Attachment to 5-9600-H-156

UPDATED EMERGENCY DETECTION SYSTEM ANALYSIS OF UPPER STAGE MALFUNCTIONS FOR THE AS-503 C' MISSION

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1.0 INTRODUCTION

This report presents an analysis of the S-II and S-IVB malfunctions for the AS-503 C' mission. This analysis is intended to supplement Reference 1 by giving C' EDS results for malfunction cases where results are different. Differences between the "D" and "C'" mission EDS results will be analyzed by considering vehicle differences.

The significant upper stage baseline vehicle change from AS-503 "D" mission to AS-503 "C'" mission is the C' spacecraft is 7300 pounds lighter. This has three effects on the vehicle characteristics:

a) Total mass is decreased. This increases performance and acceleration.

b) Center of gravity is shifted aft approximately 0.2 meters at 400 seconds of flight time.

c) The moment of inertia is decreased by approximately 0.7% at 400 seconds of flight time.

The effects of "b" and "c" increase the loss of control region for S-II dual control engine out by about 25 seconds. Other vehicle changes do not cause significant difference between "D" and "C'" mission upper stage EDS results.

Recommended EDS abort cues and limit settings are summarized in Table 1-I.

Upper stage malfunctions evaluated are as follows:

a) Actuator hardover - updated.
b) Actuator to null - no change.
c) Loss of inertial attitude - no change.
d) Saturated error and rate signals - no change.
e) Loss of inertial velocity - updated.
f) S-II single engine-out - updated.
g) S-IC and S-II single engine-out - updated.
h) S-II dual engine-out - updated.
i) Early staging - updated.
j) Loss of rate signal - no change.
k) P.U. system malfunctions - updated.

An S-IC EDS Summary is presented in Section 3.0.

TABLE 1-I AS-503/CSM-103 EDS ABORT LOGIC AND LIMIT SUMMARY

MANUAL

STAGE	FLIGHT TIME (SEC)	PARAMETER	LIMIT
S-II and S-IVB	All Phases	Roll Rate Pitch or Yaw Rate FDO Display	20 deg/sec 10 deg/sec* Limits Exceeded
S-II 2 Engine Failures		Engine Status Lights Pitch or Yaw Rate Abort Request Light	4 deg/sec (abort)
Abort & Early Stage Logic		Engine Status Lights Voice Abort Request Light	Abort, Early Stage or Continue Mission Based on Ground Request

AUTOMATIC

S-II and S-IVB	All Phases	AUTOMATIC ABORT NOT REQUIRED

* 1. Overrate light will be lighted at 9.2 ± 0.8 deg/sec.
2. Except dual engine failures.

2.0 ANALYSIS

2.1 ACTUATOR MALFUNCTIONS

2.1.1 Actuator Hardover

Reference 1 analysis of dynamics is valid for S-II and S-IVB. Additional analysis shows that a base heating problem may exist for an S-II actuator hardover inboard. Figure 1 shows the resulting inboard pitch deflection of Engine #1 when Engine #2 is hardover inboard in the pitch plane. All other actuator (both pitch and yaw) deflections were less than 1 degree.

Inboard deflections of Engines 1 and 2 will expose the base area of the S-II to more radiation from the engine plumes. The extent of increase heating and the effect of this increase is not known at this time. The crew must depend on ground control for confirmation of this condition. EDS recommendation is that abort be initiated on ground command.

2.1.2 Actuator to Null

Reference 1 analysis is valid for S-II and S-IVB.

2.2 LOSS OF INERTIAL ATTITUDE

Reference 1 analysis is valid.

2.3 SATURATED ERROR AND RATE SIGNALS

Reference 1 analysis is valid.

2.4 LOSS OF INERTIAL VELOCITY

No abort situations occur for EPO of the "C'" mission for loss of inertial velocity. Updated data is presented in Reference 2 for the "C'" mission. Reference 3 shows that reignition after an X or Z accelerometer failure during boost to parking orbit will result in atmospheric reentry. Therefore, the EDS recommendation is that reignition not be attempted after an accelerometer failure in boost to parking orbit.

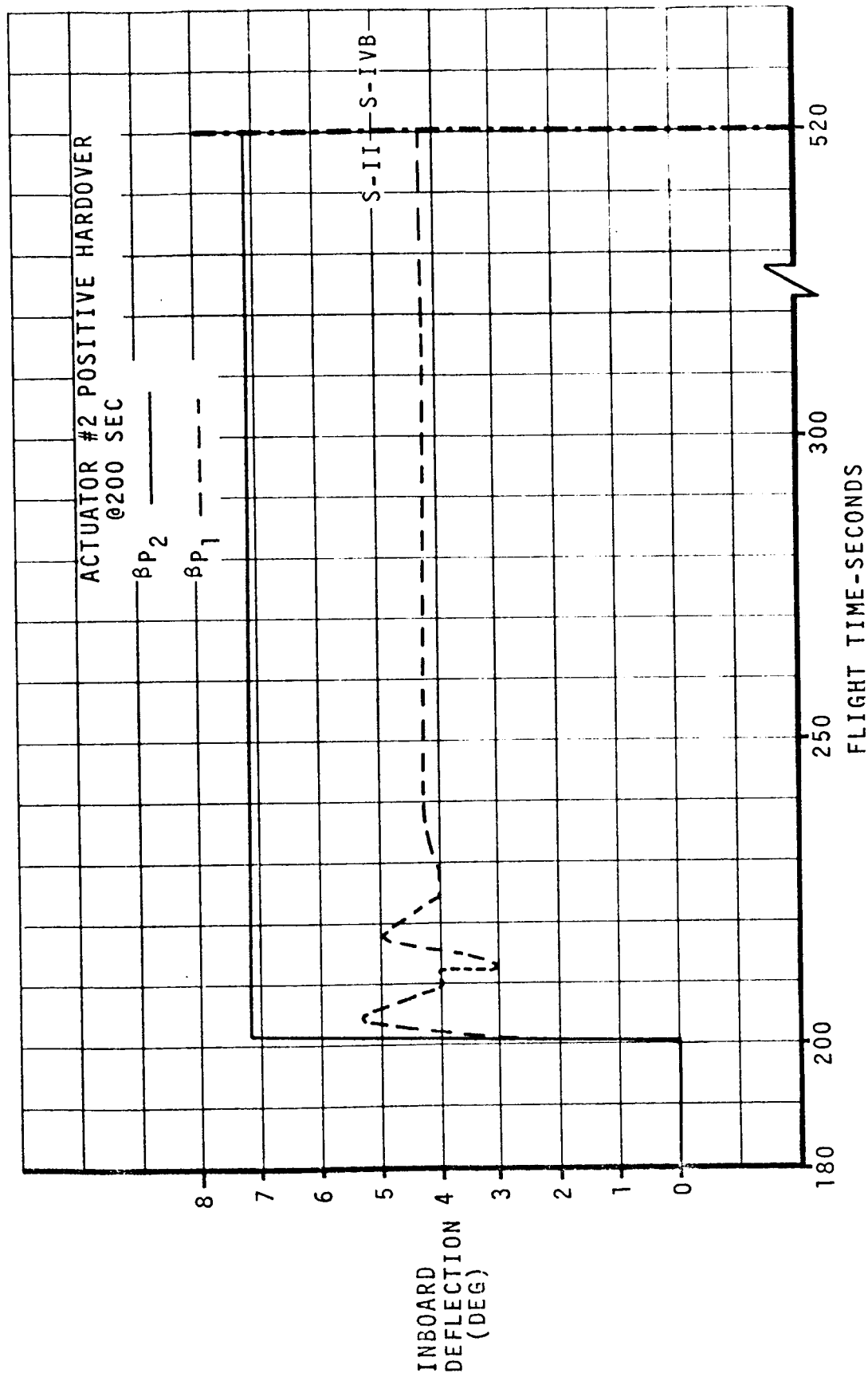

FIGURE 1 PITCH ACTUATOR RESPONSE TO AN S-II ACTUATOR HARDOVER

2.5 S-II SINGLE ENGINE MALFUNCTION

For all cases of S-II single engine malfunction, parking orbit was achieved. Adequate propellant remained at S-IVB first cutoff for restart and second burn. Figure 2 shows S-IVB propellant remaining at S-IVB first cutoff after an S-II single engine malfunction.

No abort is required for a single engine failure in S-II flight due to EDS limits, FDO limits, or loss of control.

Two periods during S-II flight present problems for single engine failure. They are:

1) An engine failure 2 to 4 seconds prior to second plane separation

2) An engine failure within 5 seconds of MRS.

For the first case, an engine failure 2 to 4 seconds prior to second plane separation, collision between the interstage and a J-2 engine bell can occur. A detailed report of this problem is presented in Reference 4.

For the second case an extended CHI freeze will result. The extended CHI freeze is caused by decrementing T_{2i} by an amount greater than Δt (computation cycle time) during the artificial TAU mode. The total duration of the CHI freeze with an engine failure at MRS is 30 seconds. The normal duration is about 12 seconds. This 18 second extension of the CHI freeze period does not cause any guidance problem or loss of control. It does, however, cause a small decrease in payload.

Figures 3 and 4 show the effects on guidance for a single engine failure at MRS; Figures 5 and 6 show effects on the trajectory. Figures 7 and 8 show control engine actuator responses for S-II single engine failure.

2.5.1 Single Engine Failures in S-IC and S-II

Reference 7 indicates that except for Engine #1 and #4 failures in the hi-q region and certain wind conditions, S-IC single-engine failures do not result in loss of control. Each failure considered separately will cause payload loss as indicated by Figure 9 for S-IC and Figure 2 for S-II. Since dual engine

2.5.1 (Continued)

failures have been considered in EDS analysis, the possibility of a dual engine failure, one in S-IC and one in S-II, does exist and is treated here in terms of payload only. Because of the numerous combinations of engine number and failure times possible, a rigid analysis of performance has not been made. However, a few representative cases have been run which might yield some measure of performance. Figure 9 represents insertion payload for #1 S-IC engine failures. Figure 2 represents insertion payload for #2 S-II engine failures. The same performance cases are shown on the composite Figure 10. Thus for an S-IC #1 engine out at 100 seconds and an S-II #2 engine failure at 300 seconds of flight time, payload at POI, as indicated by the composite, would be 58,000 kg. or a loss of approximately 13,700 kg. from nominal payload.

Because of trajectory, environmental and guidance effects, not all engines will yield the same performance slopes shown for the representative cases and the composite payload chart should be used only as a relative indicator of performance rather than a rule.

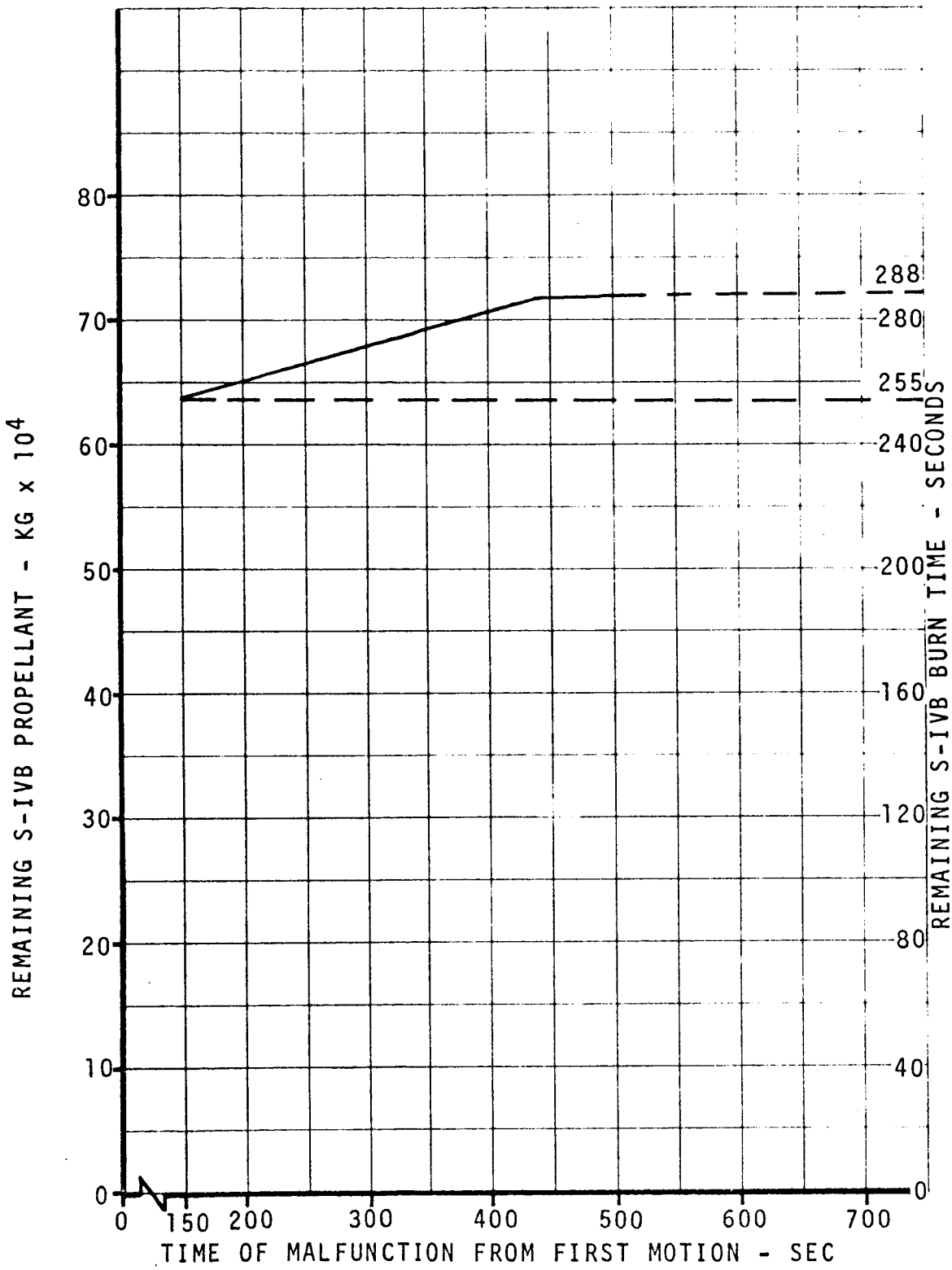

FIGURE 2 S-IVB PROPELLANT AT P.O.I. FOR S-II SINGLE ENGINE FAILURE

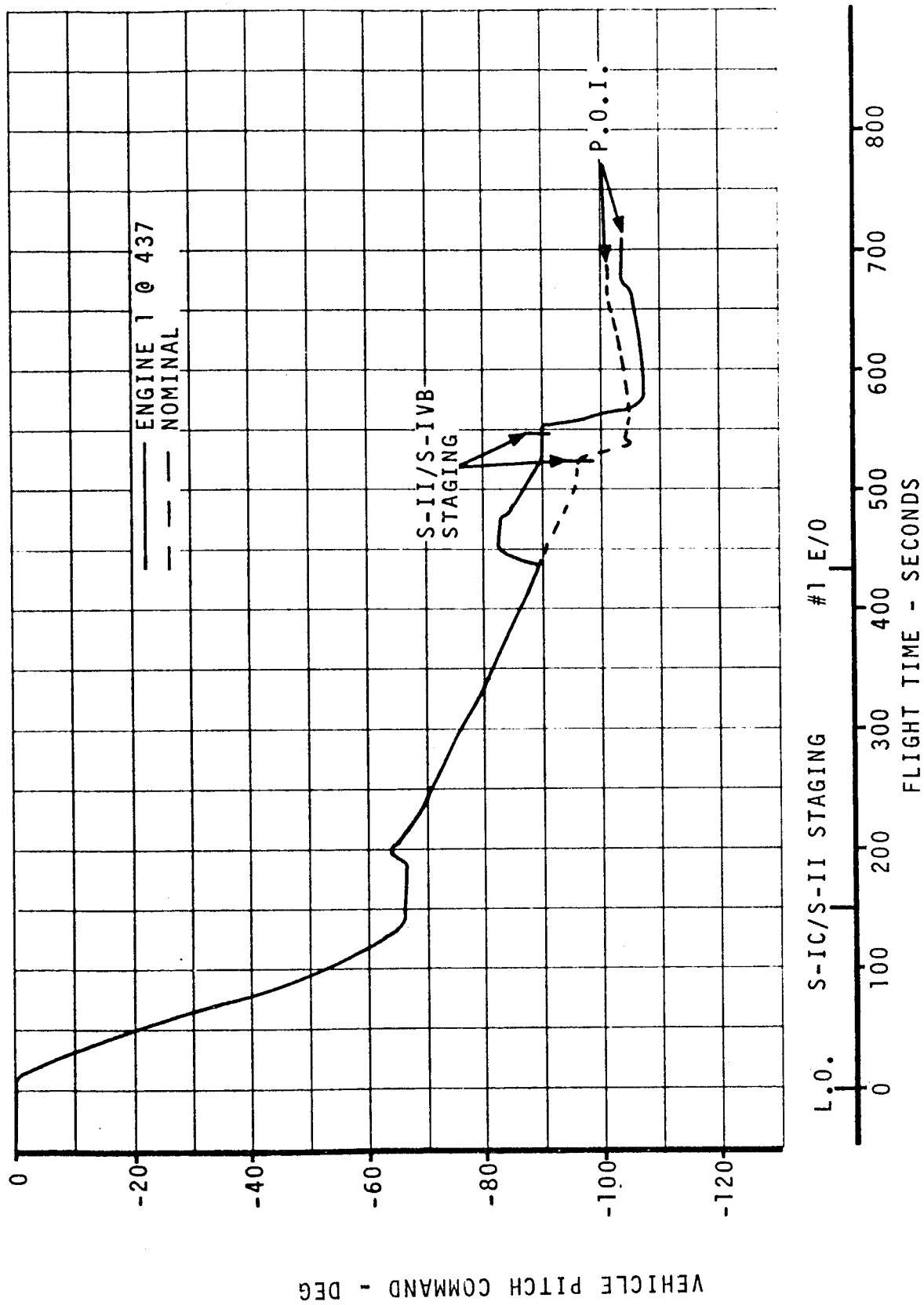

FIGURE 3 VEHICLE PITCH COMMAND AFTER S-II ENGINE OUT

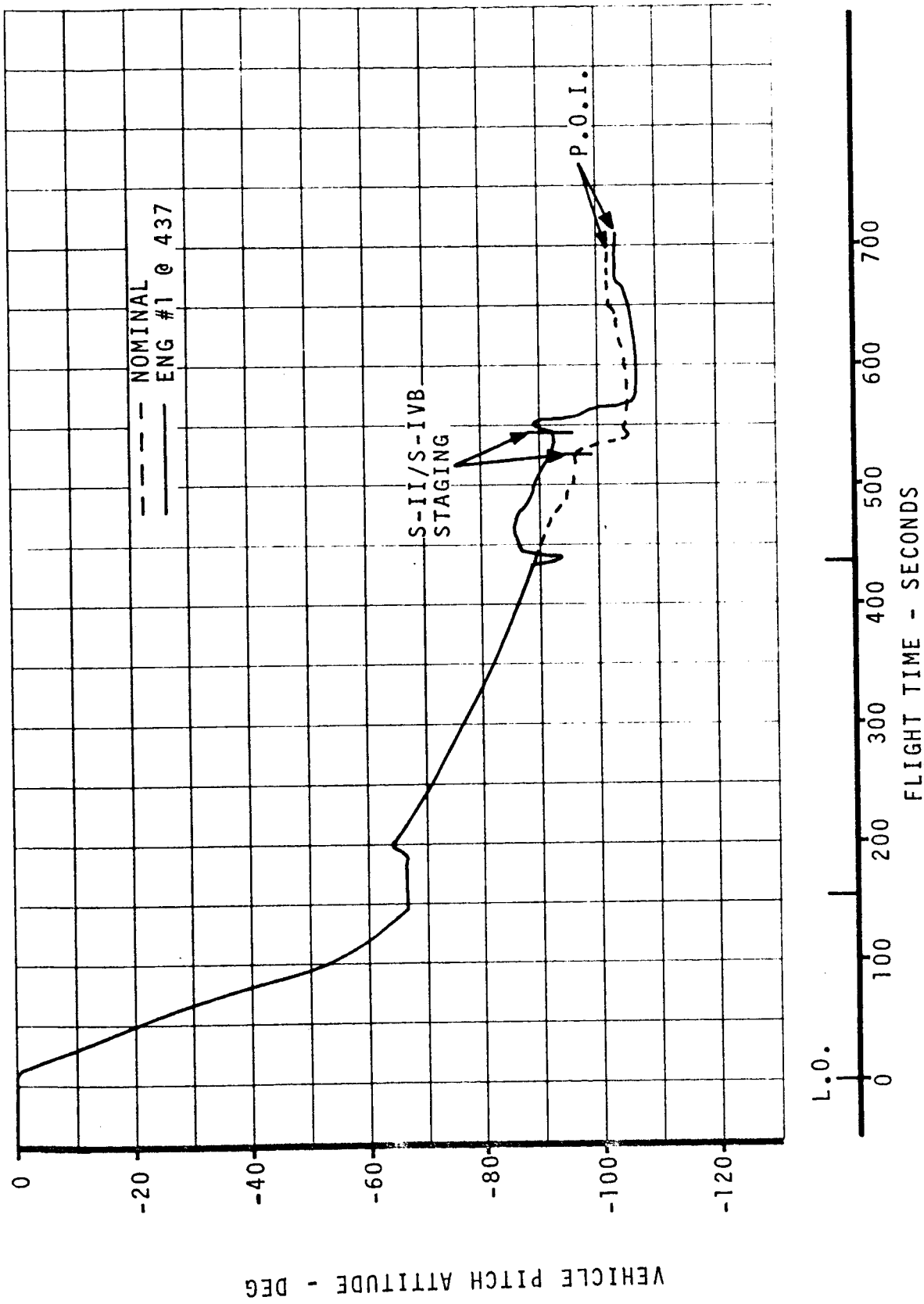

FIGURE 4 VEHICLE PITCH ATTITUDE AFTER S-II ENGINE OUT

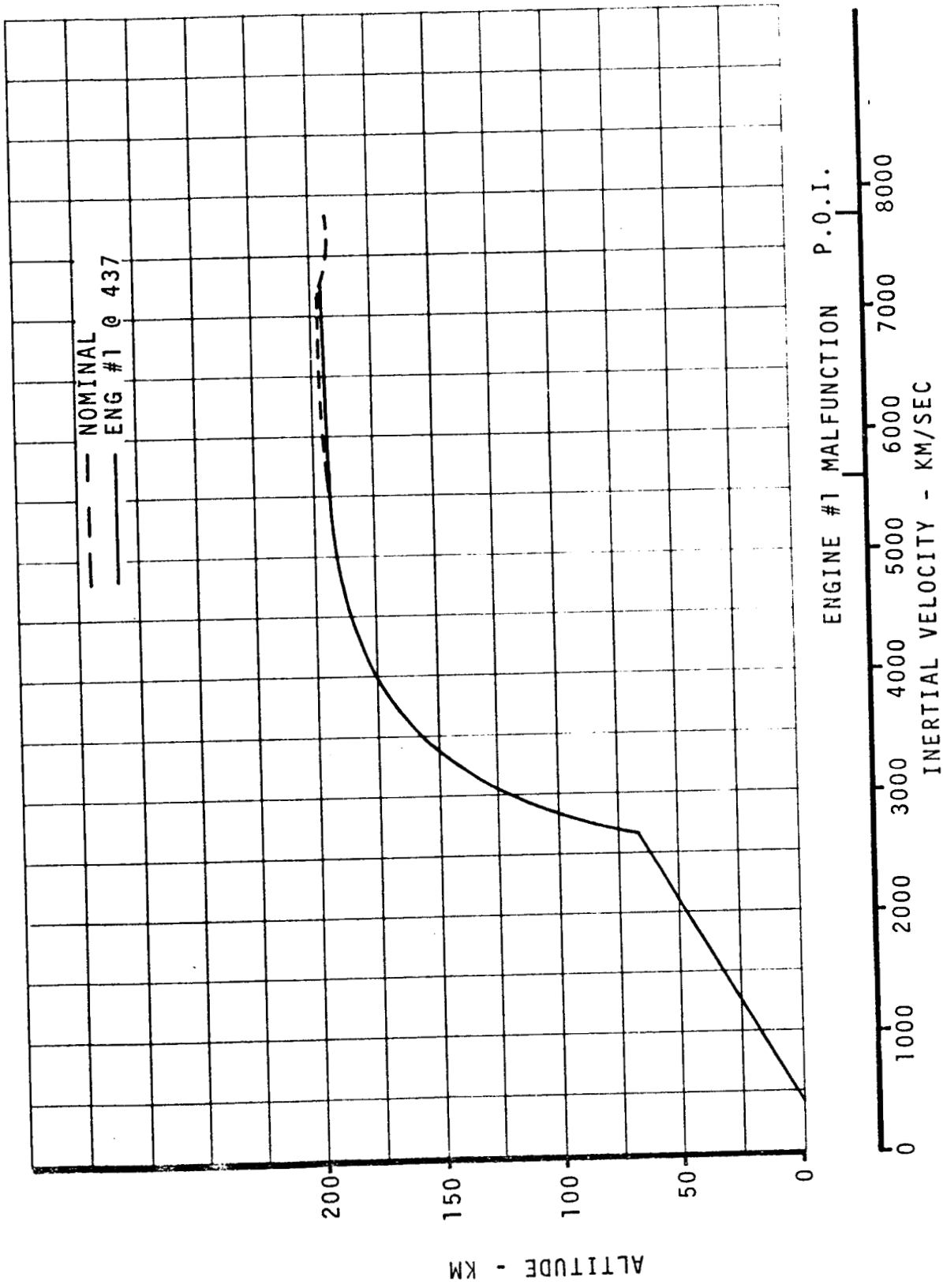

FIGURE 5 TYPICAL H-V HISTORY FOR S-II SINGLE ENGINE MALFUNCTION

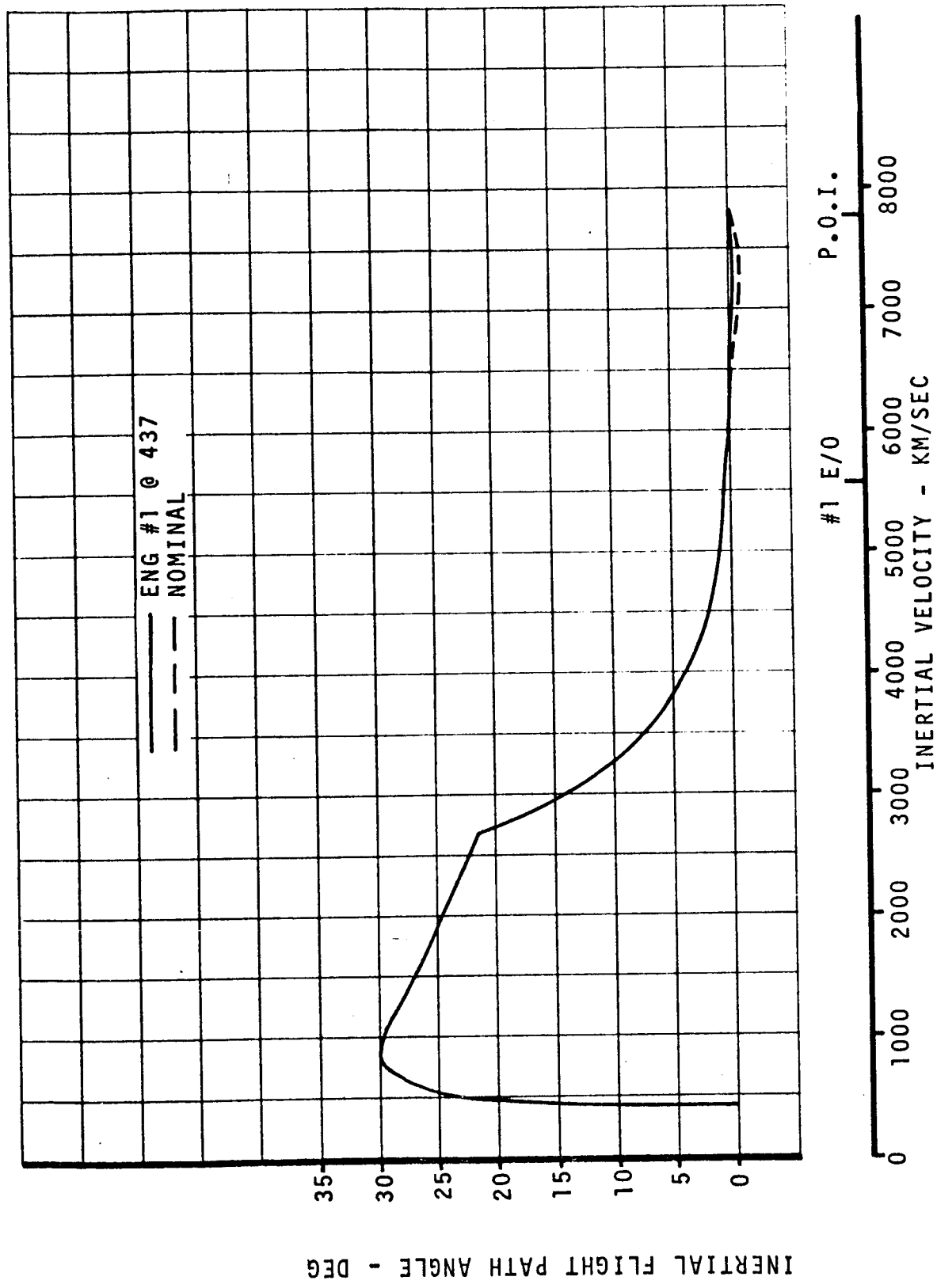

FIGURE 6 TYPICAL γ-V HISTORY FOR S-II SINGLE ENGINE MALFUNCTION

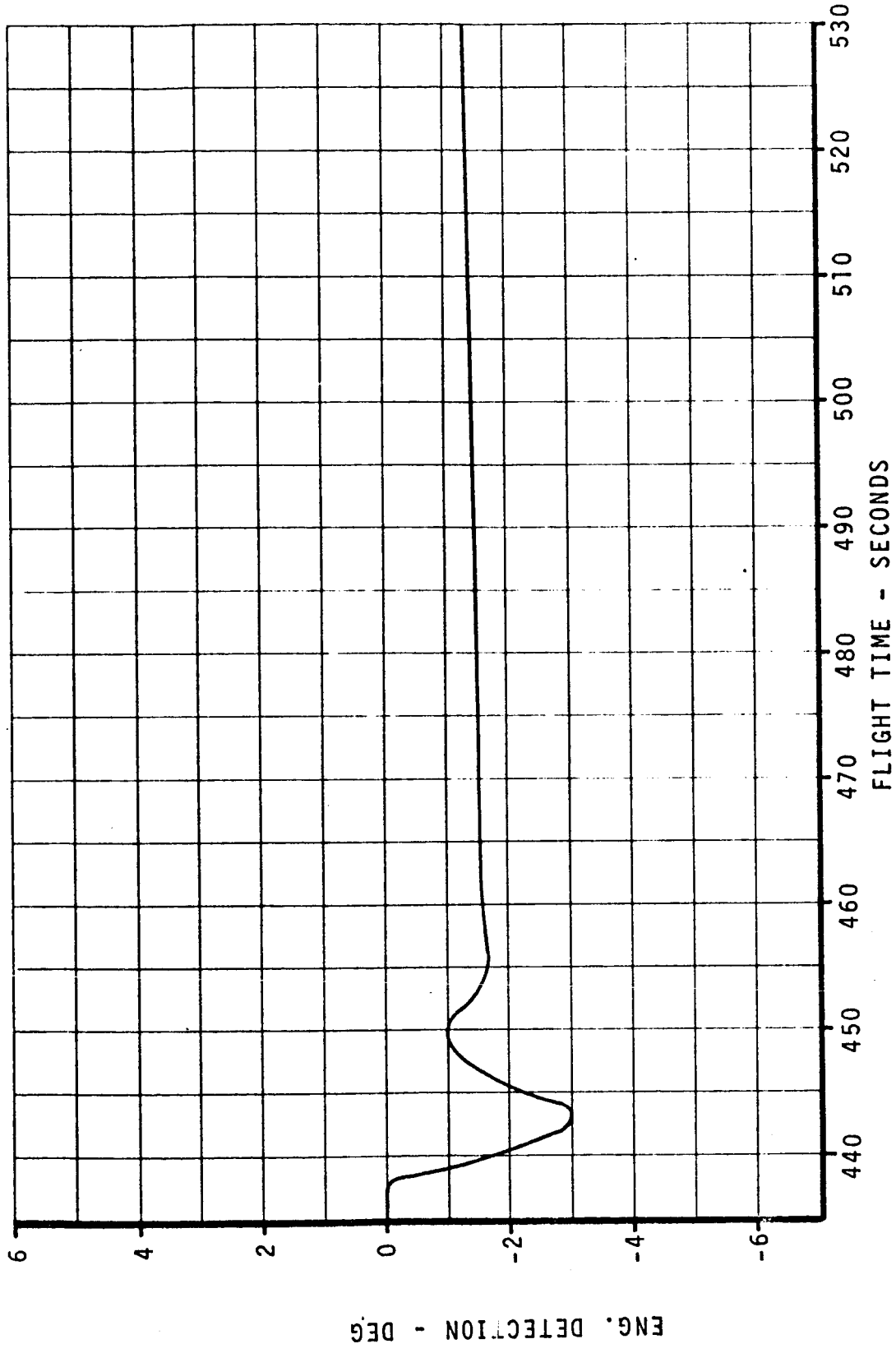

FIGURE 7 NO. 2 PITCH ACTUATOR RESPONSE FOR S-II ENGINE NO. 1 OUT AT 437 SECONDS

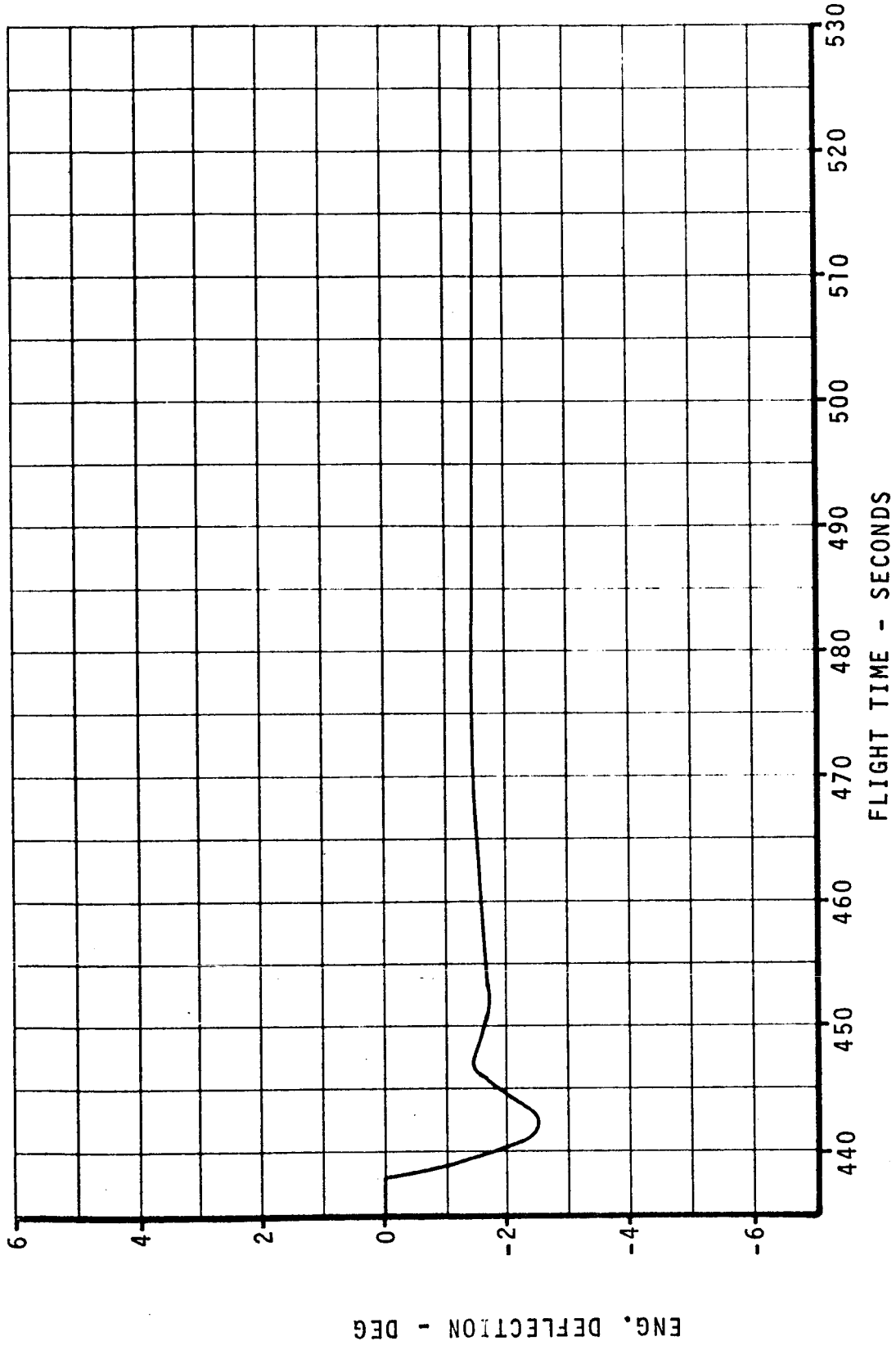

FIGURE 8 NO.2 YAW ACTUATOR RESPONSE FOR S-II ENGINE NO. 1 OUT AT 437 SECONDS

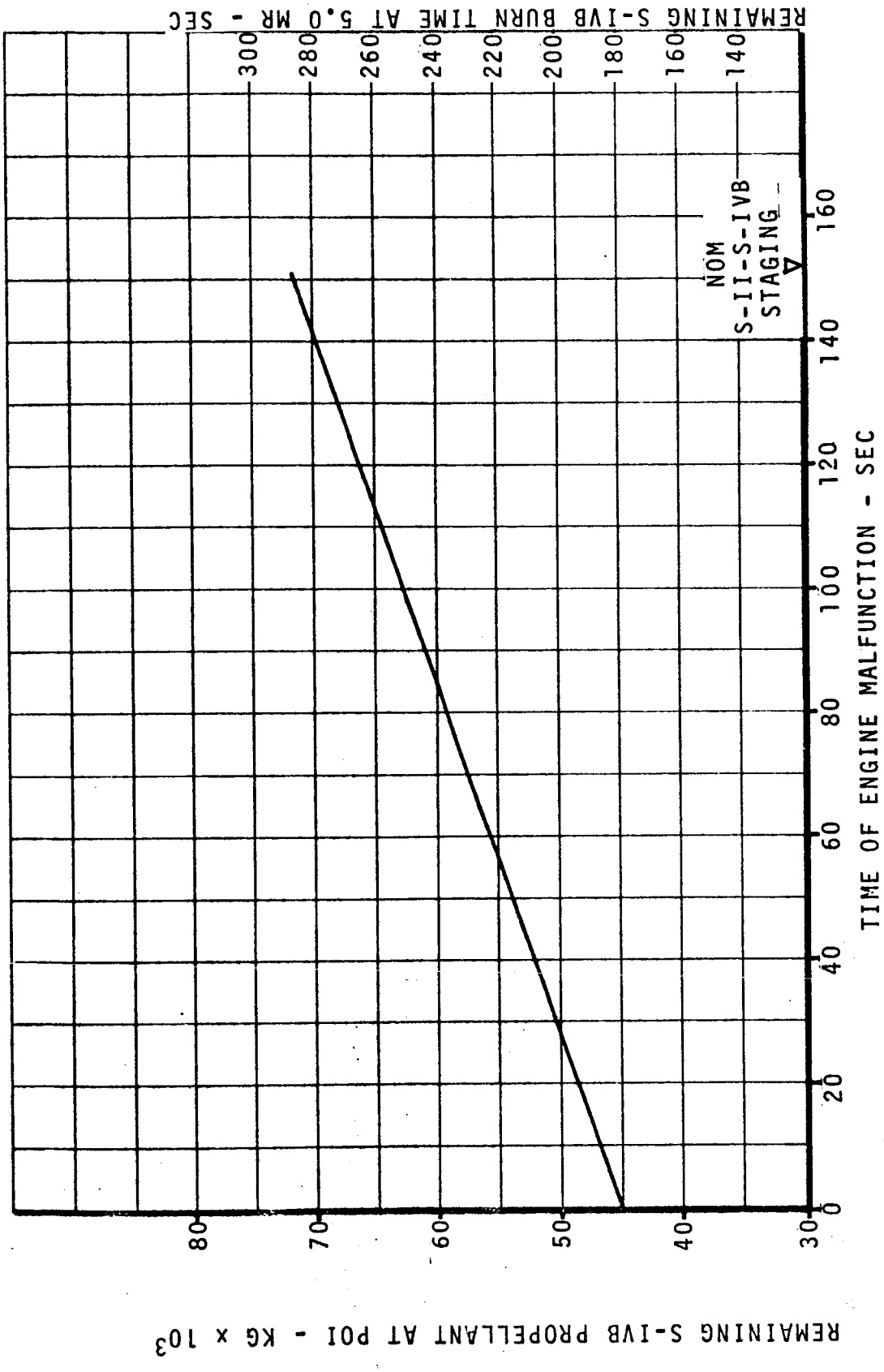

FIGURE 9 S-IVB BURN CAPABILITY AT POI FOR S-IC SINGLE ENGINE FAILURE

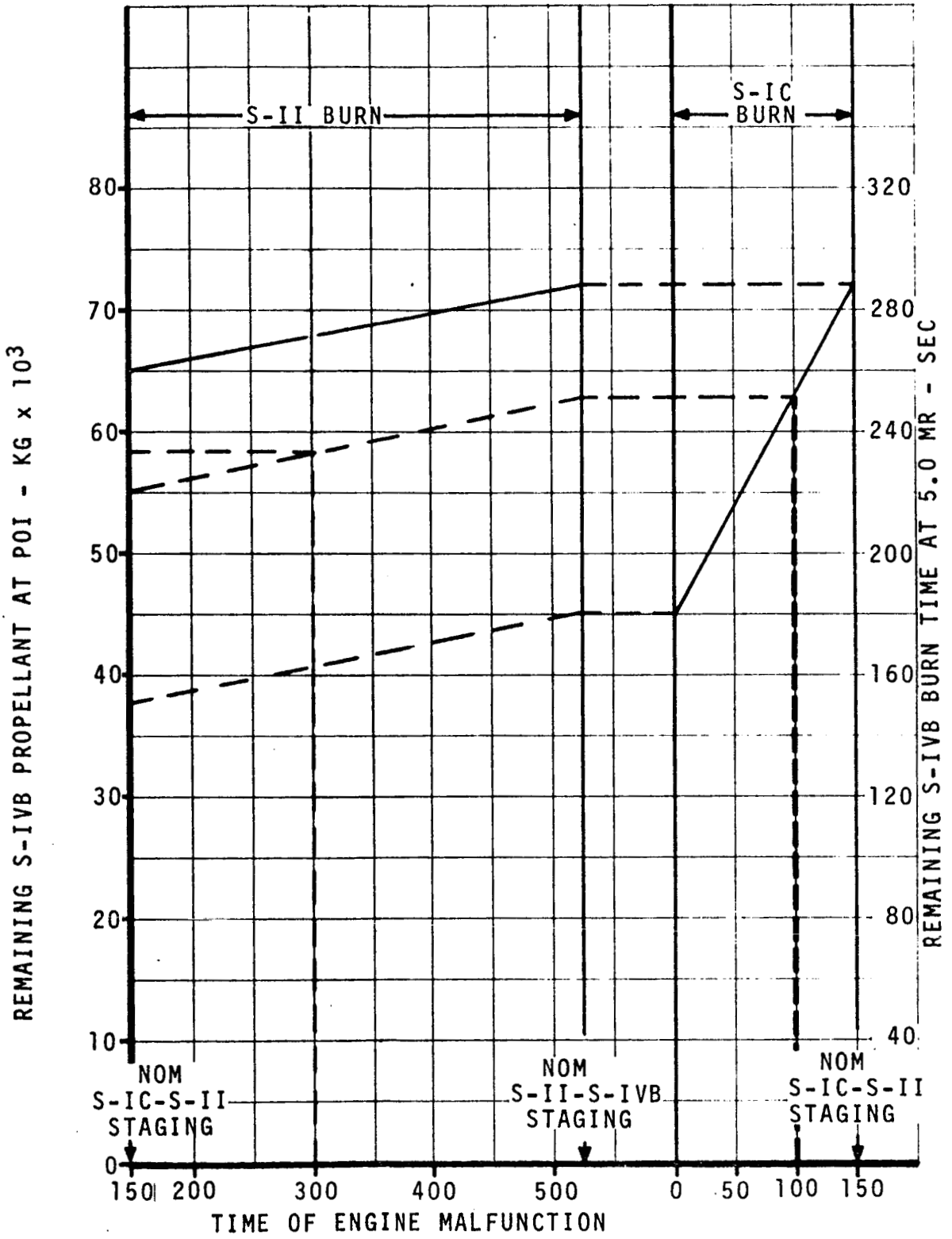

FIGURE 10 S-IVB CAPABILITY FOR S-IC AND S-II SINGLE ENGINE FAILURES

2.6 DUAL ENGINE-OUT - S-II

The spacecraft for the AS-503 C' mission is 3300 kilograms lighter than the spacecraft used in the analysis presented in Reference 1. The decrease in mass results from the removal of the Lunar Module. The absence of the mass from the spacecraft shifts the vehicle center of gravity (CG) to the rear of the vehicle. Since the CG of the vehicle at liftoff is 0.2 meters aft of the CG for the previous analysis, the region of loss of control shown in Figure 11 is extended by 25 seconds for upper and lower dual engine failure cases and 5 seconds for side dual engine failures. For center and one control engine or diametrically opposing engines the region of propellant depletion is reduced because the vehicle is lighter and thus has higher accelerations due to thrust. The region of failure to achieve a 75 nautical mile orbit is changed because the reduced moment of inertia lets the vehicle respond to the guidance commands more rapidly. Reference 5 gives a detailed dual engine out analysis.

The region of loss of control for sequential engine failures can be extended as much as 60 seconds beyond the region of control loss for simultaneous dual engine failures. Since the location of the CG is a major factor in the controllability of the vehicle, it follows that the reduced flowrates resulting from an engine failure impede the forward progression of the CG as propellant is expended. The retarded CG motion extends the period during which a second engine failure could cause loss of control. Thus the overall loss of control region is extended. The extensions of the loss of control boundaries for a dual S-II engine failure can be calculated from Figure 24 using the time of the first engine failure.

2.6.1 Summary

The controllability of the vehicle subsequent to an S-II dual engine failure is lessened due to the vehicle CG being shifted aft because of the 3300 kilogram reduction in the spacecraft mass. Also, rates build up more rapidly because of smaller moment of inertia. However, the smaller moment of inertia reduces the region of guidance problems because the vehicle can respond more rapidly to the guidance commands.

Immediate structural failure for dual adjacent control engines-out (worst case) does not result for any station investigated, but a more detailed examination is indicated for localized stress in the engine vicinity.

2.6.2 Illustrations

Figure 11 shows the interval of time for which dual engine out combinations lose control during S-II or cause IGM to be unable to steer the S-IVB into parking orbit. Figures 12 and 13 show guidance and path angle profiles respectively for a typical loss of control case. Figures 14, 15, and 16 show guidance and trajectory data for a dual engine failure that does not lose control or create guidance problems. Figures 17 and 18 show guidance and trajectory data for dual engine failure in S-II which cause guidance problems in S-IVB. Also shown is the result of early staging at CHI freeze + 5 seconds. Figures 19 through 22 show performance subsequent to various combinations of S-II dual engine failures. Figure 23 shows time to initiate early staging at CHI freeze + 5 seconds for S-II engine out. Figure 24 shows the extension of time loss of control results subsequent to S-II sequential dual engine failures as a function of failure time of the first engine. Figure 25 through 28 show engine actuator displacements subsequent to S-II dual engine failures.

2.6.3 Recommendations

1) Abort: See Table 1-I.

2) Early Staging: Early staging is advantageous only in cases where S-II dual engine failures result in S-IVB guidance problems. In cases where guidance problems occur in S-IVB after a dual engine failure in S-II, an early staging can be commanded at CHI freeze + 5 seconds, and a suitable parking orbit can be achieved. Outside this region a loss of payload, as shown in Figure 19, results from early staging at CHI freeze + 5 seconds. If possible the S-II stage should thrust until propellant depletion occurs in order to gain as much velocity as possible.

3) IGM Update: Add dual engine out logic so that the guidance scheme will be properly updated. See Reference 5.

2.7 EARLY STAGING

No early staging should be initiated prior to 350 seconds flight time because the propellant on board the S-IVB is not sufficient to boost the S-IVB into parking orbit. Also, early staging after a malfunction which causes rates greater than 2°/sec cannot be

2.7 (Continued)

accomplished because of the large attitude deviations which accumulate during the long period from staging to engine ignition. Early staging can be used to prevent the guidance problem in S-IVB subsequent to a dual engine failure in the S-II. The staging should not be attempted at the time of malfunction, but rather at CHI freeze + 5 seconds to ensure very small body rates. Even though this action prevents failure to achieve orbit due to guidance problems, it reduces orbital payload in all cases. The payload in terms of remaining S-IVB burn time is shown in Figure 19. Figure 23 shows time of CHI freeze subsequent to an engine failure and CHI freeze biased by 5 seconds. This chart provides the time of early staging as a function of malfunction time. Analysis of problems encountered by early staging from out of control vehicle is presented in Reference 6.

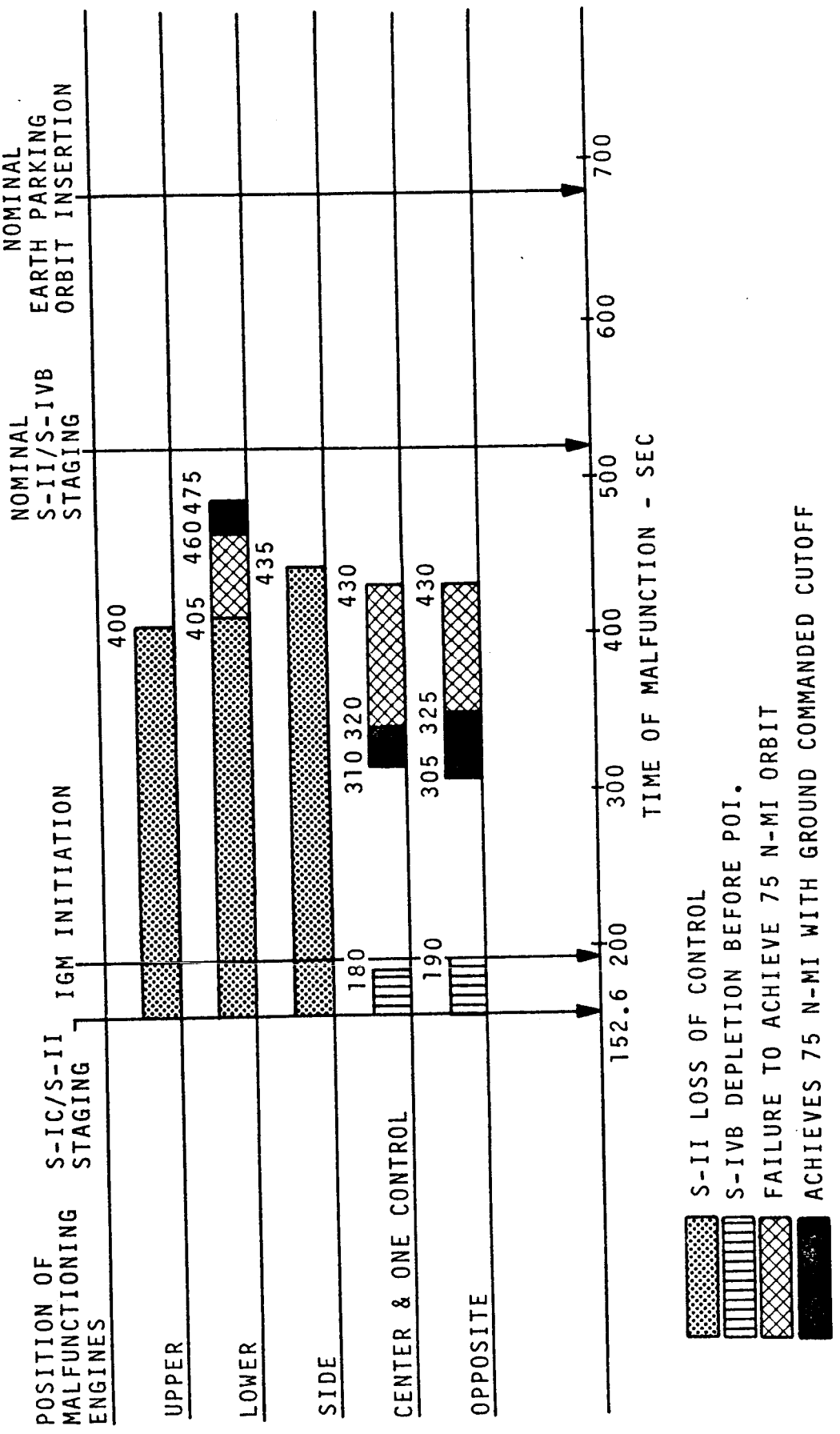

FIGURE 11 CRITICAL REGIONS FOR S-II DUAL ENGINE MALFUNCTION

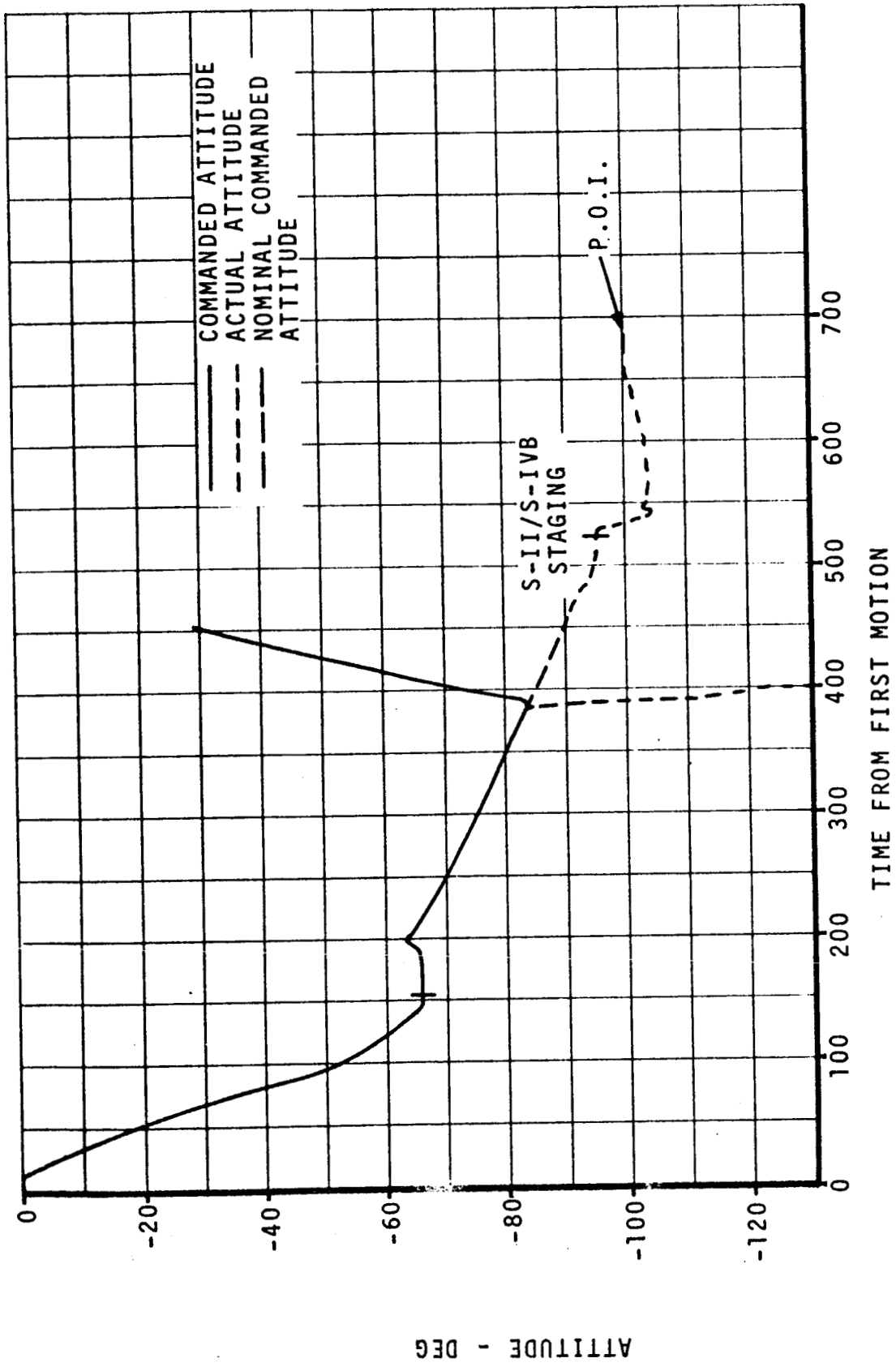

FIGURE 12 LOSS OF CONTROL FOR LOWER ENGINES MALFUNCTION AT 390 SEC

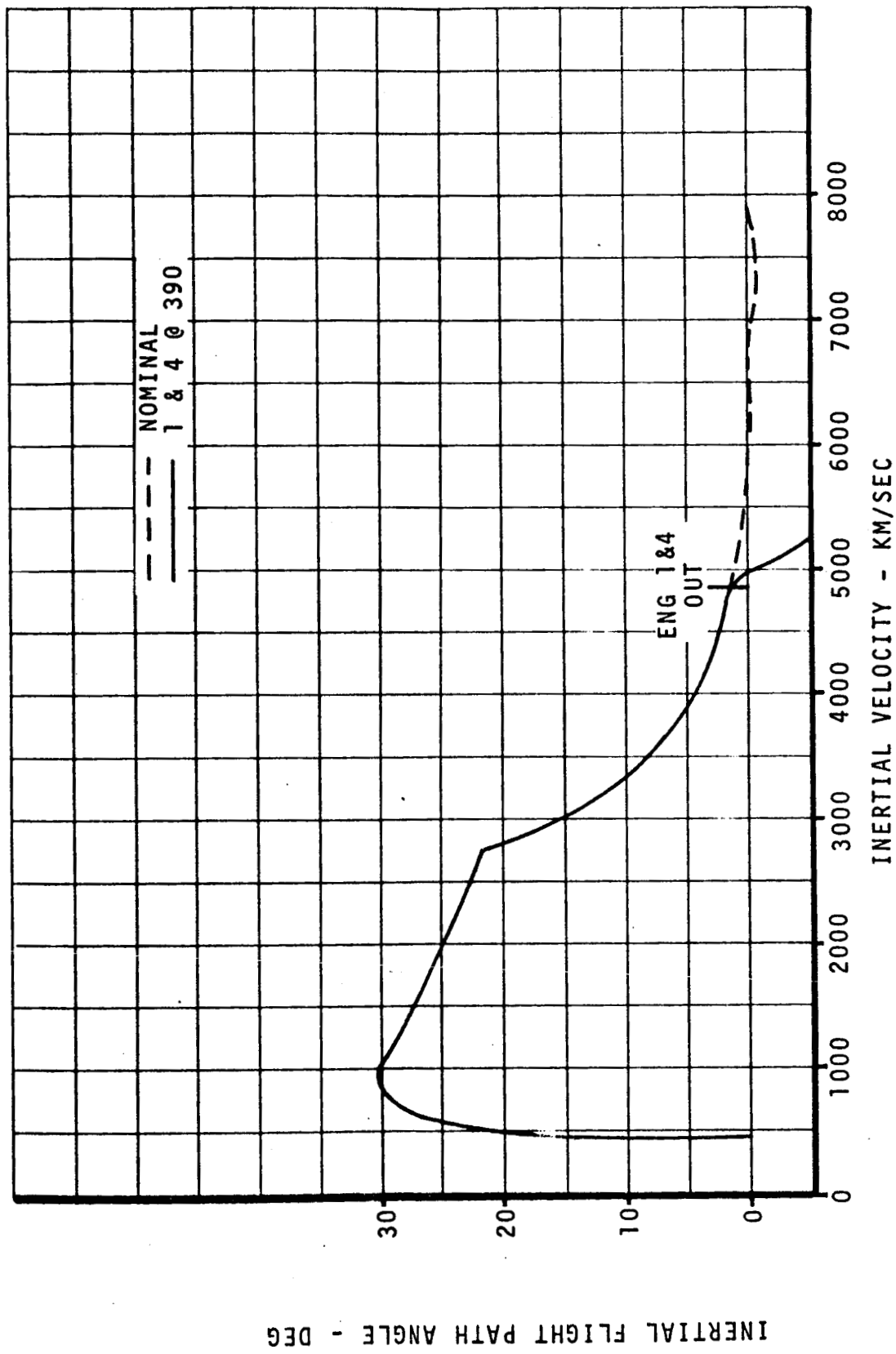

FIGURE 13 γ-V HISTORY FOR DUAL S-II LOWER ENGINE FAILURE

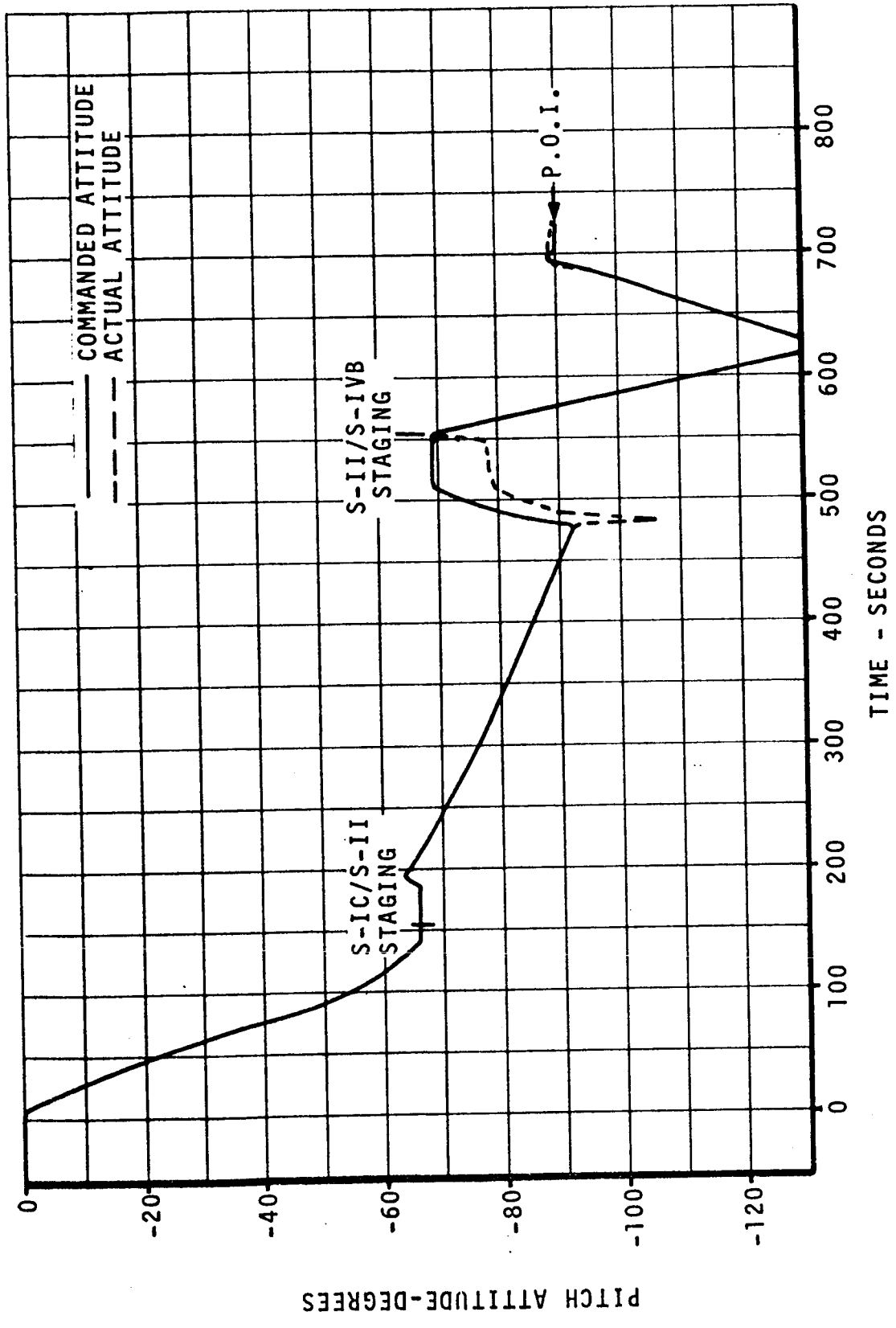

FIGURE 14 TYPICAL GUIDANCE FOR LOWER ENGINE FAILURE IN CONTROL REGION

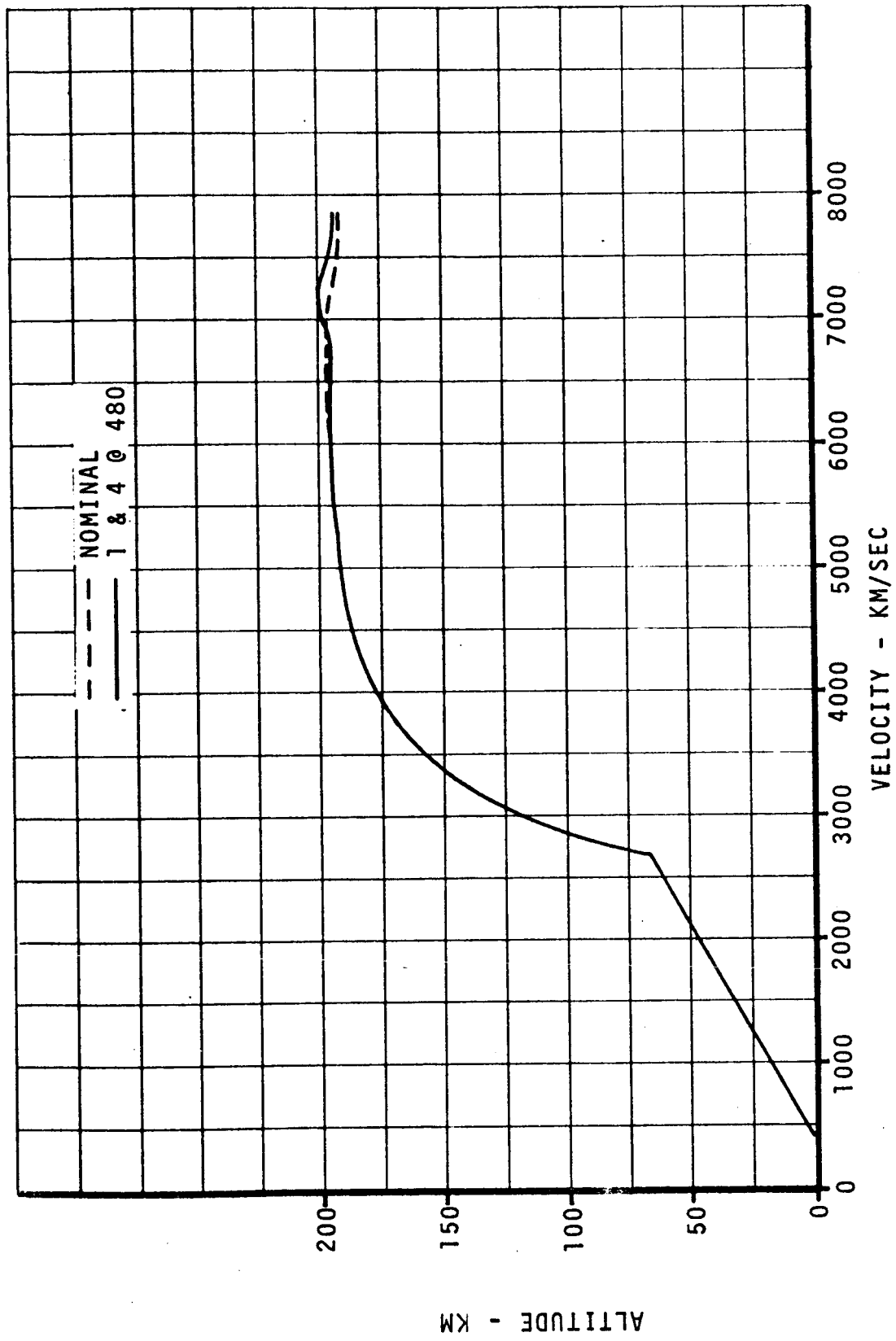

FIGURE 15 TYPICAL H-V HISTORY FOR LOWER ENGINES IN CONTROL REGION

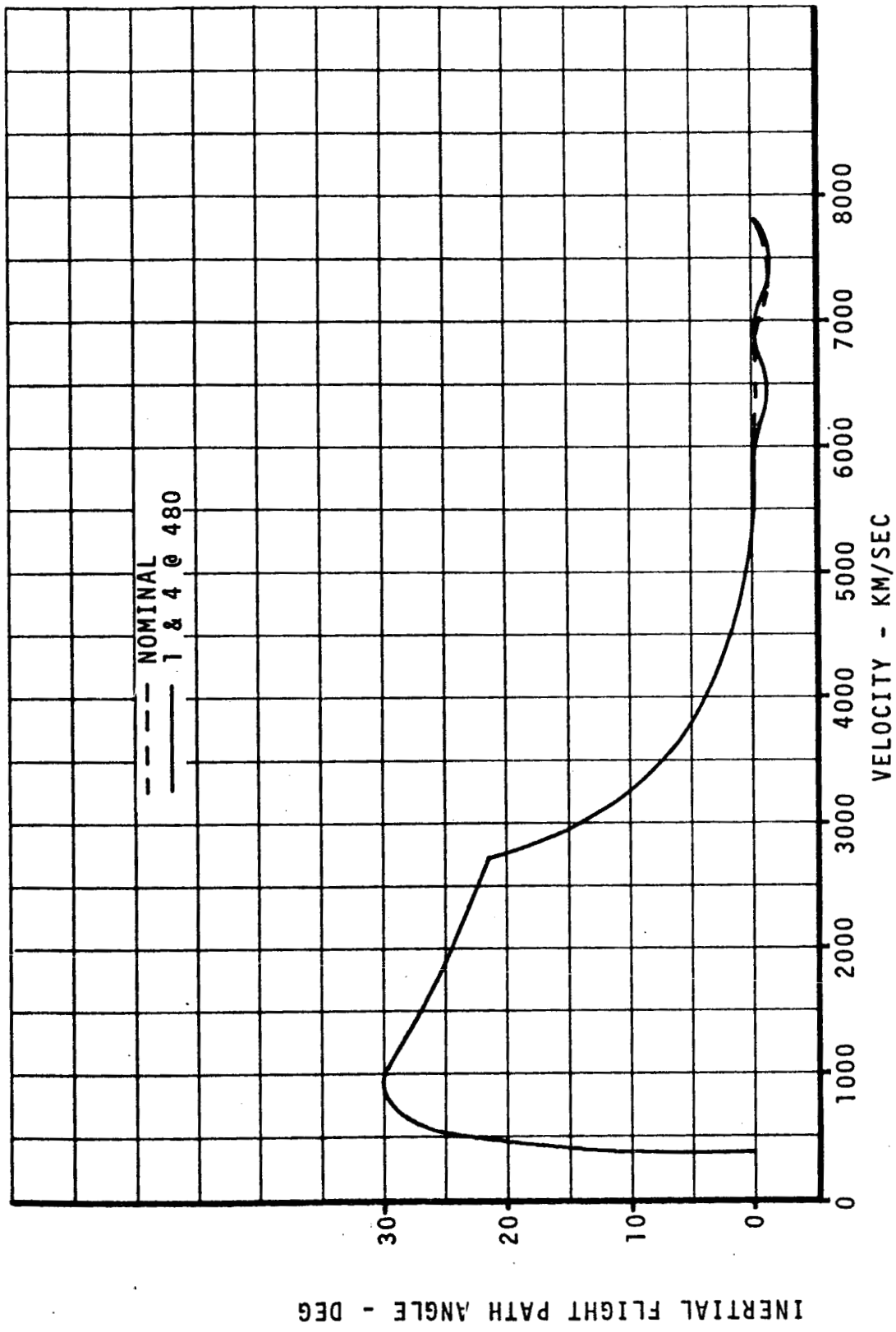

FIGURE 16 γ-V HISTORY FOR LOWER E/O IN CONTROL REGION

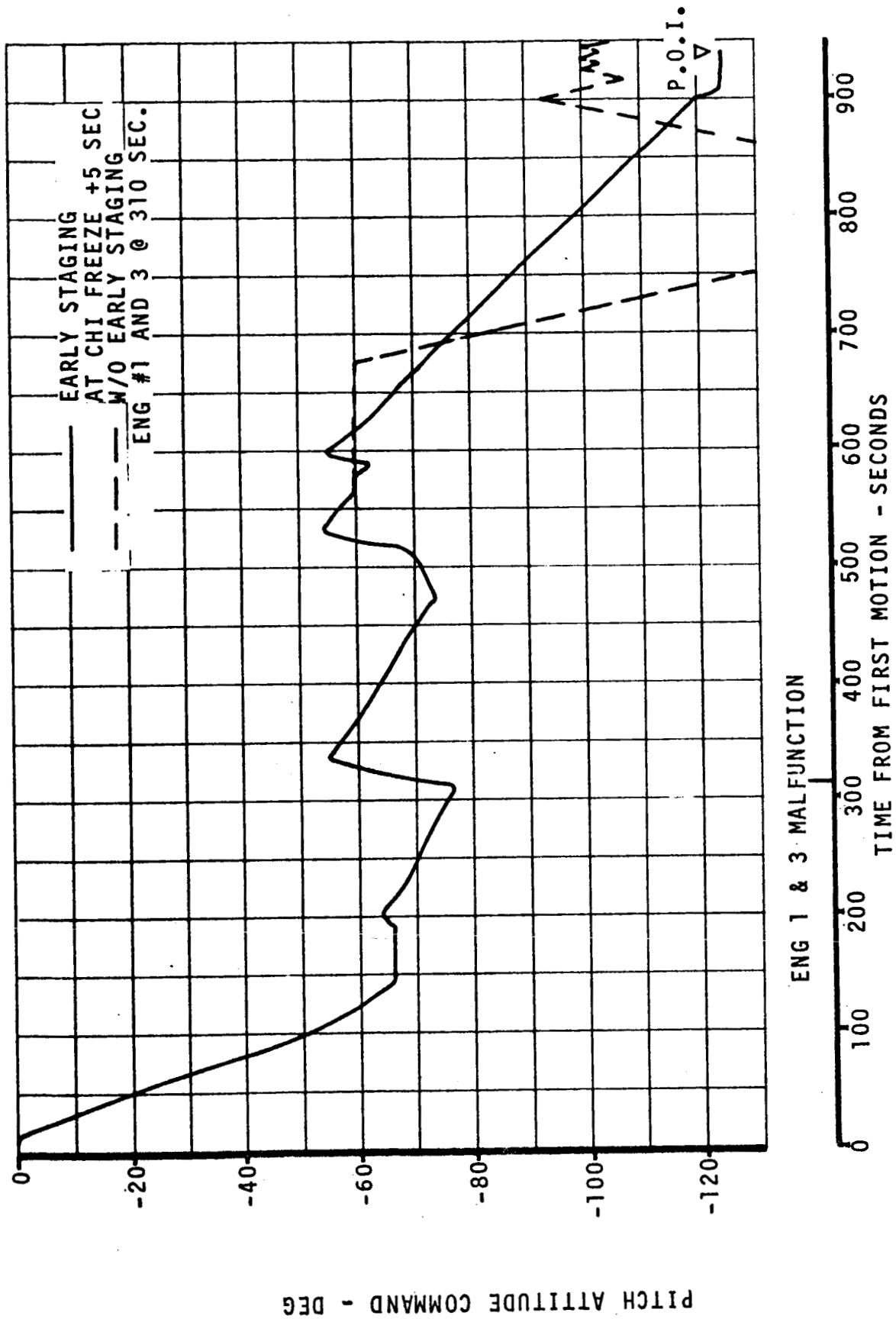

FIGURE 17 DUAL OPPOSITE S-II ENGINE OUT GUIDANCE RESPONSE

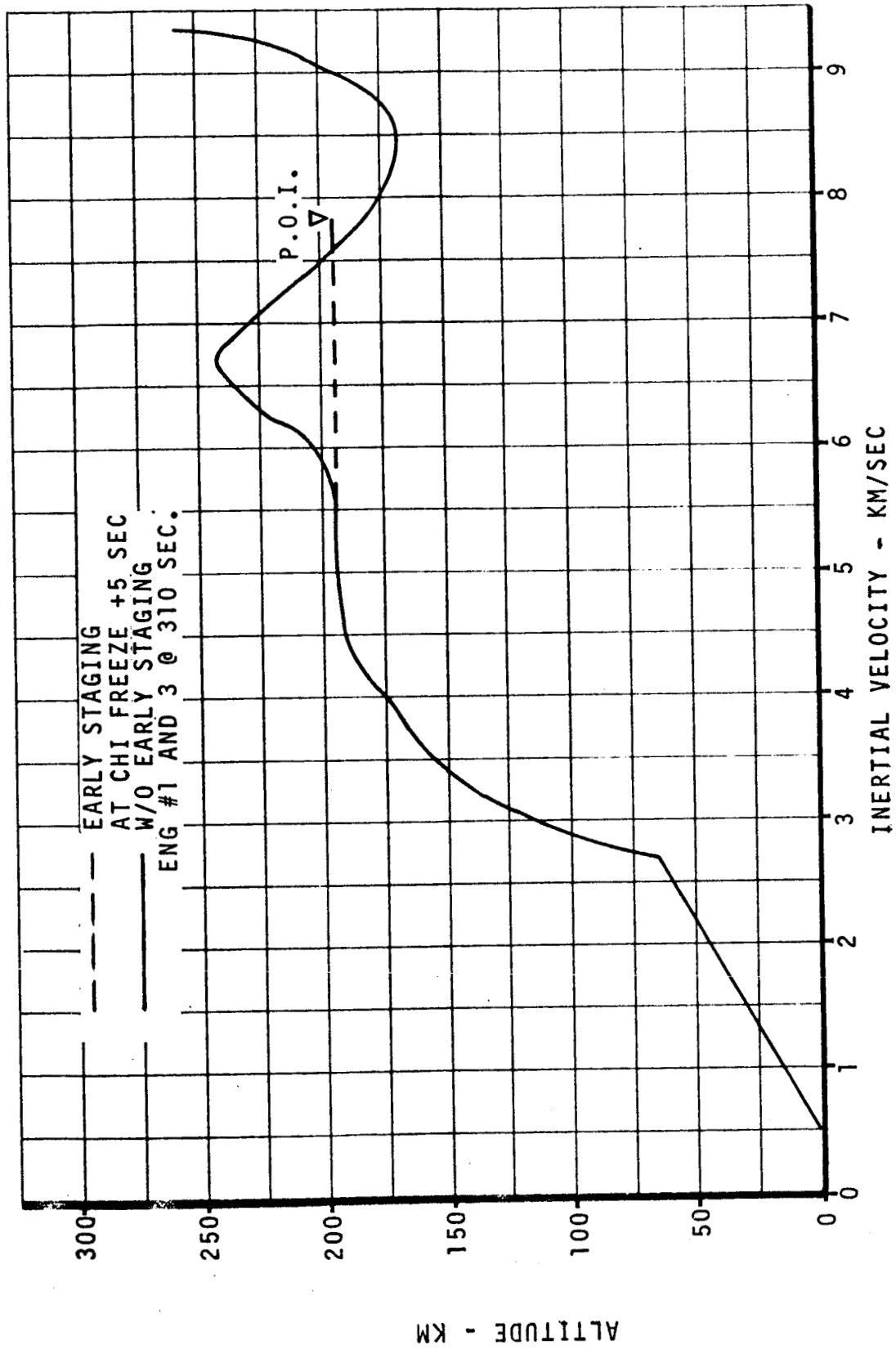

FIGURE 18 DUAL OPPOSITE S-II ENGINE OUT TRAJECTORY

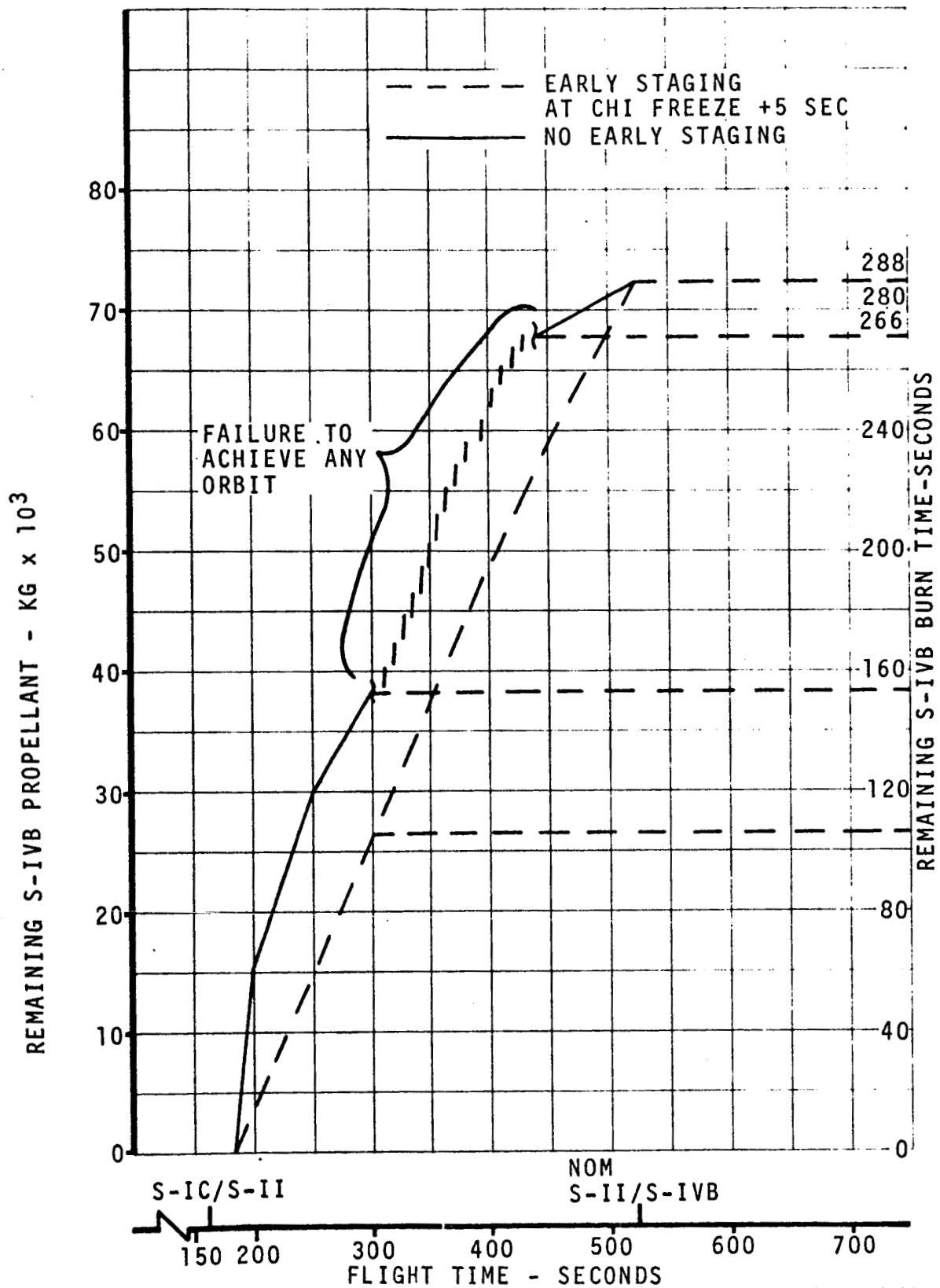

FIGURE 19 REMAINING S-IVB PROPELLANT AT P.O.I. AFTER DUAL S-II OPPOSITE FAILURE

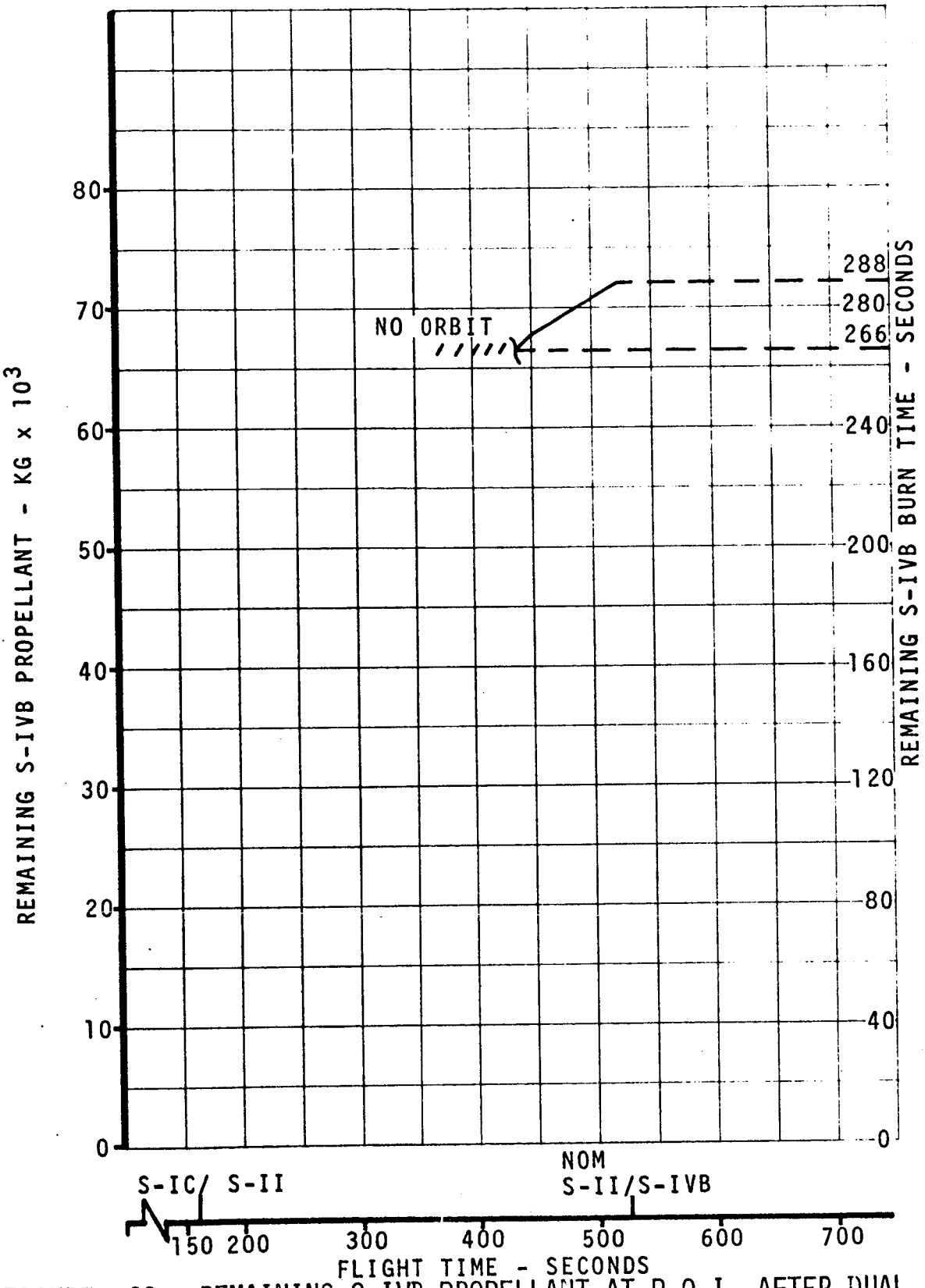

FIGURE 20 REMAINING S-IVB PROPELLANT AT P.O.I. AFTER DUAL S-II SIDE FAILURE

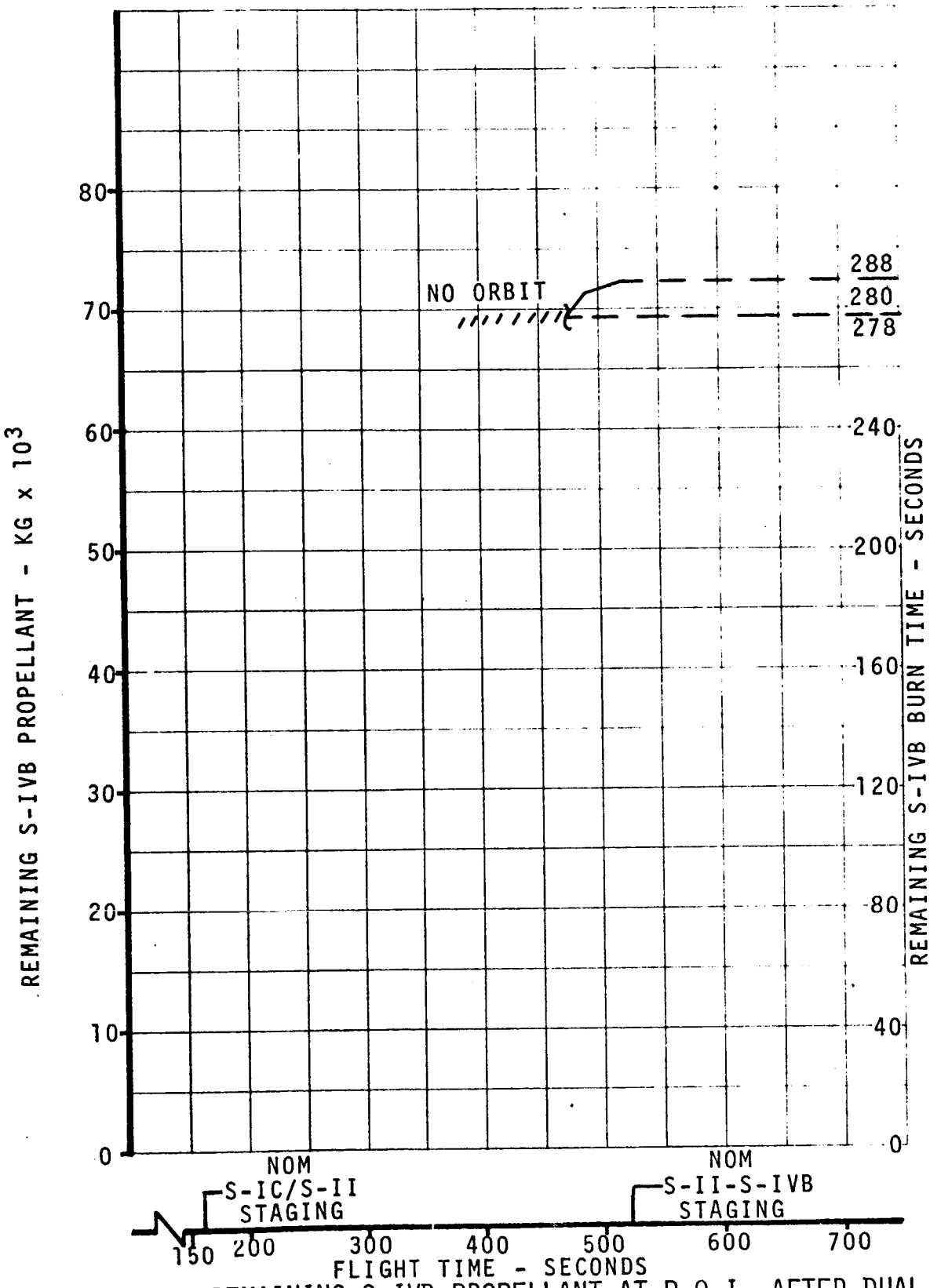

FIGURE 21 REMAINING S-IVB PROPELLANT AT P.O.I. AFTER DUAL S-II LOWER FAILURE

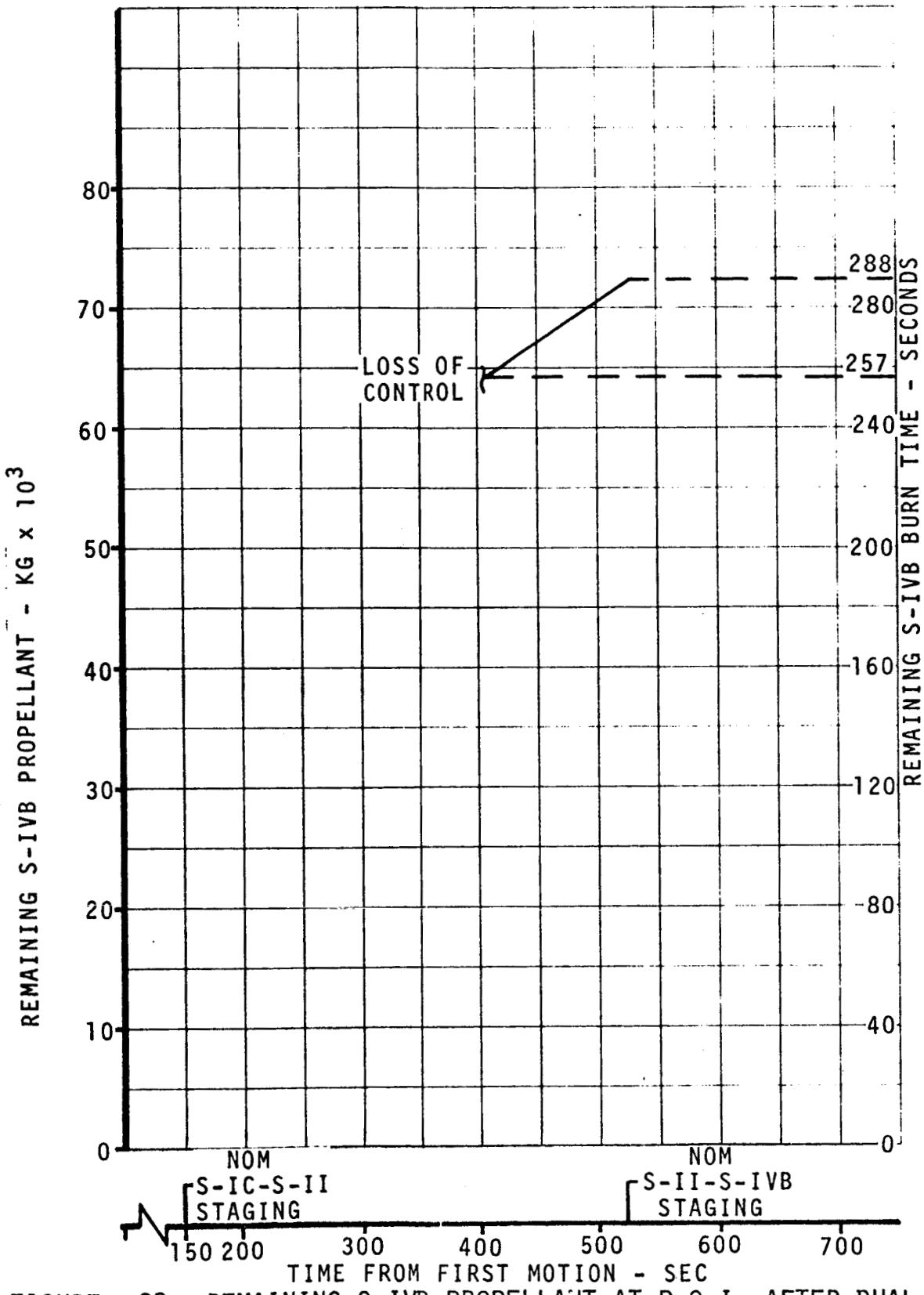

FIGURE 22 REMAINING S-IVB PROPELLANT AT P.O.I. AFTER DUAL S-II UPPER FAILURE

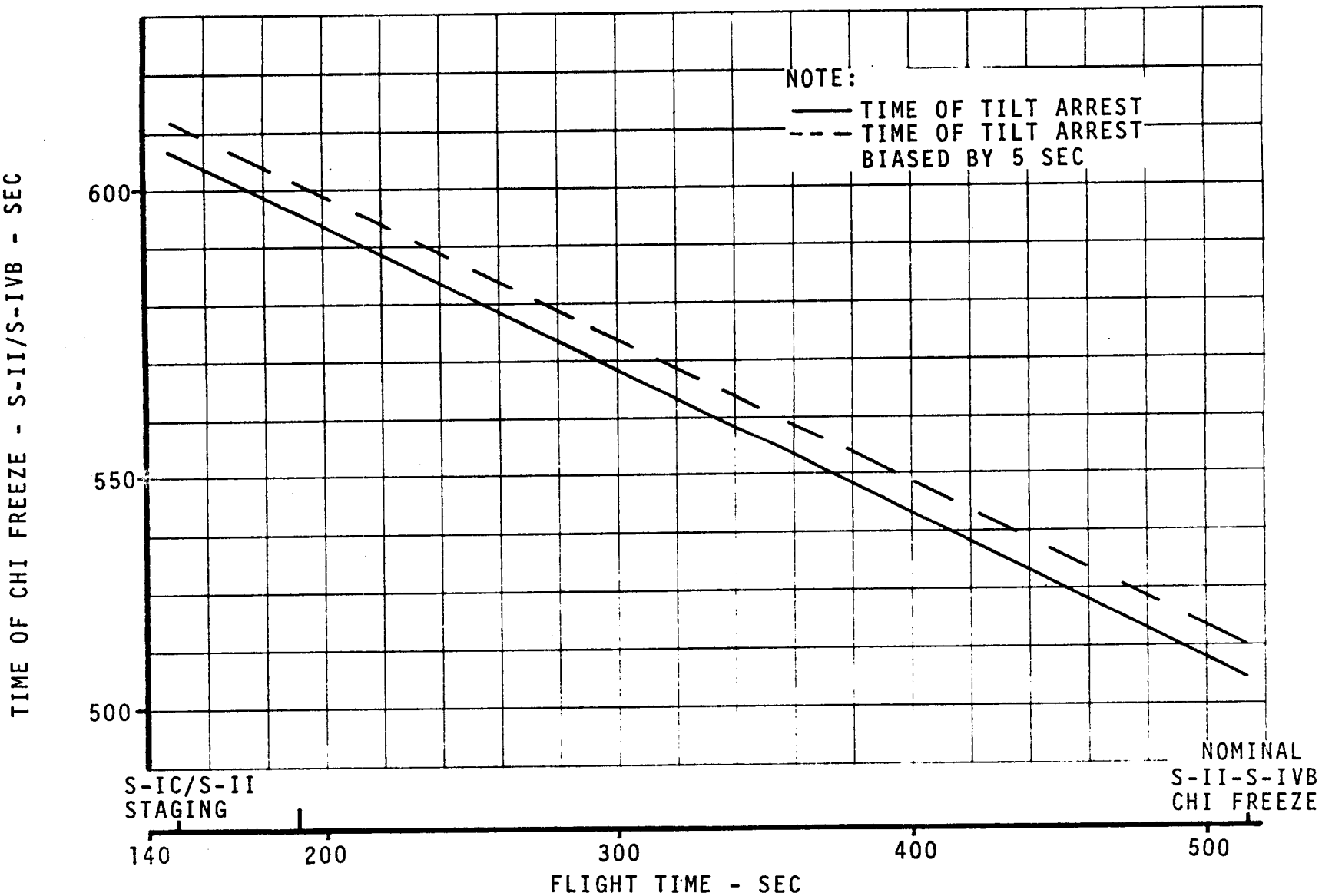

FIGURE 23 TIME OF S-II/S-IVB CHI FREEZE FOR DUAL S-II ENGINE FAILURE

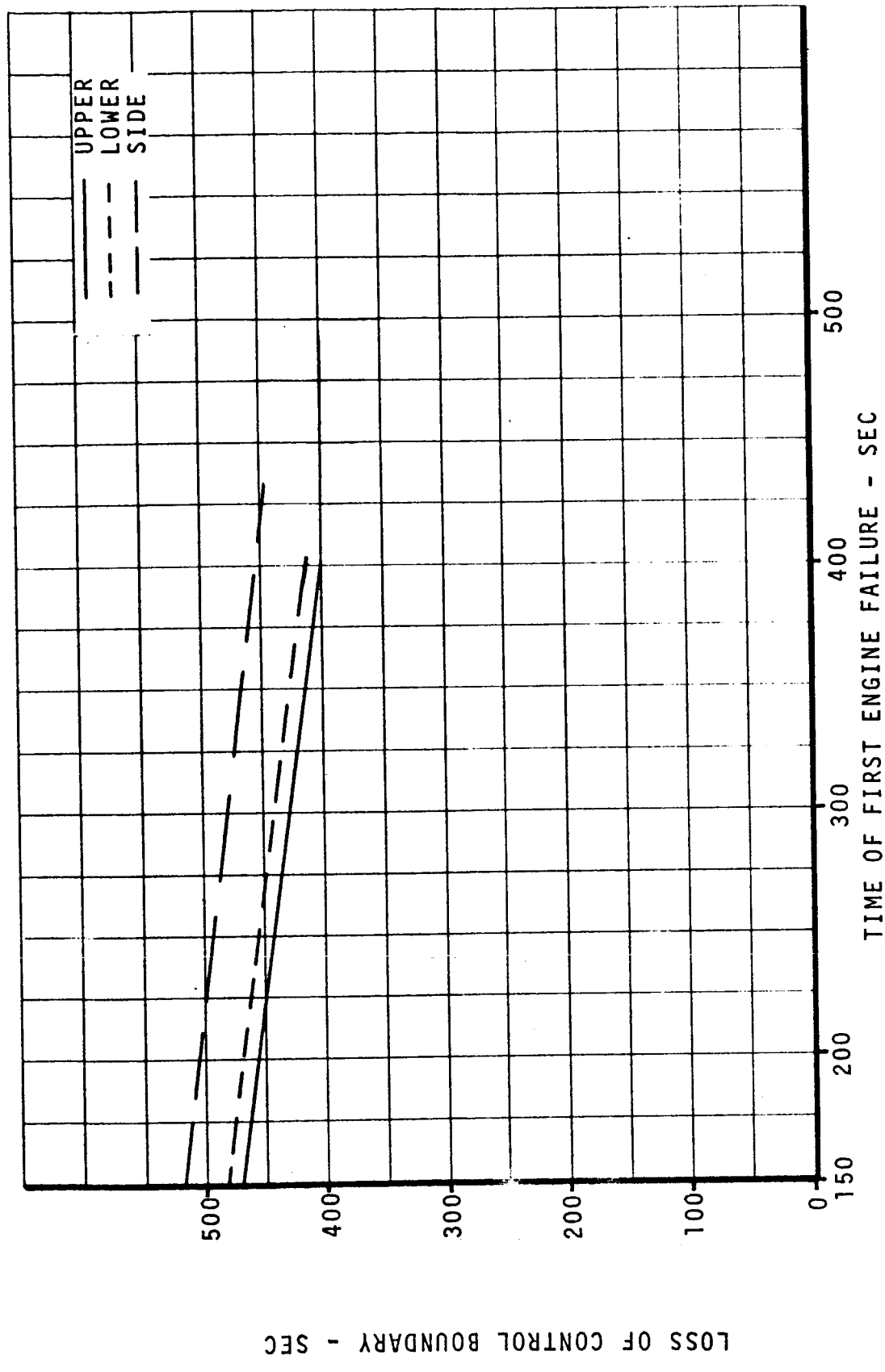

FIGURE 24 EXTENSION OF LOSS OF CONTROL REGION FOR S-II SEQUENTIAL ENGINE MALFUNCTIONS

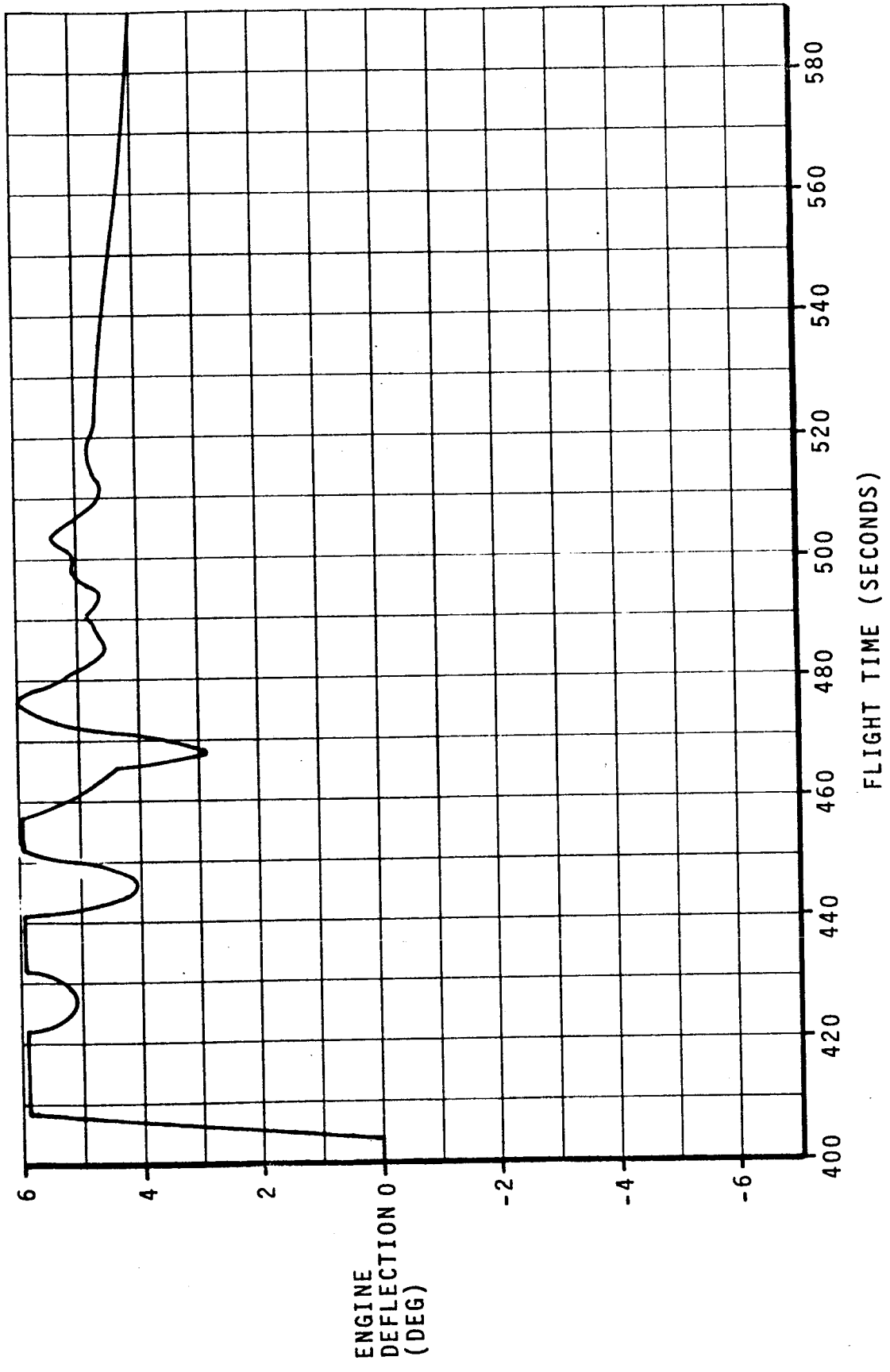

FIGURE 25 ENGINE #1 PITCH ACTUATOR RESPONSE TO ENGINE #2 AND #3 FAILURE AT 405 SECONDS

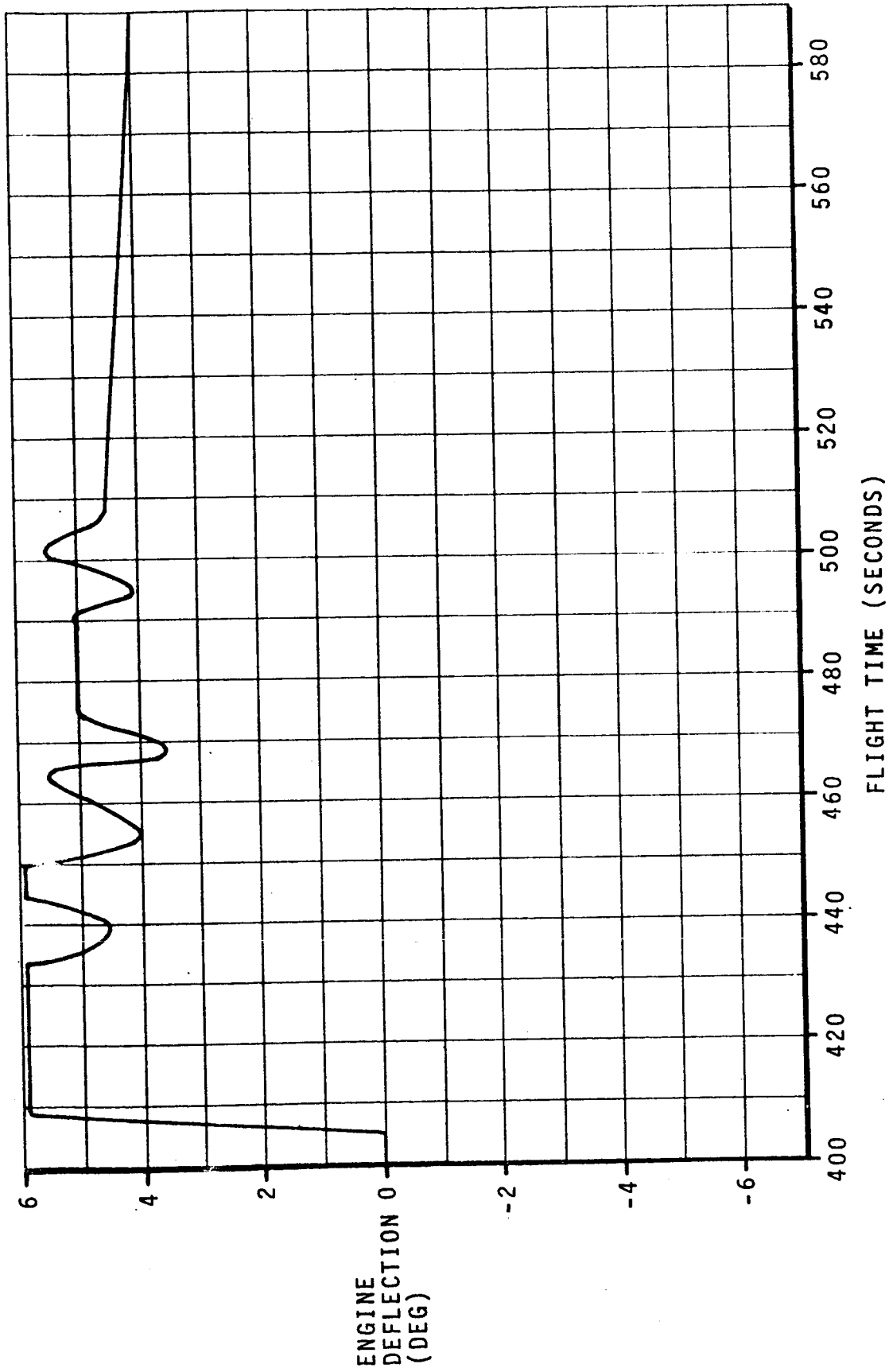

FIGURE 26 ENGINE #4 PITCH ACTUATOR RESPONSE TO ENGINE #2 AND #3 FAILURE AT 405 SECONDS

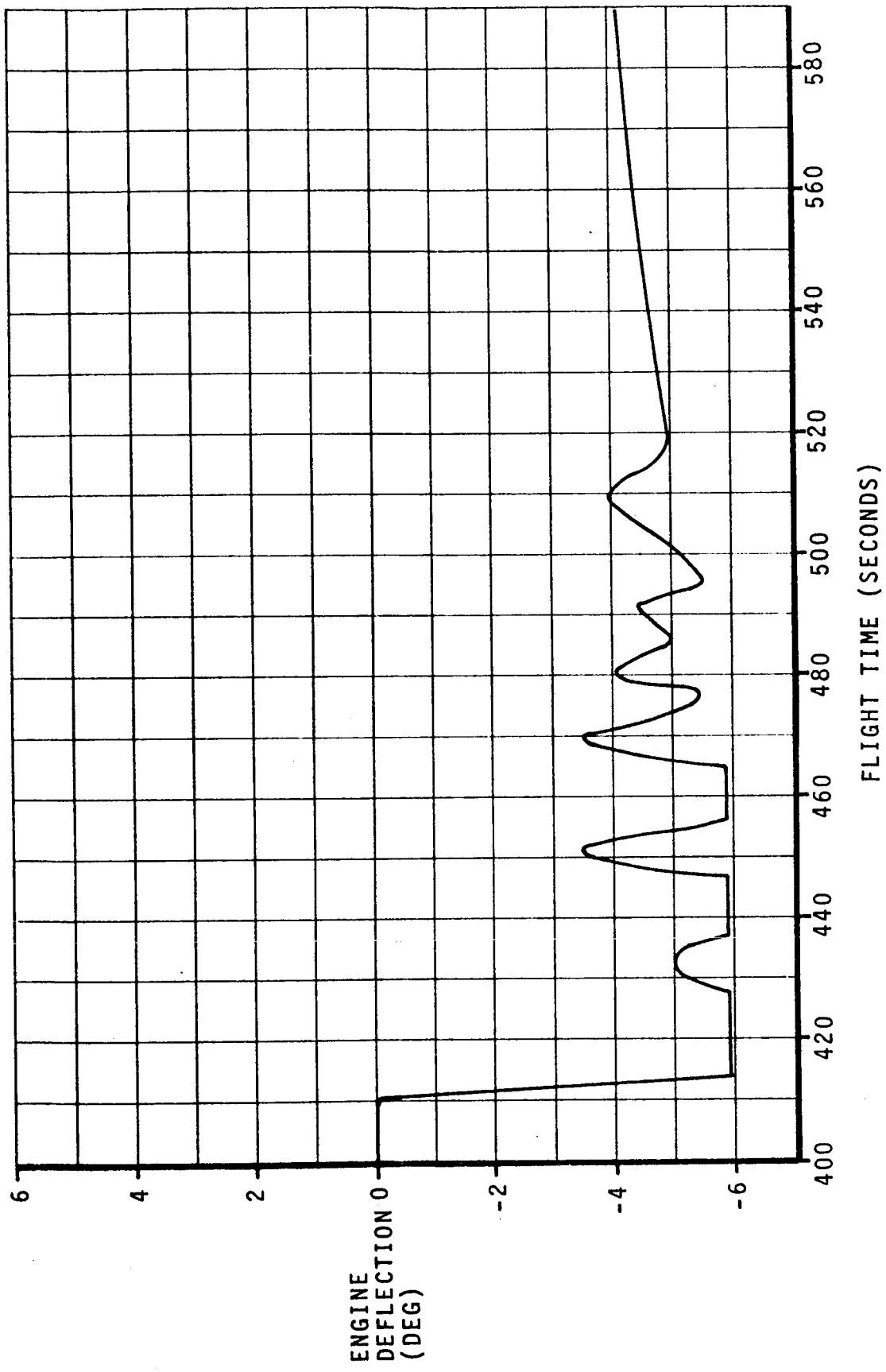

FIGURE 27 ENGINE #2 PITCH ACTUATOR RESPONSE TO ENGINE #1 AND #4 FAILURE AT 410 SECONDS

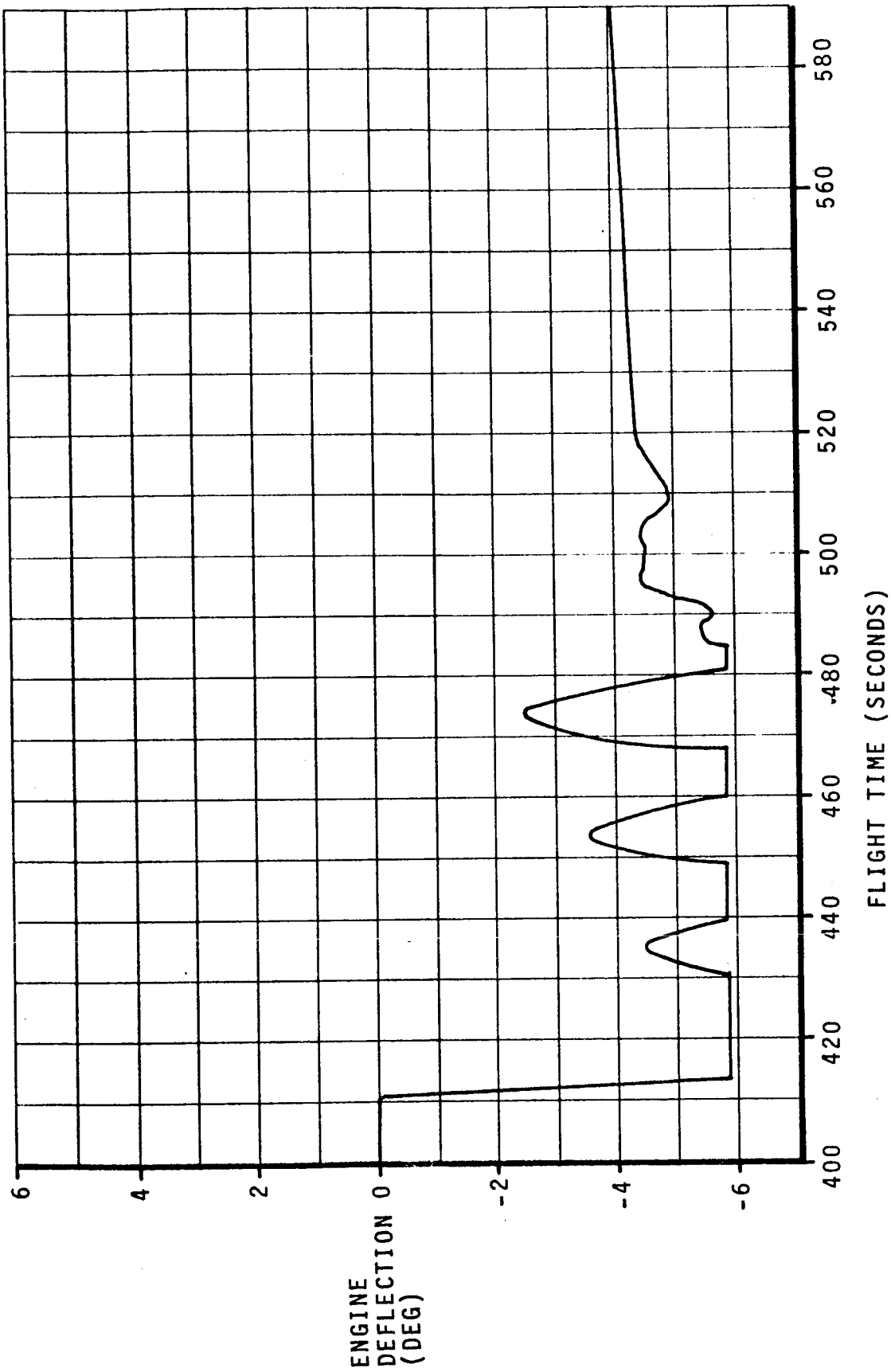

FIGURE 28 ENGINE #3 PITCH ACTUATOR RESPONSE TO ENGINE #1 AND #4 FAILURE AT 410 SECONDS

2.8 LOSS OF RATE SIGNAL

Reference 1 analysis is valid.

2.9 P.U. SYSTEM MALFUNCTIONS

The "C'" mission gives no significant change from the results presented in Reference 1 for EPO P.U. system malfunctions. There is a significant difference in P.U. system malfunctions for 2nd S-IVB burn since the "C'" mission does not use an open loop guidance scheme. Detailed 2nd burn results of this malfunction are given in Reference 3.

3.0 S-IC SUMMARY

Figure 29 shows the regions of possible vehicle loss for all malfunctions studied in Reference 7 and 8. Regions of possible crew loss for four critical malfunctions are shown in Figure 30. The probability of vehicle loss during S-IC flight is 2650×10^{-6}. The probability of crew loss during S-IC flight is 211×10^{-6}.

MALFUNCTION (UNRELIABILITY)(β)=CN	POSSIBLE HAZARD	LIFTOFF — TIME FROM LIFTOFF - SEC (0, 20, 40, 60, 80, 100, 120, 140) — S-IC OECO	ABORT CUES
Loss of Thrust One Engine (1300).(.016)=21	TC CNTRL SEP		Near Pad Eng. status light Abort request light High-q Eng. status light ΔP=3.2 psid Pitch or yaw rate=±4°/sec
One Actuator Fully Deflected (4200).(.045)=190	TC CNTRL SEP		Near Pad Abort Request Light High-q Roll error = ± 5° ΔP=3.2 psid Pitch or yaw rate = ±4°/sec
Loss of Inertial Attitude (2100).(1) = 2100	TC CNTRL SEP		All Phases Guidance Failure Light(s) Pitch or Yaw error= ±5° Pitch or Yaw Rate=±4°/sec

KEY:

TC = Tower Collision
CNTRL = Loss of Control
SEP = Loss of Control after Separation
IIIIII =POSSIBLE REQUIREMENT FOR ABORT
▬▬▬ =CERTAIN REQUIREMENT FOR ABORT

FIGURE 23 S-IC MALFUNCTION SUMMARY

MALFUNCTION (UNRELIABILITY)(β)=CN	POSSIBLE HAZARD	LIFTOFF — TIME FROM LIFTOFF - SEC (0 20 40 60 80 100 120 140) — S-IC OECO	ABORT CUES
Loss of Attitude Rate Signal (40).(1)=40	TC CNTRL SEP		All Phases Pitch or yaw rate = ±4°/sec Roll rate = ±20°/sec ΔP = 3.2 psid (High-q)
Control Feedback Signal Saturated (230).(1)=230	TC CNTRL SEP		All Phases Pitch or yaw rate =±4°/sec Roll rate = ±20°/sec
Loss of Thrust Two Engines (<1).(1)= <1	TC CNTRL SEP		All Phases Eng. Status Lights Pitch or yaw rate = ±4°/sec
Loss of Attitude Error Signal (70).(1)=70	TC CNTRL SEP		All Phases Pitch or yaw error = ±5° ΔP = 3.2 psid Pitch or yaw rate = ±4°/sec
One Actuator Inoperative (750).(<10^{-3})= <1	NO VEHICLE LOSSES		
Loss of Inertial Velocity (1935)(10^{-4})= <1	No Effect on S-IC Flight Possible sub-nominal orbit and partial mission loss		

FIGURE 29 S-IC MALFUNCTION SUMMARY (CONTINUED)

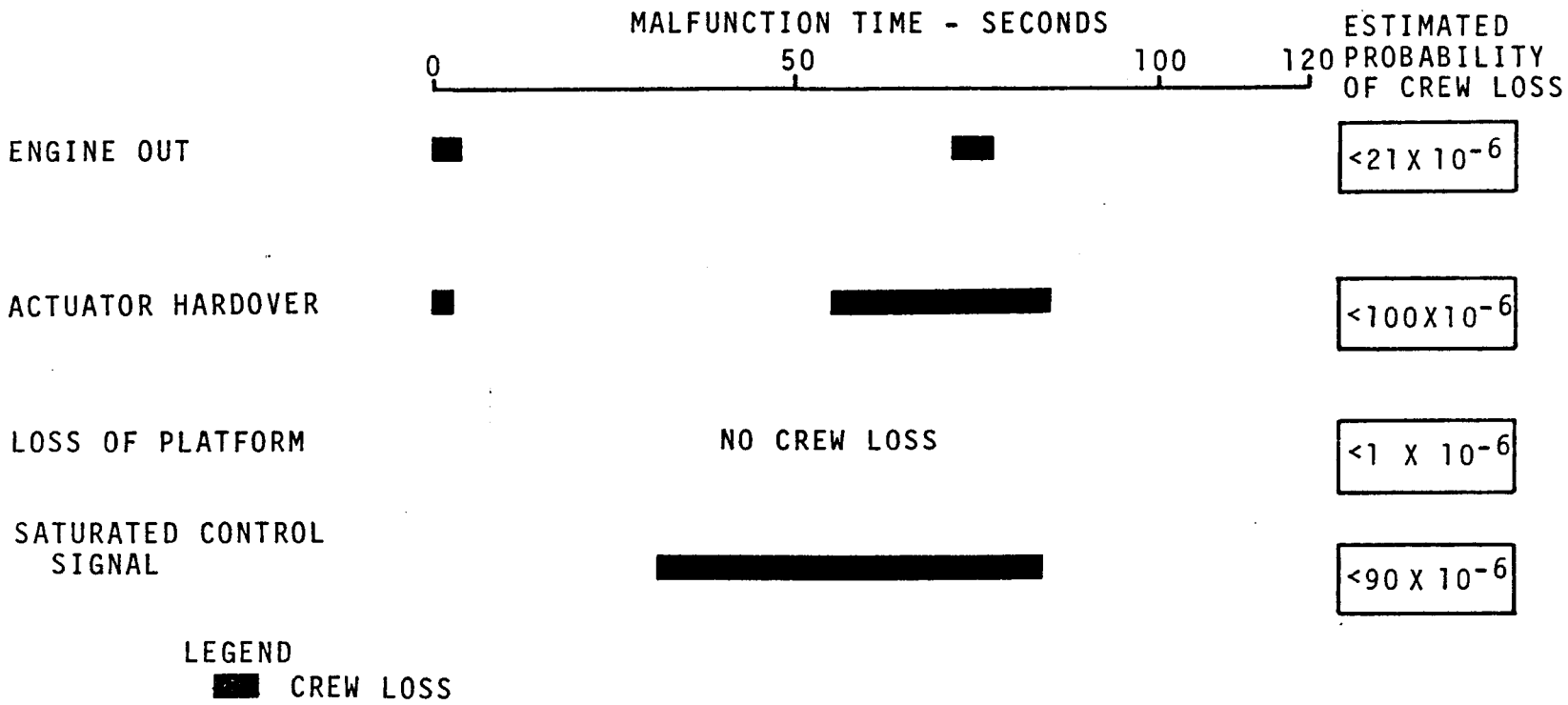

FIGURE 30 S-IC MALFUNCTIONS CAUSING POSSIBLE CREW LOSS

REFERENCES

1. Boeing Document D5-15555-3C, "Saturn V Launch Vehicle Emergency Detection System Analysis, SA-503," dated September 20, 1968.

2. Boeing Memorandum 5-9600-H-137, "Preliminary Report, AS-503 C' Launch Vehicle Operational Abort and Alternate Mission Trajectories," dated October 21, 1968.

3. Boeing Memorandum 5-9600-H-149, "Preliminary Report, AS-503 C' Launch Vehicle Operational Abort and Alternate Mission Trajectories," dated November 5, 1968.

4. North American Aviation Letter 67MS2216, "Contract NAS7-200, "Collision Boundary and Probability of Collision During Second Plane Separation, Action Item 96, Ninth Dynamics and Control Working Group Meeting," dated June 19, 1967.

5. Boeing Coordination Sheet EDS-H-161, "S-II Dual E/O Analysis," dated September 19, 1968.

6. Boeing Coordination Sheet EDS-H-190, "Early S-II/S-IVB Staging Immeidately after Dual S-II Engine Failure," dated November 4, 1968.

7. Boeing Memorandum 5-9600-H-151, "Updated Emergency Detection System Analysis of the Hi-q and Upper S-IC Malfunctions for the SA-503 C' Mission," dated November 8, 1968.

8. Boeing Memorandum 5-9600-H-143, "Updated Emergency Detection System Analysis of Near Pad Malfunctions for SA-503 C' Mission," dated November 1, 1968.

VERIFIED GOVERNMENT FURNISHED DOCUMENTATION

DRL-049 LINE ITEM	VEHICLE	EXHIBIT FF NO. (PAGE NO.)	DESCRIPTION	DATE REQ'D.	DATE REC'D.
151	503	0140 0141 0142	(1) NASA TMX 53517, "Static Aerodynamic Characteristics of the Apollo-Saturn V Vehicle," 16 September 1966.		6/17/68
			(2) NASA TMX 53599, "Range Safety Aerodynamics Characteristics of the Apollo/Saturn V Vehicle," April 21, 1967.		6/17/68
			(3) MSFC Memorandum R-AERO-AD-68-35, "Effects of Flow Separation on Apollo Saturn V First Stage Aerodynamics," June 10, 1968.		
		0147	(1) MSFC Memorandum R-AERO-DD-95-65, "Slosh Damping Values for Saturn V, SA-501 through 503 during Powered Flight," dated 12-17-65.		
			(2) MSFC Memorandum R-AERO-DD-7-66, "Saturn V Design Sloshing Data," dated 2-24-66.		
		0148	MSFC Memorandum R-AERO-FF-31-68, "Revised Saturn V Launch Vehicle Flight Dynamics Analysis, AS-502," March 21, 1968. (D5-15509(F)-2B).		6/17/68
			Boeing Memorandum 5-9450-H-073, "SSR-220, Saturn V S-IC/S-II Staging Limits," dated August 30, 1968.		
		0149	MSFC Memorandum R-AERO-P-251-67, "Final Documentation of the Ninth Flight Limits Sub-Panel Meeting," June 6,1967.		
		0151	NASA Support Manual SM2A-02,"Apollo Spacecraft Familiarization," 1 December 1966.		
		0152	NASA TMX 53328, "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development," (1966 Revision) 1 May 1966.		

VERIFIED GOVERNMENT FURNISHED DOCUMENTATION

DRL-049 LINE ITEM	VEHICLE	EXHIBIT FF NO. (PAGE NO.)	DESCRIPTION	DATE REQ'D.	DATE REC'D.
151	503	0153	(1) NASA TMX 53009, "Directional Wind Component Frequency Envelopes, Cape Kennedy, Florida, Atlantic Missile Range," 21 February 1964.		6/17/68
			(2) NASA R-AERO-Y-66-65, "Redefinition of the Saturn IB/V Synthetic Wind Profiles," 10 September 1965.		
			(3) MSFC Memorandum R-AERO-Y-118-66, "Cape Kennedy Wind Component Statistics (0 - 60 km. Alt.), for all Flight Azimuths for Monthly and Annual Reference Periods," October 25, 1966. Amendment December 5, 1966.		6/17/68
		0154	NASA TMX 53139, "Reference Atmosphere for Patrick AFB, 1963 Rev," 23 September 1964. NASA M-DE 8020.08B, SE 015-001-1, "Natural Environment and Physical Standards for the Apollo Programs," April, 1965.		
		0386	(1) Boeing Memorandum 5-9600-H-122, "Preliminary AS-503 C' Mission Launch Vehicle Operational Trajectory (December Launch Window)," dated October 8, 1968.		
			(2) MSFC Memorandum R-SE-F-58-68, "Early Nominal S-IC Center Engine Shutdown at T1 + 125.2 Seconds," dated July 10, 1968.		
			(3) P&VE Memorandum R-P&VE-PA-68-M-586, "F-1 Engine Malfunction Curves for S-IC Stage Engine Out Condition," dated July 29, 1968.		
			(4) Flight Program Change Request No. 16, "Open Loop P.U.," dated September 18, 1968.		

VERIFIED GOVERNMENT FURNISHED DOCUMENTATION

DRL-049 LINE ITEM	VEHICLE	EXHIBIT FF NO. (PAGE NO.)	DESCRIPTION	DATE REQ'D.	DATE REC'D.
151	503	0184	(1) MSFC R-ASTR-NFS-134-66, "The Linear Equations and Nonlinear Models for the Saturn V Vehicle Thrust Vector Control System," 1 April 1966.		
			(2) North American Aviation Handout, "S-II Stage Vehicle Dynamics and Control Working Group Splinter Meeting, S&ID-Seal Beach," dated May 2, 1967.		
		0187	(1) MSFC Drawing 10M30792, "Failure Effects Analysis and Criticality Determination Reports, Vol. I-Vol. VII," August 10, 1967.		
			(2) MSFC Drawing 10M30803, "Reliability Analysis Model Summary," SA-503," April 5, 1968.		
			(3) MSFC Memorandum R-ASTR-S-66-46, "Failure Modes of the Saturn V Vehicle, Action Item 13.7," August 26, 1966.		
		0188	Technical Manual MSFC No. 111-5-509-7, "Apollo-Saturn Emergency Detection System Description," 1 August 1966, changed 1 July 1967.		
		0189 0190	(1) MSFC R-ASTR-F-67-83, "Stabilization Networks for S-IC Stage Burn, Pitch and Yaw," 22 March 1967.		6/17/68
			(2) MSFC Memorandum R-ASTR-F-66-183, "AS-503, S-II Stage, Pitch, Yaw and Roll Control Gains Shaping Network Characteristics and Control Sensor Locations," October 10, 1966.		
			(3) MSFC Memorandum R-ASTR-F-66-177, "AS-503 S-IVB Stage Burn, Pitch and Yaw Control Gains, Shaping Network Characteristics and Control Sensor Locations," September 15, 1966.		

VERIFIED GOVERNMENT FURNISHED DOCUMENTATION

DRL-049 LINE ITEM	VEHICLE	EXHIBIT FF NO. (PAGE NO.)	DESCRIPTION	DATE REQ'D.	DATE REC'D.
151	503	0189 0190	(4) Boeing Coordination Sheet FCD-H-052, "SA-501 through SA-504 S-IC Flight Control Systems Release," March 23, 1967.		
			(5) Boeing Coordination Sheet FCD-H-053, "SA-501 through SA-504 S-IC Pitch (Yaw) Flight Control System Definition for BHA-0030," April 4, 1967.		
		0192	(1) IBM Document 7915041, "LVDC Equation Defining Document for the AS-503 Flight Program," 21 November 1966.		
			(2) Flight Program Change Request, "AS-503 C' Mission Presettings," dated September 12, 1968.		
		0193	NASA Drawing No. 40M33623A, "Interface Control Document Definition of Saturn V AS-503 Flight Sequence Program," 8/12/66. (Updated revision).		
		0232	(1) Boeing Coordination Sheet ST-H-68-22, dated 3-18-68, as amended by Boeing Coordination Sheet ST-H-68-52R, dated 6-26-68, as amended by ST-H-68-64, dated 9-5-68.		
			(2) Boeing Document D5-15574-1, "Saturn V Post Flight Structural Loads Flight Evaluation," dated 2-5-68. (SAF No. S8-60-102).		
		0241	Boeing Document D5-15579-3B, "Saturn V Operational Structural Capability, SA-503," dated 3-6-68. (SAF No. S8-65-103).		

VERIFIED GOVERNMENT FURNISHED DOCUMENTATION

DRL-049 LINE ITEM	VEHICLE	EXHIBIT FF NO. (PAGE NO.)	DESCRIPTION	DATE REQ'D.	DATE REC'D.
151	503	0244	(1) MSFC Memorandum R-P&VE-VAW-68-123, "Saturn V/AS-503 Preliminary Predicted Operational Mass Characteristics, Depletion Cut-off (Mission C')," dated September 23, 1968.		6/17/68
			(2) Data Fax Transmission 9-197-Houston-MSC, Station No. 8324, "S/C-103 Weights Data, REF. NR Mission Run, 15 March 1968," from Alden Mackey ES2-2278 to Carlos Hagood, R-AERO-F, dated 5-8-68.		
		0275	MSFC Drawing No. 10M30633B, "Saturn V/SA-503 Flight Sequence," April 20, 1967.		
		0280	Boeing Document D5-15579-3B, "Saturn V Operational Structural Capability, SA-503," dated 3-6-68. (SAF No. S8-65-103).		
		0404	N/A		
		0341	Boeing Memorandum 5-9540-H-956, "AS-503 C' Mission Configuration/Pitch Dynamic Characteristics," dated September 27, 1968.		