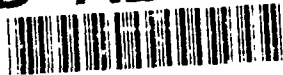


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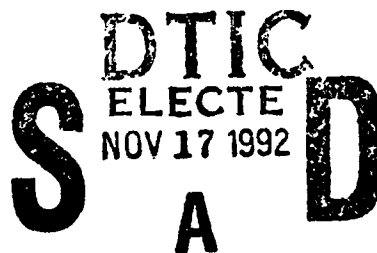
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PL-TR-92-2175

**SPIRIT II VEHICLE (A26.780)
FINAL POST FLIGHT REPORT**

C. P. Chalfant

**Orbital Sciences Corporation
Space Data Division
3380 South Price Road
Chandler, Arizona 85348**



26 May 1992

**Final Report
21 December 1988-28 March 1992**

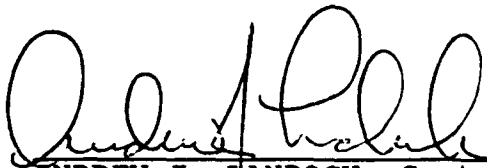
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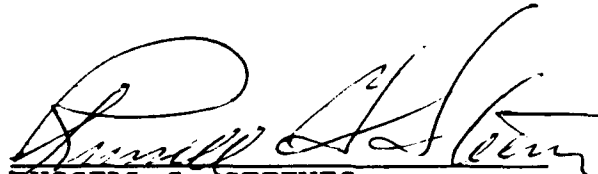


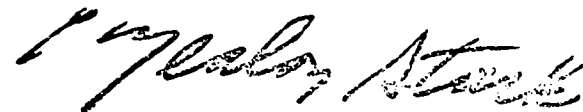
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92-29606

This technical report has been reviewed and approved for publication.


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13. ABSTRACT (Maximum 200 words) The Spirit II Launch Vehicle System was launched successfully from Poker Flat Research Range on 28 March 1992. All flight objectives were achieved and a peak altitude of 326 Km achieved. The vehicle liftoff weight was 20,092 pounds. The first stage, powered by the Talos motor, boosted the vehicle to an altitude of 6000 feet. The first stage experienced minor wind disturbances. The second stage, Aries motor (a surplus solid propellant motor from the Minuteman I missile), performed as predicted. The inertial guidance system achieved the pre-programmed burnout conditions. The spent second stage impacted 157 Km uprange.				
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1. INTRODUCTION

1.1 Purpose. This document provides the post flight analysis for Flight A26.780, Spirit II.

1.2 Scope. A post flight analysis of the telemetry and tracking data has been performed. This flight data is compared to post flight computer simulations.

1.3 Responsible Organization. Orbital Sciences Corporation/Space Data Division (OSC) was responsible for vehicle preparation and launch.

2. SUMMARY

2.1 Launch Particulars.

2.1.1 Launch Date and Time. The launch occurred on 29 March 1992, local time of 2307:45 (807:45 UT).

2.1.2 Launch Site. The vehicle was launched from Pad 4 at the University of Alaska's Poker Flat Research Range (PFRR). The 20K MRL launcher was modified by the addition of a step rail and zero-length rail retractor installed by OSC.

2.2 Performance. The vehicle attained an apogee of 326 km and impacted at a range of approximately 159 km. All vehicle performance and guidance parameters were met.

2.3 Launch Configurations. The launcher configuration is illustrated in Figure 1. Vehicle stations' numbers and major components are presented in Figure 2.

2.4 Launch Sequence. The sequence of events for the boost phase of the vehicle are shown in Table 1.

2.5 Vehicle Weights. The entire payload and interstage were weighed and the center of gravity (CG) determined. The values determined were a total weight of 3081.8 pounds with the CG located 92 inches forward of the aft interstage flange. This is vehicle Station No. 147. The vehicle mass properties are presented in Table 2. Using individual hardware weights, the estimated liftoff weight was determined to be 20,092 pounds.

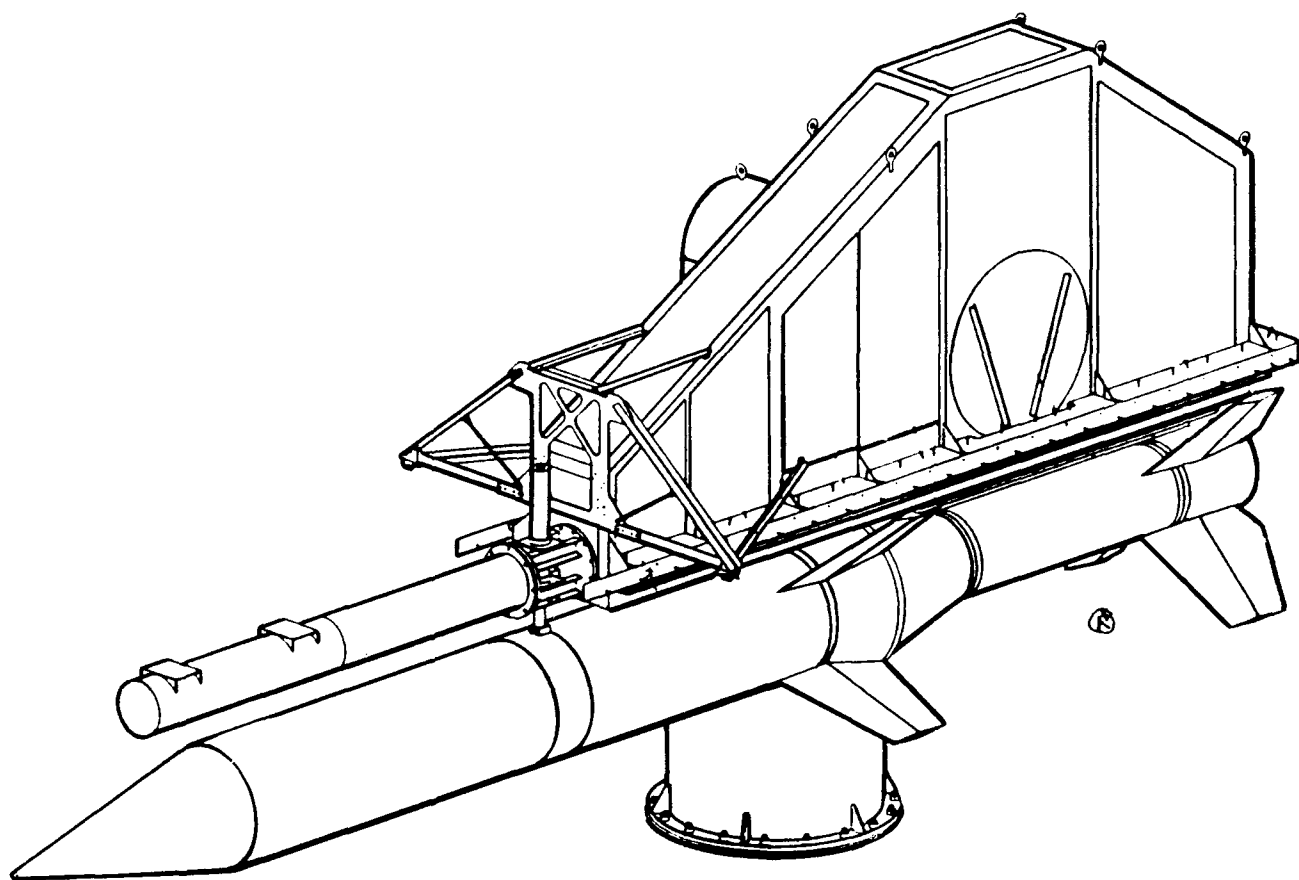


Figure 1. Spirit II Vehicle on 20K Launcher

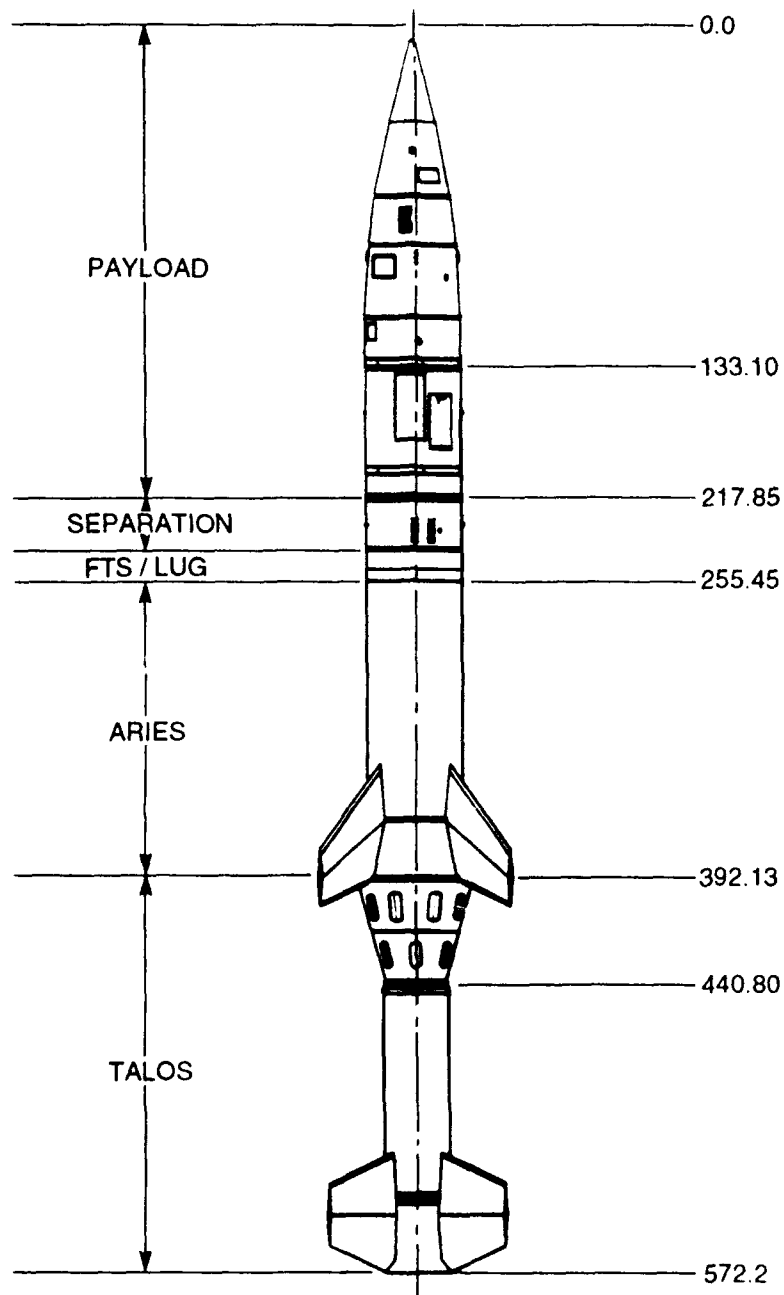


Figure 2. Spirit II Vehicle Configuration

TABLE 1. SEQUENCE OF EVENTS

TIME SEC	EVENT	ALTITUDE FEET	VELOCITY FEET/SEC
0.0	IGNITION	647	0
6.3	TALOS BURNOUT	3,855	782
9.9	TALOS SEPARATION	--	--
10.0	ARIES IGNITION	5,947	681
34.0	MAXIMUM DYNAMIC PRESSURE	35,998	2,016
73.0	ARIES BURNOUT	205,539	7,282
80.0	PAYLOAD SEPARATION	255,417	--

TABLE 2. MASS PROPERTIES

SPIRIT II VEHICLE		PFRR						
ELEMENT DESCRIPTION		WEIGHT (LB)	CENTER OF GRAVITY LOCATIONS (INCHES)			MOMENTS OF INERTIA (SLUG-FT**2)		
			X	Y	Z	IX	IY	IZ
PAYLOAD_SEP		3081.8000	0.0000	0.0000	147.00	2420.00	2420.00	118.00
ARIES		12163.7002	0.0000	0.0000	312.61	4084.78	4084.78	742.25
TALOS		4846.5000	0.0000	0.0000	491.45	2622.00	2622.04	147.90
SYSTEM TOTALS:								
TOTAL SYSTEM WEIGHT		20092.00 LBS						
SYSTEM CG								
LOCATION:	X-AXIS	0.0000 INCHES						
	Y-AXIS	0.0000 INCHES						
	Z-AXIS	330.3470 INCHES						
MOMENTS								
OF INTERIA:	X-AXIS	59422.64 SLUG-FT**2						
	Y-AXIS	59422.68 SLUG-FT**2						
	Z-AXIS	1008.15 SLUG-FT**2						

3. FLIGHT RESULTS

3.1 Performance

3.1.1 Weight. Based on weigh-in data taken at PFRR, the estimated vehicle liftoff weight was 20092 pounds.

3.1.2 Velocity and Peak Altitude. OSC's 6DOF trajectory simulation program predicted an apogee of 324 Km and a second stage burnout speed of 7285 feet/second.

The simulation velocity and altitude values are compared to INS telemetry data in Figure 3 and Figure 4. The maximum measured speed occurred at T + 72.2 seconds and reached a value of 7339 feet/second.

The on-board calculation of peak altitude performed at stage 2 burnout resulted in a predicted altitude of 324.5 Km. The INS measured an apogee of 325 Km. The TRADATS system at PFRR indicated an apogee of 326 Km, while the radar altitude was 325 Km.

3.1.3 Impact Point. The 6DOF predicted impact point is compared with the on-board Instantaneous Impact Prediction (IIP) calculation in Table 3.

TABLE 3. IMPACT DATA

SOURCE	LATITUDE (DEG)	LONGITUDE (DEG)
6DOF	66.5170	-147.1187
INS	66.5200	-147.084

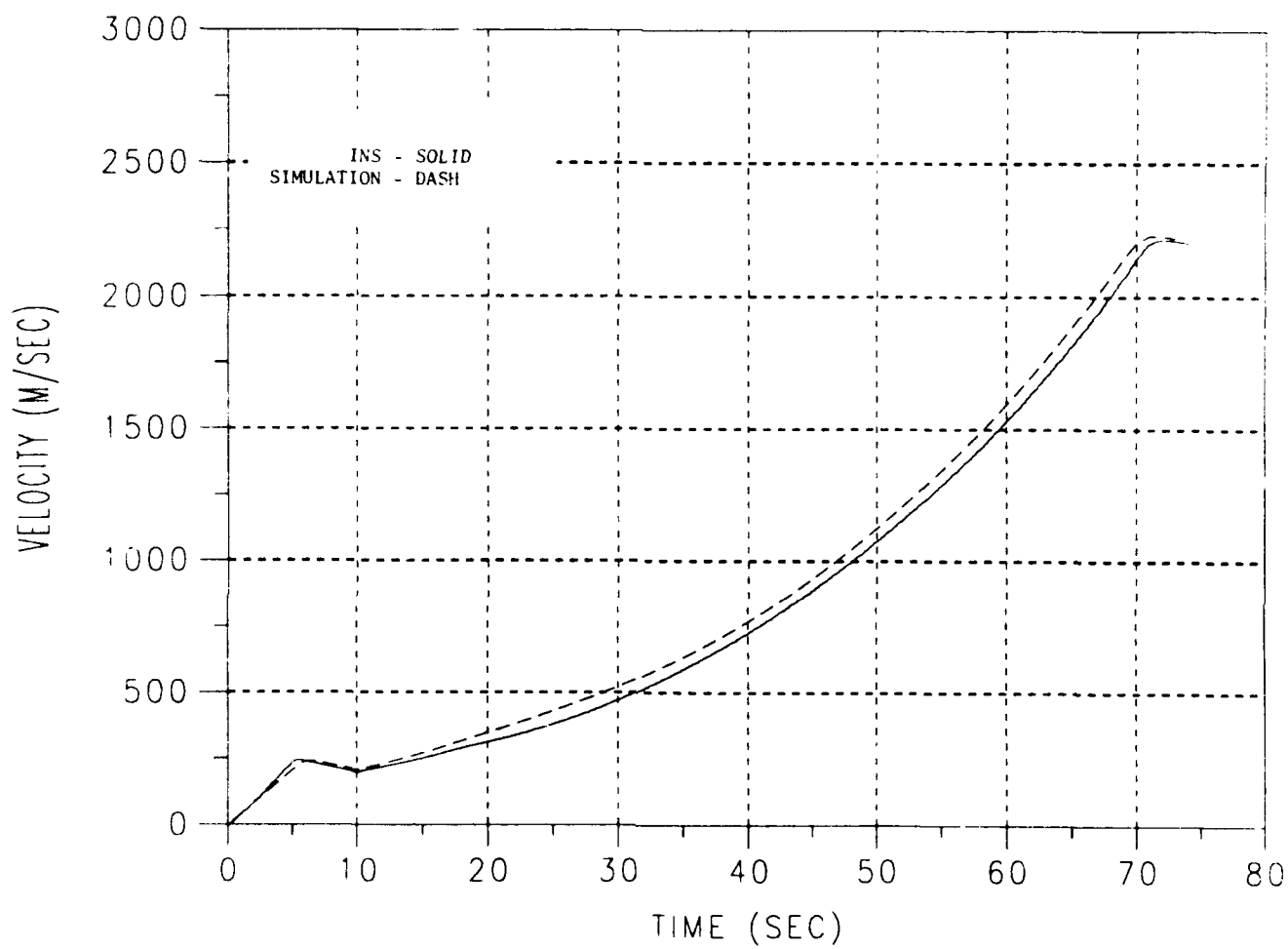


Figure 3. Velocity Comparison

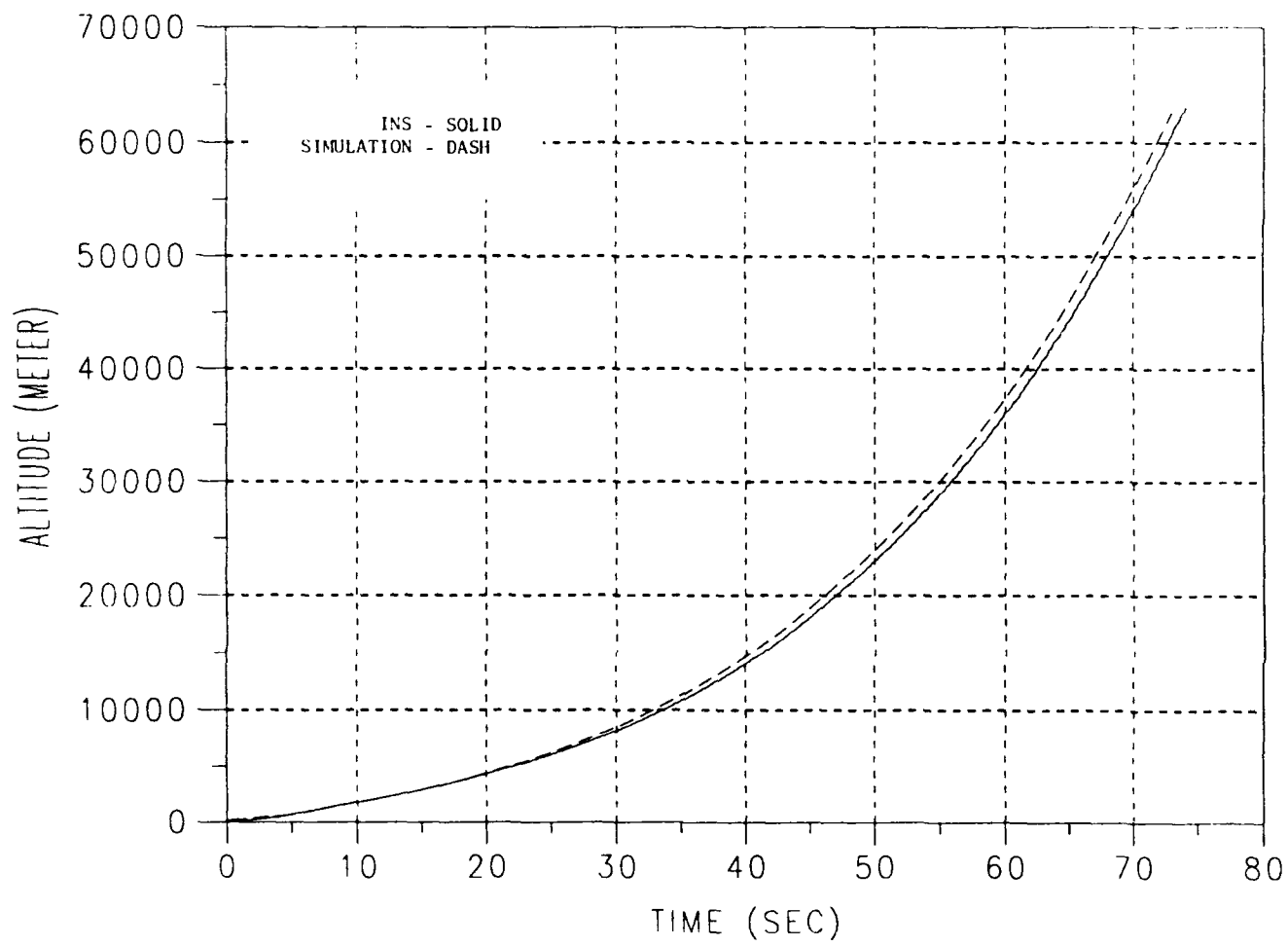


Figure 4. Altitude Comparison

The 6DOF predicted impact range was 164 Km at an azimuth of 06.8 degrees. The TRADAT system indicated an impact range of 159.42 Km at an azimuth of 6.12 degrees. The radar measured an impact range of 159 Km on an azimuth of 06.5 degrees.

3.1.4 Motor Data. Motor chamber pressures were measured. These pressure traces are presented in Figures 5 and 6. Motor performance is evaluated by determining the value of integrated pressure. This value is noted in each Figure. The indicated performance of each motor is considered to be nominal. There was very little Talos after-burning or chuffing. The estimated motor soak temperature was 65° F. The Aries motor serial number was 22694. The Talos motor was from Lot 10.

The Nozzle Control Unit (NCU) voltage monitor indicated two data drop-outs during Aries burn. The cause was not determined. The NCU battery lost voltage at T + 7 minutes.

3.2 Guidance Performance. Telemetry data is compared to post-flight simulations in order to evaluate the performance of the hardware and software.

3.2.1 Vehicle Position. Flight pitch, yaw and roll data are compared to post flight wind simulations in Figures 7, 8, and 9. It can be seen during Talos boost that significant variations in yaw and roll values occurred.

Additional simulations were performed by adding a Talos thrust misalignment. An angular thrust misalignment reproduces the flight yaw data as illustrated in Figure 10. The value simulated was 0.057 degrees or 3.45 minutes. The addition of a thrust offset produces the observed roll motion, but not the exact magnitude. An .08 inch offset produced a roll angle of 35 degrees as compared to the observed value of 50 degrees (Figure 11). These thrust misalignments are well below the three sigma value of 12 minutes specified by Wallops.

The post burnout roll data is presented in Figure 12. A very slow roll-up after burnout (and loss of roll control) can be seen. Upon payload separation, a significant reduction in roll moment of inertia occurs, and roll position increases. The booster spin jets are activated 0.1 seconds after payload separation. The roll direction is reversed (as expected) and a spin rate of 40-50 degrees/second is built up.

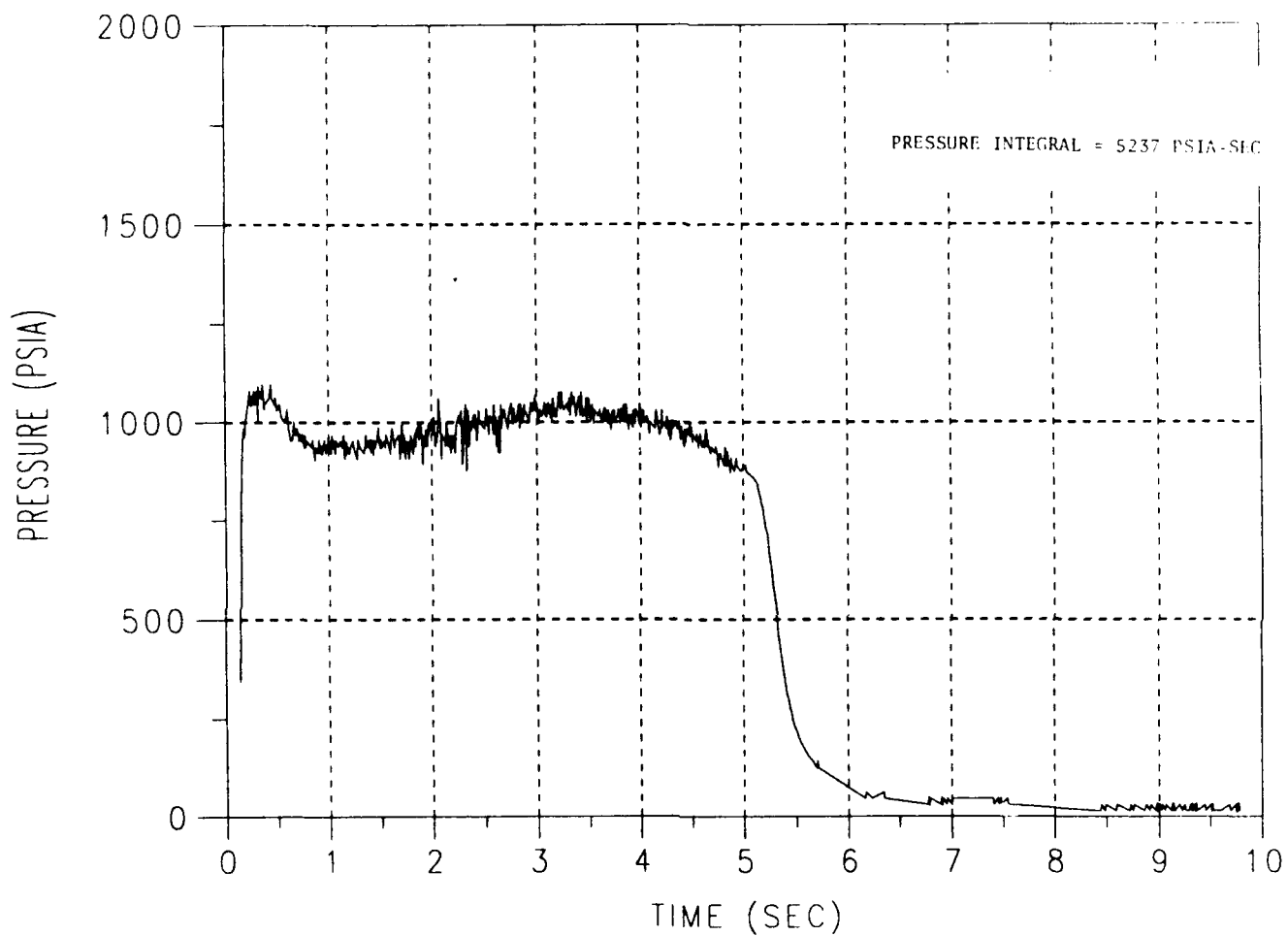


Figure 5. Talos Chamber Pressure

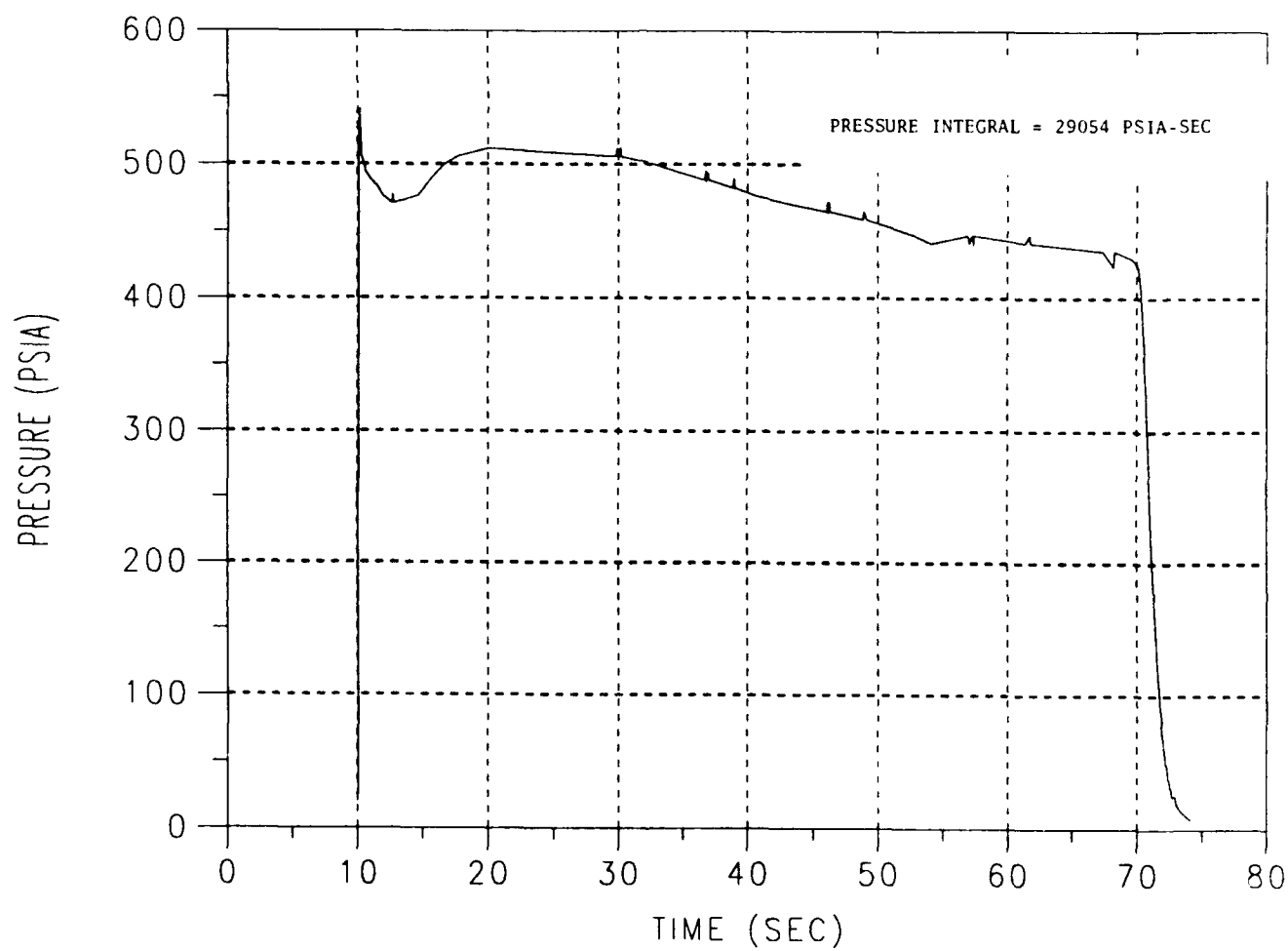


Figure 6. Aries Chamber Pressure

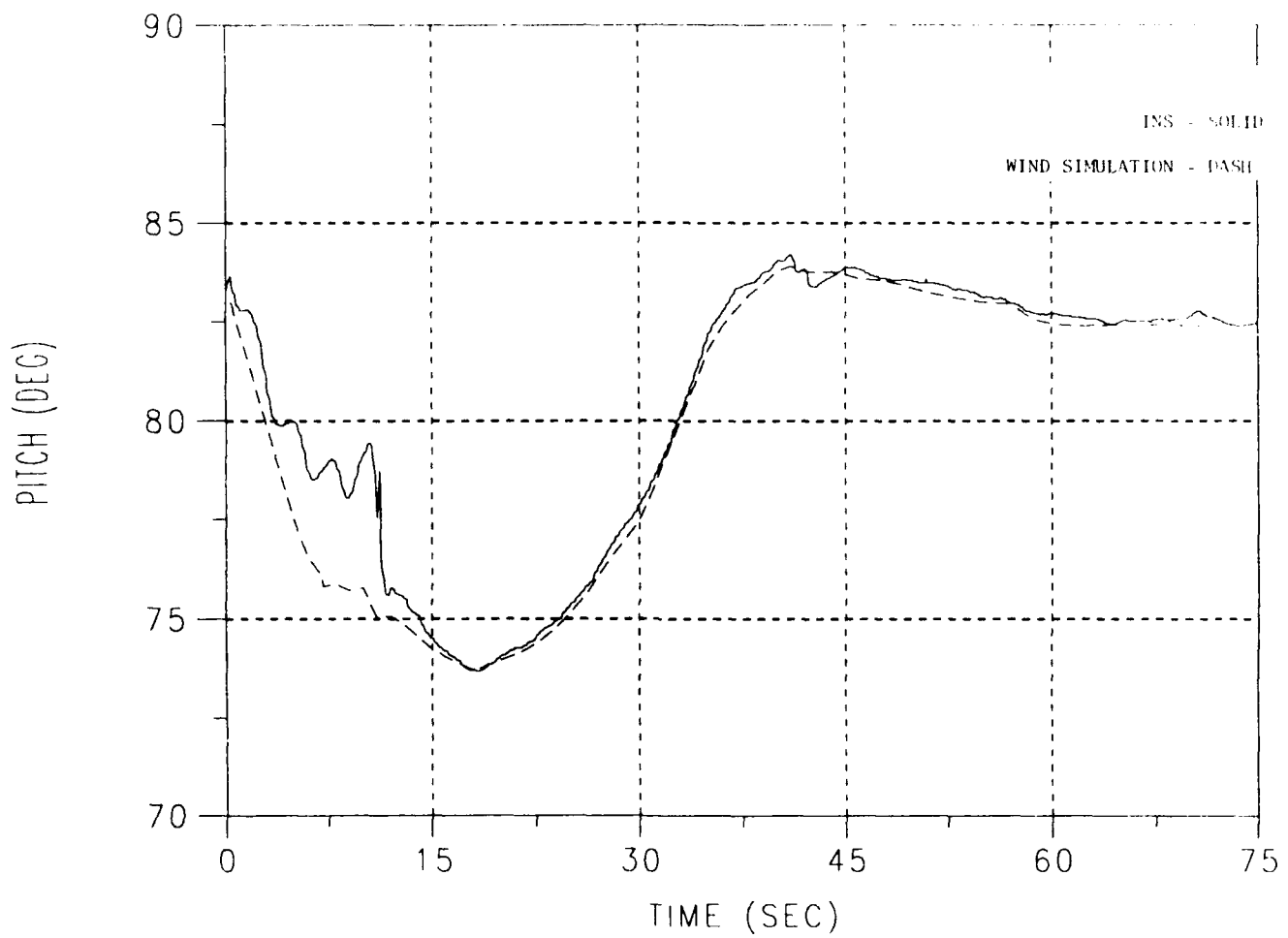


Figure 7. Vehicle Pitch Position

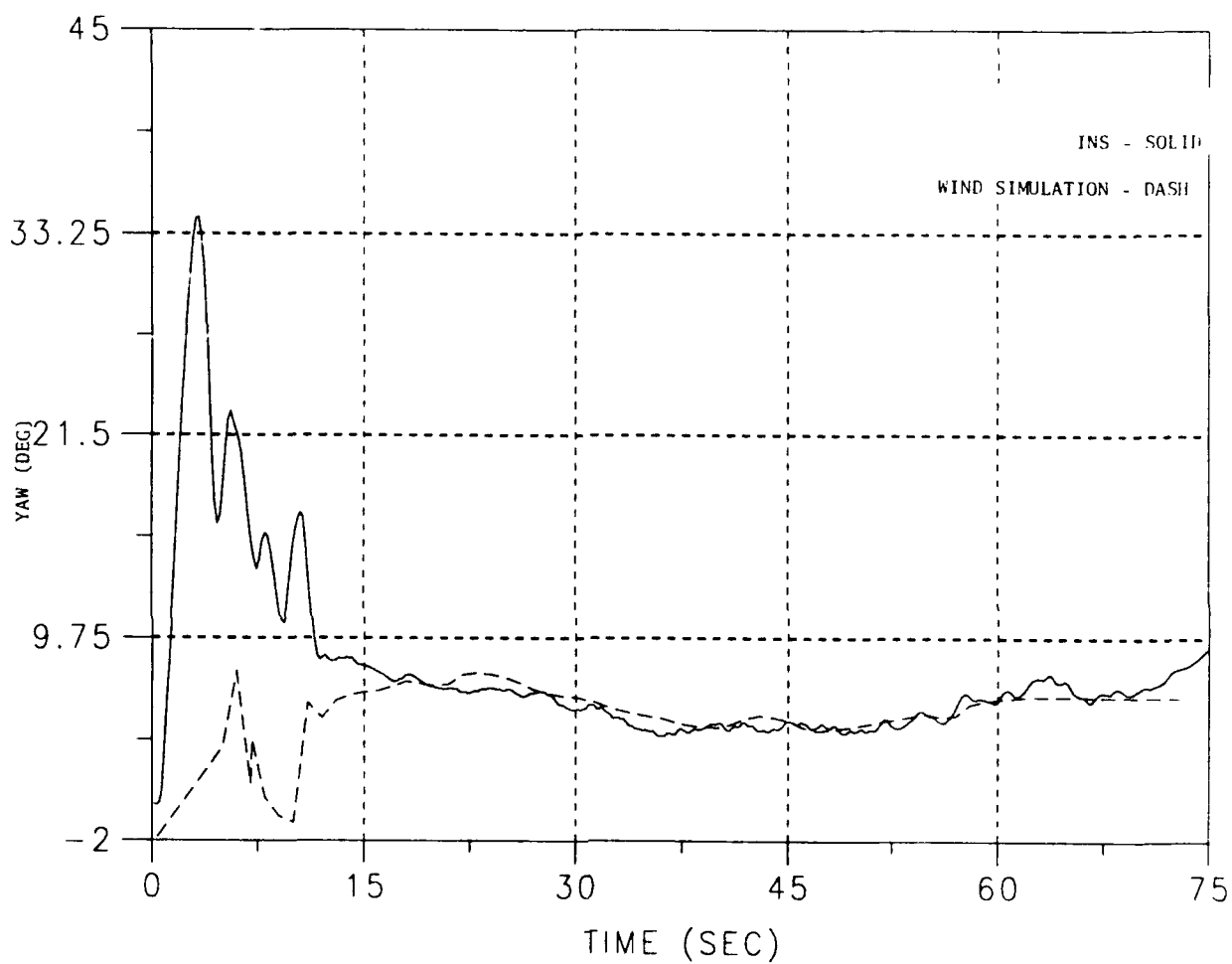


Figure 8. Vehicle Yaw Position

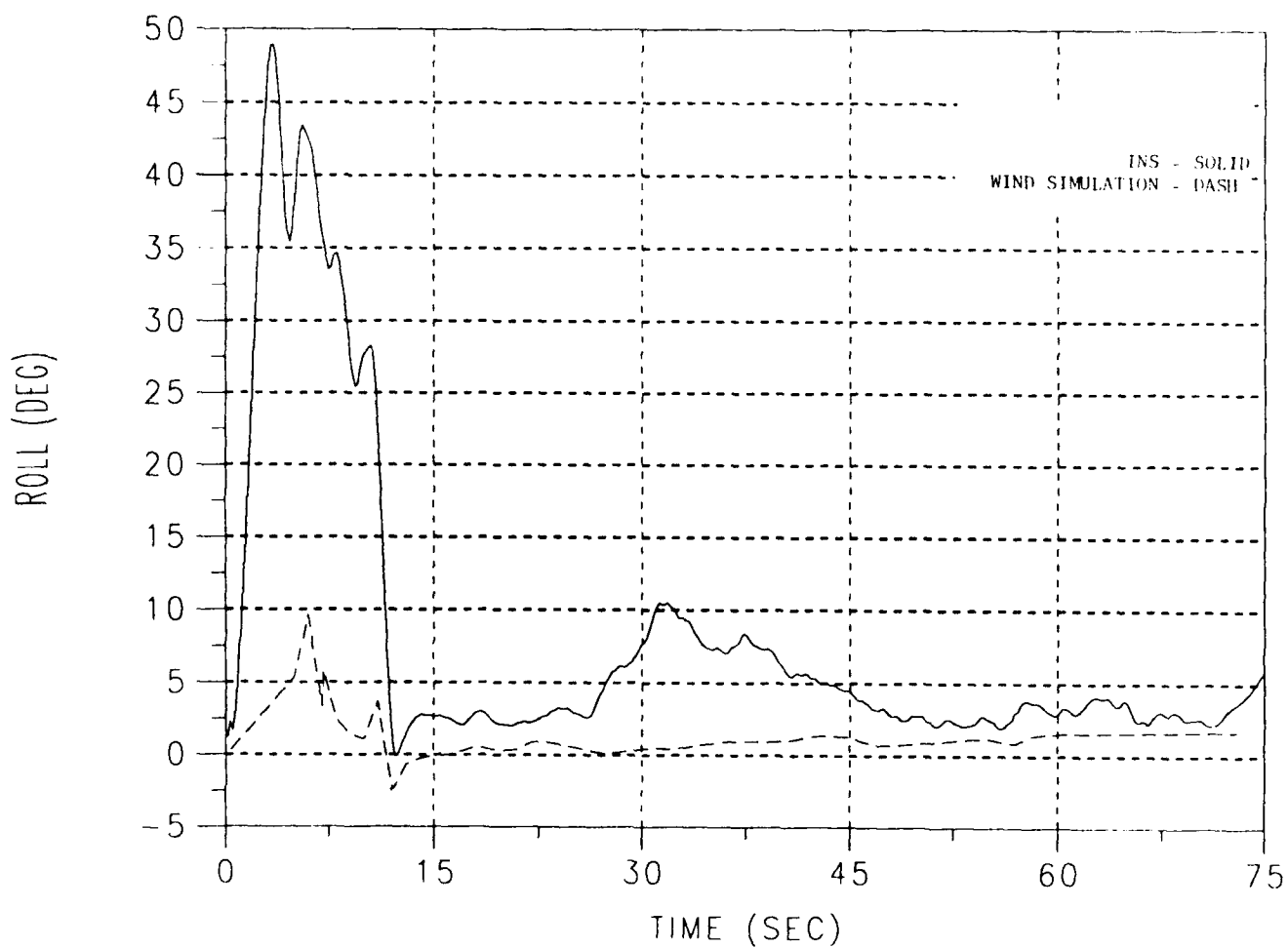


Figure 9. Vehicle Roll Position

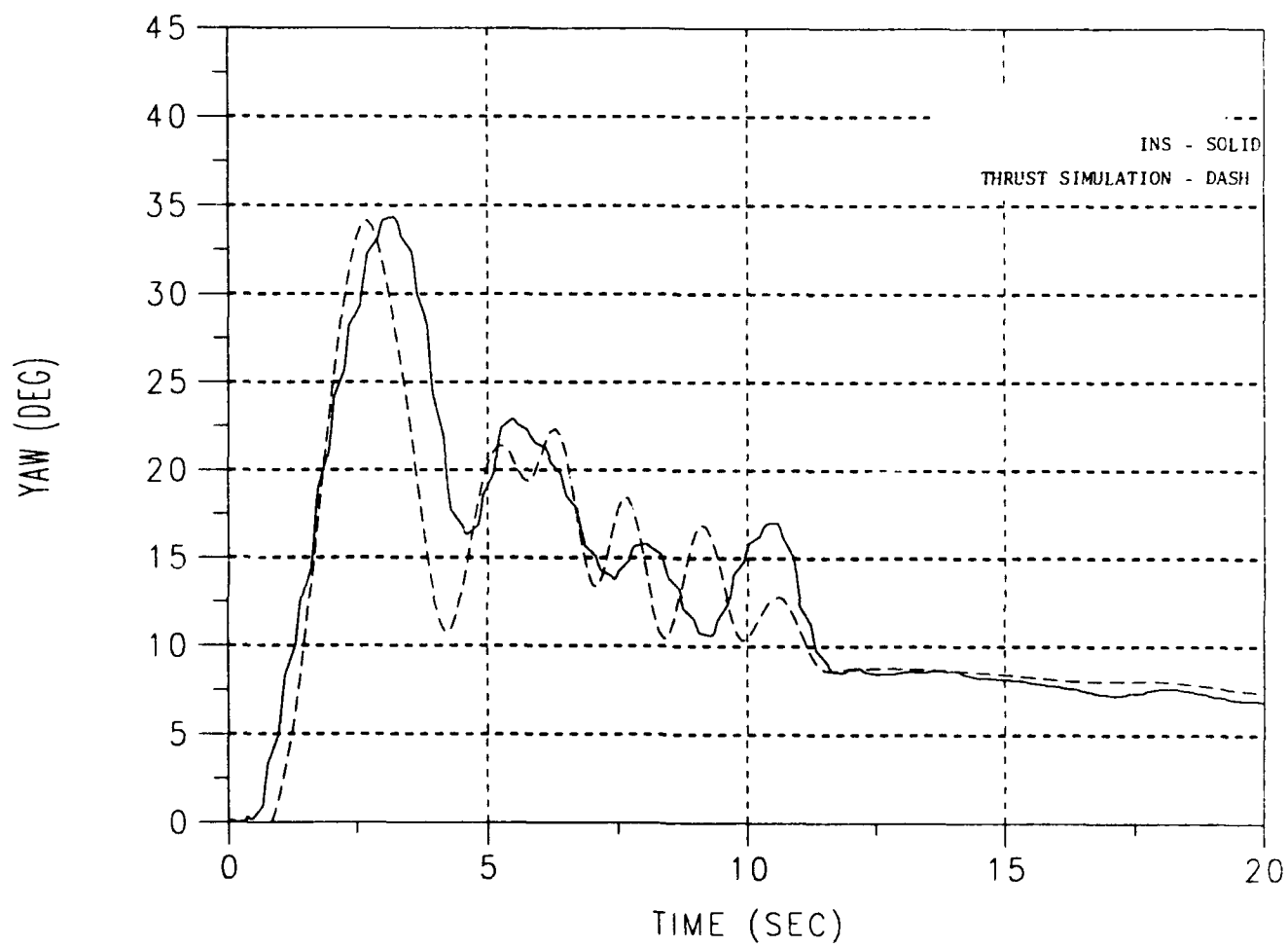


Figure 10. Vehicle Yaw Position (Thrust Misalignment)

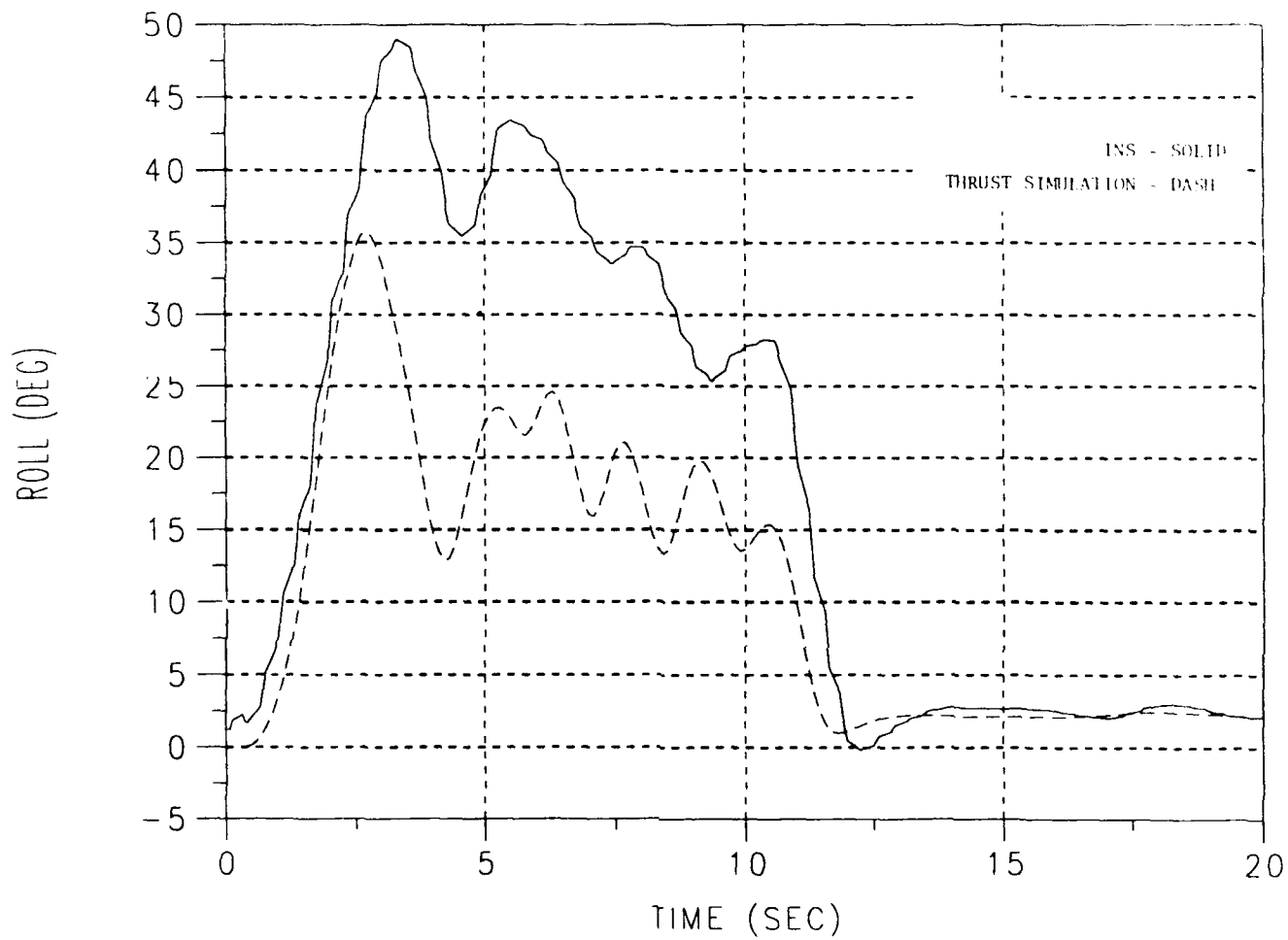


Figure 11. Vehicle Roll Position (Thrust Misalignment)

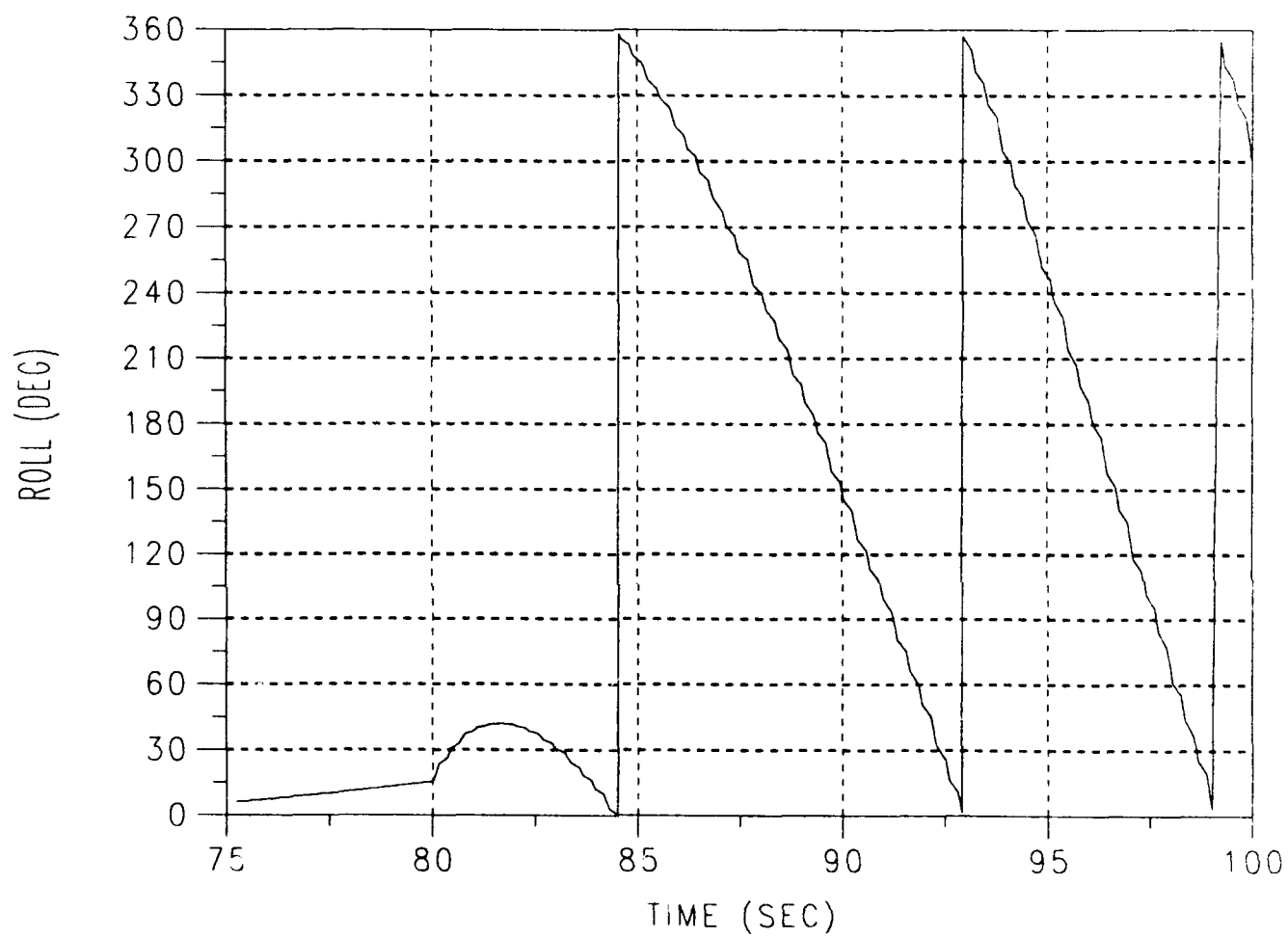


Figure 12. Post Burnout Roll Position

3.2.2 Aries Nozzle Motion The second stage flight data is compared to the wind simulation results in Figures 13, 14, and 15. There are no apparent unusual movements. The NCU voltage monitor has two unexpected voltage drops; however, nozzle movement at these times is unaffected.

3.2.3 Post Flight Simulations. The post-flight simulations include the wind fields measured at T-2 hours and the winds measured by the 250 foot tower at T=0. The launcher was set at an azimuth of 358.2 degrees and an elevation of 83.0 degrees, which indicates the winds were quite mild. The required launcher settings were 06.8 degrees in azimuth and an elevation of 82.0 degrees.

3.3 Timing. Decoding the NASA 28-bit timing code results in a T=0 time of 2307:45.250. All telemetry timing is based on this T=0 time. The following timing was determined:

a. Talos ignition	0.151 seconds
b. Talos pressure @ 0	6.080
c. Aries Ignition	10.0716
d. Talos Separation	10.0884
e. Aries pressure @ 0	74.1063
f. Payload separation	80.0491

A closer look at the Aries ignition and Talos separation event is seen in Figure 16. V-band firing current phase is seen at 10.010 seconds, while the Aries ignition current phase occurred at 10.050 seconds. Initial chamber pressure rise is about 100 milliseconds later with the steep pressure rise occurring at 10.0716 seconds. The Talos interstage disconnect occurs at 10.0884, with Aries chamber pressure at a value of approximately 200 psia.

The Guidance Control Computer (GCC) timing code called for a 100 millisecond delay between the separation and ignition phases. The actual delay was 40 milliseconds.

Talos separation occurred 16.8 milliseconds after Aries ignition. Assuming a nozzle pressure ratio of 33.3, the pressure in the interstage at separation is estimated at 6 psia, while ambient pressure at this time is approximately 12 psia. It can be postulated that stagnation pressure of the exhaust gases on the Talos motor dome caused separation.

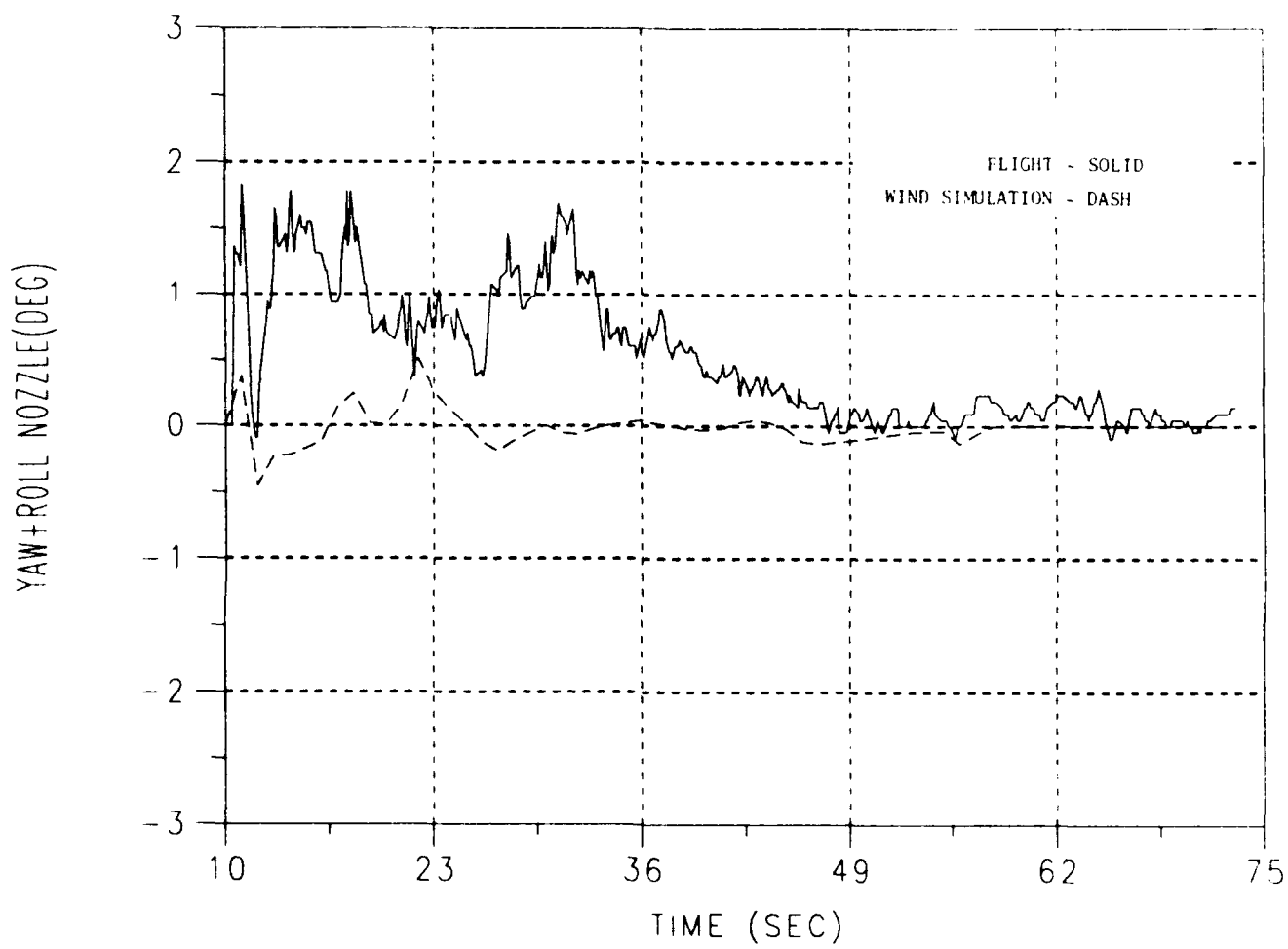


Figure 13. Nozzle No. 1

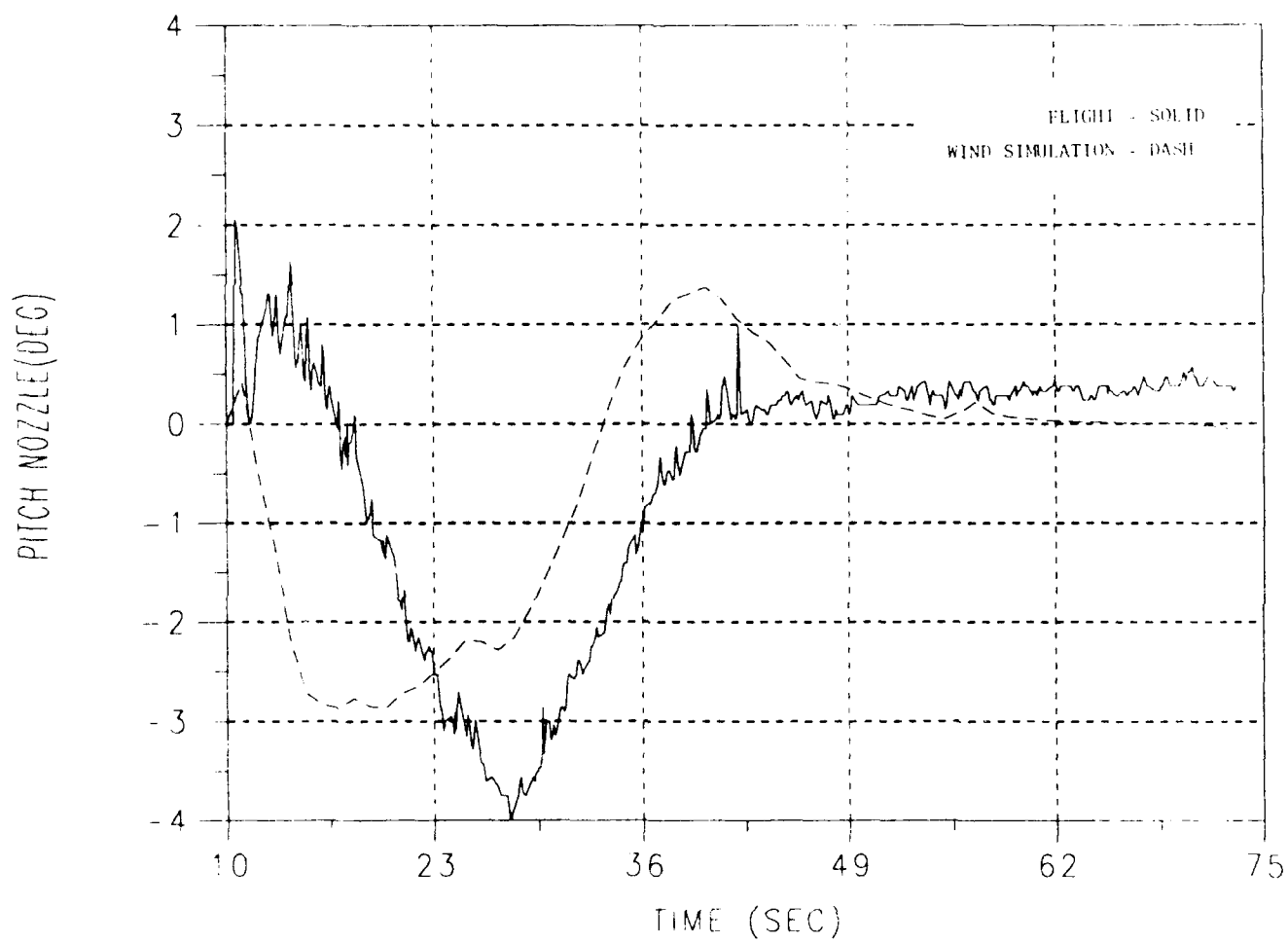


Figure 14. Nozzle No. 2

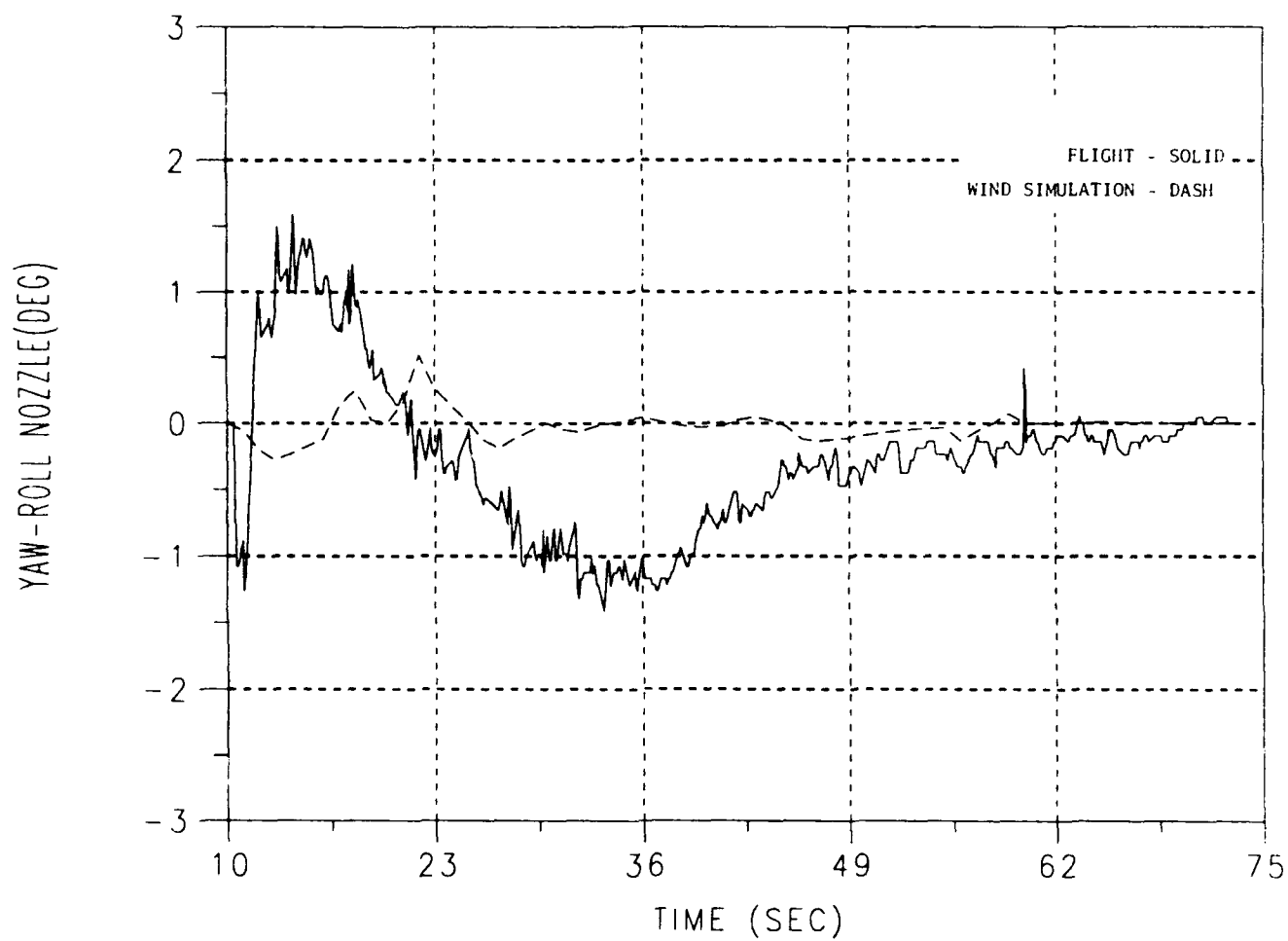


Figure 15. Nozzle No. 3

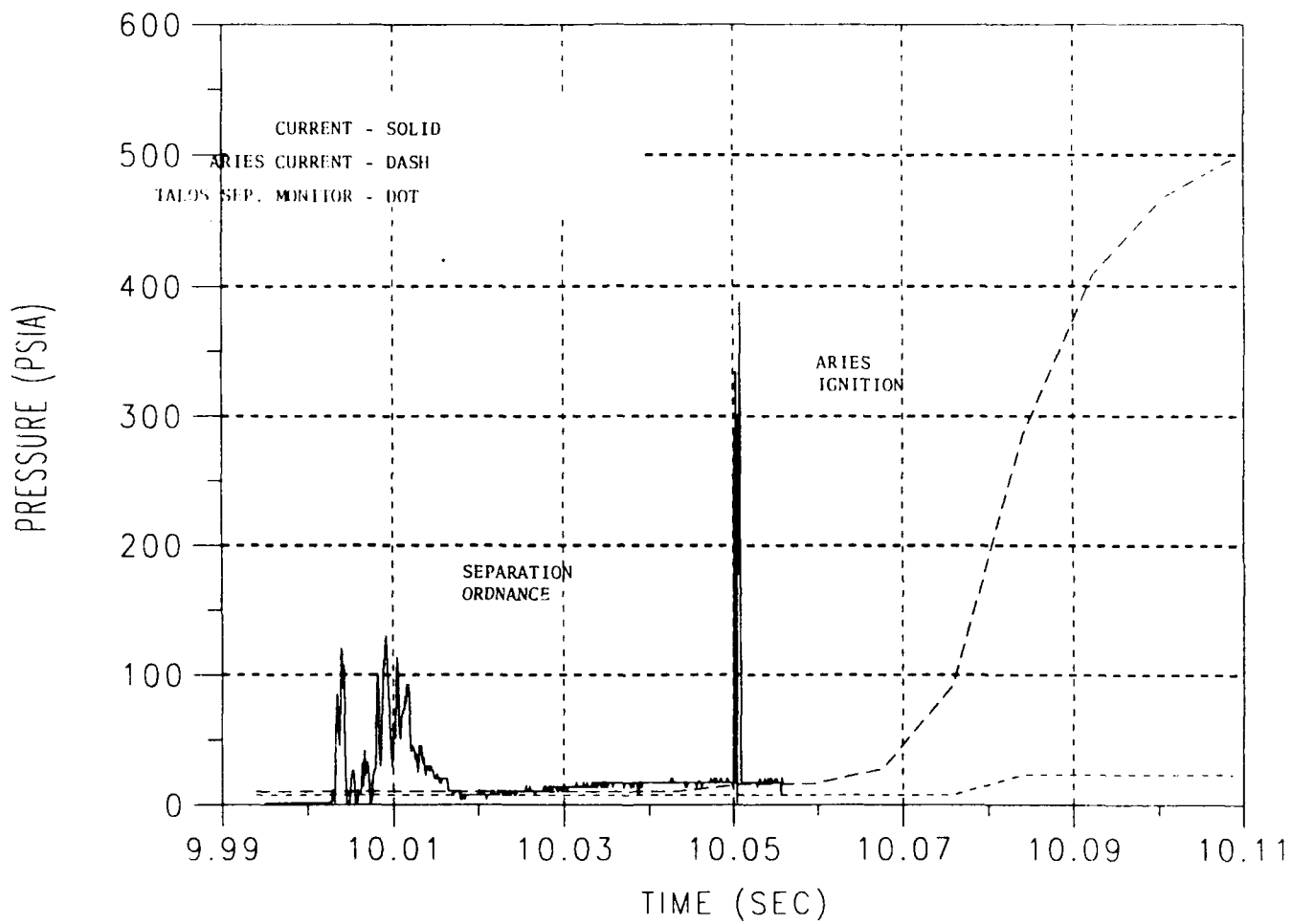


Figure 16. Separation Event

4. LAUNCH OPERATIONS

4.1 Launcher Rework. A crew of four OSC personnel installed launcher hardware during the period from 30 July to 13 August 1991. A Talos step I-beam, aluminum rails, and zero-length rail retractor assembly were installed and aligned.

4.2 Launch Preparations. A crew of four engineers prepared the vehicle hardware and subsystems during the period from 3 December to 21 December 1991. Talos and Aries motors were built-up and installed on the launcher. Checkout of the guidance system was completed.

During the period from 6 January to 16 January 1992, the guidance system was checked out on the launcher with equipment installed in the blockhouse.

4.3 Hot Counts. The first hot count occurred on 23 January 1992. The following launch windows were supported:

- a. Fifth window - 23 January to 10 February
- b. Sixth window - 22 February to 9 March
- c. Seventh window - 22 March to 4 April