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GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

R-ASTR-NG-27-65
WBChubb/lw/876-8476

TO Mr. Paul, R-P&VE-P

DATE April 8, 1965

FROM Chief, Guidance and Control Systems Analysis Branch, R-ASTR-NG

SUBJECT Control Engine Deflection Patterns for S-II Stage Flight

REFERENCES a. Stability and Criticallity Analysis of the S-II Flight Control System. SID 64-1594 of 31 August 1964

b. Memo "Request for Gimbal Patterns for S-II Stage Flight, R-P&VE-PT-65-M-13-E, 9 Feb 1965

c. Internal Letter, NAA SII-SI-64-1016 "Control Engine Position caused by Hydraulic System Failure," October, 1964

1. The information requested in Paragraph a. of Reference b. is shown in the form of an analog computer run on Page 30 of Reference a. The responses shown are those for the begin burn case since these represent worst case transient conditions. The initial conditions used in these studies are shown on Page 14 of Reference a. The maximum gimbal angles required for the nominal case considering the assumptions used in the simulation are approximately 4°.

2. Table 1 below lists the relevant failures in the thrust vector control system that were studies in Reference a. The probabilities of occurrence of these failures is also given. The probability data was obtained from information presented at the February 1965 meeting of the Crew Safety Panel.

TABLE 1

		Probability of Occurrence
(a)	Loss of thrust on one engine.	Classified
(b)	One actuator inoperative at the null position.	.032%
(c)	One actuator oscillatory	.005%
(d)	One actuator hardover	.81%
(e)	Loss of hydraulic pressure	1.3%
	The probability of loss of hydraulic pressure over the total S-II flight time is 1.3%. The probability of occurrence of this failure during the transient time of the nominal case is 3/370 x 1.3% = .01%	

3. Gimbal patterns versus time for the disturbances listed in Table 1 are given on Pages 32 through 43 in Reference a. Table 2 summarizes these maximum and steady-state engine deflections. It should be noted that in the one actuator hardover case, the number four pitch actuator was assumed to be hardover in the plus direction. If it had been hardover in the minus direction, the resulting steady-state actuator deflections would be opposite in sign to those in the steady-state engine deflection column in Table 2.

4. Some vehicle and actuator geometry tolerances must be considered for the maximum engine deflection criteria. Individual actuator tolerances are $\pm .5°$. The probability that maximum tolerances are acting on both actuators, of a particular engine deflected a maximum amount in an inward direction, is very small. The tolerance for the engine thrust vector is $\pm .75°$. The probability that this tolerance would add directly to the actuator tolerance is highly improbable and yet possible, therefore, $\pm 1.25°$ tolerance deflection should be kept in mind for design purposes.

5. Limiting the toe-in gimbal angle range in the control computer is feasible providing stability and flight dynamic, etc. conditions are not affected significantly. Additional studies by appropriate groups would have to be conducted in these areas.

6. Additional and future information in regard to gimbal patterns for the S-II stage flight should be referred to the Flight Dynamics and Control Working Group in order to ensure that all appropriate contractor and MSFC elements are aware of the problems. Impact of the problem, (and potential solutions) in areas of their responsibility should then be considered.

J. L. Mack

1 Enc:
a/s

Approval:

G. B. Gassaway

for F. B. Moore,
Chief, Guidance and Control
Division

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Copies to: Mr. Drummond, I-E-J
Mr. Palaoro, R-P&VE-X
Mr. Marshall, R-P&VE-XH
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Mr. Rodgers/Mr. Whitefield, R-P&VE-PAS
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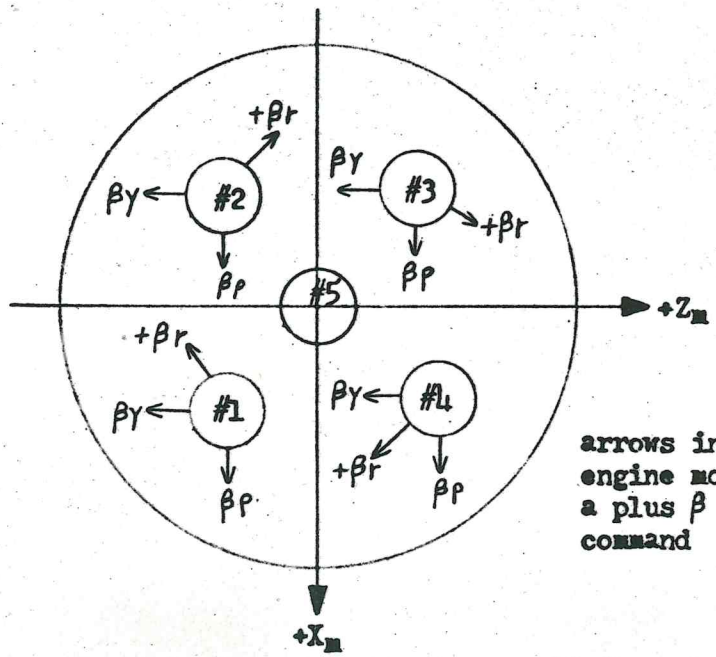
	Maximum Engine Deflection									Steady State Engine Deflection							
	β_P				β_Y				Time	β_P				β_Y			
	1	2	3	4	1	2	3	4	sec	1	2	3	4	1	2	3	4
(a) Loss of thrust on one engine	-4.0	-4.0	-6.0	X	-2.5	-2.5	-2.5	X	3	-2.4	-2.4	-2.4	X	+2.4	+2.4	+2.4	X
(b) One actuator inoperative at the null position	-4.0	-4.0	-4.3	0	-3.0	-2.5	-2.5	-3.0	2	0	0	0	0	0	0	0	0
(c) One actuator oscillatory	-4.0	-4.0	-4.0	-7.5	-3.0	-3.0	-3.0	-3.0	2.5	±2.5	0	0	±1.0	±1.0	±1.0	±1.0	±1.0
(d) One actuator hard over	-4.0	-4.0	-6.0	+7.0	-3.0	-2.5	-2.5	-3.0	2.5	-1.4	-1.4	-4.2	+7.0	-1.4	+1.4	+1.4	-1.4
(e) Loss of hydraulic pressure *										+.25	+.25	+3.5	-4.0	+3.0	-.25	-.25	-2.5

* In accordance with reference "C" if hydraulic pressure is lost on an actuator the engine will be restrained at its commanded position in both the pitch and yaw planes until the actuator lock-up system is engaged. The numbers in the table assume the loss of hydraulic pressure occurred at the worse time during the nominal condition case.



arrows indicate engine motion for a plus β engine command

Table 2