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RESULTS OF THE  
THIRD SATURN IB LAUNCH  
VEHICLE TEST FLIGHT

[U]

AS-202

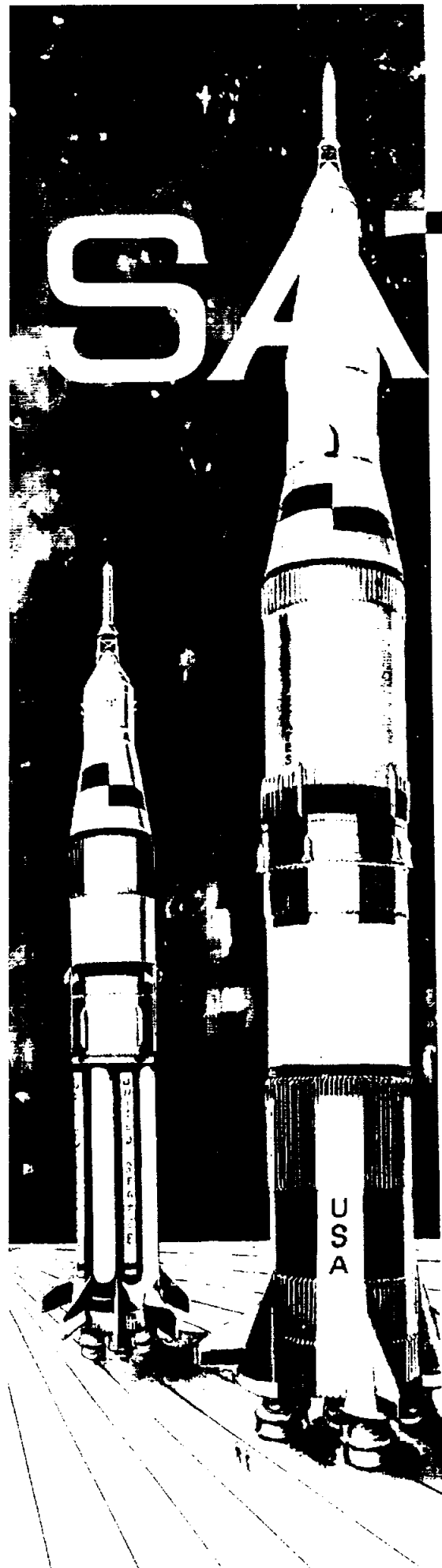
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RESULTS OF THE THIRD SATURN IB LAUNCH VEHICLE TEST FLIGHT  
AS-202

By

Saturn Flight Evaluation Working Group

George C. Marshall Space Flight Center

(U) ABSTRACT

Saturn IB AS-202 was launched at 1215:32 EST on August 25, 1966 from KSC LC34, under surface conditions of light winds, moderate temperature and humidity, and good visibility. The vehicle lifted off after a total delay of 45 min due to holds, on a launch azimuth 100 deg east of north and rolled to a flight azimuth 105 deg east of north. The actual trajectory was near nominal.

All major systems performed within design limits and close to predicted values throughout flight. Although no malfunctions or deviations occurred that adversely affected flight or mission, certain refinements for future flights are indicated in camera coverage, camera recovery, guidance, and SPS ignition sequence.

The AS-202 test flight demonstrated the structural integrity and compatibility of the stages of the launch vehicle and the spacecraft during powered flight and coast. It permitted evaluation of performance of the launch vehicle propulsion, guidance, control, separation, structural and electrical systems, and the efficiency of mission support facilities and operations.

The report is contained in two volumes: Volume I contains only unclassified data; Volume II only classified.

Any questions or comments pertaining to the information contained in this report are invited and should be directed to:

Director, George C. Marshall Space Flight Center  
Huntsville, Alabama 35812  
Attention: Chairman, Saturn Flight Evaluation Working Group  
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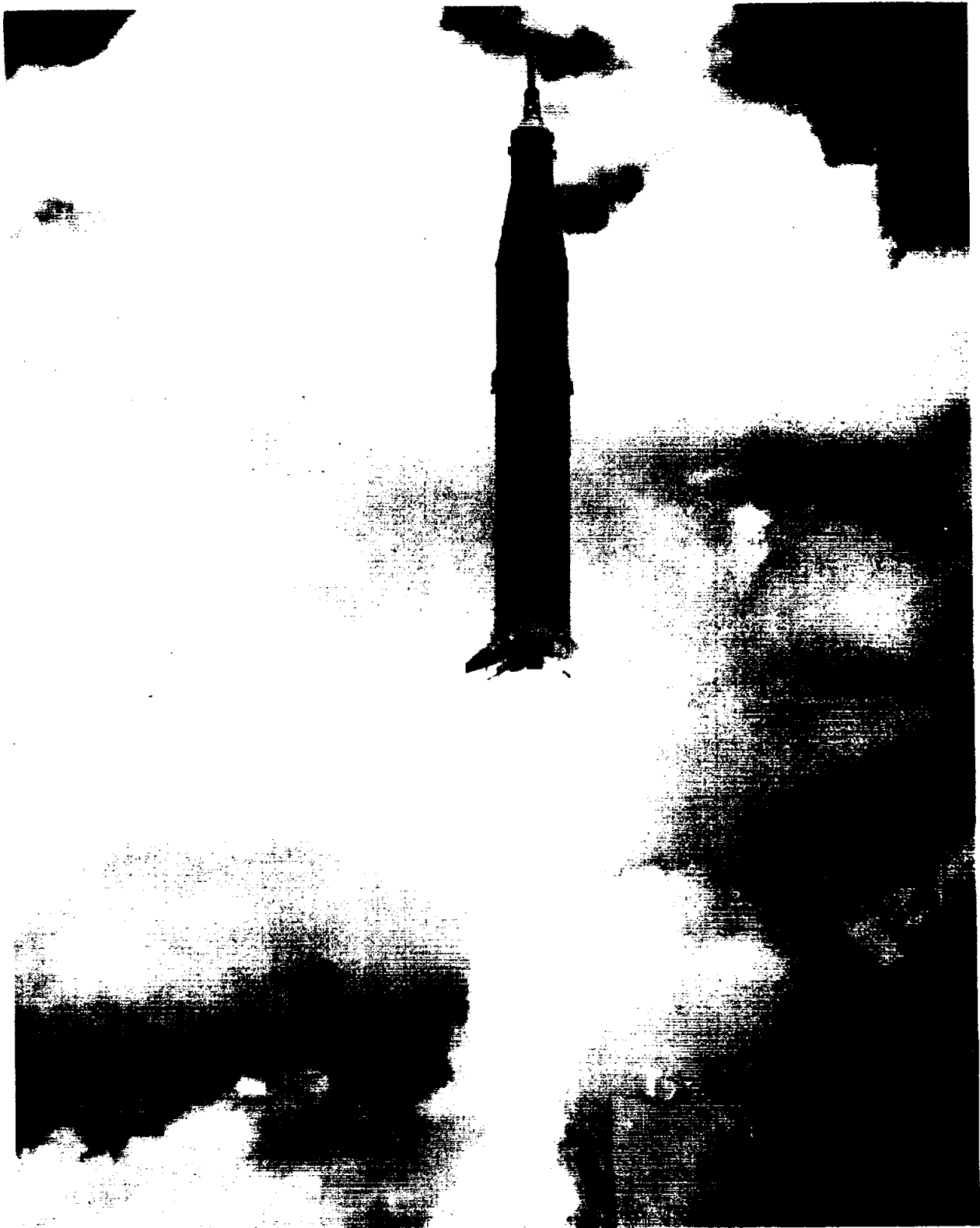
VOLUME II

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1.0 (U) INTRODUCTION

Volumes I and II of this report, present the results of the early engineering evaluation of AS-202, the third Saturn IB vehicle flight-tested. Volume II presents only those data which are classified. The evaluation is centered on the performance of the major vehicle systems, with special emphasis on malfunctions and deviations.

This report is published by the Saturn Flight Evaluation Working Group--composed of representatives of Marshall Space Flight Center, John F. Kennedy Space Center, and MSFC's prime contractors--and in cooperation with the Manned Spacecraft Center. Significant contributions to the evaluation have been made by:

George C. Marshall Space Flight Center

Research and Development Operations

Aero-Astroynamics Laboratory  
Astrionics Laboratory  
Computation Laboratory  
Propulsion and Vehicle Engineering Laboratory

Industrial Operations

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Manned Spacecraft Center

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The official MSFC position at this time is represented by this report. It will not be followed by a similar report unless continued analysis or new evidence should prove the conclusions presented herein to be significantly incorrect. Final stage evaluation reports will, however, be published by the stage contractors. Reports covering major subjects and special subjects will be published as required.

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## 2.0 (C) LAUNCH VEHICLE GUIDANCE ERROR ANALYSIS

The velocity errors shown in this report are within the accuracy of the established postflight trajectory data and the preflight estimates of the guidance hardware errors.

Preflight estimates of the component and system errors were obtained from a series of laboratory tests made several weeks prior to vehicle launch. Prelaunch telemetry was sampled for an indication of platform orientation errors. This telemetry, adjusted for preflight estimates of accelerometer bias and scale factor errors, indicated that the ST-124M3 stabilized platform was aligned well within the  $3\sigma$  tolerance. Postflight analyses also verify this.

The predicted errors of the ST-124M3 inertial platform system for the AS-202 flight test were based on laboratory calibration of the ST-124M3 stabilized platform system. These errors are shown in Table 2-I and Figure 2-1 along with guidance error solutions based on both the postflight reference trajectory and GLOTRAC data. The  $3\sigma$  value for each error component is also shown.

Telemetered platform velocities at principal event times are shown in Table 2-II for comparison with corresponding values taken from the postflight and preflight reference trajectories. The differences between the telemetered velocities and postflight trajectory data are within the noise level of the data compared. The cross range velocity telemetered from the guidance computer included about 28 excess negative pulses (-1.4 m/s) accumulated due to vibrations during the first 8 sec of flight (See Vol. I, Section 12.4.2.2). The differences between the telemetered data and the preflight trajectory reflect the non-standard performance of the vehicle as well as small errors in the guidance hardware performance.

The telemetered guidance velocities were differenced against both the postflight reference trajectory and GLOTRAC data. These differences (tracking minus guidance) are shown plotted versus range time in Figure 2-2. The  $\pm 3\sigma$  velocity component errors at S-IVB cutoff are shown for comparison. Guidance error analyses were made to determine sets of guidance system errors that would simulate the observed velocity differences for both the postflight reference trajectory and GLOTRAC data. Before comparisons were made, the telemetered cross range velocity was adjusted for the excess pulses accumulated during the first 8 sec of flight. Velocity differences associated with the error solutions are shown as points enclosed in squares and triangles for the trajectory and GLOTRAC data, respectively. GLOTRAC lost lock at about 415 sec and the error solution was terminated at that point. Although the error solutions fit the velocity difference curves, the accuracies associated with the tracking data are no better than  $\pm 0.5$  m/s at S-IVB cutoff.

TABLE 2-I (C) GUIDANCE INTELLIGENCE ERRORS

Parameter	Symbol	Units	Laboratory and Pre-Launch Meas. Error Sources	Error Source Established Fm. Traj Analysis	Error Sources Established Fm. GLOTRAC Analysis	3 $\sigma$ Error Band
<b>1. System Errors</b>						
<b>a. Platform Leveling</b>						
1) About X Axis	$L_X$	deg		$0.4 \times 10^{-3}$	$0.105 \times 10^{-3}$	$0.5 \times 10^{-2}$
2) About Z Axis	$L_Z$			$-0.6 \times 10^{-3}$	$-0.85 \times 10^{-3}$	$0.5 \times 10^{-2}$
<b>b. Flight Azimuth Alignment</b>						
	$A_{ZA}$	deg		$-0.1 \times 10^{-2}$	$-0.47 \times 10^{-3}$	0.01
<b>c. Accelerometer Misalignment</b>						
1) Range (X) Accel Rotated Toward Z Axis	$M_{XZ}$	deg	$-0.4 \times 10^{-3}$	$-0.4 \times 10^{-3}$	$-0.4 \times 10^{-3}$	0.01
2) Altitude (Y) Accel Rotated Toward X Axis	$M_{YZ}$		$-0.297 \times 10^{-2}$	$-0.3 \times 10^{-2}$	$-0.5 \times 10^{-3}$	$0.42 \times 10^{-2}$
3) Altitude (Y) Accel Rotated Toward Z Axis	$M_{YX}$		$-0.5 \times 10^{-3}$	$-0.5 \times 10^{-3}$	$-0.5 \times 10^{-3}$	$0.89 \times 10^{-2}$
<b>d. Gyro Drift Rates, Constant</b>						
1) Yaw (X) Gyro (About X Axis)	$\delta_X$	deg/hr	0.013	0.014	0.081	0.100
2) Roll (Y) Gyro (About Y Axis)	$\delta_Y$		0.029	-0.045	-0.036	0.075
3) Pitch (Z) Gyro (About Z Axis)	$\delta_Z$		0.037	0.035	0.036	0.075
<b>e. Gyro Drift Rates, g-Dependent</b>						
1) Yaw (X) Gyro (About X Axis Due to $\ddot{X}$ )	$\delta_X/\ddot{X}$	deg/hr/g	-0.004	0.028	0.020	0.100
2) Yaw (X) Gyro (About X Axis Due to $\ddot{Y}$ )	$\delta_X/\ddot{Y}$		-0.0015	0.054	0.051	0.060
3) Roll (Y) Gyro (About Y Axis Due to $\ddot{X}$ )	$\delta_Y/\ddot{X}$		-0.007	0.020	-0.031	0.060
4) Roll (Y) Gyro (About Y Axis Due to $\ddot{Y}$ )	$\delta_Y/\ddot{Y}$		-0.0005	-0.044	-0.06	0.075
5) Pitch (Z) Gyro (About Z Axis Due to $\ddot{X}$ )	$\delta_Z/\ddot{X}$		0.018	-0.039	0.013	0.075
6) Pitch (Z) Gyro (About Z Axis Due to $\ddot{Y}$ )	$\delta_Z/\ddot{Y}$		0.007	-0.071	-0.04	0.060
<b>2. Component Errors</b>						
<b>a. Accelerometer Bias</b>						
1) Range (X) Accelerometer	$B_X$	m/s/s	$0.24 \times 10^{-3}$	$0.22 \times 10^{-3}$	$0.19 \times 10^{-3}$	$0.3 \times 10^{-3}$
2) Altitude (Y) Accelerometer	$B_Y$		$0.5 \times 10^{-4}$	$0.5 \times 10^{-4}$	$0.33 \times 10^{-4}$	$0.3 \times 10^{-3}$
3) Cross Range (Z) Accelerometer	$B_Z$		$-0.9 \times 10^{-4}$	$-0.12 \times 10^{-3}$	$-0.96 \times 10^{-4}$	$0.3 \times 10^{-3}$
<b>b. Accelerometer Scale Factor</b>						
1) Range (X) Accelerometer	$S_X$	g/g	$0.9 \times 10^{-5}$	$-0.24 \times 10^{-4}$	$-0.58 \times 10^{-4}$	$0.3 \times 10^{-4}$
2) Altitude (Y) Accelerometer	$S_Y$		$0.22 \times 10^{-4}$	$-0.35 \times 10^{-4}$	$0.23 \times 10^{-5}$	$0.3 \times 10^{-4}$
3) Cross Range (Z) Accelerometer	$S_Z$		$-0.1 \times 10^{-5}$	$-0.1 \times 10^{-5}$	$-0.1 \times 10^{-5}$	$0.3 \times 10^{-4}$

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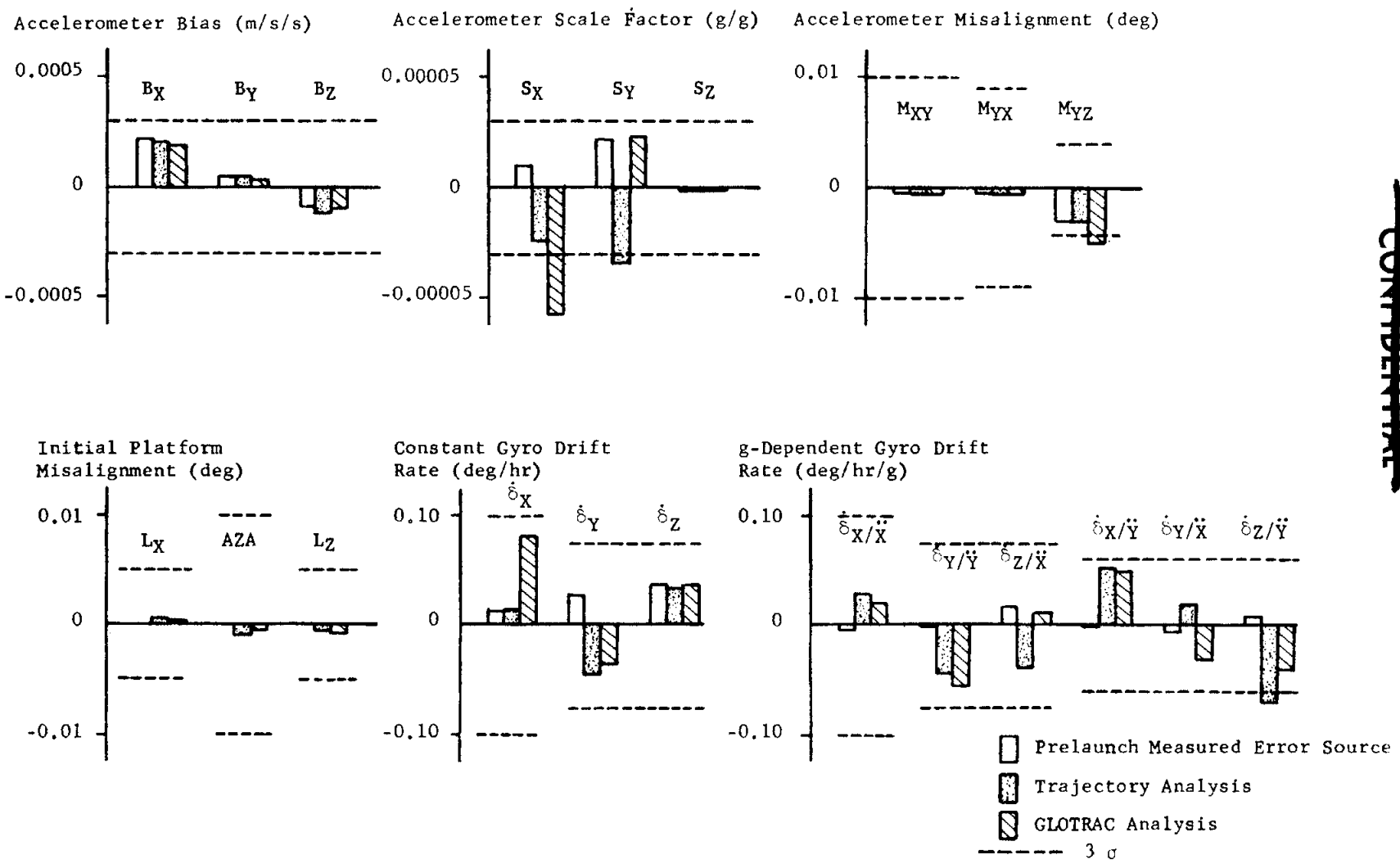


FIGURE 2-1 (C) ST-124M3 STABILIZED PLATFORM SYSTEM ERROR SOURCES

TABLE 2-II

## (C) GUIDANCE PLATFORM VELOCITY COMPARISON

Event Range Time (sec)	*	Telemetered		Trajectory	
		Accelerometer	Computer	Postflight	Preflight**
IECO 139.57	$\dot{X}$	1553.55	1553.55	1552.62	1565.95
	$\dot{Y}$	2359.45	2359.45	2358.90	2337.86
	$\dot{Z}$	-23.35	-24.75	-23.08	-11.86
OEEO 143.47	$\dot{X}$	1627.10	1627.10	1625.58	1622.04
	$\dot{Y}$	2401.60	2401.60	2400.48	2369.99
	$\dot{Z}$	-24.25	-25.65	-23.97	-12.39
Guidance Initiation 172.40	$\dot{X}$	1776.45	1776.45	1776.64	1769.02
	$\dot{Y}$	2488.15	2488.15	2488.02	2454.69
	$\dot{Z}$	-25.25	-26.65	-25.08	-15.22
S-IVB Cutoff 588.47	$\dot{X}$	6768.05	6768.05	6768.20	6784.16
	$\dot{Y}$	4126.70	4126.70	4125.57	4209.67
	$\dot{Z}$	-0.75	-2.15	0.42	-1.79
Spacecraft Separation 598.70	$\dot{X}$	6774.80	6774.80	6774.98	6789.81
	$\dot{Y}$	4127.90	4127.90	4126.76	4210.49
	$\dot{Z}$	-0.75	-2.15	0.23	-1.91

\*  $\dot{X}$  - Range Velocity (m/s)  
 $\dot{Y}$  - Altitude Velocity (m/s)  
 $\dot{Z}$  - Cross Range Velocity (m/s)

\*\* Preflight values are based on nominal event times which do not necessarily coincide with the actual event times.

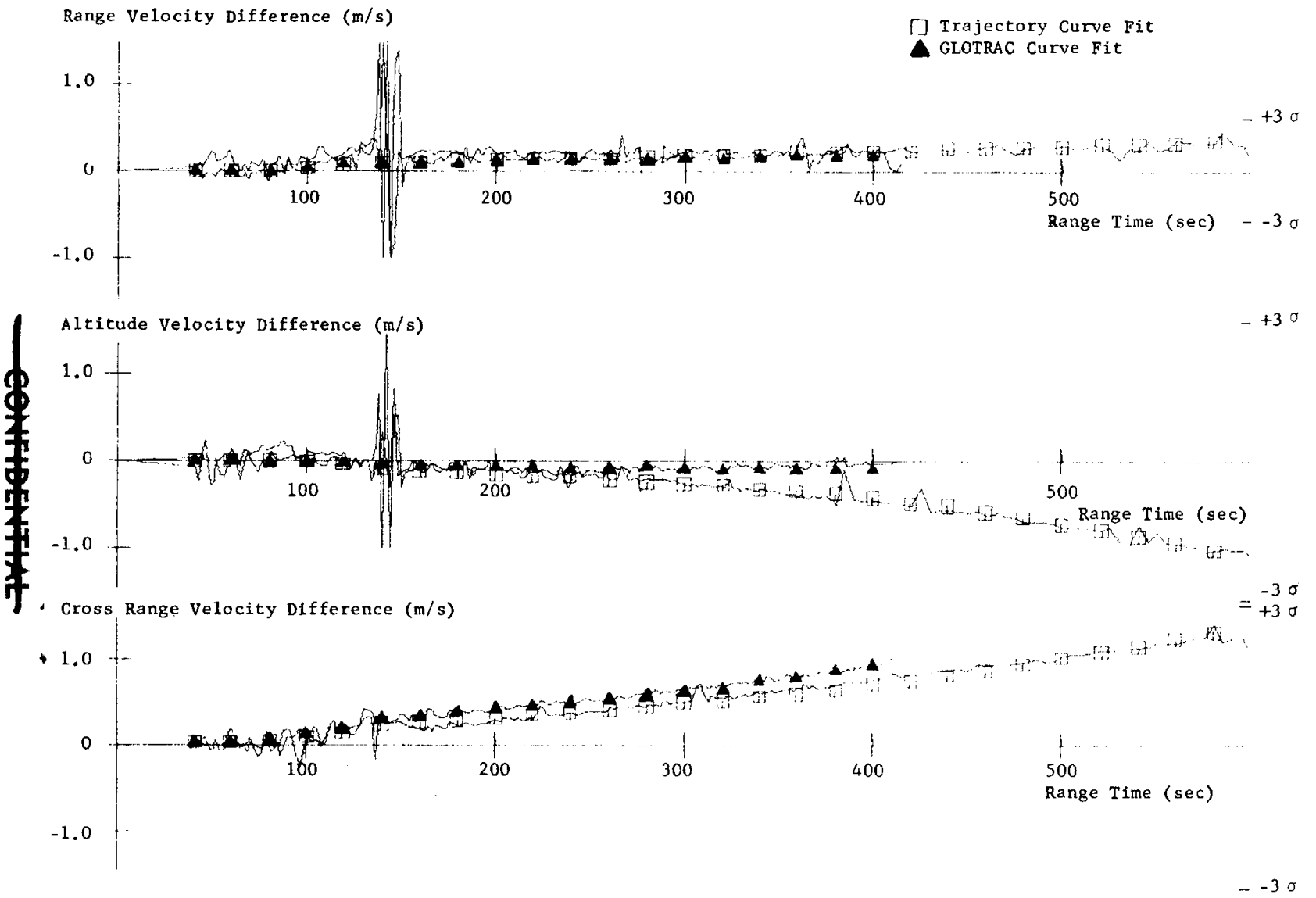


FIGURE 2-2 (C) PLATFORM VELOCITY COMPONENT DIFFERENCES (TRACKING MINUS GUIDANCE)

The AS-202 vehicle was successfully guided to satisfactory end conditions as shown by the comparisons in Table 2-III for S-IVB cutoff and spacecraft separation.

The component differences between the postflight trajectory and guidance computer values are well within the  $3\sigma$  tolerances. Since the IGM guidance scheme does not constrain the flight to a prescribed trajectory, the differences between the preflight and telemetered position and velocity components merely reflect non-standard vehicle performance and environmental conditions. The total velocity shown for the preflight trajectory indicates a cutoff velocity error of 0.32 m/s. However, the preset value for the guidance computer was 6800.00 m/s, compared with the actual cutoff velocity of 6799.95 m/s.

TABLE 2-III (C) GUIDANCE COMPARISONS  
(S-IVB Cutoff and Spacecraft Separation)

Parameter	Symbol	Units	S-IVB Cutoff			Spacecraft Separation		
			Trajectory		Guidance Computer	Trajectory		Guidance Computer
			Preflight	Postflight		Preflight	Postflight	
Total Velocity	$V_S$	m/s	6799.63	6800.22	6799.95	6798.58	6800.23	6799.89
Radial Distance	$R_S$	km	6592.061	6591.943	6592.151	6596.716	6596.695	6596.910
Path Angle	$\theta$	deg	3.996	3.986	3.994	3.832	3.822	3.834
Displacement:	*							
Range	$X_S$	km	1875.677	1831.924	1831.806	1941.970	1899.872	1899.770
Altitude	$Y_S$	km	6319.418	6332.129	6332.373	6304.227	6317.032	6317.280
Cross Range	$Z_S$	km	-45.284	-43.698	-44.723	-46.156	-44.572	-45.623
Velocity:								
Range	$\dot{X}_S$	m/s	6636.88	6647.26	6647.21	6616.02	6627.52	6627.41
Altitude	$\dot{Y}_S$	m/s	-1476.19	-1431.63	-1430.48	-1563.18	-1520.48	-1519.31
Cross Range	$\dot{Z}_S$	m/s	-87.60	-85.61	-87.81	-86.99	-85.07	-87.41

\*Earth-Center Plumblne Coordinate System

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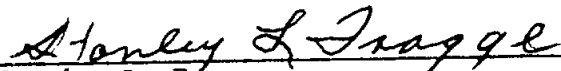
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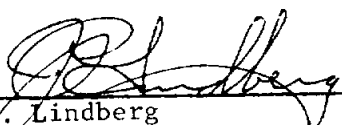
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AS-202  
VOLUME II

By Saturn Flight Evaluation Working Group

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\_\_\_\_\_  
Stanley L. Fragge  
Security Classification Officer

This report has been reviewed and approved for technical accuracy.

  
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