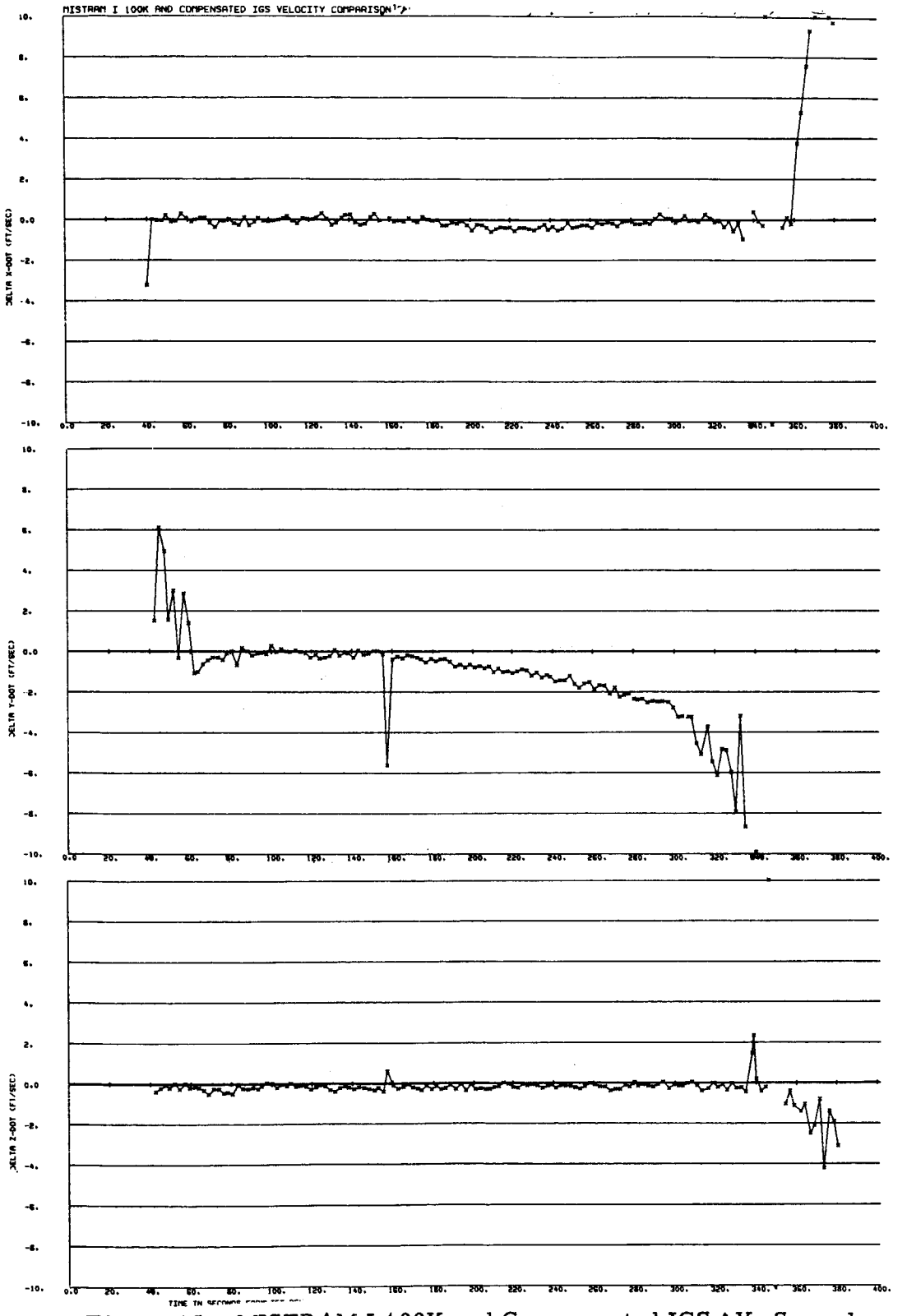

Figure 15. MISTRAM I 100K and Compensated IGS ΔV, Sensed Coordinates

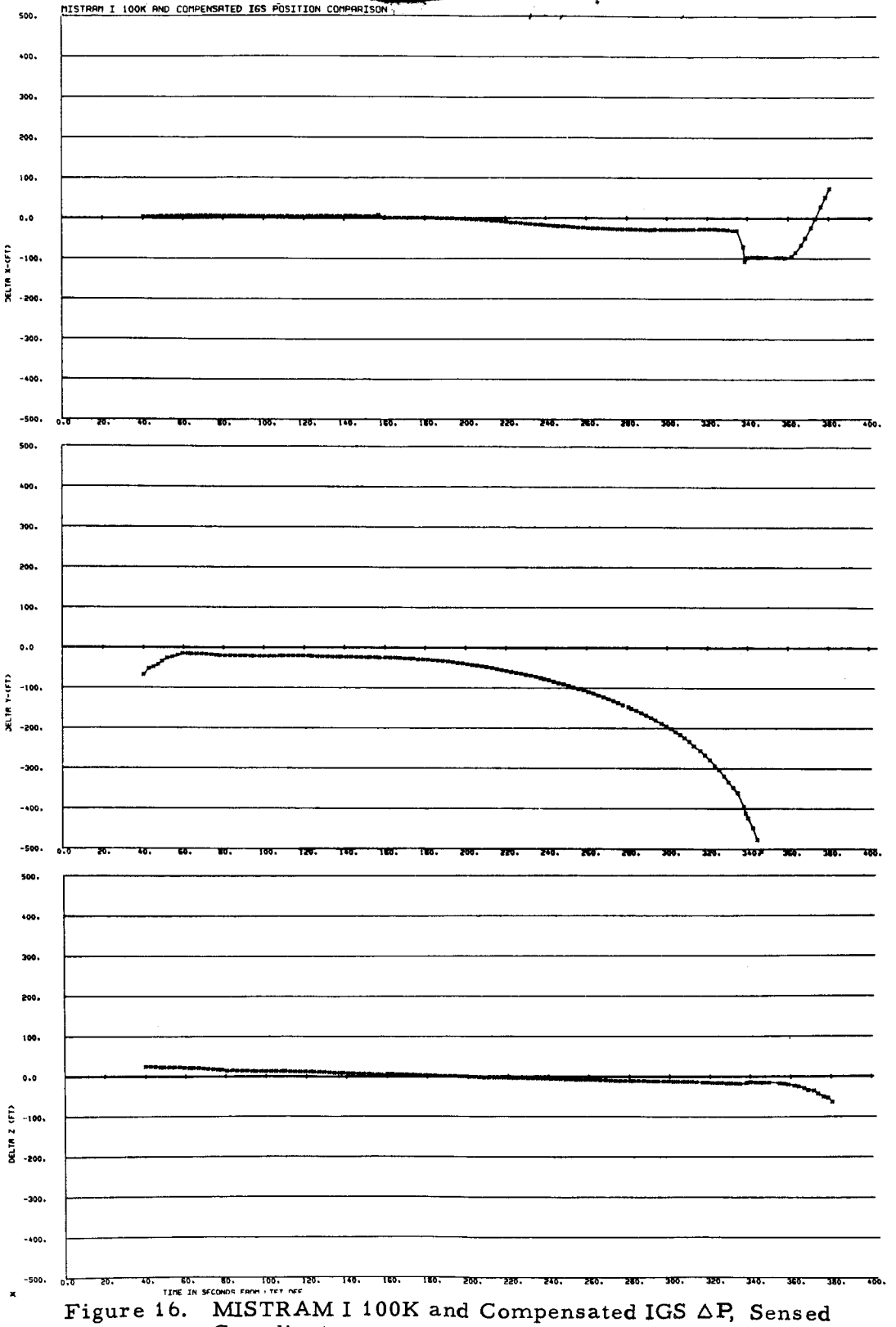

Figure 16. MISTRAM I 100K and Compensated IGS ΔP, Sensed Coordinates

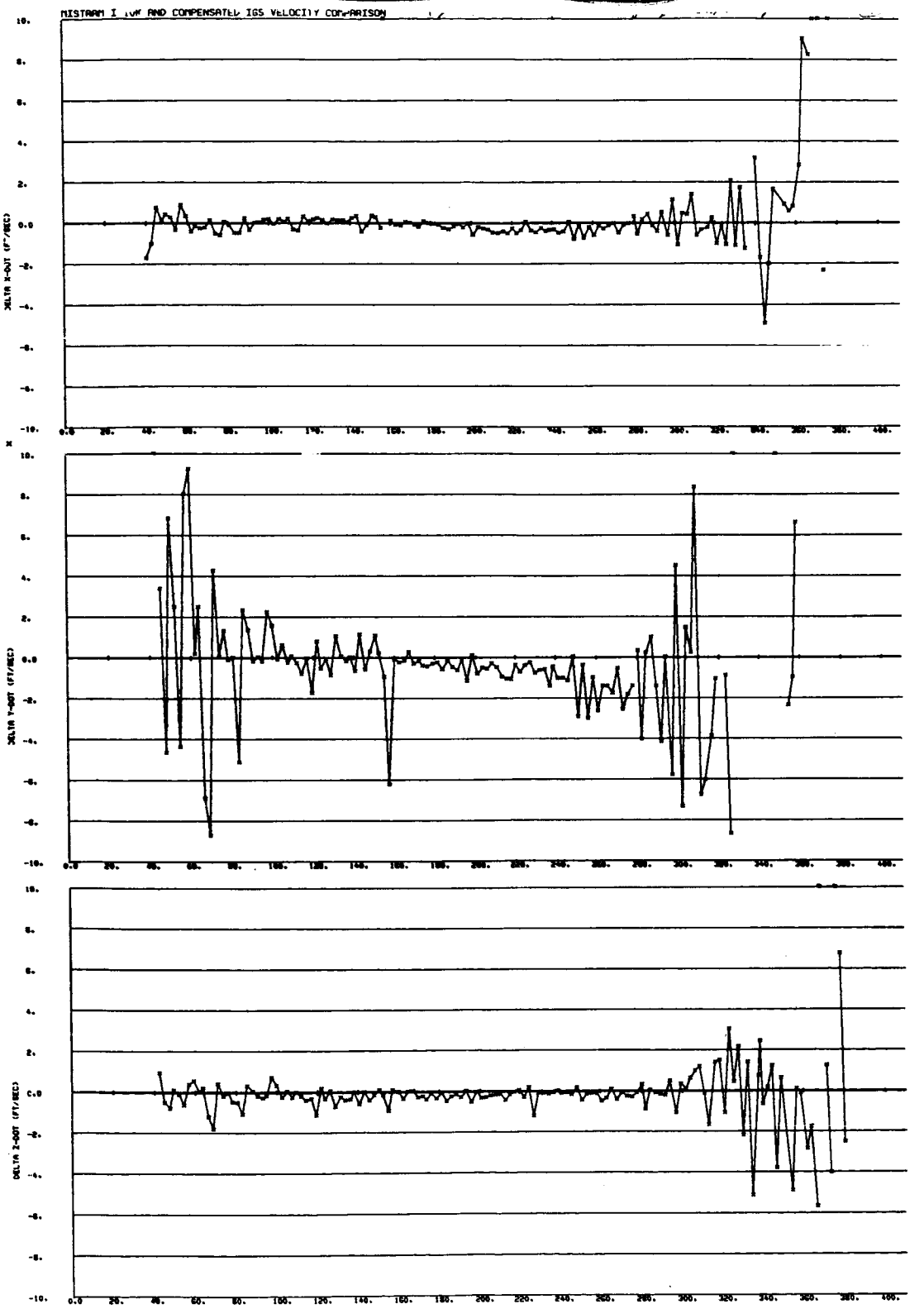

Figure 17. MISTRAM I 10K and Compensated IGS ΔV, Sensed Coordinates

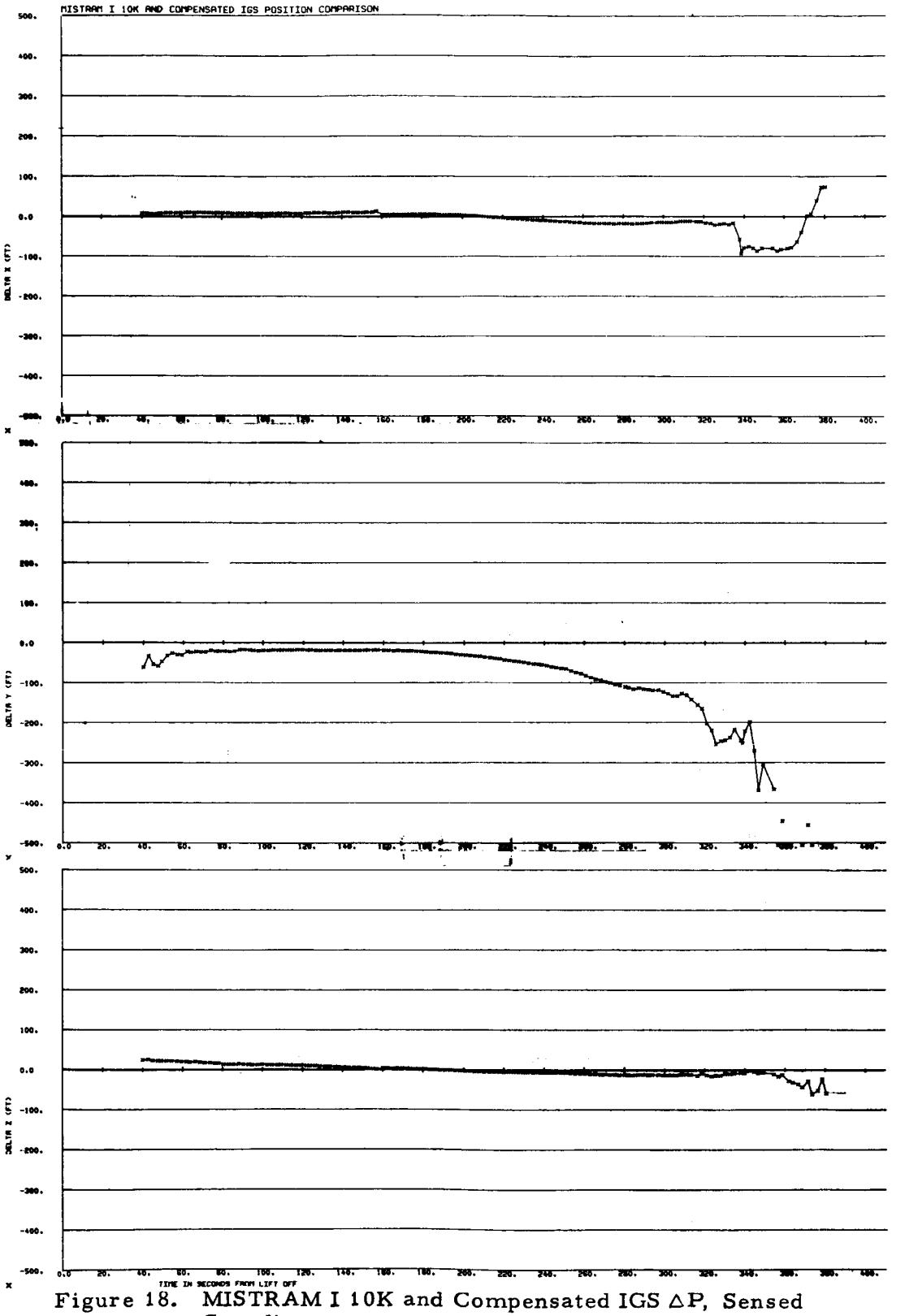

Figure 18. MISTRAM I 10K and Compensated IGS ΔP, Sensed Coordinates

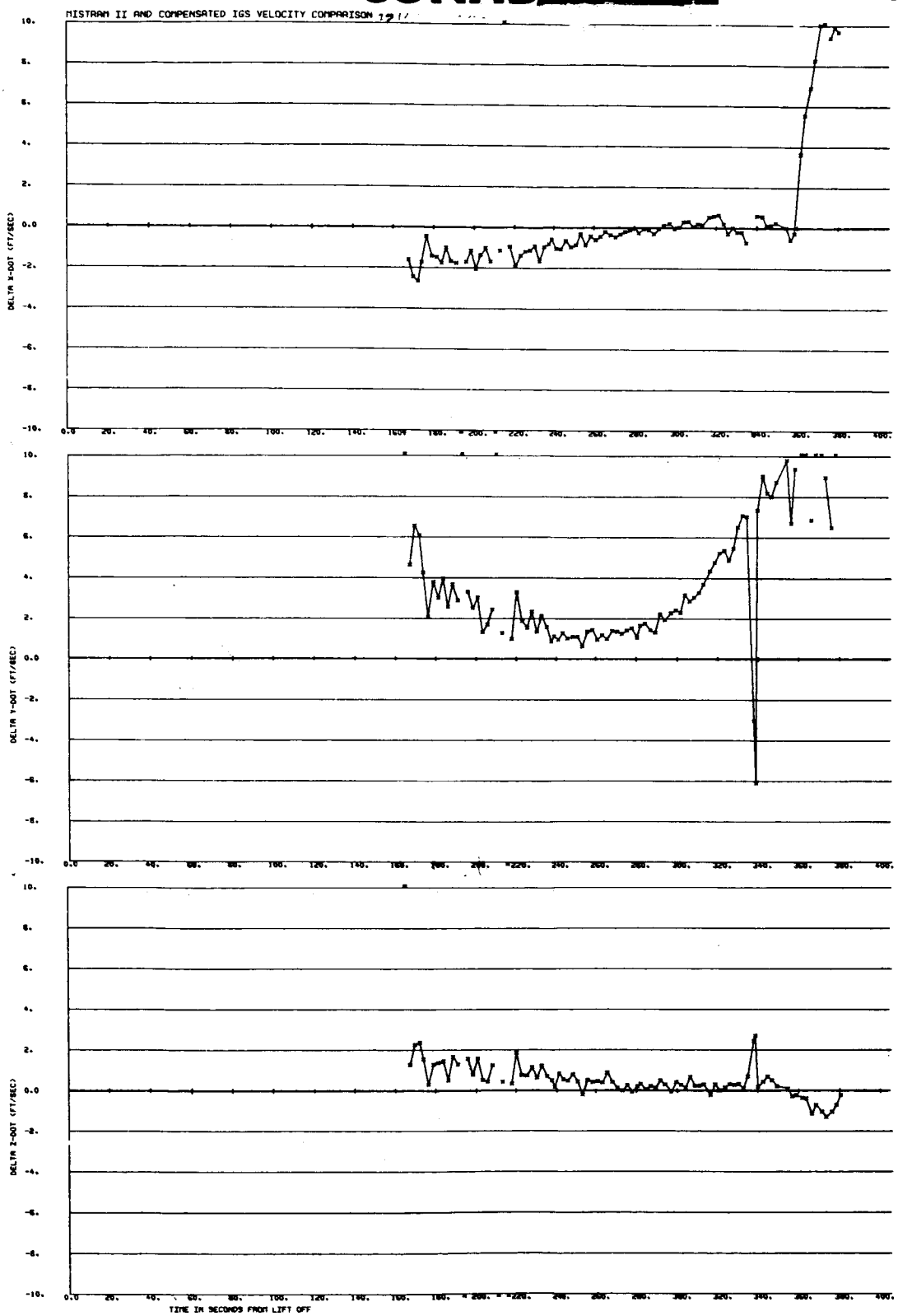

Figure 19. Passive MISTRAM and Compensated IGS ΔV, Sensed Coordinates

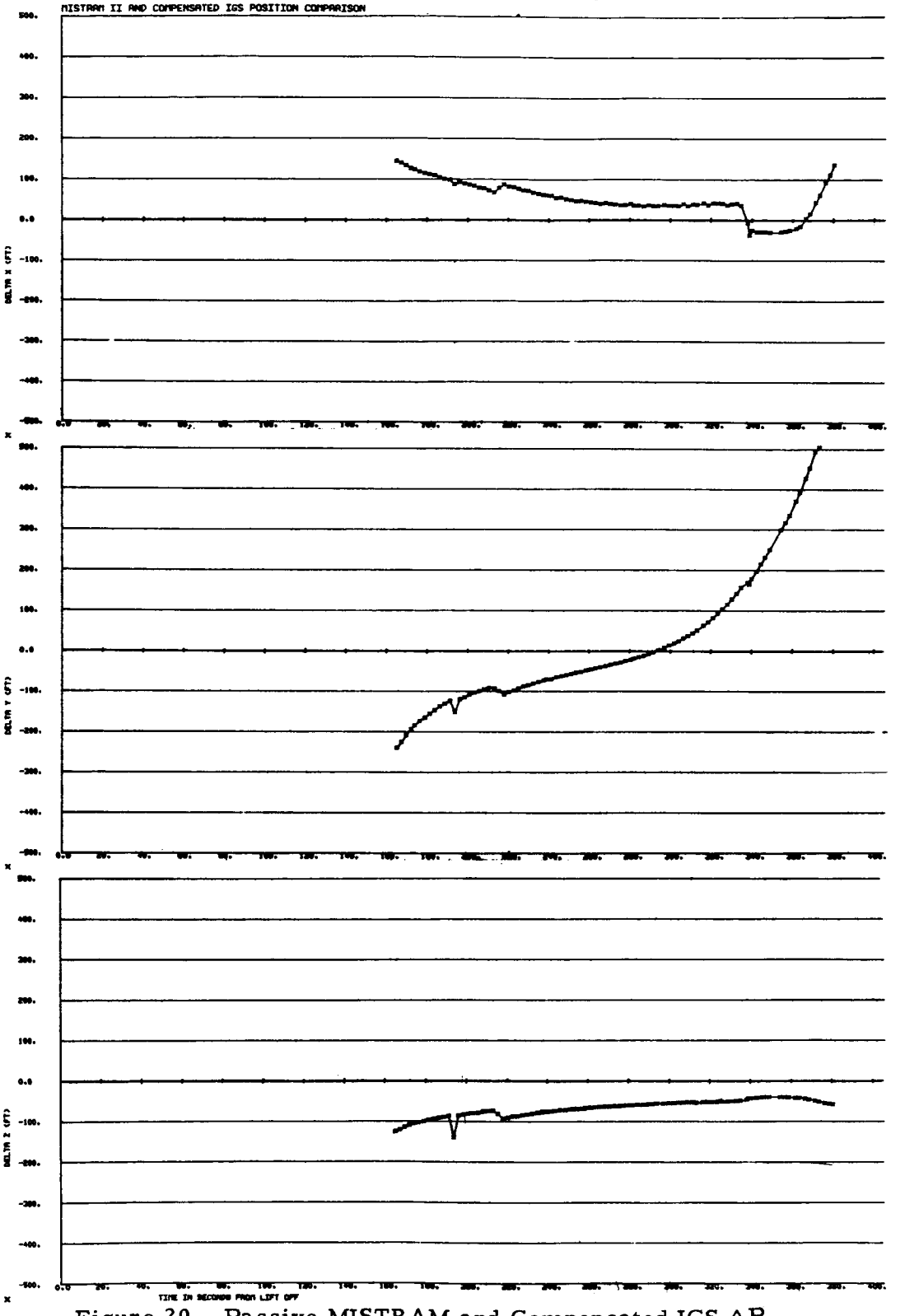

Figure 20. Passive MISTRAM and Compensated IGS ΔP, Sensed Coordinates

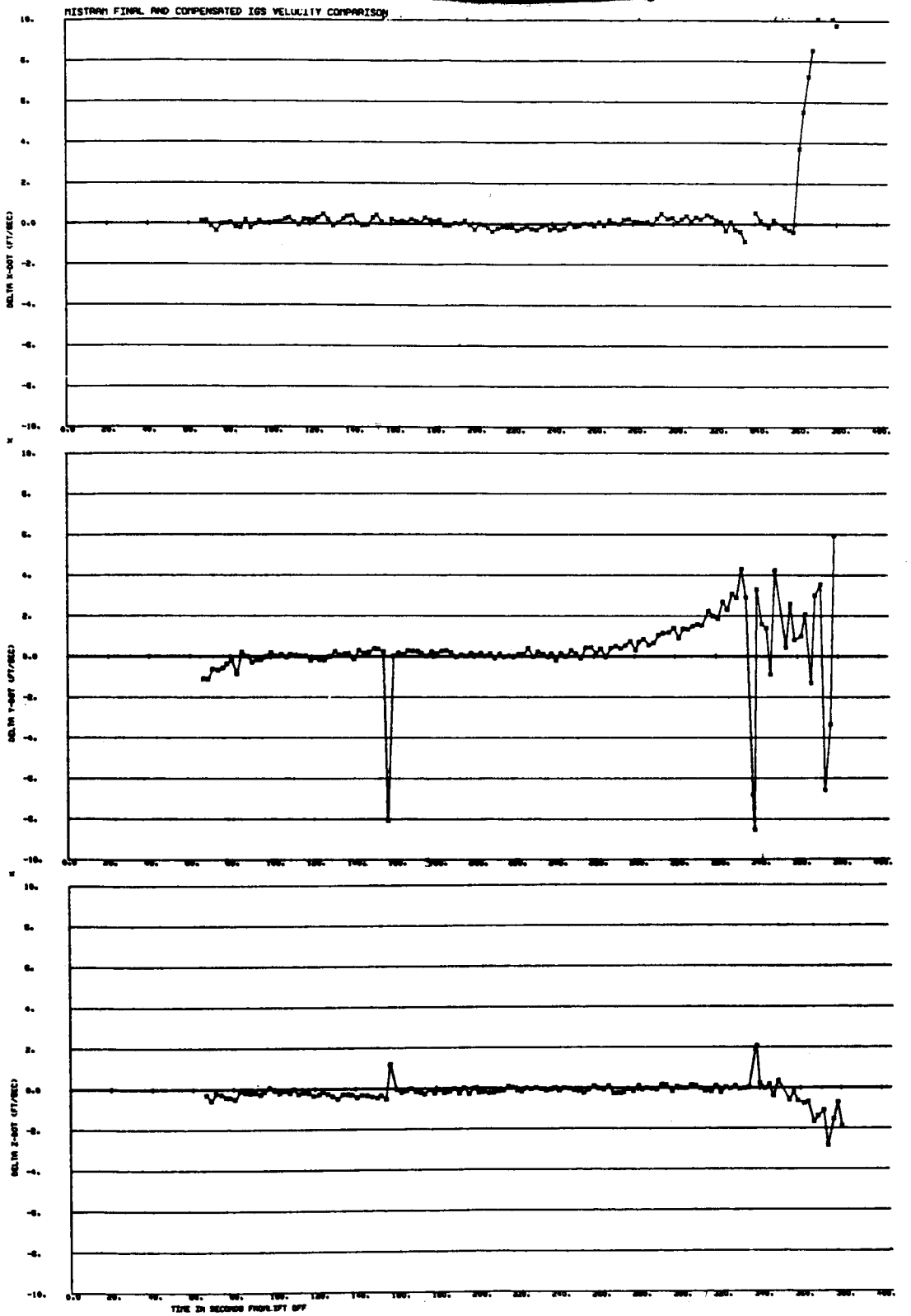

Figure 21. MISTRAM Final and Compensated IGS ΔV Sensed Coordinates

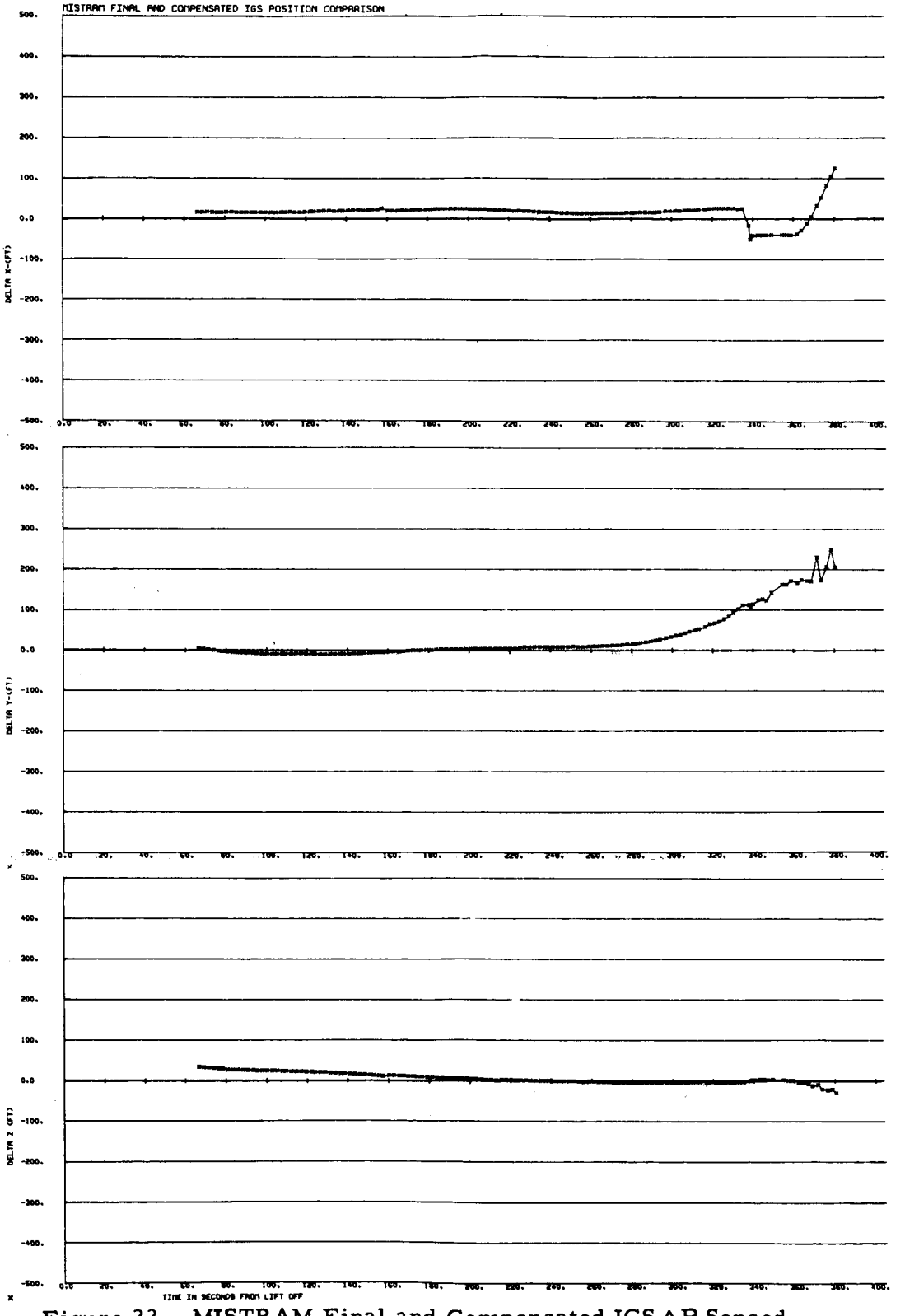

Figure 22. MISTRAM Final and Compensated IGS ΔP Sensed Coordinates

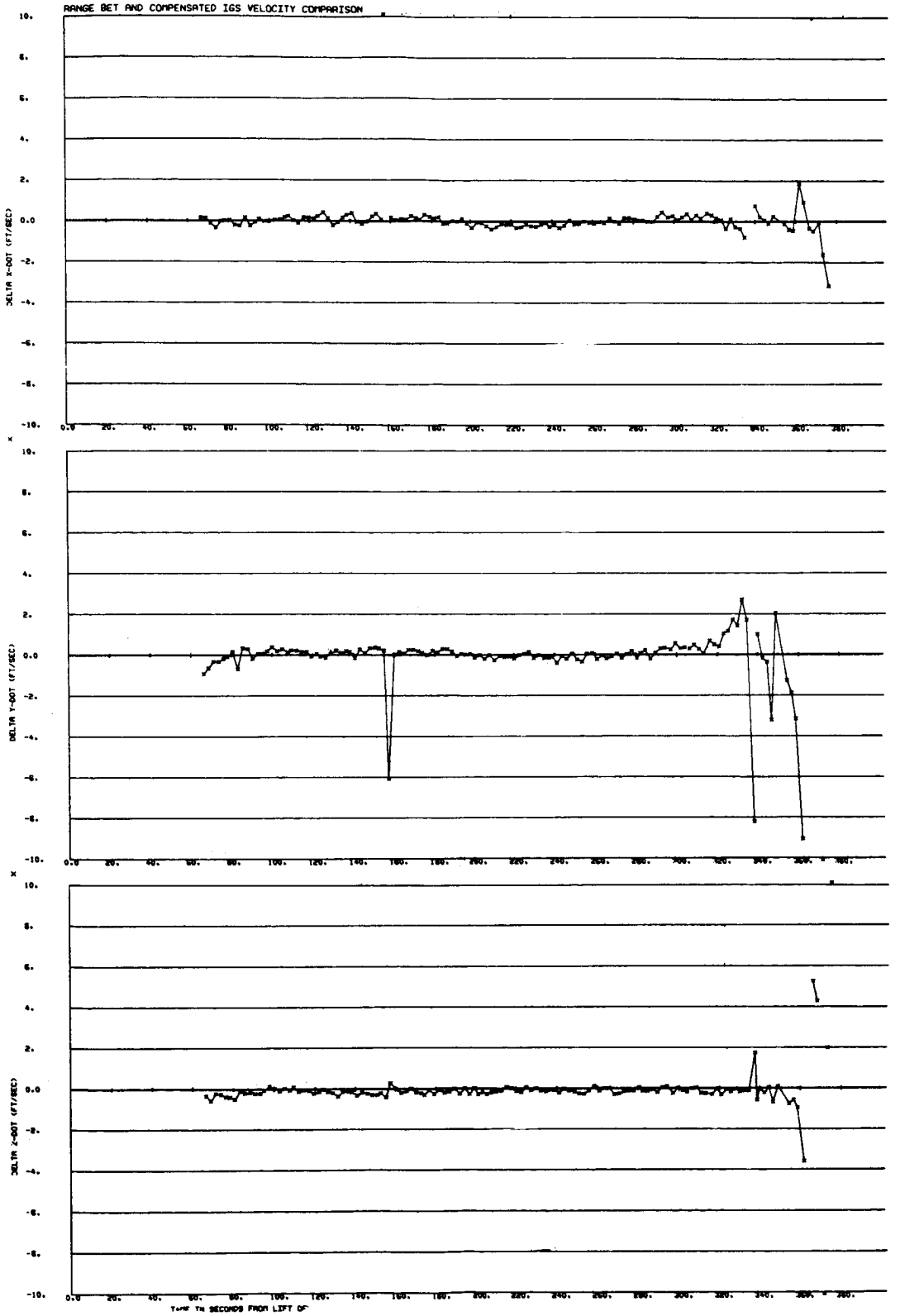

Figure 23. Range BET and Compensated IGS ΔV, Sensed Coordinates

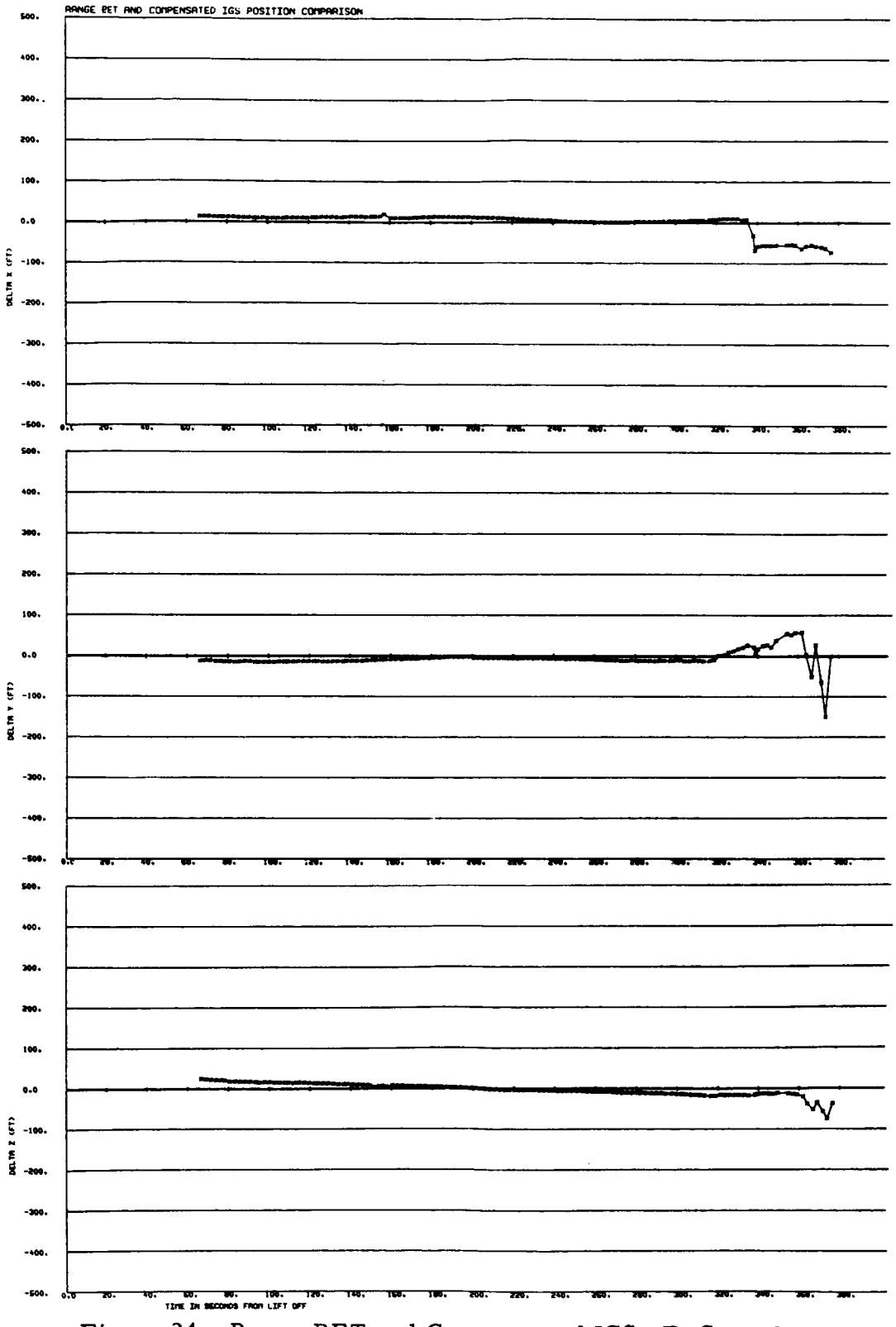

Figure 24. Range BET and Compensated IGS ΔP, Sensed Coordinates

5. TRAJECTORY RECONSTRUCTION

This section provides a description of the trajectory reconstruction for the ascent and reentry flight phases. A listing of the BET is presented in Appendix A.

The ascent data are provided in an earth-centered inertial coordinate system. The z axis is aligned with the earth's rotational axis, positive north, and the x-y plane is the equatorial plane with the x-z plane containing the Greenwich meridian at platform release time. Trajectory parameters such as velocity magnitude, altitude, flight path angle, heading, latitude, and longitude are also printed, as well as the sensed trajectory from the "EDIT" program which includes the acceleration profile.

The ascent reconstruction consists of IGS data, corrected for IMU error source magnitudes presented in Section 2.

5.1 REENTRY TRAJECTORY RECONSTRUCTION

A detailed reentry reconstruction was severely compromised by the loss of spacecraft telemetry data during the dynamic atmospheric reentry portion of flight. Therefore, a reentry trajectory of varying quality was reconstructed as follows:

a) 335,000 to 180,000 feet

High-speed tracking data from MLA, PAT, GBI, and GTI were processed to give the spacecraft trajectory in an earth referenced set of parameters. The coverage of the tracking data was as follows:

Radar		Data Spans (in sec from retrofire)
0:18	(Patrick AFB)	1347 - 1606
3:18	(GBI)	1398 - 1640
7:18	(GTI)	1569 - 1601
19:18	(Merritt Island)	1317 - 1588

When tracking data overlapped, it was statistically merged together into a "best" trajectory. BET position estimates should be accurate to 1000 through 2000 feet; however, instantaneous velocity errors may be as large as 500 ft/sec or more. The GBI determined trajectory (1603 through 1636 seconds from retro) is from data collected at 1 degree elevation. It is obviously subject to major errors (the spacecraft is shown as rising) and should be disregarded for analysis purposes. It is included only for completeness because of the interest in data at this time of flight.

The reconstruction consists of the following segments:

Time from Retro	Gemini 6 Elapsed Time	Source
1320 - 1436	92278 - 92394	Merritt Island
1436 - 1602	92394 - 92560	BET
1603 - 1636	92561 - 92594	GBI

b) 85,000 to 59,000 feet (92689 - 92721 GET)

The data given over this period are uncorrected guidance data. Since there was no period of overlapping IGS telemetry and ground tracking data during or after the high acceleration portion of reentry, no attempt was made to specify the accuracy of these parameters.

6. ONBOARD RADAR PERFORMANCE

This section is devoted to a presentation of the onboard radar data together with comparisons of the telemetered data with predicted radar values. Serious problems in the terminal guidance scheme, the radar, and the IGS itself could be reflected in such comparison if the comparisons were accurate. However, it is evident from examining the different sets of data (Figures 25 through 33) that the trajectories of Gemini 6 and the target vehicle Gemini 7 were not determined with sufficient accuracy to yield anything more than a very gross check on the radar.

6.1 TRAJECTORY RECONSTRUCTION

Using the TRW System orbit determination program, trajectories for Gemini 6 and Gemini 7 were generated during the rendezvous period (Revolution 166). The Gemini 7 trajectory was based on a curvefit that contained station passes over ASC 165, PRE 166, HAW 166, PRE 167, and HAW 167. Except for the low elevation (6 degrees) pass at Ascension Island, there was no ground tracking of Gemini 7 from three revolutions prior to one revolution after rendezvous. Therefore, an accurate rendezvous reconstruction or analysis was severely compromised. This trajectory was used throughout the analysis.

The results of two TRW produced Gemini 6 trajectories are presented here. The first trajectory (used in Reference 5) was a composite of an orbital curve fit before the brake maneuver and another fit using HAW 04 and Cal 04 data extrapolated backwards to just after these maneuvers. IGS thrusting data prior to the brake maneuver was included in the orbital fit. The comparison in Figures 25 through 27 show the results of the fit. A second trajectory was produced by constructing a tape of artificial spacecraft accelerations that matched the observed telemetry data. This was done in an attempt to get a more realistic trajectory during the entire rendezvous span and see if such smooth step acceleration functions could be more accurately handled in the orbit reconstruction program. Figures 28 through 30 show the results of this trajectory. Figures 31 through 33 are comparisons produced by NASA/MSC, and Figures 34 through 39 are plots of the telemetered onboard radar data used in the comparisons.

6.2 CONCLUSIONS

No conclusion concerning the onboard radar accuracy can be realistically made in the presence of such dramatically diverse comparison results. The fact that the vehicles were together at a given time is irrefutable which means the prediction schemes are in error either due to insufficient data or some procedural error.

The excessively noisy real time telemetry data seriously impaired a more thorough analysis. It is suggested that every effort be made to keep the IGS on during the total rendezvous interval. Reference 5 should be consulted for further scrutiny of the rendezvous interval of this mission.

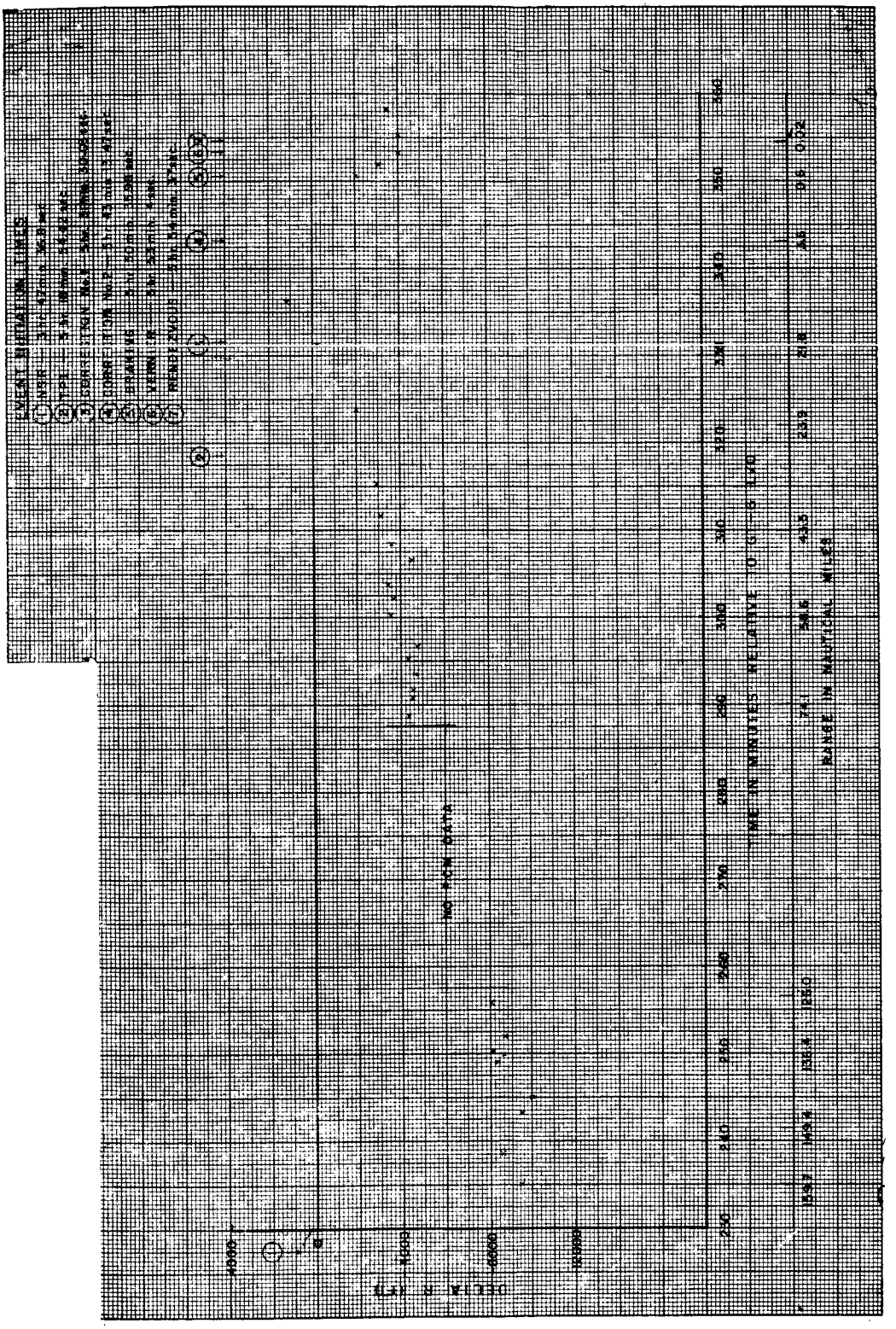

Figure 25. TRW Range Comparison (Original Gemini 6 Trajectory)

CONFIDENTIAL

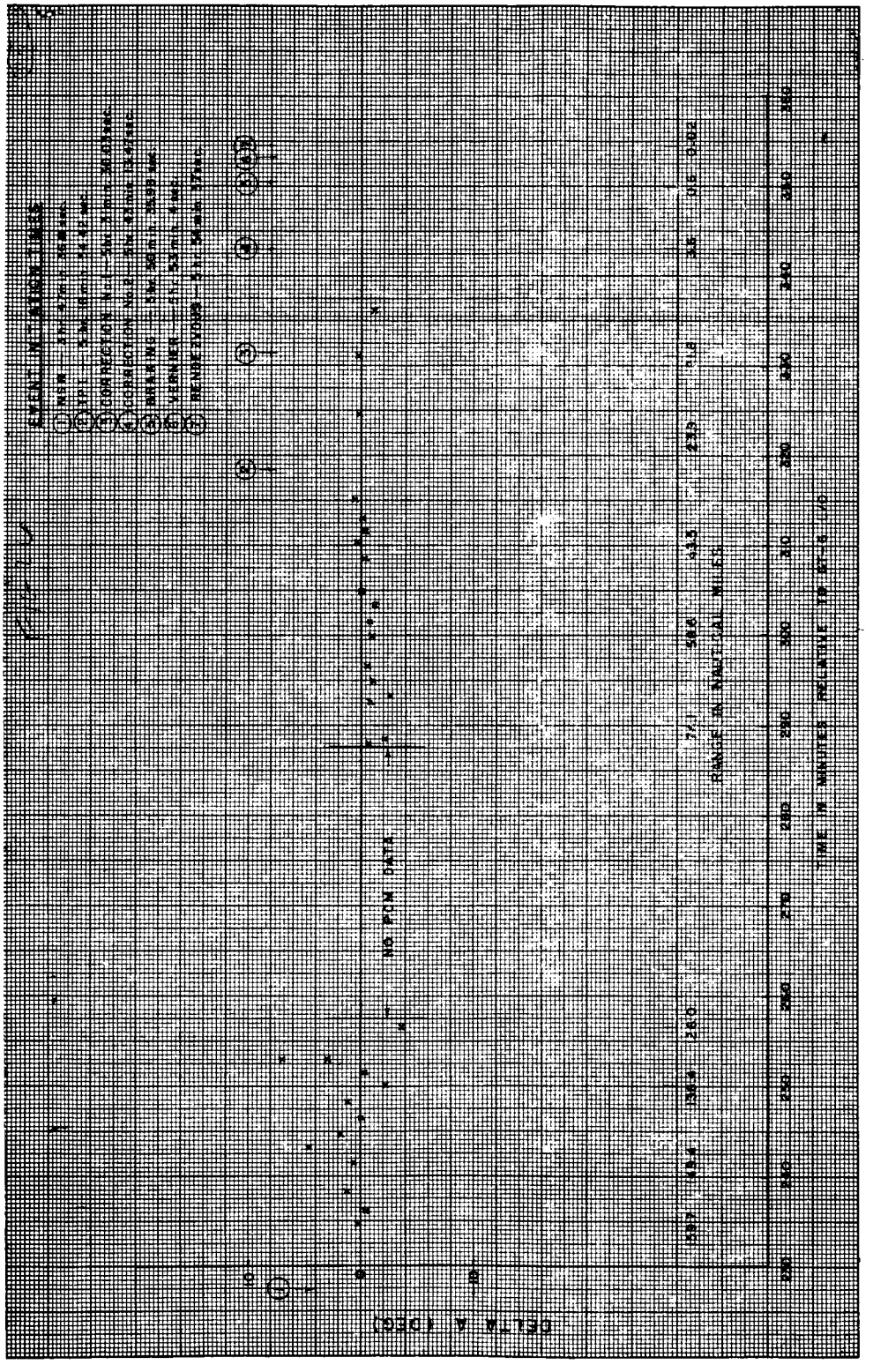

Figure 26. TRW Azimuth Comparison (Original Gemini 6 Trajectory)

CONFIDENTIAL

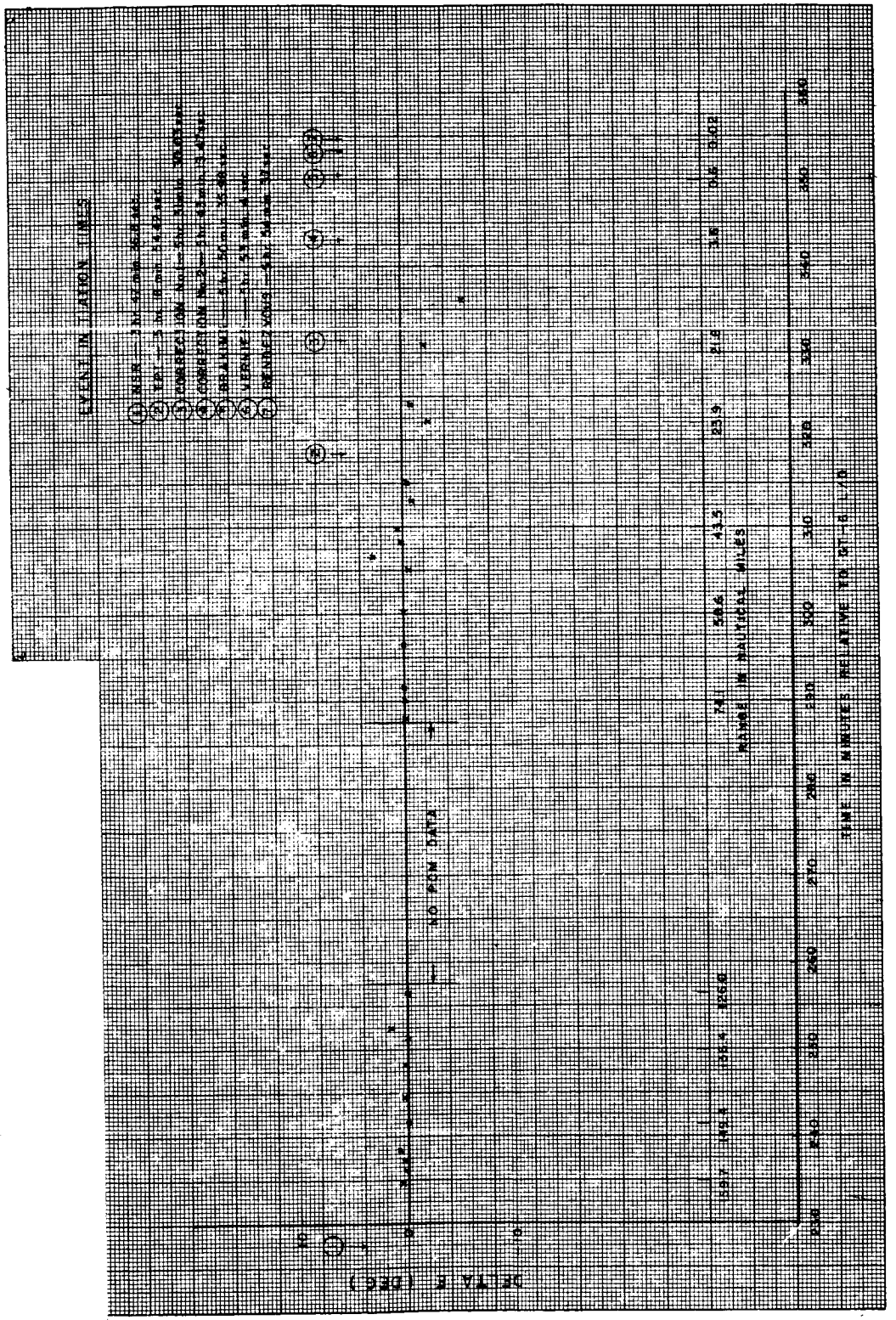

Figure 27. TRW Elevation Comparison (Original Gemini 6 Trajectory)

CONFIDENTIAL

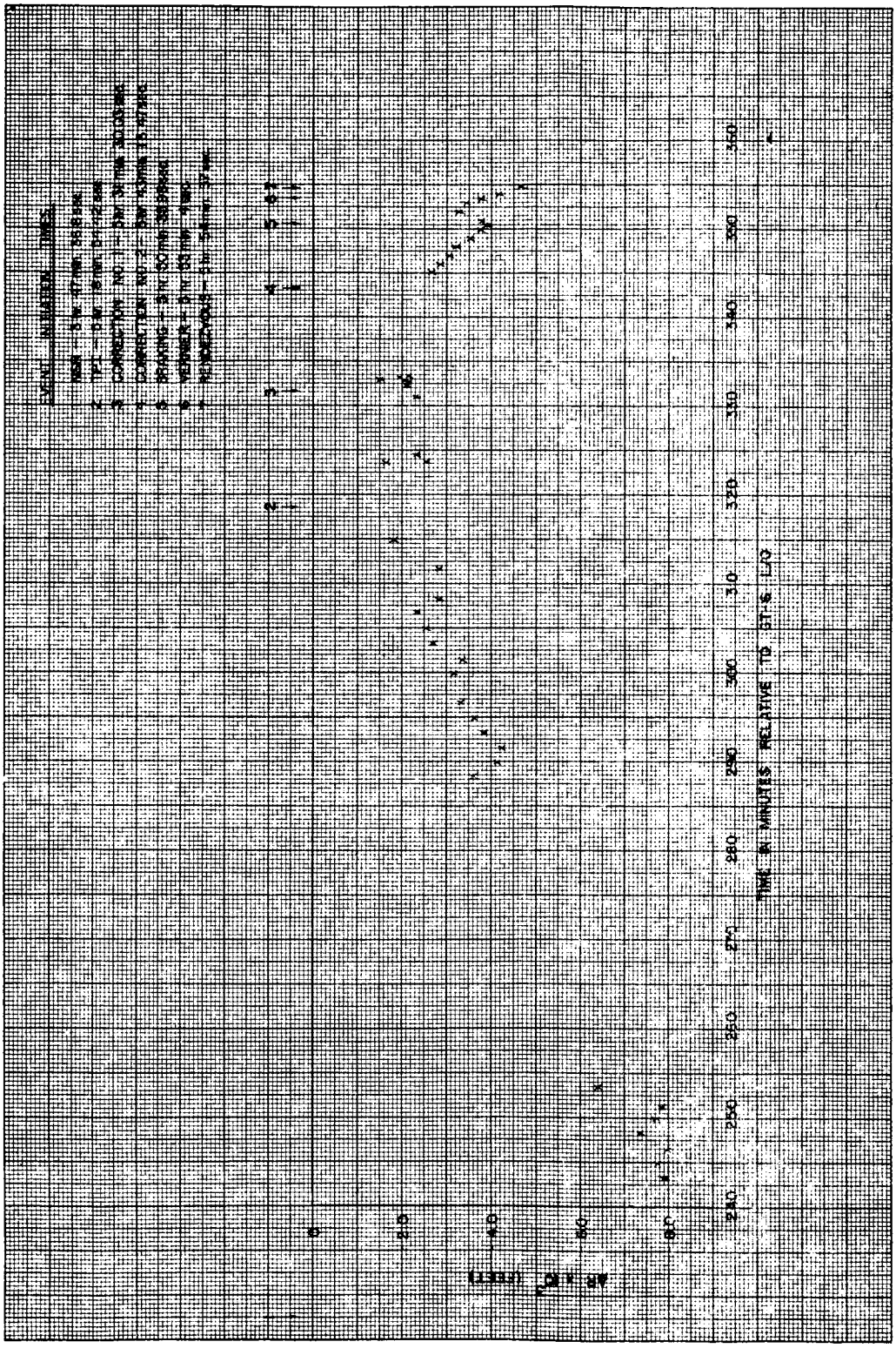

Figure 28. TRW Range Comparison (Second Gemini 6 Trajectory)

CONFIDENTIAL

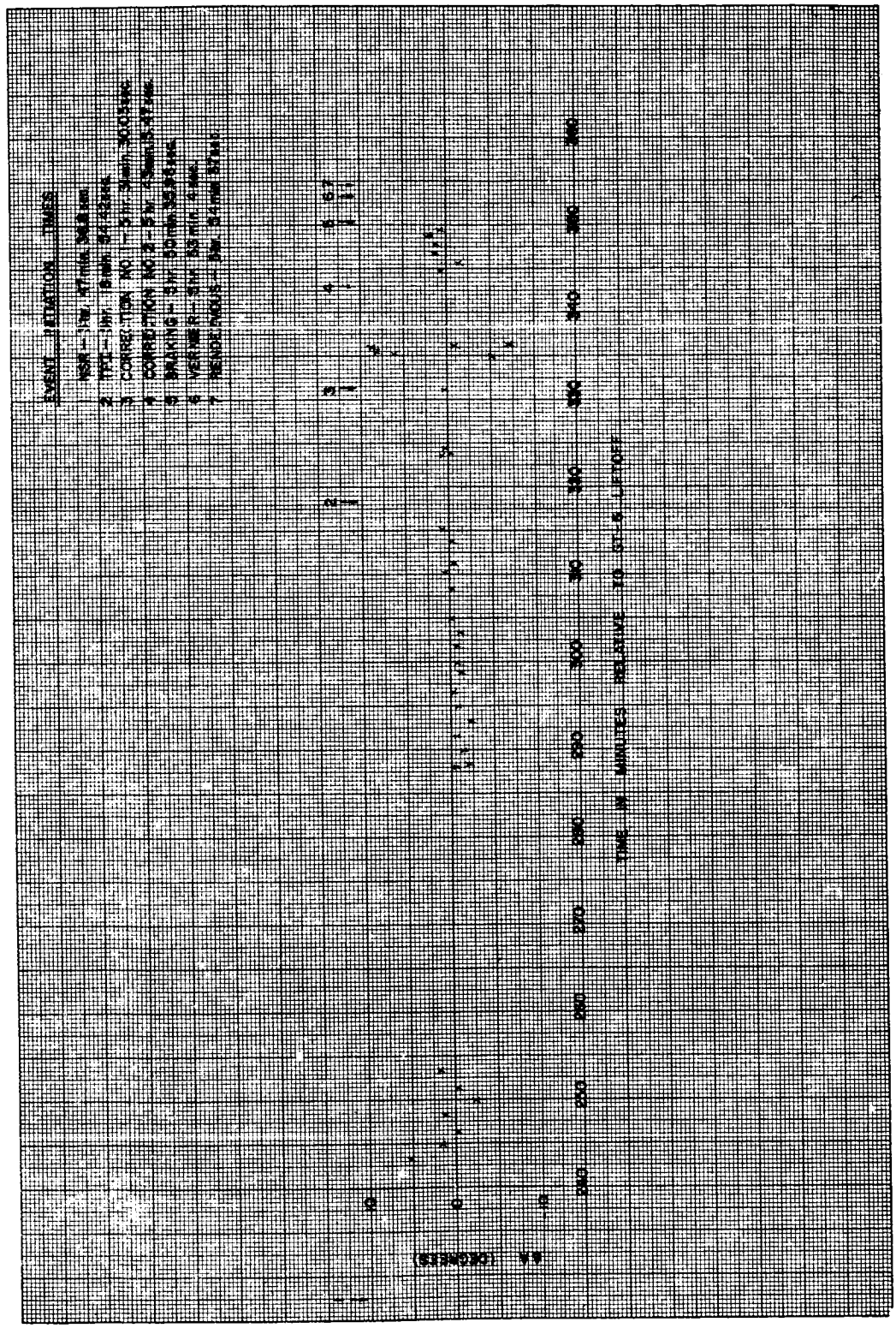

Figure 29. TRW Azimuth Comparison (Second Gemini 6 Trajectory)

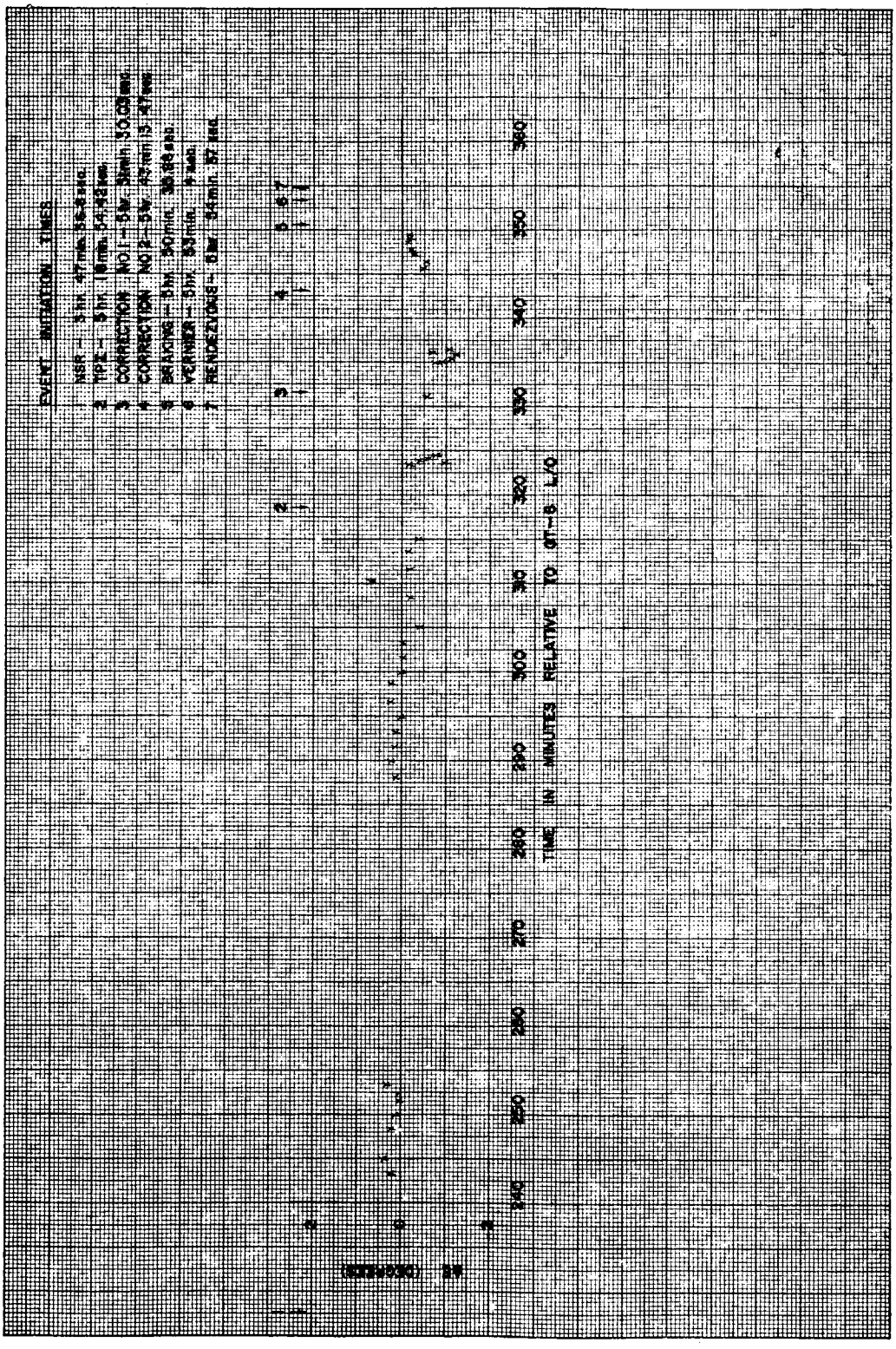

Figure 30. TRW Elevation Comparison (Second Gemini 6 Trajectory)

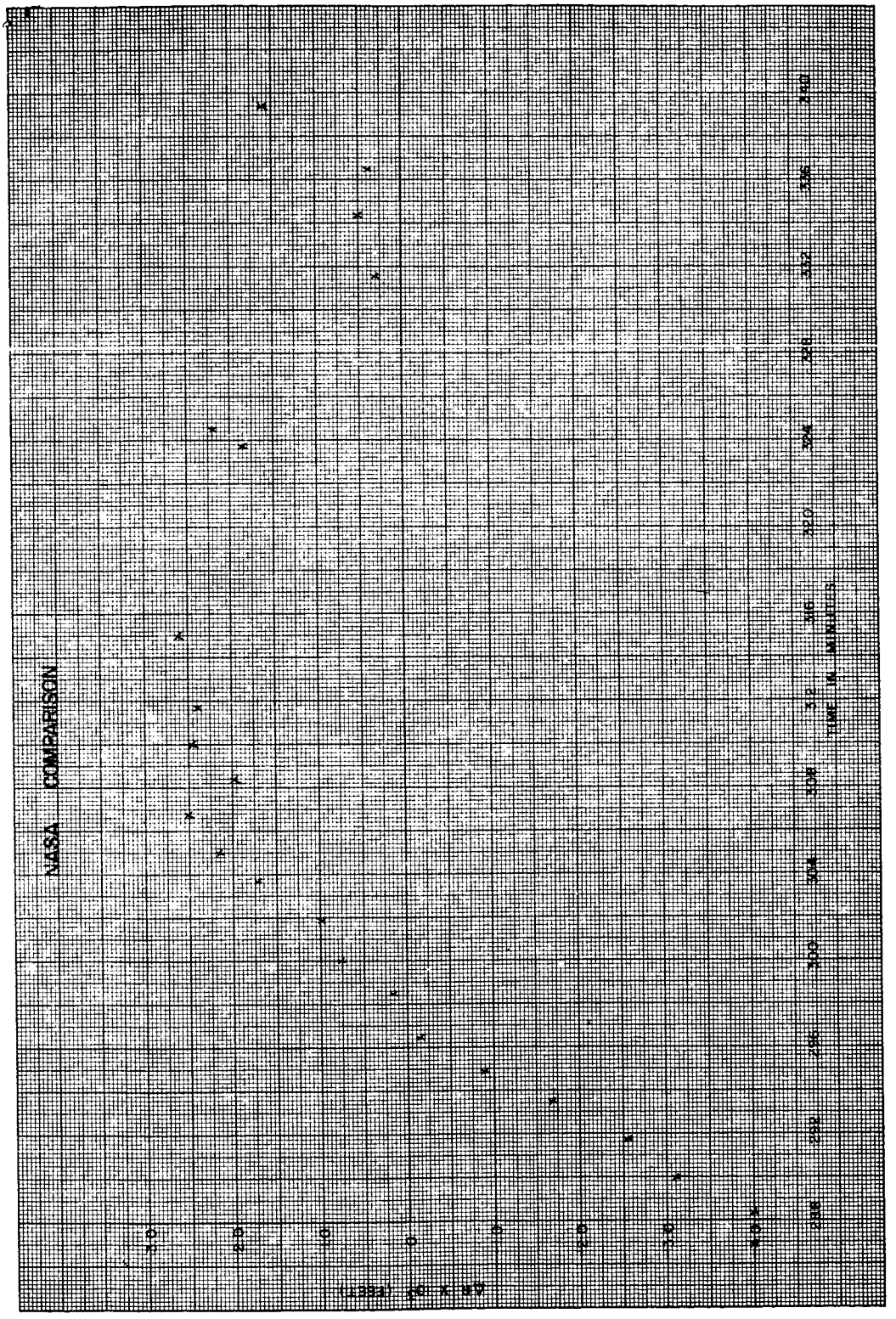

Figure 31. NASA Range Comparison (Second Gemini 6 Trajectory)

CONFIDENTIAL

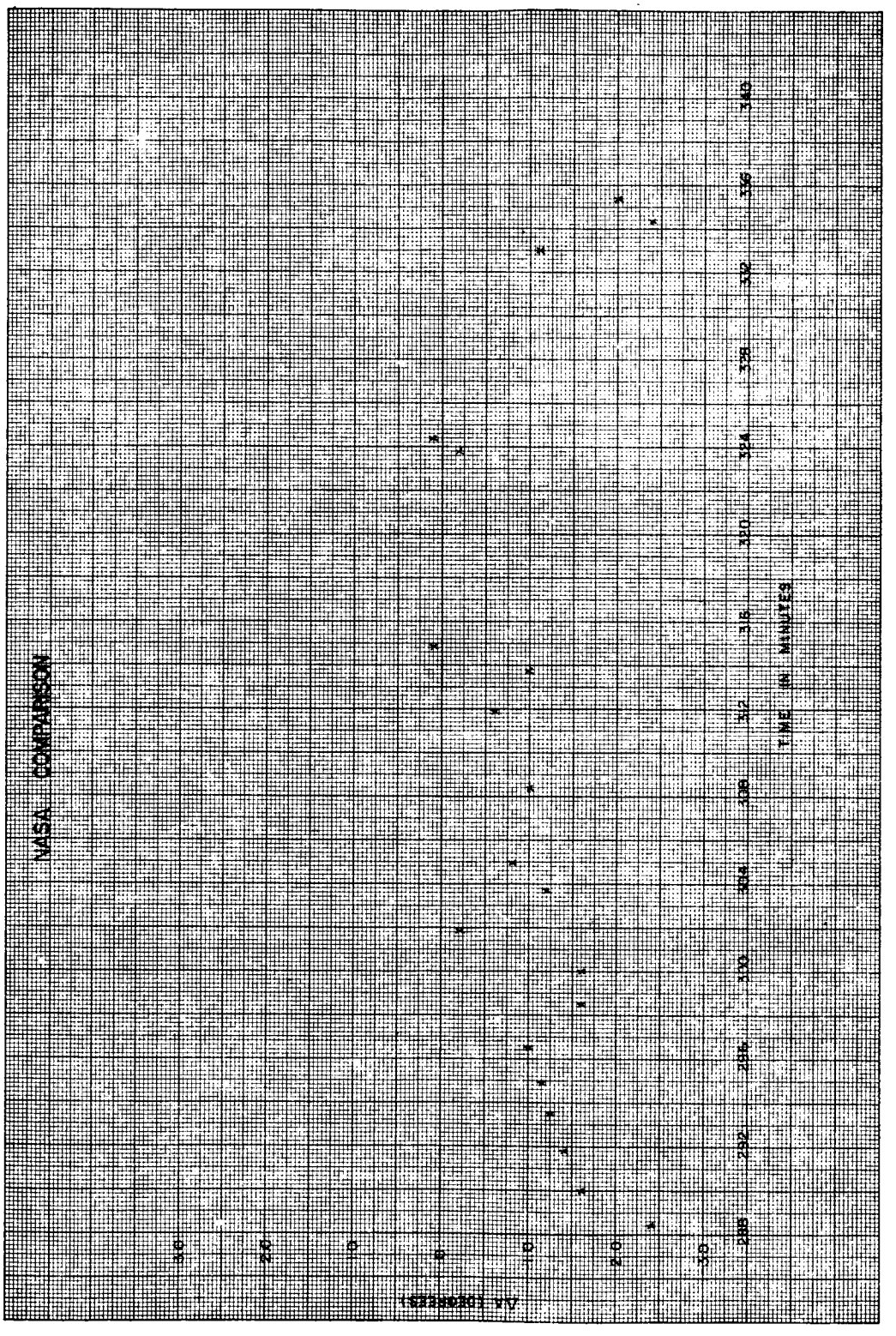

Figure 32. NASA Azimuth Comparison (Second Gemini 6 Trajectory)

CONFIDENTIAL

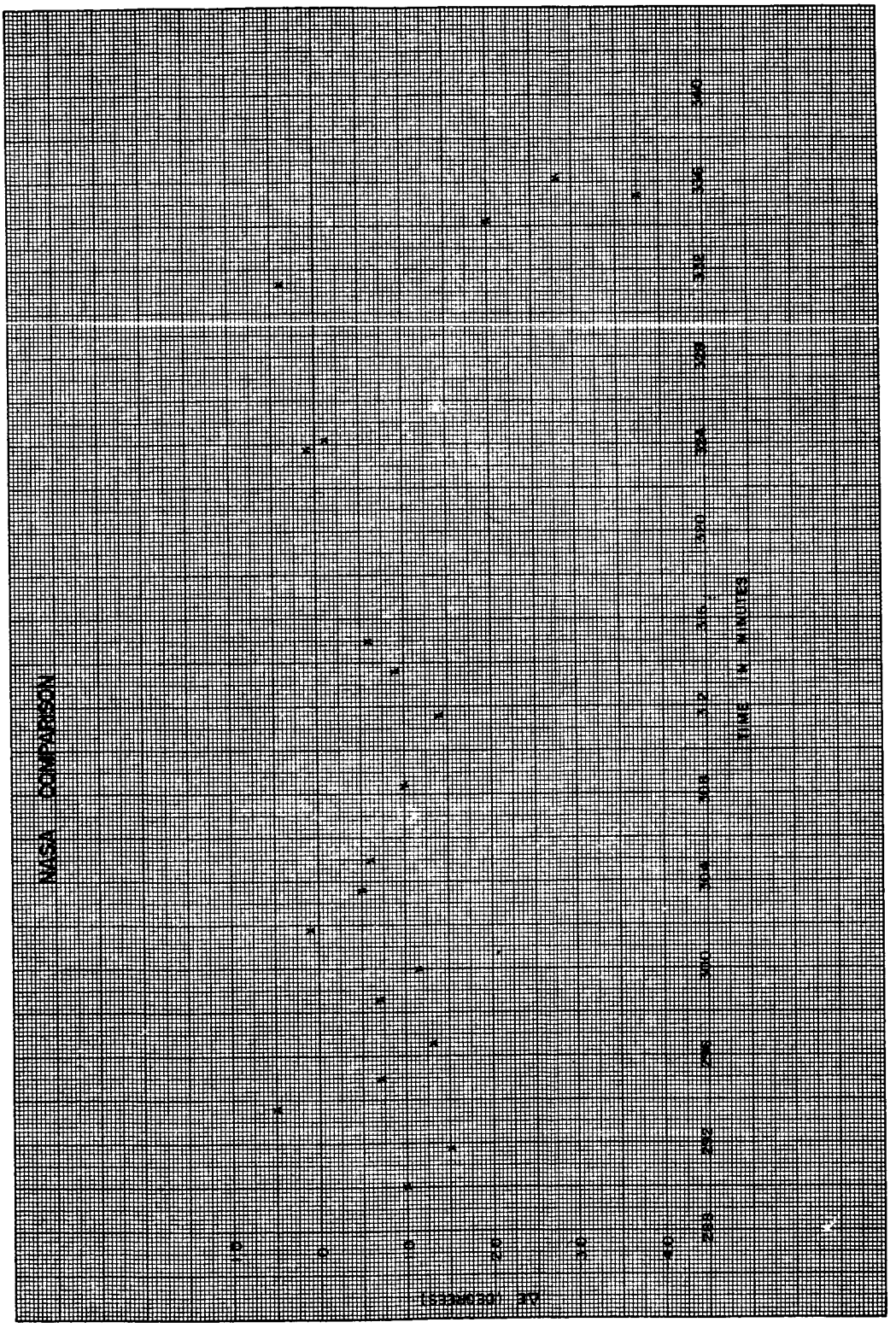

Figure 33. NASA Elevation Comparison (Second Gemini 6 Trajectory)

CONFIDENTIAL

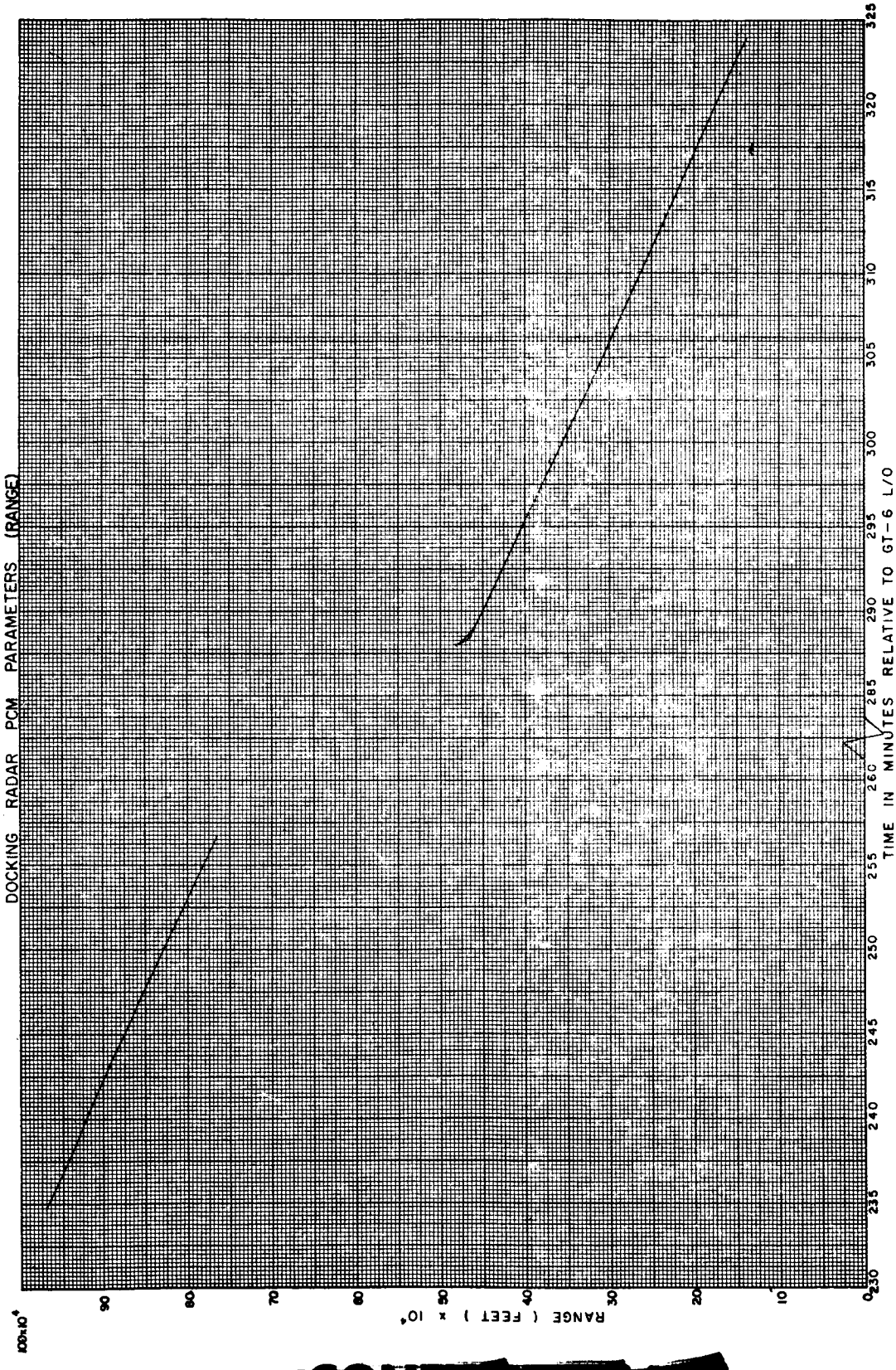

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Figure 34. Radar PCM Range (230 through 325 Seconds)

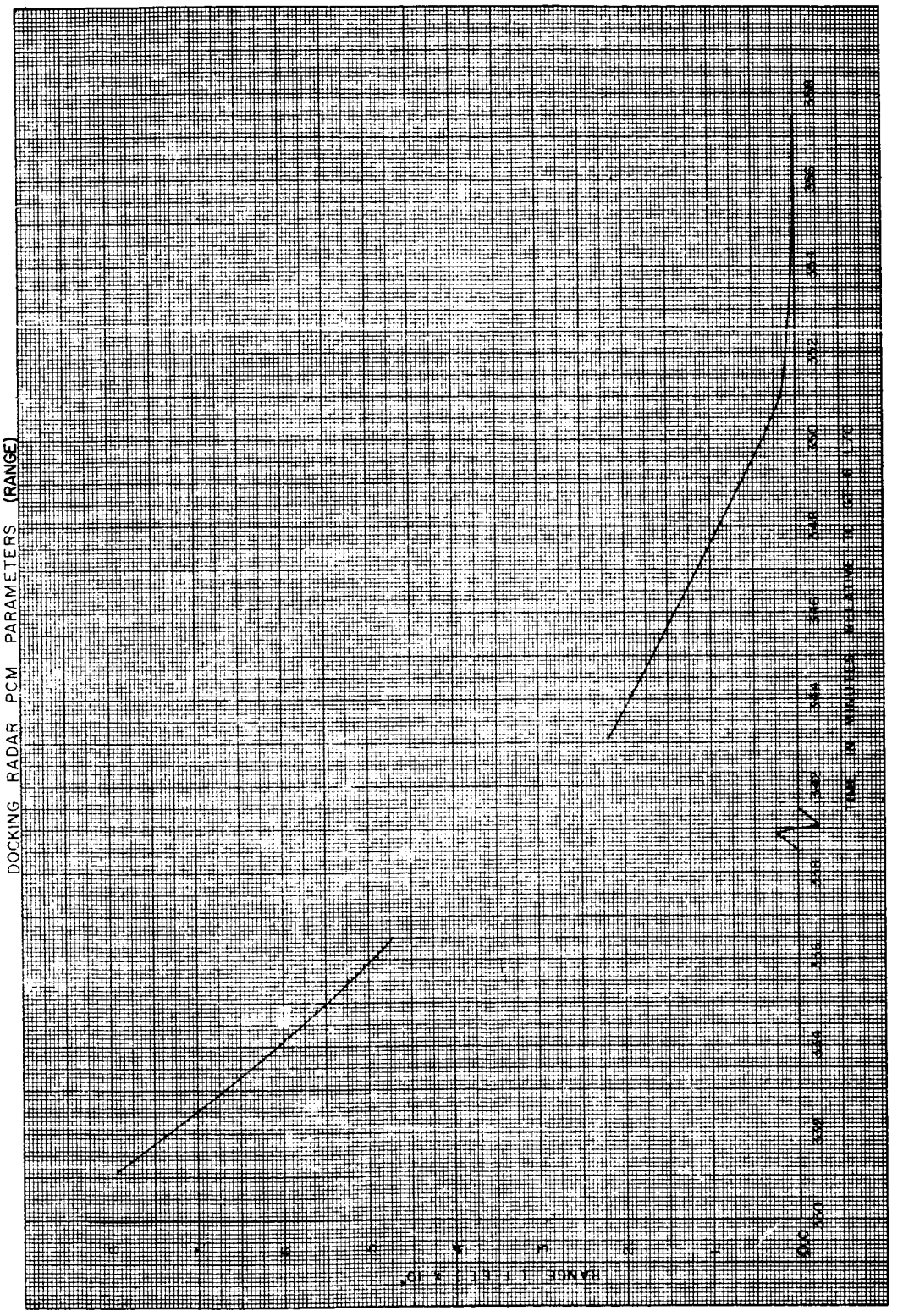

Figure 35. Radar PCM Range (330 through 358 Seconds)

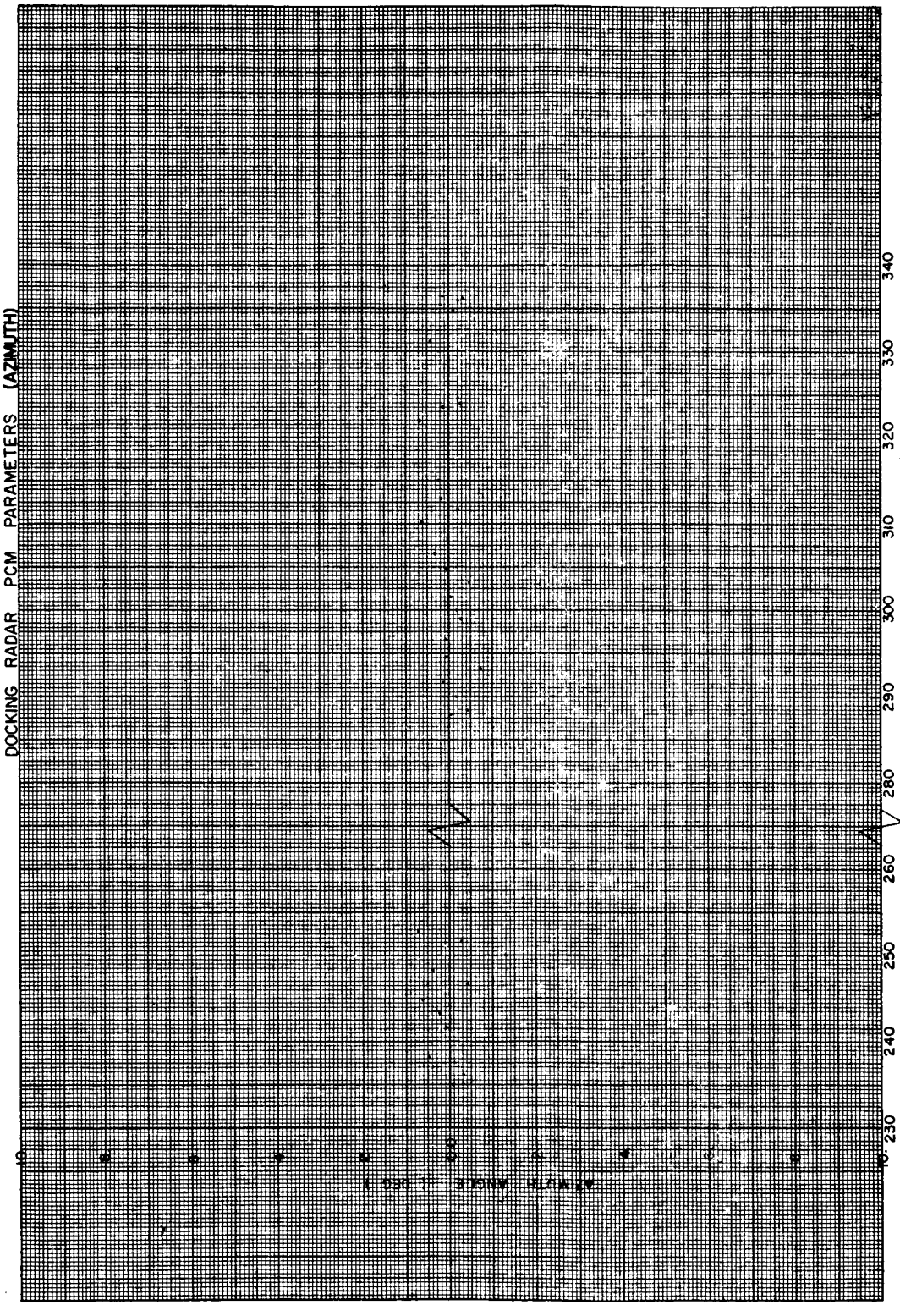

Figure 36. Radar PCM Azimuth (230 through 340 Seconds)

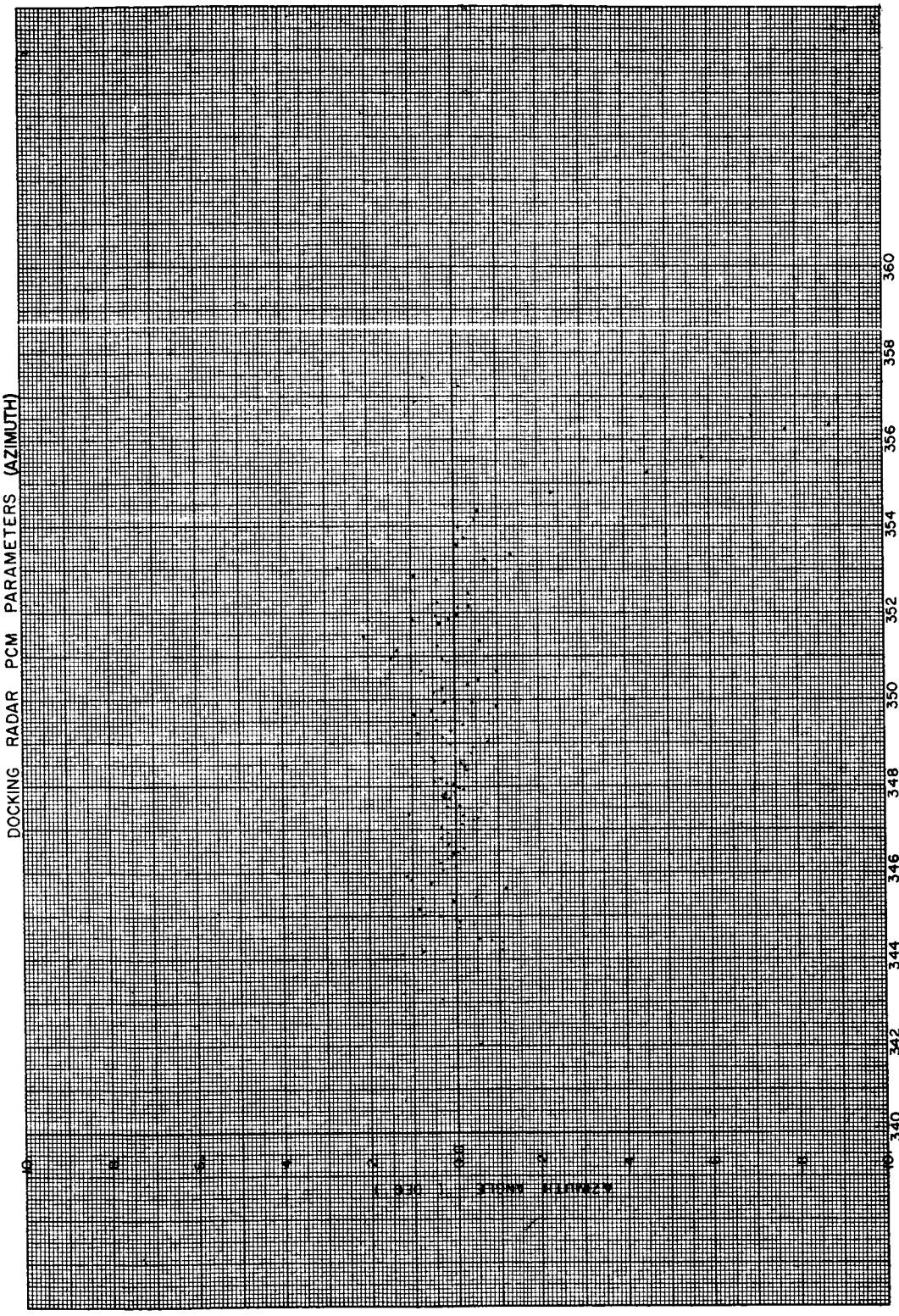

Figure 37. Radar PCM Azimuth (340 through 358 Seconds)

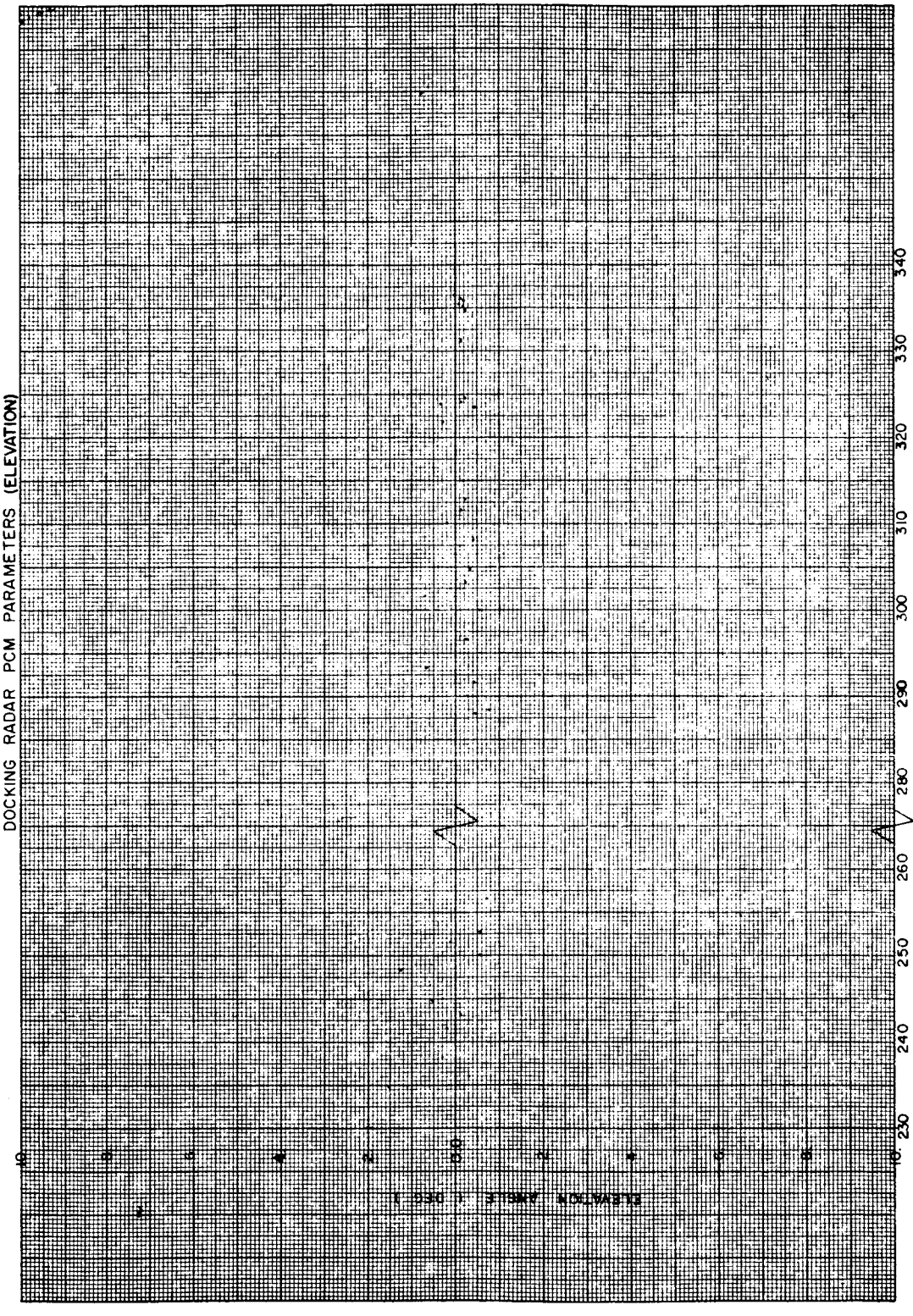

Figure 38. Radar PCM Elevation (230 through 340 Seconds)

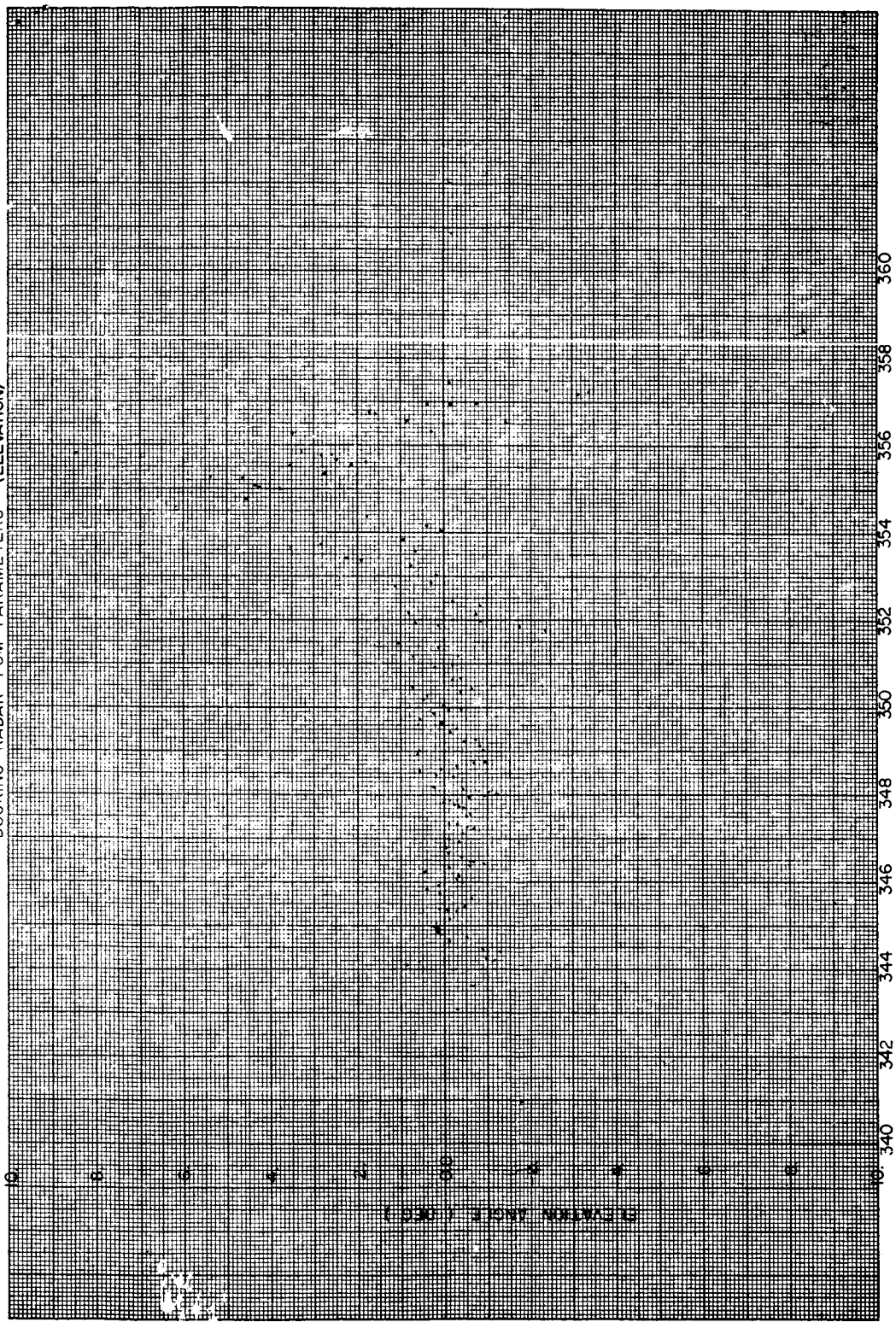

Figure 39. Radar PCM Elevation (340 through 358 Seconds)

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APPENDIX A

TRAJECTORY RECONSTRUCTION

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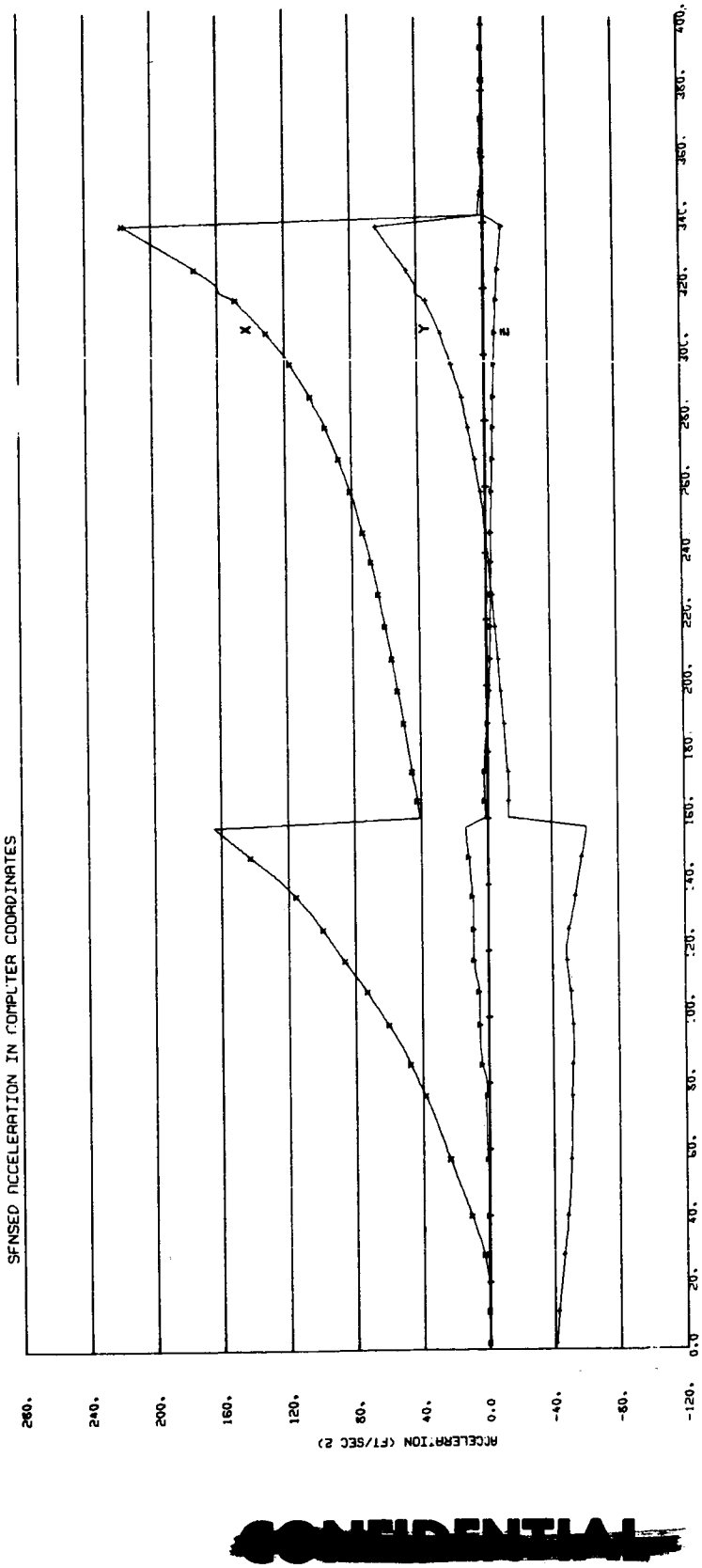

Figure A-1. Ascent Sensed Acceleration

Table A-1. Ascent Trajectory Reconstruction—Earth-Centered Inertial Coordinates

GEMINI TRAJECTORY IN ECIG

TIME IN SECONDS FROM LIFTOFF

TIME	X	Y	Z	X-DOT	Y-DOT	Z-DOT
1.642	3026477	-18152112	9927350	1325.538	208.578	6.778
4.043	3029637	-18151634	9927976	1328.659	190.923	17.103
6.442	3032803	-18151204	9928031	1331.797	172.278	27.614
8.783	3035978	-18150817	9928110	1335.142	153.036	39.057
11.163	3039160	-18150475	9928218	1338.897	133.471	50.962
13.558	3042344	-18150183	9928353	1342.511	112.767	63.098
15.915	3045534	-18149940	9928518	1346.400	91.369	75.977
18.749	3049362	-18149719	9928755	1351.362	64.796	91.698
21.138	3052545	-18149594	9928991	1355.822	40.478	104.075
23.215	3055416	-18149532	9929225	1359.978	18.944	114.979
25.705	3058810	-18149518	9929541	1366.929	-8.220	134.998
28.154	3062225	-18149573	9929899	1377.502	-35.893	152.315
30.684	3065672	-18149697	9930300	1392.065	-63.697	170.574
32.534	3068330	-18149838	9930638	1406.090	-85.081	185.626
35.076	3071961	-18150086	9931125	1427.993	-113.864	205.334
37.567	3075450	-18150406	9931663	1454.420	-142.500	226.404
40.057	3079108	-18150796	9932256	1484.978	-171.102	248.813
42.546	3082847	-18151257	9932903	1519.856	-199.573	272.553
45.035	3086679	-18151790	9933611	1559.751	-227.973	296.949
47.525	3090616	-18152392	9934381	1604.201	-256.207	322.085
49.429	3093705	-18152901	9935014	1641.390	-277.762	341.985
51.925	3097868	-18153630	9935899	1694.546	-306.099	367.426
54.422	3102171	-18154428	9936849	1752.704	-333.872	393.644
56.916	3106619	-18155298	9937865	1814.864	-361.956	421.120
59.410	3111226	-18156234	9938951	1880.254	-389.850	450.376
61.902	3115993	-18157239	9940112	1950.414	-416.072	481.421
63.808	3119769	-18158050	9941053	2006.487	-435.363	504.699
66.304	3124871	-18159166	9942360	2083.784	-459.168	540.365
68.800	3130172	-18160342	9943750	2165.748	-482.158	573.340
71.293	3135679	-18161570	9945222	2252.627	-503.119	607.098
73.783	3141401	-18162849	9946776	2343.186	-524.293	641.690
76.273	3147350	-18164180	9948418	2437.902	-545.324	676.898
78.174	3152054	-18165233	9949729	2515.050	-561.550	702.113
80.665	3158457	-18166657	9951514	2623.381	-581.610	731.722
83.157	3165135	-18168124	9953381	2735.846	-598.723	767.792
85.650	3172097	-18169638	9955347	2851.655	-612.405	811.083
88.144	3179358	-18171183	9957428	2972.077	-625.323	857.960
90.638	3186928	-18172756	9959627	3099.165	-637.099	905.180
93.134	3194829	-18174362	9961946	3232.528	-648.970	953.075
95.638	3201085	-18175605	9963796	3339.522	-658.937	989.553
97.535	3209606	-18177257	9966327	3486.157	-665.634	1037.759
100.031	3218499	-18178927	9968978	3640.284	-672.121	1086.356
102.532	3227804	-18180614	9971757	3802.441	-676.784	1135.986
105.026	3237498	-18182302	9974652	3972.307	-677.381	1185.457
107.547	3247735	-18184008	9977703	4152.118	-676.227	1235.556
109.451	3255775	-18185294	9980092	4293.165	-673.627	1273.954
111.948	3266733	-18186965	9983337	4484.319	-667.236	1326.241
114.446	3278172	-18188621	9986719	4682.403	-655.833	1383.321
116.939	3290107	-18190238	9990241	4887.469	-639.508	1440.849
119.435	3302579	-18191811	9993908	5105.988	-620.048	1497.013
121.938	3315640	-18193336	9997725	5331.801	-596.742	1553.782
123.842	3325962	-18194453	10000727	5508.945	-579.410	1598.519
126.340	3340021	-18195874	10004795	5748.591	-557.920	1658.864
128.838	3354689	-18197241	10009016	5996.594	-536.982	1720.749
131.333	3369970	-18198556	10013387	6253.809	-516.986	1783.615
133.828	3385906	-18199821	10017919	6521.397	-496.766	1849.256
136.324	3402529	-18201034	10022619	6799.714	-475.050	1917.656
138.229	3415686	-18201922	10026323	7019.463	-457.664	1972.088
140.733	3433642	-18203040	10031354	7319.273	-434.013	2045.757
143.233	3452319	-18204093	10036561	7630.788	-408.540	2122.088
145.727	3471754	-18205079	10041953	7955.777	-382.002	2201.694
148.248	3492244	-18206006	10047609	8299.385	-353.171	2285.494
150.744	3513402	-18206850	10053421	8656.297	-322.746	2372.149
152.650	3530163	-18207442	10058006	8940.178	-298.175	2441.039
155.146	3552959	-18208144	10064216	9327.942	-264.179	2534.819
157.162	3572095	-18208648	10069406	9654.276	-235.191	2613.552
160.140	3600916	-18209233	10077154	9731.841	-160.965	2595.738
162.641	3625368	-18209561	10083633	9822.770	-101.373	2585.994
165.138	3650012	-18209740	10090080	9915.711	-41.741	2577.179
167.360	3672145	-18209773	10095800	9999.914	11.572	2569.976
169.825	3696910	-18209673	10102124	10095.466	70.045	2562.121
172.290	3721913	-18209427	10108430	10192.653	129.786	2554.770
173.977	3739160	-18209173	10112733	10260.263	171.010	2548.655
176.441	3764564,	-18208677	10119002	10360.921	232.086	2540.076
178.908	3790258	-18208027	10125258	10463.280	294.096	2529.957
181.382	3816269	-18207223	10131504	10567.826	356.466	2519.177
183.846	3842438	-18206265	10137696	10674.070	420.140	2506.828
186.275	3868490	-18205169	10143768	10780.281	483.195	2493.674
188.695	3894719	-18203922	10149788	10888.355	546.762	2479.573
191.117	3921222	-18202520	10155775	10998.503	610.937	2464.057
193.538	3947983	-18200962	10161721	11110.115	676.395	2447.804
195.962	3975050	-18199243	10167632	11223.985	742.556	2430.122
198.384	4002372	-18197363	10173496	11339.120	809.845	2411.975
200.812	4030042	-18195315	10179328	11456.443	878.053	2392.617
203.233	4057932	-18193104	10185099	11575.764	947.429	2372.685
205.654	4086102	-18190726	10190818	11696.636	1017.644	2352.039
208.076	4114578	-18188175	10196489	11819.349	1089.279	2330.650
210.497	4143342	-18185450	10202105	11944.003	1161.749	2308.852
212.919	4172422	-18182547	10207669	12070.861	1235.901	2286.254
215.340	4201800	-18179465	10213177	12199.624	1310.980	2263.417
217.763	4231516	-18176196	10218632	12330.448	1387.456	2239.672
220.182	4261503	-18172746	10224020	12463.168	1465.047	2215.360
222.608	4291911	-18169095	10229366	12598.238	1544.455	2190.434
225.028	4322563	-18165260	10234637	12735.351	1625.125	2165.153
227.448	4353550	-18161229	10239845	12874.563	1706.965	2139.488
229.868	4384876	-18156998	10244991	13016.034	1790.017	2113.305
232.289	4416560	-18152562	10250075	13159.897	1874.797	2086.336
234.714	4448647	-18147912	10255101	13306.666	1960.748	2058.958
237.140	4481107	-18143049	10260062	13455.916	2048.650	2031.140
238.862	4503558	-18139594	10263422	13559.297	2109.540	2011.983
241.233	4536716	-18134355	10268280	13713.308	2199.863	1983.483
243.660	4570184	-18128905	10273058	13869.266	2291.900	1954.690

Table A-1. Ascent Trajectory Reconstruction—Earth-Centered Inertial Coordinates (Continued)

GEMINI TRAJECTORY IN ECIG

TIME IN SECONDS FROM LIFTOFF

TIME	X	Y	Z	X-DOT	Y-DOT	Z-DOT
246.087	4604034	-18123230	10277766	14028.436	2385.626	1925.287
248.513	4638260	-18117327	10282400	14190.511	2481.343	1895.219
250.959	4673176	-18111136	10286959	14356.602	2578.470	1864.629
253.406	4708517	-18104708	10291524	14526.145	2677.052	1833.295
255.856	4744306	-18098024	10295975	14699.036	2779.929	1801.177
258.302	4780479	-18091097	10300341	14874.907	2883.710	1768.465
260.752	4817144	-18083903	10304633	15054.567	2989.448	1734.769
263.205	4854300	-18076436	10308846	15238.330	3098.158	1699.967
265.655	4891865	-18068710	10312969	15425.417	3208.969	1664.593
268.102	4929833	-18060723	10316996	15616.312	3321.713	1628.253
270.550	4968303	-18052449	10320937	15811.020	3437.723	1591.058
272.996	5007223	-18043895	10324783	16009.978	3555.847	1553.221
275.444	5046568	-18035041	10328539	16213.668	3677.419	1514.288
277.889	5086553	-18025901	10332191	16421.435	3801.612	1474.304
280.336	5127000	-18016443	10335750	16634.123	3928.545	1433.834
282.015	5155048	-18009774	10338133	16782.891	4017.584	1405.127
284.460	5196357	-17999788	10341519	17004.029	4149.858	1362.811
286.903	5238179	-17989484	10344795	17230.635	4284.936	1319.625
289.351	5280630	-17978829	10347970	17463.195	4424.099	1274.396
291.707	5322051	-17968242	10350923	17693.052	4561.847	1231.052
294.021	5363250	-17957528	10353720	17924.390	4700.772	1186.439
297.064	5418267	-17942938	10357237	18237.069	4889.963	1125.268
299.381	5460812	-17931434	10359790	18482.517	5039.008	1077.288
301.707	5504098	-17919534	10362238	18735.621	5192.973	1027.655
304.025	5547834	-17907313	10364562	18995.221	5351.097	976.648
306.343	5592161	-17894724	10366765	19262.402	5514.116	923.979
308.658	5637078	-17881764	10368841	19536.977	5681.964	869.648
310.982	5682796	-17868362	10370797	19821.548	5856.007	813.161
313.297	5729028	-17854596	10372612	20113.895	6035.439	754.661
316.340	5790837	-17835858	10374787	20513.004	6282.125	674.221
316.657	5838737	-17821075	10376276	20828.797	6477.642	610.898
320.983	5867569	-17805771	10377420	21157.520	6681.430	544.273
323.302	5937011	-17790038	10378803	21497.491	6892.330	475.580
325.621	5987279	-17773800	10379824	21851.271	7111.378	404.083
327.938	6038319	-17757065	10380675	22219.990	7339.167	330.151
330.254	6090231	-17739792	10381351	22603.969	7576.745	253.015
332.577	6143209	-17721905	10381844	23006.745	7824.852	172.115
334.892	6196941	-17703496	10382147	23427.011	8083.910	88.294
337.942	6269260	-17678307	10382245	23980.917	8429.105	-24.325
338.737	6288369	-17671574	10382214	24127.321	8520.559	-54.244
340.093	6321204	-17659938	10382112	24213.191	8600.802	-85.643
342.405	6377183	-17639976	10381873	24200.295	8662.878	-120.959
344.528	6428546	-17621525	10381583	24185.587	8718.604	-152.376
346.660	6480089	-17602879	10381225	24169.514	8773.971	-184.096
348.938	6535110	-17582831	10380767	24150.498	8832.259	-218.131
354.408	6667095	-17534135	10379349	24100.369	8969.906	-299.618
356.505	6717604	-17515274	10378689	24080.243	9022.292	-330.477
358.603	6768095	-17496293	10377962	24060.182	9074.731	-362.081
361.823	6845534	-17466935	10376719	24030.882	9155.984	-410.040
363.887	6895106	-17447988	10375841	24011.802	9207.968	-440.915
366.605	6960331	-17422870	10374587	23986.612	9276.546	-481.878
368.663	7009690	-17403720	10373563	23967.525	9328.190	-513.086
371.381	7074794	-17378277	10372114	23942.295	9395.486	-553.336
373.438	7124014	-17358901	10370944	23922.263	9446.819	-584.381
376.261	7191511	-17332131	10369235	23893.251	9516.784	-626.146
378.433	7243380	-17311404	10367840	23871.047	9570.568	-658.330

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Table A-2a. Ascent Trajectory Reconstruction—Special Earth-Fixed Coordinates

GEMINI 6C RECONSTRUCTED ASCENT TRAJECTORY

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
1.642	1341.6	14.0	.958	89.954	10.5	28.507	-80.555
4.023	1342.4	24.6	1.680	89.974	48.5	28.507	-80.555
6.402	1343.2	36.7	2.471	89.967	177.2	28.507	-80.555
8.783	1344.5	50.1	3.397	89.938	330.5	28.507	-80.555
11.163	1346.5	103.0	4.785	89.899	556.2	28.507	-80.555
13.538	1348.7	137.4	5.620	89.874	870.7	28.507	-80.555
15.918	1351.6	152.8	6.483	89.835	1142.5	28.507	-80.555
18.760	1356.0	184.0	7.499	89.808	1640.5	28.507	-80.555
21.138	1360.4	217.2	8.013	89.764	2115.7	28.507	-80.555
23.515	1365.3	238.6	10.071	89.728	2564.5	28.507	-80.555
25.705	1372.4	271.2	11.385	89.668	3210.6	28.507	-80.555
28.164	1380.4	305.4	12.714	89.643	3836.7	28.507	-80.555
30.484	1403.0	341.0	14.098	89.579	4730.5	28.508	-80.555
32.564	1420.8	368.7	15.023	89.488	5412.8	28.508	-80.554
35.076	1447.2	408.5	16.266	89.412	6377.6	28.508	-80.554
37.567	1478.8	451.4	17.512	89.302	7437.2	28.508	-80.554
40.057	1515.4	497.5	18.476	89.164	8505.0	28.508	-80.553
42.546	1556.6	541.2	19.747	88.998	9853.7	28.508	-80.552
45.035	1604.0	590.6	20.772	88.839	11217.5	28.508	-80.551
47.535	1656.2	647.7	21.606	88.671	12687.5	28.509	-80.550
50.020	1709.5	696.5	22.343	88.541	13885.5	28.509	-80.549
52.525	1765.7	746.2	23.103	88.417	15554.5	28.509	-80.547
54.622	1827.1	807.8	23.767	88.287	17336.2	28.509	-80.546
56.916	1897.6	876.5	24.377	88.148	19231.7	28.510	-80.541
59.410	1977.4	944.8	24.936	87.978	21245.7	28.510	-80.538
61.907	2061.6	1018.6	25.287	87.758	23379.0	28.511	-80.535
63.838	2114.8	1077.0	25.704	87.569	25091.2	28.511	-80.531
64.304	2200.7	1157.7	26.031	87.307	27442.7	28.512	-80.527
68.800	2291.2	1241.2	26.270	87.001	29914.0	28.512	-80.522
71.203	2386.6	1328.9	26.419	86.847	32502.0	28.513	-80.516
73.783	2485.4	1420.2	26.548	86.655	35209.0	28.514	-80.509
76.277	2588.2	1514.0	26.647	86.463	38036.2	28.515	-80.502
78.174	2670.0	1592.6	26.668	86.375	40290.0	28.516	-80.496
80.665	2784.6	1697.4	26.604	86.356	43227.7	28.517	-80.488
83.157	2903.0	1807.6	26.527	86.183	46408.7	28.518	-80.479
85.650	3027.2	1923.7	26.435	85.980	49795.2	28.519	-80.469
88.144	3156.0	2045.4	26.340	85.567	53223.5	28.520	-80.458
90.639	3290.0	2173.1	26.234	85.257	56783.5	28.522	-80.446
93.134	3432.0	2307.2	26.085	84.592	60490.5	28.524	-80.433
95.038	3544.5	2414.2	25.916	84.213	63392.7	28.525	-80.422
97.535	3697.8	2560.2	25.694	84.567	67330.7	28.527	-80.408
100.031	3857.0	2713.0	25.435	84.401	71402.0	28.529	-80.392
102.532	4025.7	2873.2	25.142	84.214	75615.5	28.532	-80.375
105.026	4200.4	3040.2	24.814	84.053	79949.5	28.535	-80.356
107.547	4384.5	3216.7	24.457	83.935	84461.7	28.537	-80.337
109.451	4528.6	3355.1	24.175	83.801	87958.2	28.540	-80.321
111.968	4723.7	3547.0	23.793	83.653	92656.2	28.543	-80.299
114.464	4926.3	3738.7	23.396	83.485	97480.0	28.546	-80.275
116.539	5137.3	3942.7	22.966	83.267	102423.2	28.550	-80.250
119.435	5366.6	4166.7	22.510	83.116	107488.0	28.554	-80.223
121.938	5595.6	4377.6	22.049	82.877	112682.5	28.558	-80.195
123.862	5765.4	4552.1	21.714	82.880	116712.7	28.561	-80.172
126.360	6000.1	4790.2	21.319	82.771	121110.0	28.566	-80.140
128.838	6261.7	5037.6	20.955	82.680	127640.2	28.571	-80.107
131.333	6523.7	5294.0	20.415	82.613	133304.7	28.576	-80.071
133.828	6796.7	5563.5	20.306	82.552	139118.5	28.582	-80.034
136.324	7080.9	5843.7	20.005	82.492	145090.7	28.587	-79.995
138.220	7305.6	6065.4	19.766	82.446	149756.5	28.592	-79.963
140.733	7617.2	6368.6	19.510	82.383	156049.7	28.598	-79.919
143.232	7930.9	6683.6	19.243	82.344	162492.2	28.605	-79.874
145.727	8263.6	7013.2	18.991	82.269	169111.7	28.612	-79.826
148.268	8615.6	7362.0	18.744	82.258	175900.5	28.619	-79.775
150.744	8981.2	7724.7	18.509	82.222	183020.0	28.627	-79.721
152.650	9272.2	8013.6	18.336	82.197	188520.7	28.633	-79.679
155.146	9666.8	8408.5	18.117	82.167	195021.5	28.641	-79.621
157.142	10004.5	8741.1	17.948	82.146	202068.0	28.648	-79.571
160.140	10073.4	8805.0	17.544	82.190	211174.5	28.659	-79.497
162.641	10158.0	8887.2	17.219	82.243	218740.5	28.668	-79.433
165.138	10245.2	8971.5	16.902	82.293	226223.0	28.677	-79.369
167.360	10324.9	9048.4	16.625	82.335	232824.0	28.685	-79.312
169.935	10415.7	9136.5	16.327	82.386	240082.5	28.694	-79.247
172.290	10508.6	9226.5	16.029	82.437	247276.5	28.703	-79.182
173.677	10573.5	9289.5	15.827	82.473	252161.5	28.709	-79.136
176.441	10670.3	9383.6	15.531	82.529	259243.2	28.718	-79.070
178.908	10768.8	9479.4	15.234	82.590	266269.2	28.727	-79.002
181.382	10860.8	9577.7	14.939	82.654	273244.0	28.736	-78.934
183.866	10972.5	9677.8	14.644	82.730	280122.2	28.745	-78.864
186.279	11075.5	9778.2	14.354	82.807	286834.5	28.753	-78.795
188.659	11180.5	9880.7	14.067	82.889	293457.0	28.762	-78.726
191.117	11287.7	9985.4	13.781	82.978	300017.2	28.771	-78.655
193.538	11396.7	10391.0	13.495	83.069	306496.5	28.780	-78.584
195.662	11508.0	10760.6	13.210	83.166	312915.7	28.789	-78.511
198.194	11621.1	10311.6	12.926	83.263	319247.0	28.797	-78.438
200.812	11736.5	10424.7	12.643	83.365	325540.0	28.806	-78.364

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Table A-2a. Ascent Trajectory Reconstruction—Special Earth-Fixed Coordinates (Continued)

GEMINI 6C RECONSTRUCTED ASCENT TRAJECTORY

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
203.223	11854.2	10540.3	12.361	83.448	331732.5	28.815	-78.289
205.654	11974.1	10657.0	12.082	83.574	337847.0	28.823	-78.213
208.074	12096.1	10777.7	11.803	83.680	343896.7	28.832	-78.136
210.467	12220.5	10900.0	11.527	83.787	349946.2	28.840	-78.058
212.919	12347.5	11024.9	11.251	83.895	355720.5	28.849	-77.979
215.340	12476.0	11152.4	10.978	84.003	361530.7	28.857	-77.899
217.763	12608.8	11282.3	10.708	84.113	367254.0	28.866	-77.818
220.183	12743.0	11414.7	10.439	84.224	372890.7	28.874	-77.736
222.602	12880.2	11550.0	10.173	84.335	378440.2	28.882	-77.653
225.024	13019.0	11688.0	9.905	84.444	383930.5	28.890	-77.569
227.444	13159.3	11828.4	9.643	84.554	389331.5	28.898	-77.484
229.868	13302.4	11972.1	9.384	84.667	394617.7	28.906	-77.397
232.288	13448.5	12118.5	9.125	84.779	399835.2	28.914	-77.310
234.714	13597.0	12269.5	8.872	84.892	404937.0	28.922	-77.221
237.140	13747.7	12421.7	8.619	85.004	410029.5	28.930	-77.131
239.567	13900.1	12575.1	8.368	85.081	414442.5	28.935	-77.068
241.993	14029.4	12647.7	8.702	85.193	418361.5	28.943	-76.976
243.660	14102.6	12748.8	7.958	85.304	423182.0	28.950	-76.883
244.887	14358.5	13014.4	7.714	85.416	427913.5	28.958	-76.788
246.113	14520.5	13183.5	7.478	85.529	432553.0	28.965	-76.692
247.340	14705.0	13367.4	7.249	85.642	437141.2	28.973	-76.594
248.568	14894.3	13555.4	7.029	85.756	441639.7	28.980	-76.494
249.796	15067.4	13717.7	6.777	85.871	446049.0	28.987	-76.393
251.307	15244.7	13903.4	6.548	85.985	450358.5	28.994	-76.291
252.752	15446.2	14094.1	6.322	86.101	454580.7	29.001	-76.187
253.975	15642.7	14289.6	6.055	86.218	458711.5	29.008	-76.082
255.655	15843.6	14489.2	5.893	86.335	462730.0	29.015	-75.975
256.177	16048.5	14693.4	5.693	86.453	466662.5	29.021	-75.866
270.550	16258.5	14902.5	5.496	86.571	470488.7	29.028	-75.756
272.704	16472.5	15116.4	5.219	86.689	474211.5	29.034	-75.645
274.444	16690.7	15334.4	5.004	86.807	477834.5	29.040	-75.532
277.995	16912.3	15557.2	4.792	86.924	481367.7	29.046	-75.417
280.734	17151.8	15795.5	4.586	87.045	484761.2	29.052	-75.300
282.915	17316.2	15956.5	4.441	87.128	487041.0	29.056	-75.219
284.660	17556.1	16195.7	4.237	87.248	490271.7	29.062	-75.099
286.403	17806.4	16443.7	4.037	87.369	493393.5	29.067	-74.978
288.251	18050.0	16688.3	3.837	87.490	496411.2	29.072	-74.854
291.757	18317.1	16955.5	3.647	87.607	499217.2	29.077	-74.734
294.021	18588.5	17205.7	3.461	87.724	501862.2	29.082	-74.613
297.644	18814.8	17551.3	3.217	87.878	505180.2	29.088	-74.452
299.381	19187.4	17823.5	3.032	87.956	507500.5	29.092	-74.327
301.707	19469.1	18104.8	2.847	88.115	509800.0	29.096	-74.200
304.027	19758.7	18393.5	2.664	88.235	512099.2	29.100	-74.071
306.342	20057.4	18692.2	2.484	88.355	514175.2	29.104	-73.939
308.650	20365.0	18998.5	2.305	88.477	516133.5	29.107	-73.806
310.592	20686.5	19318.7	2.125	88.600	517970.2	29.110	-73.670
313.757	21017.4	19647.3	1.947	88.725	519697.7	29.113	-73.533
316.740	21464.0	20087.5	1.711	88.899	521763.5	29.117	-73.348
318.657	21821.4	20454.6	1.523	89.015	523185.5	29.119	-73.205
320.683	22204.1	20827.1	1.385	89.143	524477.5	29.122	-73.058
323.302	22580.5	21213.4	1.178	89.273	525624.2	29.124	-72.909
325.621	22982.0	21615.5	1.003	89.404	526633.5	29.125	-72.758
327.938	23403.0	22035.5	.831	89.536	527494.2	29.126	-72.603
330.244	23861.2	22477.6	.660	89.670	528207.0	29.128	-72.446
332.577	24301.6	22933.6	.489	89.807	528760.7	29.128	-72.285
334.892	24782.7	23415.0	.321	89.945	529170.2	29.129	-72.121
337.942	25419.2	24051.4	.119	90.129	529457.5	29.128	-71.900
339.737	25587.7	24220.0	.061	90.173	529488.7	29.128	-71.841
340.863	25688.5	24327.7	.029	90.234	529506.2	29.128	-71.740
343.405	25784.4	24336.6	.027	90.321	529534.5	29.127	-71.568
344.528	25789.5	24341.7	.027	90.403	529550.2	29.126	-71.411
346.660	25793.5	24345.7	.027	90.484	529584.0	29.125	-71.252
348.998	25795.8	24348.0	.028	90.571	529610.2	29.124	-71.083
354.405	25797.2	24349.5	.030	90.780	529678.2	29.119	-70.676
356.525	25797.1	24349.5	.031	90.859	529703.2	29.117	-70.520
358.603	25797.2	24349.6	.032	90.940	529730.7	29.115	-70.364
361.993	25719.3	24351.5	.033	91.062	529774.2	29.111	-70.125
363.887	25770.5	24352.8	.034	91.141	529802.7	29.108	-69.971
366.605	25722.5	24354.7	.034	91.248	529840.5	29.104	-69.769
369.463	25723.5	24356.1	.035	91.335	529868.7	29.101	-69.616
371.781	25725.8	24358.0	.038	91.430	529900.2	29.097	-69.414
373.638	25726.5	24358.8	.039	91.509	529941.5	29.093	-69.261
376.241	25726.4	24358.8	.040	91.616	529984.2	29.088	-69.051
378.439	25726.6	24358.8	.042	91.698	530022.0	29.083	-68.890

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Table A-2b. Ascent Trajectory Reconstruction—Special Earth-Fixed Coordinates

GEMINI AC RECONSTRUCTED ASCENT TRAJECTORY

TIME * (SEC)	RELATIVE FLT. PATH ANGLE (DEGREES)	RELATIVE HEADING ANGLE (DEGREES)	TARTIAL LONG. (DEGREES)	GEOCENTRIC LAT. (DEGREES)	RADIUS TO EARTH CENTER (FEET)
4.921	89.210	-42.807	-80.534	28.364	20905874.0
7.387	88.995	1.454	-80.524	28.364	20909934.0
9.841	89.210	2.187	-80.514	28.365	20910042.7
12.062	88.544	7.749	-80.504	28.365	20910205.0
14.462	88.647	15.455	-80.494	28.366	20910421.7
16.917	88.633	14.720	-80.485	28.366	20910689.2
19.194	88.605	15.312	-80.475	28.365	20911008.0
22.028	88.550	17.645	-80.463	28.366	20911586.0
24.617	88.665	18.774	-80.453	28.366	20911981.2
26.696	88.384	20.550	-80.444	28.366	20912440.0
28.994	88.235	24.799	-80.434	28.366	20913084.7
31.479	87.525	53.233	-80.423	28.366	20913802.0
33.969	86.250	64.856	-80.413	28.366	20914604.7
35.869	84.678	69.445	-80.405	28.367	20915277.7
38.355	83.153	74.278	-80.394	28.367	20916242.5
40.846	81.072	76.772	-80.383	28.367	20917302.2
43.336	78.885	78.038	-80.372	28.367	20918459.7
45.825	76.639	78.847	-80.361	28.367	20919718.5
48.314	74.316	79.591	-80.349	28.367	20921082.0
50.804	71.950	80.153	-80.338	28.367	20922551.7
53.708	70.242	80.510	-80.328	28.368	20923749.5
55.204	67.667	81.185	-80.316	28.368	20925418.2
57.701	65.719	81.698	-80.303	28.369	20927199.7
60.195	63.605	82.055	-80.290	28.369	20929094.7
62.689	61.456	82.208	-80.276	28.369	20931108.5
65.181	59.725	82.141	-80.262	28.369	20933241.0
67.087	58.719	82.068	-80.251	28.350	20934653.0
68.583	56.835	81.976	-80.236	28.350	20937303.7
72.079	54.787	81.848	-80.220	28.351	20939774.5
74.572	53.049	81.802	-80.204	28.352	20942361.7
77.062	51.456	81.771	-80.187	28.353	20945066.7
79.552	49.961	81.767	-80.170	28.354	20947894.0
81.453	48.825	81.908	-80.156	28.354	20950127.0
83.944	47.290	82.267	-80.137	28.355	20953183.7
86.436	45.838	82.293	-80.117	28.357	20956383.5
88.929	44.474	82.021	-80.097	28.358	20959644.7
91.423	43.207	81.690	-80.076	28.359	20963075.5
93.917	41.570	81.452	-80.053	28.361	20966634.0
96.413	40.801	81.272	-80.030	28.363	20970329.2
98.317	39.915	81.170	-80.012	28.364	20973240.0
100.814	38.771	81.085	-79.986	28.366	20977175.7
103.310	37.644	81.018	-79.960	28.368	20981244.7
105.811	36.533	80.961	-79.933	28.371	20985455.7
108.205	35.439	80.937	-79.904	28.373	20989787.0
110.876	34.355	80.926	-79.874	28.376	20994296.5
112.730	33.557	80.934	-79.850	28.378	20997790.7
115.227	32.540	80.896	-79.817	28.382	21002485.5
117.723	31.448	80.789	-79.783	28.385	21007305.7
120.218	30.456	80.663	-79.748	28.389	21012245.2
122.714	29.475	80.643	-79.710	28.392	21017307.0
125.217	28.614	80.605	-79.671	28.397	21022496.2
127.121	27.943	80.582	-79.641	28.400	21026523.0
129.619	27.135	80.570	-79.599	28.405	21031915.5
132.117	26.364	80.576	-79.555	28.410	21037440.7
134.612	25.714	80.606	-79.509	28.415	21043099.7
137.107	25.084	80.637	-79.461	28.420	21048908.0
139.603	24.480	80.664	-79.411	28.426	21054874.2
141.408	24.061	80.680	-79.372	28.431	21059535.2
144.012	23.529	80.708	-79.318	28.437	21065814.0
146.512	23.022	80.735	-79.262	28.444	21072257.7
149.008	22.547	80.763	-79.203	28.450	21078870.2
151.527	22.090	80.793	-79.142	28.458	21085750.2
154.023	21.655	80.825	-79.078	28.465	21092765.0
155.920	21.366	80.849	-79.027	28.472	21098257.5
158.425	20.993	80.883	-78.959	28.480	21105649.7
160.441	20.697	80.911	-78.901	28.487	21111789.0
163.419	20.171	80.974	-78.814	28.497	21120894.7
165.920	19.776	81.048	-78.740	28.506	21128641.5
168.417	19.361	81.119	-78.666	28.515	21135915.0
170.639	19.055	81.181	-78.599	28.523	21142507.7
173.104	18.693	81.252	-78.524	28.532	21149747.0
175.569	18.331	81.323	-78.448	28.541	21156942.0
177.246	18.085	81.373	-78.396	28.547	21161820.7
179.720	17.727	81.448	-78.319	28.556	21168893.2
182.187	17.368	81.522	-78.241	28.565	21175910.0
184.661	17.011	81.620	-78.162	28.574	21182875.5
187.125	16.656	81.717	-78.083	28.583	21189744.7
189.594	16.305	81.817	-78.003	28.591	21196447.7
191.976	15.964	81.922	-77.924	28.600	21203061.2
194.396	15.622	82.034	-77.843	28.609	21209608.2
196.817	15.280	82.148	-77.762	28.618	21216082.5
199.241	14.938	82.269	-77.679	28.626	21222492.7
201.663	14.602	82.390	-77.596	28.635	21228825.2
204.091	14.265	82.516	-77.511	28.644	21235088.0

* Time from platform release

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Table A-2b. Ascent Trajectory Reconstruction—Special Earth-Fixed Coordinates (Continued)

GEMINI 6C RECONSTRUCTED ASCENT TRAJECTORY

TIME (SEC)	RELATIVE FLT. PATH ANGLE (DEGREES)	RELATIVE HEADING ANGLE (DEGREES)	INERTIAL LONG. (DEGREES)	GEOCENTRIC LAT. (DEGREES)	RADIUS TO EARTH CENTER (FEET)
206.512	13.931	82.642	-77.426	28.652	21241282.7
208.933	13.601	82.771	-77.349	28.661	21247398.2
211.355	13.271	82.900	-77.263	28.670	21253410.2
213.776	12.947	83.030	-77.165	28.678	21259370.0
216.198	12.622	83.161	-77.076	28.686	21265244.5
218.619	12.302	83.291	-76.984	28.695	21271037.0
221.042	11.984	83.423	-76.895	28.703	21276753.5
223.464	11.670	83.555	-76.803	28.711	21282379.7
225.887	11.359	83.687	-76.709	28.720	21287940.7
228.307	11.047	83.819	-76.615	28.728	21293402.7
230.727	10.742	83.949	-76.520	28.736	21298780.2
233.147	10.441	84.081	-76.423	28.744	21304073.2
235.568	10.142	84.213	-76.325	28.752	21309282.5
237.993	9.848	84.345	-76.227	28.760	21314414.2
240.419	9.557	84.474	-76.126	28.767	21319460.7
242.841	9.261	84.566	-76.057	28.773	21322868.2
244.912	9.077	84.697	-75.954	28.780	21327779.2
246.930	8.906	84.826	-75.851	28.788	21332592.0
249.366	8.520	84.955	-75.746	28.795	21337315.7
251.792	8.247	85.085	-75.640	28.803	21341947.7
254.239	7.978	85.216	-75.532	28.810	21346528.2
256.685	7.712	85.347	-75.422	28.817	21351010.2
259.136	7.447	85.478	-75.311	28.824	21355421.2
261.581	7.187	85.609	-75.198	28.831	21359723.5
264.031	6.931	85.741	-75.084	28.838	21363938.5
266.484	6.678	85.874	-74.968	28.845	21368062.2
268.934	6.423	86.006	-74.851	28.852	21372082.7
271.391	6.176	86.140	-74.733	28.858	21375999.5
273.839	5.930	86.272	-74.612	28.865	21379819.0
276.295	5.686	86.405	-74.491	28.871	21383535.2
278.723	5.448	86.537	-74.367	28.877	21387152.0
281.168	5.211	86.671	-74.242	28.883	21390659.0
283.615	4.979	86.803	-74.115	28.889	21394066.2
286.294	4.823	86.935	-74.027	28.893	21396342.0
287.739	4.563	87.028	-73.897	28.898	21399567.0
290.182	4.371	87.162	-73.766	28.904	21402683.0
292.630	4.151	87.296	-73.632	28.909	21405665.5
295.086	3.960	87.429	-73.501	28.914	21408462.2
297.300	3.798	87.543	-73.371	28.919	21411176.5
300.343	3.467	87.723	-73.197	28.924	21414457.5
302.660	3.264	87.851	-73.069	28.929	21416863.2
304.984	3.042	87.981	-72.935	28.933	21419168.5
307.306	2.843	88.112	-72.787	28.937	21421354.7
309.622	2.646	88.242	-72.646	28.940	21423427.0
311.937	2.470	88.374	-72.503	28.944	21425381.5
314.241	2.276	88.507	-72.357	28.947	21427224.0
316.576	2.083	88.642	-72.210	28.950	21428939.2
319.610	1.827	88.819	-72.013	28.954	21431001.2
321.934	1.636	88.953	-71.860	28.956	21432420.7
324.262	1.444	89.091	-71.703	28.958	21433710.5
326.581	1.256	89.229	-71.545	28.960	21434857.2
328.900	1.067	89.359	-71.383	28.962	21435862.7
331.217	.883	89.510	-71.219	28.963	21436722.2
333.533	.700	89.652	-71.052	28.964	21437434.0
335.856	.519	89.797	-70.881	28.965	21437994.7
338.171	.340	89.942	-70.708	28.965	21438396.0
341.221	.120	90.133	-70.474	28.965	21438683.5
342.014	.058	90.183	-70.412	28.965	21438714.7
343.472	.030	90.248	-70.306	28.965	21438732.7
345.684	.026	90.341	-70.124	28.964	21438761.7
347.807	.029	90.426	-69.957	28.963	21438787.5
349.939	.029	90.511	-69.790	28.962	21438813.5
352.217	.029	90.603	-69.611	28.960	21438841.2
357.687	.032	90.823	-69.181	28.956	21438911.7
359.784	.033	90.908	-69.017	28.954	21438940.7
361.882	.034	90.993	-68.852	28.952	21438970.7
365.102	.035	91.122	-68.599	28.948	21439018.2
367.166	.036	91.206	-68.437	28.945	21439049.5
369.884	.036	91.316	-68.224	28.941	21439091.2
371.942	.037	91.400	-68.067	28.939	21439123.0
374.660	.041	91.510	-67.868	28.933	21439168.2
376.717	.041	91.594	-67.687	28.930	21439204.0
379.540	.043	91.707	-67.465	28.924	21439254.5
381.712	.044	91.794	-67.295	28.920	21439294.5

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Table A-3. Ascent (Uncorrected) Sensed Trajectory - IGS Coordinates

GEMINI EDIT PROGRAM

TIME IN SECONDS FROM LIFTOFF

COMPUTED POSITION VELOCITY AND ACCELERATION IN GUIDANCE THRUST COORDINATES

TIME (SECS)	X (FT)	Y (FT)	Z (FT)	XDOT (FT/SEC)	YDOT (FT/SEC)	ZDOT (FT/SEC)	XDDOT (FT/SEC**2)	YDDOT (FT/SEC**2)	ZDDOT (FT/SEC**2)
1.642	-	-401		-.10	-172.71	.11	.00	-40.88	.00
4.023	-	-928	1	.06	-270.08	.51	.04	-41.18	.13
6.402		-1687	2	.12	-368.37	.61	.10	-41.47	.19
8.783	1	-2683	4	.39	-467.69	1.20	.13	-41.85	.23
11.163	2	-3914	8	.96	-567.53	2.00	.17	-42.22	.29
13.538	5	-5382	13	1.23	-668.29	2.49	.18	-42.64	.28
15.915	8	-7091	20	1.70	-770.08	3.29	.20	-43.12	.24
18.749	14	-9447	30	2.28	-893.08	3.76	.26	-43.71	.29
21.138	20	-11706	40	2.95	-998.16	4.65	.47	-44.28	.27
23.215	27	-13875	51	3.68	-1090.49	5.36	.93	-44.79	.28
25.705	39	-16730	64	6.26	-1202.88	5.74	1.89	-45.40	.25
28.194	61	-19866	80	12.38	-1316.82	6.42	3.31	-46.00	.31
30.684	103	-23286	96	22.46	-1431.89	7.20	4.89	-46.55	.32
32.584	156	-26092	111	33.05	-1520.82	8.20	6.15	-46.95	.32
35.076	259	-30029	132	50.23	-1638.57	8.57	7.84	-47.48	.35
37.567	410	-34258	154	71.97	-1757.45	9.44	9.55	-47.96	.45
40.057	621	-38782	179	97.96	-1877.47	10.80	11.34	-48.42	.58
42.546	901	-43606	208	128.11	-1998.62	12.66	13.17	-48.84	.46
45.035	1263	-48733	242	163.34	-2120.70	14.27	15.05	-49.24	.47
47.525	1718	-54165	279	203.12	-2243.71	15.89	16.94	-49.58	.53
49.429	2136	-58528	311	236.73	-2338.52	17.17	18.41	-49.81	.62
51.925	2786	-64521	354	285.03	-2463.18	17.51	20.30	-50.13	.28
54.422	3564	-70828	398	338.39	-2588.46	17.95	22.04	-50.51	.00
56.916	4479	-77441	444	395.72	-2715.08	19.69	23.75	-50.89	.63
59.410	5540	-84372	493	456.38	-2842.83	20.54	25.42	-51.21	1.11
61.902	6759	-91616	548	522.22	-2970.69	24.08	27.13	-51.31	1.64
63.808	7804	-97370	597	575.19	-3068.70	27.75	28.53	-51.30	1.88
66.304	9330	-105189	674	648.23	-3196.66	33.40	30.42	-51.19	2.04
68.800	11044	-113328	763	726.44	-3324.32	37.94	32.36	-51.14	2.05
71.293	12959	-121774	864	810.43	-3451.26	43.17	34.20	-51.24	2.06
73.783	15085	-130527	977	897.56	-3579.13	48.51	36.06	-51.43	1.89
76.273	17432	-139597	1105	988.84	-3707.73	53.74	38.32	-51.43	1.10
78.174	19382	-146740	1210	1063.11	-3805.95	55.40	40.19	-51.41	.93
80.665	22159	-156380	1345	1167.47	-3933.00	53.91	42.70	-51.40	1.41
83.157	25204	-166341	1483	1277.01	-4061.19	58.73	44.85	-51.67	3.11
85.650	28528	-176623	1644	1391.11	-4190.31	70.86	46.94	-52.08	4.80
88.144	32144	-187237	1839	1510.17	-4321.18	85.70	49.20	-52.46	5.63
90.638	36067	-198178	2071	1636.03	-4452.16	100.23	51.74	-52.76	5.70
93.134	40314	-209456	2339	1768.08	-4584.48	114.26	54.57	-52.82	5.55
95.038	43781	-218262	2566	1874.18	-4685.19	124.52	56.95	-52.78	5.47
97.535	48641	-230146	2894	2019.91	-4816.79	138.04	59.99	-52.55	5.48
100.031	53873	-242332	3255	2173.45	-4947.68	151.65	63.20	-52.76	5.57
102.532	59510	-254870	3653	2335.50	-5078.16	165.97	66.51	-51.91	5.42
105.026	65545	-267696	4084	2505.56	-5207.11	180.07	69.86	-51.52	5.67
107.547	72086	-280984	4556	2685.96	-5336.46	194.18	73.16	-51.17	5.92
109.451	77335	-291239	4936	2827.75	-5433.69	205.23	75.65	-50.89	6.53
111.948	84635	-304966	5468	3020.52	-5560.38	221.73	79.02	-50.40	7.57
114.444	92424	-319002	6048	3221.51	-5685.94	243.54	82.44	-49.67	8.63
116.939	100719	-333337	6684	3432.33	-5808.73	266.46	86.41	-48.85	8.88
119.435	109560	-347988	7376	3652.99	-5929.37	288.06	90.12	-48.30	8.91
121.938	118990	-362977	8125	3883.58	-6048.55	310.37	93.61	-48.53	8.91
123.842	126557	-374583	8733	4064.30	-6141.08	327.61	96.17	-49.09	8.93
126.340	137013	-390079	9579	4308.38	-6265.33	349.90	99.47	-50.17	8.80
128.838	148089	-405987	10481	4560.66	-6391.94	371.89	103.02	-51.23	8.67
131.333	159792	-421996	11435	4821.97	-6521.03	392.76	106.92	-52.16	8.72
133.828	172160	-438431	12441	5093.53	-6652.70	414.43	111.10	-53.01	9.00
136.324	185224	-455203	13504	5376.23	-6785.92	437.40	115.69	-53.81	9.45
138.229	195674	-468223	14355	5599.53	-6888.95	454.01	119.19	-54.37	9.78
140.733	210079	-485651	15528	5904.13	-7026.29	480.87	124.42	-55.18	10.23
143.233	225226	-503382	16762	6220.79	-7164.77	505.91	129.79	-55.98	10.66
145.727	241151	-521427	18060	6551.15	-7305.63	534.06	135.73	-56.85	11.15
148.248	258106	-540030	19442	6900.56	-7450.00	562.79	141.96	-57.79	11.66
150.744	275780	-558807	20884	7263.56	-7595.40	592.51	148.79	-58.77	12.22
152.650	289893	-573385	22035	7552.35	-7708.13	616.30	154.39	-59.58	12.68
155.146	309233	-592812	23614	7945.98	-7858.18	648.71	161.73	-60.64	13.29
157.162	325590	-608781	24949	8278.97	-7981.33	675.99	167.66	-61.50	13.77
160.140	350338	-632581	26972	8370.36	-8013.41	680.88	41.01	-15.08	1.41
162.641	371399	-652667	28679	8472.70	-8049.08	684.08	41.41	-14.82	1.45
165.138	392686	-672811	30391	8577.17	-8085.27	687.78	42.21	-14.56	1.49
167.360	411855	-690818	31924	8671.76	-8117.75	691.39	42.97	-14.70	1.55
169.825	433361	-710873	33633	8778.77	-8154.66	695.09	43.77	-14.49	1.54
172.290	455133	-731017	35351	8887.71	-8190.65	698.99	44.59	-14.49	1.47
173.977	470166	-744851	36532	8963.44	-8214.98	701.42	45.29	-14.22	1.32
176.441	492410	-765135	38264	9076.13	-8249.84	704.72	46.12	-13.98	1.07
178.908	514948	-785535	40006	9190.65	-8283.46	706.81	46.87	-13.51	.71
181.382	537827	-806067	41757	9307.49	-8316.57	708.30	47.65	-13.11	.30
183.846	560905	-826597	43502	9426.06	-8348.34	709.39	48.47	-12.74	-.09
186.275	583941	-846910	45222	9544.54	-8378.77	707.68	49.30	-12.35	-.52
188.695	607193	-867230	46933	9664.94	-8408.28	706.06	50.12	-11.95	-.80
191.117	630748	-887629	48640	9787.47	-8436.86	703.15	50.97	-11.53	-1.27
193.538	654593	-908087	50339	9911.73	-8464.10	699.93	51.76	-11.07	-1.58
195.962	678770	-928634	52030	10038.31	-8490.42	695.40	52.55	-10.62	-1.86
198.384	703237	-949228	53708	10166.42	-8515.61	690.78	53.42	-10.15	-2.14
200.812	728076	-969931	55379	10296.86	-8539.87	685.16	54.24	-9.76	-2.34
203.233	753174	-990642	57031	10429.53	-8562.90	679.23	55.11	-9.31	-2.55
205.654	778585	-1011399	58668	10563.92	-8585.00	672.80	55.98	-8.87	-2.70
208.076	804334	-1032216	60289	10700.45	-8605.77	666.07	56.86	-8.41	-2.84
210.497	830406	-1053074	61893	10839.10	-8625.81	659.04	57.79	-7.96	-2.95
212.919	856828	-1073987	63480	10980.28	-8644.32	651.71	58.73	-7.51	-3.06
215.340	883583	-1094936	65049	11123.60	-8662.10	644.28	59.67	-7.04	-3.19
217.763	910710	-1115943	66601	11269.24	-8678.55	636.35	60.61	-6.56	-3.30
220.182	938148	-1136955	68130	11417.02	-8693.86	628.12	61.59	-6.05	-3.39
222.608	966036	-1158070	69644	11567.53	-8707.84	619.78	62.60	-5.56	-3.45
225.028	994213	-1179198	71134	11720.38	-8720.69	611.55	63.63	-5.09	-3.52
227.448	1022763	-1200276	72603	11875.56	-8732.41	602.81	64.68	-4.62	-3.61
229.868	1051691	-1221421	74052	12033.27	-8743.20	593.97	65.76	-4.16	-3.73
232.289	1081016	-1242599	75479	12193.72	-8752.45	584.84	66.89	-3.67	-3.90
234.714	1110781	-1263832	76885	12357.31	-8760.98	575.40	67.92	-3.16	-3.96
237.140	1140959	-1285093	78270	12523.84	-8767.97	566.06	69.44	-2.35	-3.92

CONFIDENTIAL

Table A-3. Ascent (Uncorrected) Sensed Trajectory - IGS Coordinates (Continued)

GEMINI EDIT PROGRAM

TIME IN SECONDS FROM LIFTOFF

COMPUTED POSITION VELOCITY AND ACCELERATION IN GUIDANCE THRUST COORDINATES

TIME (SECS)	X (FT)	Y (FT)	Z (FT)	XDOT (FT/SEC)	YDOT (FT/SEC)	ZDOT (FT/SEC)	XDDOT (FT/SEC**2)	YDDOT (FT/SEC**2)	ZDDOT (FT/SEC**2)
238.802	1161870	-1295670	79205	12639.21	-8772.26	559.66	70.11	-2.34	-3.89
241.233	1192813	-1321008	80554	12811.02	-8777.60	550.02	71.29	-1.79	-3.93
243.660	1224113	-1342314	81878	12985.15	-8781.41	540.58	72.53	-1.31	-3.99
246.087	1255839	-1363628	83178	13162.83	-8783.87	530.84	73.85	-.76	-4.06
248.513	1287988	-1384937	84453	13343.76	-8784.90	520.79	75.23	-.24	-4.16
250.959	1320857	-1406428	85715	13529.15	-8785.11	510.55	76.62	.35	-4.25
253.406	1354197	-1427926	86951	13718.39	-8783.67	500.00	78.07	1.00	-4.32
255.856	1388032	-1449435	88163	13911.48	-8780.17	489.35	79.58	1.70	-4.43
258.302	1422303	-1470908	89347	14107.91	-8775.14	478.50	81.15	2.42	-4.56
260.752	1457115	-1492401	90505	14308.58	-8768.86	467.86	82.79	3.21	-4.69
263.205	1492467	-1513901	91637	14513.76	-8759.51	455.29	84.50	3.99	-4.84
265.655	1528284	-1535350	92738	14722.77	-8748.72	443.44	86.25	4.86	-4.95
268.102	1564560	-1556738	93807	14935.93	-8736.17	430.98	88.05	5.66	-5.04
270.550	1601392	-1578107	94847	15153.56	-8720.96	418.63	89.96	6.56	-5.14
272.996	1638733	-1599421	95856	15375.85	-8704.10	405.97	91.94	7.52	-5.22
275.444	1676654	-1620708	96834	15603.51	-8684.47	393.11	94.00	8.43	-5.32
277.889	1715077	-1641909	97779	15835.74	-8662.47	379.85	95.87	9.50	-5.45
280.336	1754121	-1663080	98693	16073.44	-8638.62	366.59	98.10	10.26	-5.54
282.015	1781243	-1677566	99300	16239.70	-8620.49	357.08	100.18	11.13	-5.64
284.460	1821255	-1698612	100156	16486.83	-9592.22	343.21	102.65	12.16	-5.78
286.903	1861846	-1719569	100978	16739.94	-8561.79	328.95	104.92	13.19	-5.90
289.351	1903130	-1740482	101765	16999.75	-8528.07	314.28	107.64	14.45	-6.05
291.707	1943490	-1760536	102488	17256.52	-8492.71	300.01	110.54	15.83	-6.21
294.021	1983710	-1780141	103166	17514.93	-8454.87	285.45	113.39	17.29	-6.37
297.064	2037536	-1805786	104004	17864.35	-8399.48	265.63	116.63	19.04	-6.56
299.381	2079251	-1825198	104602	18138.67	-8353.32	250.37	119.72	20.57	-6.70
301.707	2121773	-1844572	105166	18421.51	-8303.45	234.60	123.45	22.30	-6.88
304.025	2164815	-1863761	105692	18711.55	-8249.99	218.43	127.25	24.12	-7.11
306.343	2208521	-1882814	106179	19010.01	-8192.52	201.75	130.75	25.73	-7.32
308.658	2252890	-1901713	106626	19316.67	-8131.04	184.58	134.71	27.62	-7.58
310.982	2298135	-1920527	107034	19634.39	-8064.72	166.70	139.26	29.65	-7.83
313.297	2343973	-1939119	107399	19960.73	-7993.78	148.12	143.91	32.20	-8.08
316.340	2405386	-1963290	107811	20408.36	-7891.41	123.07	149.27	34.86	-8.36
318.657	2453061	-1981482	108074	20758.95	-7807.52	103.69	158.84	40.06	-8.91
320.983	2501794	-1999539	108292	21125.64	-7716.94	83.00	160.81	40.26	-8.00
323.302	2551208	-2017319	108460	21505.00	-7620.61	61.80	167.05	43.01	-8.37
325.621	2601539	-2034876	108577	21899.06	-7517.80	39.60	173.80	45.91	-9.74
327.938	2652739	-2052165	108643	22309.65	-7408.30	16.69	181.08	49.03	-10.17
330.254	2704908	-2069192	108654	22736.97	-7291.31	-7.32	189.01	52.44	-10.61
332.577	2758246	-2085987	108608	23184.86	-7165.57	-32.63	195.92	55.78	-10.99
334.892	2812445	-2102418	108502	23651.92	-7031.51	-58.66	199.63	57.92	-11.18
337.942	2885546	-2123593	108270	24268.39	-6850.50	-93.15	204.51	60.75	-11.43
338.737	2904890	-2129018	108193	24431.38	-6801.94	-102.26	205.78	61.48	-11.50
340.093	2938154	-2138199	108047	24537.07	-6770.37	-107.78	3.38	.11	.03
342.405	2994907	-2153852	107797	24545.67	-6767.82	-108.20	2.78	.37	.03
344.528	3047024	-2168219	107568	24550.76	-6766.61	-107.82	2.22	.60	.04
346.660	3099367	-2182643	107339	24554.63	-6765.60	-107.63	1.22	.22	.03
348.938	3155289	-2196050	107093	24556.95	-6764.90	-107.65	.79	.11	.00
354.408	3289639	-2235057	106503	24558.48	-6764.64	-107.79	.14	.16	-.02
356.505	3341130	-2249241	106277	24558.40	-6764.76	-107.71	.00	.07	-.03
358.603	3392645	-2263431	106051	24558.52	-6764.67	-107.92	.80	.03	-.03
361.823	3471745	-2285217	105704	24560.67	-6764.18	-107.95	.52	.20	-.06
363.887	3522426	-2299174	105481	24561.91	-6763.79	-108.06	.63	.23	-.10
366.605	3589182	-2317556	105187	24563.75	-6762.89	-108.38	.68	.15	-.15
368.663	3639751	-2331477	104963	24565.20	-6762.49	-109.00	.68	.09	-.18
371.381	3706516	-2349857	104667	24567.23	-6763.03	-109.32	.47	.01	-.13
373.438	3757043	-2363766	104441	24568.07	-6762.64	-109.74	.30	-.00	-.05
376.261	3826405	-2382858	104132	24567.96	-6762.66	-109.56	.02	.04	.02
378.433	3879763	-2397546	103894	24568.17	-6762.68	-109.47	-.04	-.01	.02
380.489	3930291	-2411454	103669	24568.00	-6762.70	-109.29	.01	-.03	-.00
383.214	3997229	-2429880	103371	24568.01	-6762.82	-109.61	.00	-.03	-.02
385.425	4051548	-2444833	103128	24568.11	-6762.94	-109.53	-.01	-.00	-.02
388.221	4120237	-2463741	102822	24567.90	-6762.86	-109.65	-.04	.01	.02
390.278	4170789	-2477656	102596	24567.93	-6762.67	-109.46	-.02	.01	.01
392.994	4237510	-2496023	102299	24567.74	-6762.80	-109.38	.01	-.01	.01
395.052	4288062	-2509938	102074	24567.97	-6762.82	-109.60	-.01	-.02	-.01
397.761	4354616	-2528259	101777	24567.98	-6762.94	-109.52	-.01	-.01	-.00
399.817	4405143	-2542167	101552	24567.60	-6762.75	-109.53	-.03	.01	.01
402.538	4471985	-2560567	101254	24567.81	-6762.88	-109.45	-.02	.01	.01
404.593	4522464	-2574462	101029	24567.64	-6762.69	-109.47	.01	-.01	.01
407.304	4589065	-2592796	100733	24567.65	-6762.82	-109.39	-.02	-.00	-.00
409.357	4639496	-2606678	100508	24567.68	-6762.83	-109.40	.00	-.01	.00
412.073	4706241	-2625051	100211	24567.59	-6762.86	-109.52	-.00	.01	-.02
414.129	4756744	-2638953	99986	24567.72	-6762.77	-109.34	-.01	.01	-.01
416.844	4823441	-2657313	99688	24567.63	-6762.79	-109.66	-.01	.02	.00
418.899	4873920	-2671209	99463	24567.56	-6762.71	-109.47	.00	-.01	-.00
421.620	4940785	-2689614	99165	24567.57	-6762.63	-109.39	-.01	-.01	.0
424.329	5007338	-2707935	98869	24567.47	-6762.86	-109.51	-.03	-.01	.0
426.390	5057961	-2721870	98643	24567.50	-6762.87	-109.33	.03	-.01	-.0
429.098	5124490	-2740184	98347	24567.72	-6762.79	-109.45	-.08	.06	-.0
431.312	5178880	-2755155	98105	24567.62	-6762.71	-109.46	.02	.01	-.

Table A-4. Reentry Trajectory Reconstruction

GT-6 RE-ENTRY MERRITT ISL

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES	GEODETIC LONG. (DEGREES)
92277.529	25547.1	24188.4	-3.311	93.570	335280.5	28.469	-91.449
92278.529	25531.9	24183.7	-6.260	95.665	333653.0	28.472	-91.376
92279.529	26043.6	24700.9	-2.033	99.608	329999.0	28.457	-91.303
92280.529	26470.0	25121.8	4.773	97.004	330665.0	28.445	-91.228
92281.529	26028.8	24672.9	1.479	95.996	334395.7	28.440	-91.151
92282.529	25934.9	24584.6	-1.374	97.871	331937.7	28.432	-91.078
92283.529	25994.5	24641.9	-.165	97.341	333365.2	28.422	-91.002
92284.529	25541.2	24186.8	-4.638	94.953	332053.7	28.412	-90.928
92285.529	25533.4	24186.1	-6.438	96.032	329001.7	28.409	-90.855
92286.529	25846.3	24495.7	-2.115	97.631	327733.0	28.398	-90.781
92287.529	26403.2	25054.1	4.241	97.232	326805.5	28.391	-90.707
92288.529	26375.9	25025.4	4.084	96.991	330382.0	28.379	-90.630
92289.529	25862.1	24504.7	-.239	95.818	330512.0	28.373	-90.555
92290.529	25677.8	24329.6	-4.854	97.310	330417.0	28.365	-90.481
92291.529	25631.1	24294.9	-8.218	97.997	326633.0	28.353	-90.408
92292.529	25810.7	24457.9	-2.005	97.075	322415.2	28.348	-90.336
92293.529	25980.6	24623.1	1.520	95.685	325876.7	28.338	-90.259
92294.529	25687.2	24330.1	-2.027	95.569	323453.5	28.337	-90.186
92295.529	25945.1	24590.9	.045	97.030	323088.2	28.325	-90.111
92296.529	26265.2	24910.8	4.184	95.646	324053.5	28.317	-90.036
92297.529	25937.5	24586.8	-1.308	98.098	326955.5	28.312	-89.960
92298.529	25676.3	24341.7	-8.176	98.628	322742.5	28.297	-89.888
92299.529	25572.0	24222.2	-5.413	96.434	319472.7	28.289	-89.815
92300.529	25908.9	24552.1	.517	96.192	317924.7	28.281	-89.741
92301.529	26117.8	24765.0	1.743	97.386	319458.2	28.275	-89.666
92302.529	25812.8	24456.0	-.769	96.272	319462.5	28.264	-89.591
92303.529	25796.4	24441.7	-1.535	96.883	318746.7	28.260	-89.517
92304.529	25990.8	24640.2	-.402	98.315	318691.2	28.245	-89.442
92305.529	25728.5	24375.5	-2.652	97.151	318558.7	28.239	-89.368
92306.529	25771.7	24420.7	-2.828	97.686	315840.7	28.229	-89.295
92307.529	25897.8	24544.7	-.824	97.578	315468.0	28.221	-89.221
92308.529	25801.9	24446.3	-1.167	96.780	315774.7	28.211	-89.146
92309.529	25972.9	24624.9	-1.591	98.953	314417.5	28.202	-89.072
92310.529	25938.5	24591.1	-2.068	99.012	313949.2	28.189	-88.998
92311.529	25665.1	24309.1	-2.480	96.334	312269.0	28.182	-88.924
92312.529	25758.9	24401.3	-.995	96.229	312384.5	28.174	-88.850
92313.529	25870.3	24516.3	-.804	97.465	311898.2	28.166	-88.776
92314.529	25993.6	24640.6	.412	97.792	310779.5	28.156	-88.702
92315.529	25955.8	24603.6	-.385	98.110	312014.2	28.147	-88.627
92316.529	25687.7	24336.3	-3.493	97.564	310024.0	28.138	-88.553
92317.529	25706.9	24353.4	-2.715	97.247	308633.5	28.127	-88.480
92318.529	25975.4	24623.2	-.119	98.106	308276.7	28.120	-88.406
92319.529	26016.4	24666.1	-.251	98.672	308379.7	28.110	-88.331
92320.529	25867.2	24513.3	-.871	97.641	307948.2	28.100	-88.257
92321.529	25753.5	24398.3	-1.630	97.168	308215.0	28.090	-88.182
92322.529	25773.7	24421.4	-2.184	97.904	306361.7	28.082	-88.109
92323.529	25955.5	24605.2	-.973	98.696	306010.2	28.070	-88.035
92324.529	25744.9	24390.1	-1.802	97.298	305517.2	28.061	-87.961
92325.529	25689.3	24334.4	-2.266	97.162	304586.0	28.052	-87.887
92326.529	25900.7	24547.0	-.357	97.804	303406.7	28.044	-87.813
92327.529	25941.2	24589.7	-.646	98.522	304197.2	28.033	-87.739
92328.529	25900.6	24550.6	-1.661	98.793	302542.2	28.021	-87.665
92329.529	25899.4	24548.7	-1.349	98.683	302668.5	28.031	-87.591
92330.529	25797.4	24443.3	-1.229	97.765	301451.2	28.003	-87.517
92331.529	25815.2	24459.6	-.690	97.442	301651.5	27.992	-87.443
92332.529	25983.7	24634.6	-.998	99.208	300907.5	27.982	-87.369
92333.529	25769.1	24417.7	-2.420	98.367	300399.0	27.972	-87.295
92334.529	25724.9	24371.0	-2.093	97.740	298710.7	27.963	-87.222
92335.529	25807.6	24452.0	-.571	97.546	298620.2	27.953	-87.147
92336.529	25878.3	24525.3	-.785	98.316	298420.2	27.943	-87.073
92337.529	25899.4	24549.3	-1.485	98.990	297428.7	27.932	-87.000
92338.529	25918.5	24569.9	-1.690	99.350	297184.7	27.922	-86.926
92339.529	25892.0	24540.7	-1.192	98.787	296014.7	27.907	-86.852
92340.529	25895.2	24542.3	-.547	98.455	296052.2	27.900	-86.778
92341.529	25885.6	24513.2	-1.060	98.571	295609.0	27.887	-86.704
92342.529	25928.0	24577.8	-1.439	99.086	294856.2	27.880	-86.630
92343.529	25913.5	24560.9	-.883	98.601	294001.5	27.866	-86.556

Table A-4. Reentry Trajectory Reconstruction (Continued)

GT-6 RE-ENTRY MERRITT ISL (CONT.)

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
92344.529	25780.7	24424.4	-1.232	97.506	294354.0	27.859	-86.482
92345.529	25911.0	24563.3	-1.937	99.692	292864.5	27.847	-86.408
92346.529	26078.5	24738.3	-1.850	101.347	292391.0	27.835	-86.335
92347.529	25738.8	24382.9	-1.360	98.270	291511.7	27.821	-86.261
92348.529	25562.3	24200.9	-.388	96.025	291074.0	27.815	-86.188
92349.529	25800.2	24445.2	-.568	98.088	290969.0	27.805	-86.114
92350.529	25877.4	24528.1	-1.773	99.438	290517.7	27.794	-86.040
92351.529	25818.1	24466.9	-1.717	99.021	289469.7	27.783	-85.967
92352.529	25868.6	24516.6	-.949	98.952	288998.5	27.772	-85.893
92353.529	25888.3	24536.6	-.826	99.061	288563.5	27.761	-85.819
92354.529	25852.7	24501.7	-1.407	99.205	288192.7	27.750	-85.745
92355.529	25832.3	24480.9	-1.440	99.122	287295.0	27.739	-85.672
92356.529	25839.9	24488.4	-1.298	99.129	286834.2	27.728	-85.598
92357.529	25840.6	24489.9	-1.526	99.314	286290.2	27.717	-85.525
92358.529	25840.3	24488.4	-1.131	99.113	285369.5	27.705	-85.451
92359.529	25840.5	24488.2	-.949	99.054	285106.5	27.694	-85.377
92360.529	25840.7	24489.5	-1.317	99.319	284485.5	27.684	-85.304
92361.529	25837.9	24486.9	-1.403	99.384	283957.5	27.672	-85.230
92362.529	25826.4	24475.2	-1.380	99.347	283372.7	27.660	-85.157
92363.529	25827.7	24476.9	-1.472	99.458	282554.5	27.649	-85.084
92364.529	25824.9	24473.8	-1.364	99.426	282011.7	27.638	-85.010
92365.529	25853.2	24502.2	-1.152	991493	281439.5	27.626	-84.937
92366.529	25845.4	24494.0	-1.046	99.446	280771.5	27.614	-84.863
92367.529	25852.8	24501.3	-.924	99.457	280378.7	27.603	-84.790
92368.529	25840.4	24489.9	-1.328	99.666	279930.5	27.591	-84.716
92369.529	25823.9	24473.7	-1.543	99.739	279328.0	27.580	-84.643
92370.529	25820.0	24488.8	-1.197	99.569	278524.0	27.568	-84.570
92371.529	25820.7	24469.1	-1.052	99.544	278112.7	27.556	-84.496
92372.529	25820.7	24470.1	-1.335	99.744	277469.7	27.545	-84.423
92373.529	25828.5	24478.3	-1.373	99.848	276940.5	27.533	-84.349
92374.529	25785.4	24434.7	-1.482	99.759	276236.5	27.521	-84.276
92375.529	25816.7	24466.0	-1.208	99.800	275582.0	27.509	-84.203
92376.529	25834.8	24484.2	-1.111	99.864	275214.2	27.497	-84.130
92377.529	25818.4	24468.1	-1.339	99.959	274579.5	27.485	-84.056
92378.529	25782.9	24432.3	-1.403	99.901	273963.5	27.472	-83.983
92379.529	25819.4	24468.9	-1.177	99.974	273245.2	27.461	-83.910
92380.529	25836.7	24486.2	-1.060	100.020	272870.7	27.448	-83.837
92381.529	25813.4	24463.0	-1.184	100.043	272279.5	27.436	-83.764
92382.529	25809.6	24459.5	-1.293	100.121	271752.7	27.424	-83.691
92383.529	25795.7	24445.4	-1.289	100.108	271065.2	27.412	-83.618
92384.529	25787.9	24437.4	-1.218	100.098	270518.0	27.399	-83.544
92385.529	25796.1	24446.0	-1.269	100.204	269954.5	27.387	-83.471
92386.529	25788.9	24438.9	-1.287	100.237	269364.5	27.374	-83.398
92387.529	25789.5	24439.2	-1.168	100.225	268777.5	27.362	-83.325
92388.529	25794.7	24444.5	-1.139	100.277	268312.2	27.350	-83.252
92389.529	25778.8	24428.8	-1.219	100.316	267715.5	27.337	-83.179
92390.529	25776.3	24426.4	-1.278	100.380	276126.7	27.324	-83.106
92391.529	25783.0	24433.4	-1.275	100.449	266556.5	27.312	-83.034
92392.529	25777.5	24427.7	-1.227	100.459	265998.0	27.299	-82.961
92393.529	25760.7	24410.9	-1.237	100.462	265372.0	27.286	-82.888

Table A-4. Reentry Trajectory Reconstruction (Continued)

GT-6 BET TRACKER REENTRY

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
92394.529	26128.3	24776.5	-1.507	100.043	265308.0	27.272	-82.820
92395.529	26023.6	246.3.3	-1.411	100.417	264625.5	27.259	-82.746
92396.529	25955.5	24605.2	-1.375	100.451	263981.2	27.247	-82.673
92397.529	25883.3	24532.7	-1.360	100.386	263357.0	27.234	-82.600
92398.529	25857.1	24506.9	-1.282	100.522	262739.7	27.221	-82.526
92399.529	25810.6	24460.9	-1.292	100.652	262158.5	27.208	-82.454
92400.529	25812.4	24462.6	-1.273	100.667	261561.2	27.195	-82.381
92401.529	25782.4	24432.8	-1.255	100-712	260988.5	27.182	-82.308
92402.529	25772.4	24422.5	-1.208	100.698	260412.5	27.169	-82.235
92403.529	25769.7	24423.4	-1.089	101.464	259886.2	27.156	-82.162
92404.529	25726.2	24375.4	-1.344	100.535	259309.2	27.143	-82.090
92405.529	25735.7	24385.6	-1.258	100.740	258710.0	27.130	-82.017
92406.529	25735.5	24386.1	-1.266	100.883	258133.2	27.117	-81.945
92407.529	25744.6	24395.7	-1.190	101.019	257563.2	27.103	-81.872
92408.529	25724.9	24375.9	-1.207	101.035	257011.2	27.090	-81.800
92409.529	25711.4	24362.7	-1.208	101.129	256456.2	27.077	-81.727
92410.529	25716.1	24367.6	-1.232	101.175	255899.7	27.063	-81.655
92411.529	25710.2	24361.6	-1.162	101.183	255348.2	27.050	-81.583
92412.529	25709.5	24361.0	-1.209	101.231	254803.2	27.036	-81.510
92413.529	25693.2	24344.6	-1.250	101.240	254236.2	27.022	-81.438
92414.529	25693.1	24344.7	-1.186	101.311	253680.7	27.009	-81.366
92415.529	25692.5	24344.3	-1.151	101.372	253140.0	26.995	-81.293
92416.529	25699.5	24351.0	-1.179	101.337	252609.5	26.981	-81.221
92417.529	25674.9	24326.5	-1.284	101.376	252089.5	26.967	-81.149
92418.529	25693.2	24344.0	-1.013	101.270	251499.2	26.954	-81.077
92419.529	25662.3	24313.6	-1.148	101.376	251037.2	26.940	-81.005
92420.529	25627.7	24280.4	-1.594	101.626	250356.0	26.926	-80.933
92421.529	25671.0	24322.3	-1.130	101.432	249762.7	26.912	-80.860
92422.529	25617.3	24270.7	-.990	101.883	249252.7	26.898	-80.789
92423.529	25635.5	24287.4	-1.243	101.601	248733.0	26.884	-80.717
92424.529	25635.0	24287.1	-1.315	101.643	248167.5	26.870	-80.645
92425.529	25587.9	24240.2	-1.473	101.683	247516.0	26.856	-80.573
92426.529	25604.3	24256.2	-1.269	101.653	246896.5	26.842	-80.501
92427.529	25576.3	24228.2	-1.259	101.703	246322.0	26.828	-80.429
92428.529	25612.4	24264.4	-1.239	101.731	245749.7	26.814	-80.358
92429.529	25598.6	24250.8	-1.265	101.799	245175.0	26.799	-80.286
92430.529	25545.8	24198.4	-1.241	101.898	244601.0	26.785	-80.214
92431.529	25574.0	24226.3	-1.261	101.868	244031.0	26.771	-80.143
92432.529	25573.7	24226.0	-1.216	101.891	243464.7	26.757	-80.071
92433.529	25487.1	24140.0	-1.312	102.039	242894.2	26.742	-80.000
92434.529	25561.1	24213.6	-1.312	101.984	242288.0	26.728	-79.928
92435.529	25485.1	24137.6	-1.161	102.014	241719.7	26.713	-79.857
92436.529	25513.1	24165.6	-1.255	102.027	241173.5	26.699	-79.785
92437.529	25462.4	24114.8	-1.237	102.036	240602.2	26.684	-79.714
92438.529	25489.6	24142.1	-1.233	102.095	240039.7	26.670	-79.643
92439.529	25444.5	24097.3	-1.228	102.164	239478.2	26.655	-79.572
92440.529	25431.4	24084.3	-1.228	102.214	238922.2	26.641	-79.501
92441.529	25308.8	23963.4	-1.324	102.541	238337.7	26.626	-79.430
92442.529	25500.3	24152.1	-1.156	102.079	237773.5	26.611	-79.359
92443.529	25403.3	24056.3	-1.225	102.319	237230.5	26.597	-79.288
92444.529	25379.0	24032.3	-1.220	102.389	236669.5	26.582	-79.217
92445.529	25369.7	24022.7	-1.134	102.351	236138.0	26.567	-79.146
92446.529	25270.1	23925.2	-1.370	102.729	235573.2	26.552	-79.076
92447.529	25385.8	24038.4	-1.109	102.345	235013.5	26.537	-79.005
92448.529	25382.7	24034.4	-.999	102.217	234531.5	26.522	-78.934
92449.529	25178.7	23834.0	-1.199	102.882	234045.2	26.508	-78.864

Table A-4. Reentry Trajectory Reconstruction (Continued)

GT-6 BET TRACKER REENTRY

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
92450.529	25392.9	24044.2	-.982	102.185	233539.2	26.493	-78.793
92451.529	25238.2	23892.4	-1.274	102.727	233032.7	26.478	-78.723
92452.529	25250.4	23903.7	-1.133	102.588	232461.0	26.463	-78.653
92453.529	25171.3	23826.9	-1.415	102.998	231910.2	26.448	-78.583
92454.529	25193.7	23848.3	-1.312	102.856	231292.5	26.432	-78.513
92455.529	25204.0	23858.6	-1.302	102.883	230696.7	26.417	-78.442
92456.529	25126.4	23781.2	-1.248	102.950	230110.2	26.402	-78.373
92457.529	25166.1	23819.6	-1.062	102.768	229602.2	26.386	-78.303
92458.529	25203.0	23856.2	-1.252	102.724	229079.7	26.371	-78.233
92459.529	25141.7	23796.5	-1.259	103.028	228492.5	26.356	-78.163
92460.529	25131.7	23785.6	-1.312	102.889	227925.0	26.341	-78.093
92461.529	25051.2	23706.3	-1.175	103.137	227352.2	26.325	-78.023
92462.529	25081.6	23736.7	-1.376	103.134	226779.2	26.310	-77.954
92463.529	25003.5	23658.8	-1.183	103.209	226193.2	26.294	-77.884
92464.529	25014.8	23670.2	-1.300	103.241	225638.2	26.279	-77.815
92465.529	25024.1	23678.6	-1.380	103.109	225054.0	26.263	-77.746
92466.529	24925.7	23582.5	-1.389	103.517	224424.2	26.248	-77.677
92467.529	24938.1	23592.9	-1.133	103.239	223873.5	26.232	-77.608
92468.529	24920.4	23575.7	-1.272	103.328	223327.0	26.216	-77.539
92469.529	24904.9	23560.2	-1.316	103.340	222747.0	26.201	-77.470
92470.529	24856.6	23511.7	-1.168	103.350	222196.0	26.185	-77.401
92471.529	24809.5	23466.2	-1.287	103.625	221632.0	26.169	-77.332
92472.529	24794.5	23450.6	-1.224	103.566	221087.5	26.153	-77.264
92473.529	24791.8	23447.1	-1.247	103.448	220532.2	26.137	-77.195
92474.529	24775.5	23431.1	-1.348	103.528	219944.0	26.122	-77.127
92475.529	24696.1	23352.5	-1.123	103.683	219423.0	26.106	-77.058
92476.529	24698.3	23354.4	-1.340	103.638	218850.2	26.090	-76.990
92477.529	24610.6	23267.8	-1.062	103.866	218306.0	26.074	-76.922
92478.529	24656.0	23311.7	-1.329	103.643	217796.7	26.058	-76.854
92479.529	24598.3	23254.7	-1.348	103.763	217201.0	26.042	-76.786
92480.529	24543.0	23199.8	-1.133	103.870	216637.7	26.026	-76.719
92481.529	24522.0	23178.7	-1.239	103.871	216138.7	26.010	-76.651
92482.529	24467.5	23125.0	-1.248	104.010	215578.2	25.994	-76.584
92483.529	24441.9	23099.4	-1.429	104.029	214978.2	25.978	-76.516
92484.529	24439.7	23095.9	-1.315	103.855	214407.5	25.962	-76.449
92485.529	24373.5	23030.5	-1.286	103.999	213809.2	25.946	-76.382
92486.529	24317.9	22975.2	-1.100	104.096	213324.7	25.930	-76.315
92487.529	24269.2	22926.3	-1.046	104.087	212833.0	25.914	-76.248
92488.529	24253.3	22910.3	-1.107	104.089	212391.7	25.898	-76.181
92489.529	24250.1	22909.0	-1.940	104.327	211677.5	25.882	-76.115
92490.529	24161.9	22819.0	-1.045	104.157	211033.7	25.865	-76.048
92491.529	24101.3	22758.7	-.998	104.229	210561.7	25.849	-75.982
92492.529	24070.7	22727.5	-1.084	104.157	210120.5	25.833	-75.916
92493.529	24040.3	22699.2	-1.377	104.487	209543.0	25.817	-75.850
92494.529	23969.3	22626.1	-.861	104.202	209089.5	25.801	-75.784
92495.529	23944.7	22603.2	-1.301	104.463	208582.0	25.785	-75.719
92496.529	23945.9	22603.1	-1.542	104.259	207980.2	25.768	-75.653
92497.529	23714.1	22373.9	-.179	104.781	207565.0	25.752	-75.588
92498.529	23851.3	22509.0	-1.732	104.365	207194.5	25.736	-75.523
92499.529	23713.5	22371.8	-.814	104.563	206649.2	25.720	-75.458
92500.529	23722.1	22380.3	-1.490	104.520	206100.2	25.703	-75.393
92501.529	23620.8	22276.8	-.707	104.254	205782.0	25.687	-75.328
92502.529	23591.3	22250.3	-1.328	104.708	205221.2	25.671	-75.264
92503.529	23543.7	22200.3	-.979	104.375	204813.7	25.655	-75.199
92504.529	23540.2	22195.9	-1.491	104.211	204216.7	25.639	-75.135
92505.529	23465.3	22124.1	-1.672	104.690	203535.5	25.623	-75.071

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Table A-4. Reentry Trajectory Reconstruction (Continued)

GT-6 BET TRACKER REENTRY

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE (DEGREES)	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG (DEGREES)
92506.529	23350.9	22008.4	-.893	104.592	203006.5	25.607	-75.007
92507.529	23332.5	21989.0	-.939	104.443	202646.5	25.591	-74.943
92508.529	23307.2	21963.7	-1.364	104.447	202186.7	25.575	-74.879
92509.529	23189.9	21847.2	-.852	104.623	201657.7	25.560	-74.816
92510.529	23160.4	21817.1	-1.273	104.524	201227.0	25.544	-74.753
92511.529	23156.2	21812.9	-1.684	104.494	200626.7	25.528	-74.690
92512.529	22987.0	21643.6	- .445	104.600	200184.2	25.512	-74.627
92513.529	23010.7	21667.5	-1.625	104.582	199765.7	25.496	-74.564
92514.529	22862.2	21520.2	-.614	104.843	199292.2	25.481	-74.502
92515.529	22889.9	21544.5	-1.387	104.286	198835.5	25.465	-74.439
92516.529	22726.4	21383.5	-.219	104.766	198473.0	25.449	-74.377
92517.529	22791.7	21448.9	-1.964	104.674	198079.7	25.433	-74.315
92518.529	22590.5	21247.0	-.109	104.726	197600.2	25.418	-74.254
92519.529	22666.7	21322.3	-1.659	104.498	197320.7	25.402	-74.192
92520.529	22543.5	21202.3	-1.543	105.020	196585.5	25.387	-74.131
92521.529	22466.8	21120.5	-.712	104.326	196119.7	25.371	-74.070
92522.529	22368.7	21021.6	.281	104.239	196053.0	25.356	-74.009
92523.529	22390.2	21041.1	-.927	103.925	195950.5	25.341	-73.948
92524.529	22152.5	20816.7	-.722	105.944	195594.7	25.326	-73.887
92525.529	22392.6	21040.6	-1.024	103.487	195104.7	25.310	-73.827
92526.529	22193.4	20841.3	-1.248	103.471	194727.2	25.296	-73.766
92527.529	22066.5	20732.3	-1.671	106.145	194170.7	25.280	-73.706
92528.529	22105.8	20762.9	-3.074	104.704	193273.5	25.264	-73.647
92529.529	21862.0	20525.4	-.870	105.904	192432.7	25.249	-73.587
92530.529	21693.5	20347.1	1.936	104.393	192761.7	25.233	-73.528
92531.529	21894.4	20547.1	-1.627	104.315	192861.0	25.219	-73.469
92532.529	21808.2	20467.6	-3.185	105.093	191735.5	25.203	-73.410
92533.529	21581.3	20242.6	.102	105.712	191128.2	25.188	-73.352
92534.529	21420.8	20073.8	.731	104.485	191355.5	25.172	-73.294
92535.529	21467.4	20127.3	-2.184	105.396	191028.2	25.158	-73.236
92536.529	21508.6	20159.5	-.780	104.209	190454.0	25.142	-73.178
92537.529	21217.3	19872.5	-.049	104.898	190275.0	25.128	-73.120
92538.529	21146.5	19812.1	-.771	106.380	190114.2	25.112	-73.063
92539.529	21215.0	19857.4	-.447	102.895	189926.2	25.098	-73.006
92540.529	21689.6	20354.9	-1.467	106.348	189529.5	25.083	-72.948
92541.529	21708.9	20349.7	-1.548	102.569	188864.7	25.067	-72.889
92542.529	21436.4	20097.2	-6.253	104.549	187399.7	25.054	-72.831
92543.529	21133.6	19792.1	-3.817	105.003	185403.5	25.039	-72.774
92544.529	20871.3	19537.8	2.159	106.464	184960.2	25.024	-72.717
92545.529	20564.3	19221.0	-.045	105.253	185647.2	25.008	-72.662
92546.529	20572.8	19235.4	-2.065	105.969	185276.2	24.993	-72.607
92547.529	20504.9	19173.3	-2.726	106.690	184167.5	24.977	-72.552
92548.529	20390.4	19047.9	-1.167	105.365	183518.5	24.962	-72.498
92549.529	20570.2	19232.5	-1.477	106.056	183143.0	24.947	-72.443
92550.529	20478.7	19156.5	-1.718	108.073	182596.7	24.930	-72.389
92551.529	20408.4	19072.9	.215	106.451	182312.7	24.914	-72.334
92552.529	19531.9	18196.0	.090	106.396	182212.7	24.898	-72.281
92553.529	19669.9	18340.1	-1.244	107.187	182174.7	24.883	-72.229
92554.529	19617.7	18258.5	1.089	102.882	182031.2	24.869	-72.177
92555.529	20416.3	19049.2	-.871	101.521	182198.7	24.858	-72.122
92556.529	20041.6	18701.8	.886	105.933	181842.0	24.844	-72.068
92557.529	20024.4	18669.3	2.659	103.447	182642.5	24.830	-72.014
92558.529	20392.4	19050.4	-3.909	105.216	182788.2	24.817	-71.960
92559.529	20140.6	18797.5	-.058	105.543	180470.7	24.802	-71.905
92560.529	20025.4	18702.3	4.361	107.695	182324.0	24.787	-71.853

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Table A-4. Reentry Trajectory Reconstruction (Continued)

GEMINI-6 GBI REENTRY (This data subject to gross error.)

TIME FROM LIFTOFF (SECONDS)	INERTIAL VEL. MAGNITUDE (FT/SEC)	RELATIVE VEL. MAGNITUDE (FT/SEC)	INERTIAL FLT. PATH ANGLE (DEGREES)	INERTIAL HEADING ANGLE	ALTITUDE (FEET)	GEODETIC LAT. (DEGREES)	GEODETIC LONG. (DEGREES)
92561.529	19177.6	17837.1	1.283	105.899	182627.2	24.773	-71.814
92562.529	19107.3	17762.7	1.013	105.369	184606.7	24.760	-71.763
92563.529	19059.2	17710.1	.369	104.738	183119.0	24.745	-71.712
92564.529	18824.1	17481.4	5.321	104.794	184375.5	24.734	-71.661
92565.529	18740.1	17410.0	2.864	107.179	186669.7	2 24.719	-71.612
92566.529	18808.5	17476.6	-.997	107.176	185559.0	24.703	-71.563
92567.529	18623.7	17273.0	2.575	104.401	186377.2	24.690	-71.513
92568.529	18512.6	17158.6	3.327	103.745	187830.7	24.678	-71.464
92569.529	18470.1	17132.2	.348	106.468	188249.5	24.665	-71.415
92570.529	18274.2	16947.6	2.631	107.756	188122.2	24.649	-71.366
92571.529	18185.7	16838.6	5.299	104.325	189959.2	24.635	-71.319
92572.529	18144.7	16787.0	3.917	103.092	190892.7	24.625	-71.270
92573.529	18009.1	16669.4	2.642	106.137	192876.0	24.612	-71.222
92574.529	17888.5	16559.8	3.644	107.408	193049.0	24.597	-71.175
92575.529	17836.8	16481.7	6.283	102.750	194787.2	24.583	-71.129
92576.529	17727.5	16373.6	7.228	102.474	196939.0	24.576	-71.080
92577.529	17544.9	16218.8	7.233	106.717	199163.2	24.562	-71.035
92578.529	17445.5	16128.6	7.302	107.890	201319.2	24.548	-70.990
92579.529	17358.6	16038.3	7.407	107.456	203537.2	24.534	-70.945
92580.529	17244.0	15924.1	7.370	107.549	205794.5	24.520	-70.900
92581.529	17150.0	15813.9	7.494	105.359	207939.7	24.506	-70.856
92582.529	17129.0	15777.6	7.589	102.969	210218.5	24.495	-70.811
92583.529	17025.1	15685.2	7.599	104.815	212464.5	24.485	-70.766
92584.529	16909.7	15574.3	7.574	105.520	214679.5	24.472	-70.722
92585.529	16749.2	15403.6	7.438	104.110	216894.7	24.461	-70.678
92586.529	16639.5	15306.6	7.584	105.925	218929.0	24.450	-70.635
92587.529	16579.8	15262.0	7.786	107.826	221288.0	24.436	-70.592
92588.529	16405.5	15078.6	7.763	106.701	223451.2	24.423	-70.550
92589.529	16443.9	15105.1	7.789	105.094	225624.5	24.410	-70.508
92590.529	16370.6	15030.7	7.769	104.963	227802.0	24.400	-70.465
92591.529	16015.8	14688.1	7.799	106.664	230031.0	24.388	-70.423
92592.529	15986.2	14665.9	7.854	107.617	232129.5	24.375	-70.383
92593.529	16245.8	14919.2	7.606	106.977	234328.7	24.362	-70.341
92594.529	16380.0	15037.4	8.276	104.463	236670.2	24.351	-70.299

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APPENDIX B

TRW REGRESSION PROGRAM

(REMP) MODIFICATIONS

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APPENDIX B

TRW REGRESSION PROGRAM (REMP) MODIFICATIONS

A change has been implemented in the TRW regression program (REMP) that allows the effect of unmodeled error uncertainties to be reflected in the a posteriori statistics of the error coefficients. This means that if a set of known functions are purposely omitted from the solution due to correlation or restrictions on model size, the uncertainties of these omitted errors can be effectively added to the uncertainties in the errors that are solved for. This change is mathematically sound and can be described in the following equations.

The usual expression for C_K, the a posteriori covariance matrix of the error coefficients, is

$$C_K = \left(B^T \sigma_m^{-1} B + C_{K_o}^{-1}\right)^{-1} \qquad (B.1)$$

where

$B \equiv$ partial derivations of measurements with respect to error coefficients

$\sigma m \equiv$ assumed white noise covariance matrix of data

$C_{K_o} \equiv$ a priori error coefficient uncertainties

The more valid expression for C_K, in light of functions which truly exist but are not solved for, is

$$C_K = \left(B^T \sigma_m^{-1} B + C_{K_o}^{-1}\right)^{-1} \left[B^T \sigma_m^{-1} \left(\sigma_m + \beta \Sigma_o \beta^T\right) \sigma_m^{-1} B + C_{K_o}^{-1}\right] \left(B^T \sigma_m^{-1} B + C_{K_o}^{-1}\right)^{-1} \qquad (B.2)$$

where

$\beta \equiv$ partial derivatives of measurements with respect to omitted error coefficients

$\Sigma_o \equiv$ a priori statistics of omitted terms

with manipulation, Equation (B.2) can be written as

$$C_K = C_K^* + C_K^* B^T \sigma_m^{-1} \beta \Sigma_o \beta^T \sigma_m^{-1} B C_K^* = C_K^* + \Delta C_K$$

where

$$C_K^* = \left(B^T \sigma_m^{-1} B + C_{K_o}^{-1} \right)^{-1}$$

The REMP program now computes the ΔC_K term and prints out both C_K and ΔC_K, omitting the old C_K^* terms. It is obvious that the uncertainties of the solved-for error coefficients will now be larger than before (ΔC_K being always positive), sometimes much larger, depending of course on β and Σ_o.

APPENDIX C

PREFLIGHT CALIBRATION HISTORY PLOTS

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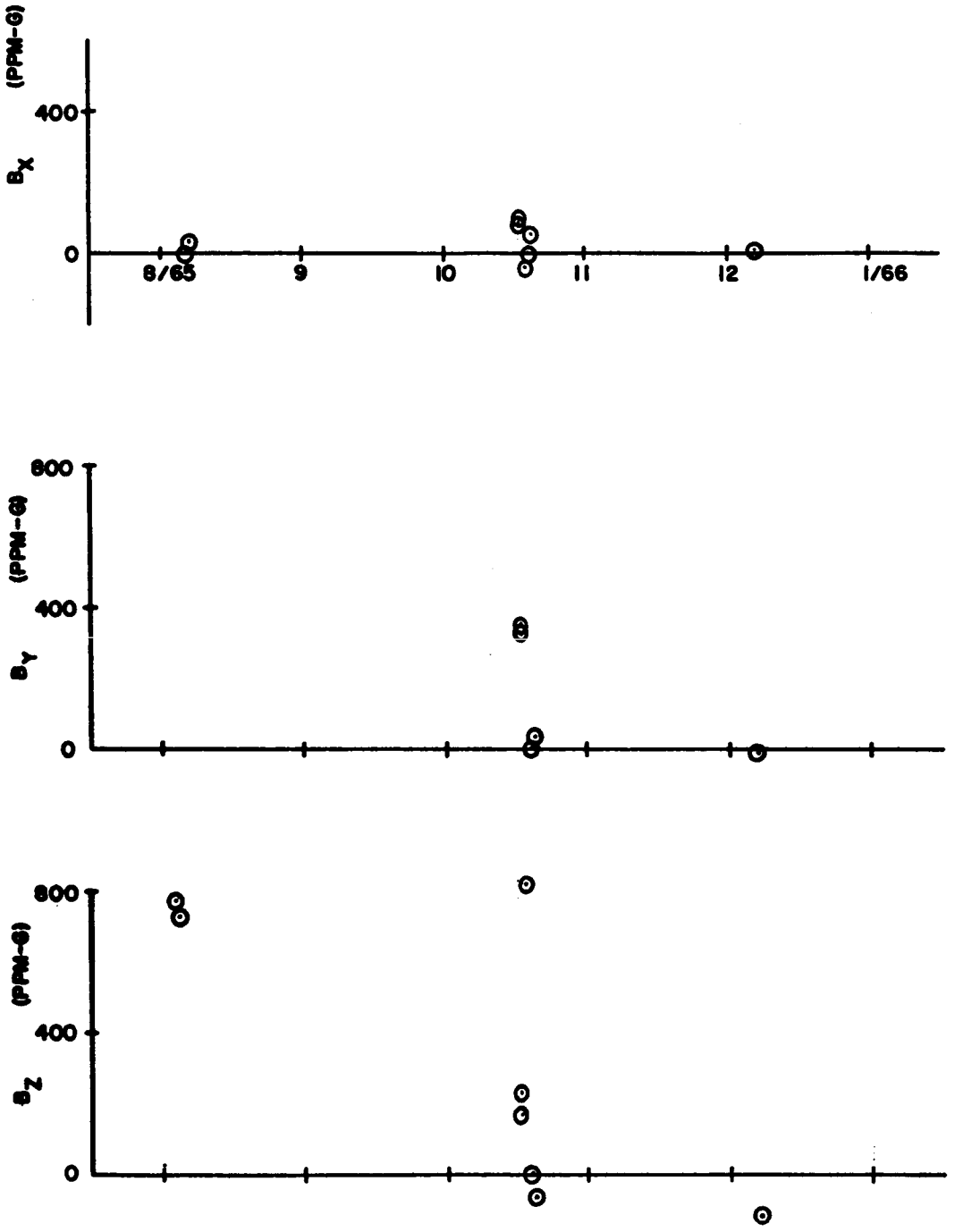

Figure C-1. Accelerometer Bias History (Deviation From Flight Constant)

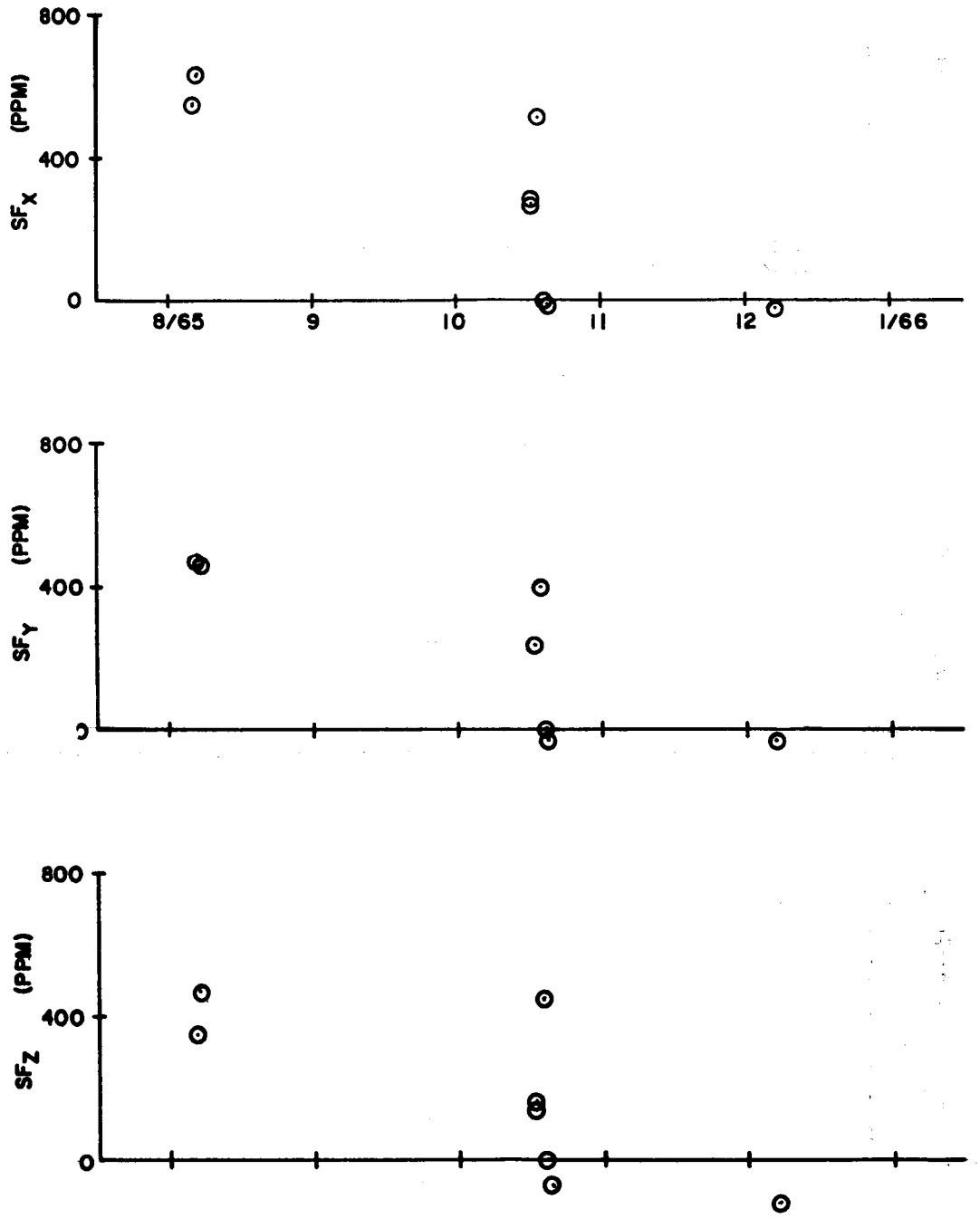

Figure C-2. Accelerometer Scale Factor History (Deviation From Flight Constant)

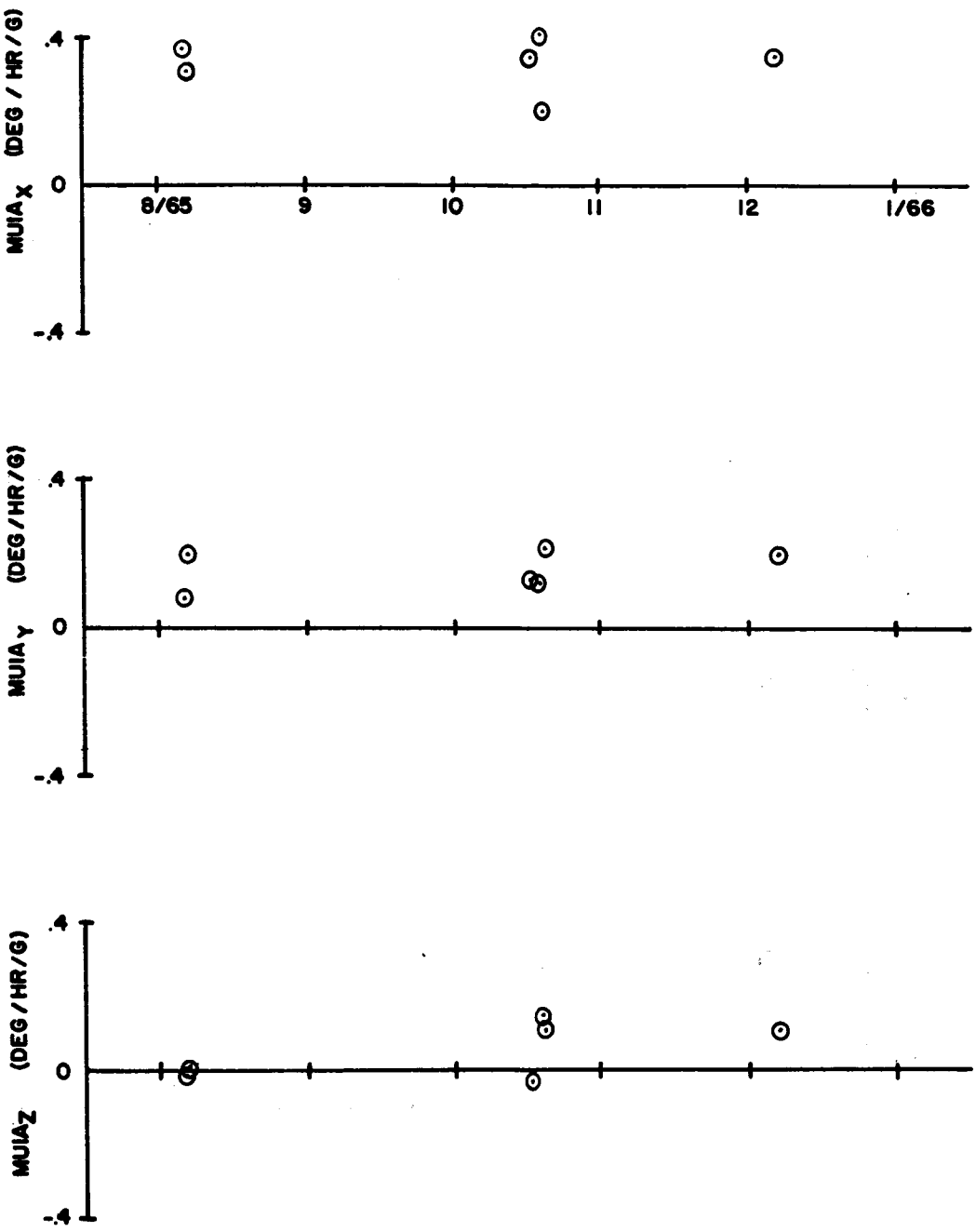

Figure C-3. Gyro Input Axis Unbalance Drift History

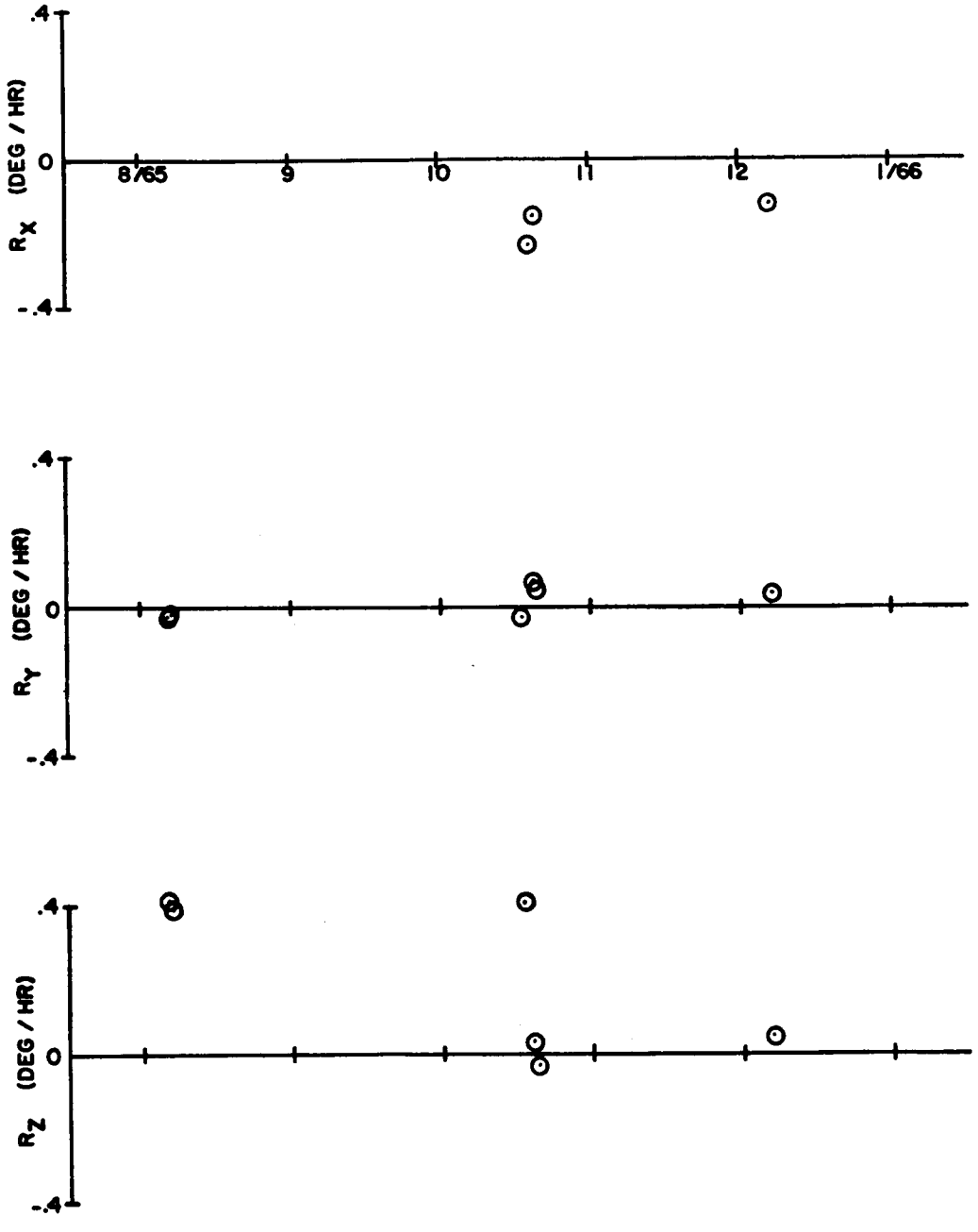

Figure C-4. Gyro Constant Drift Rate History

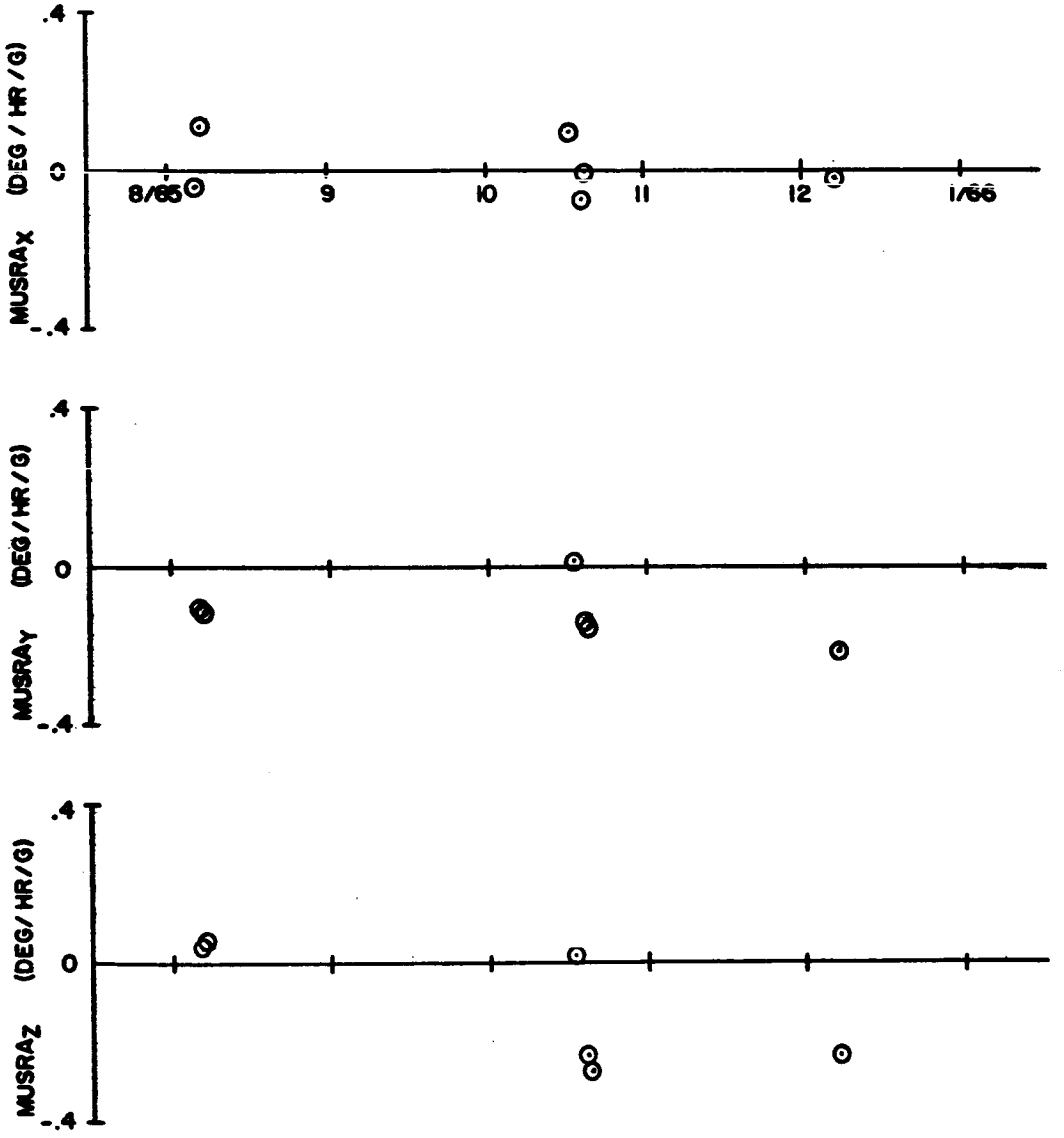

Figure C-5. Gyro Spin Axis Unbalance Drift History

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