

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

R-ASTR-NG-157
WChubb/lw/876-7418

TO See Distribution

DATE JAN 11 1965

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

SUBJECT Action Item 10.6.2 of the Guidance and Control Implementation
Sub-panel (Determining the Number of Roll Maneuvers that the
S-IVB Auxiliary Propulsion System can Perform in Earth Orbit
on Saturn IB and Saturn V)

- REFERENCES (a) Volume II "Dynamics and Control Working Group Meeting, October
6, 7, 1964" (Douglas Publication)
- (b) Estimated Auxiliary Propulsion System (APS) Propellant
Requirements and Roll Maneuver Capability for Saturn IB
and Saturn V, R-ASTR-NG-159
- (c) "Sixth Vehicle Mechanical Design Integration Working Group
Meeting 25, 26 August 1964" (Douglas Publication)

1. Action Item 10.6.2 of the Guidance and Control Implementation Sub-panel requests that MSFC determine the number of roll maneuvers that the S-IVB Auxiliary Propulsion System can perform in earth orbit on Saturn IB and Saturn V. In order to comply with this request, it is necessary to make a detailed study of the estimated fuel requirements of the Saturn V/S-IVB and Saturn IB/S-IVB Auxiliary Propulsion Systems (APS). The required study has been performed by Douglas and by MSFC. Details of the Douglas study may be found in Reference (a). Details of the MSFC study may be found in Reference (b).

2. A summary of the results of the Douglas and MSFC studies for Saturn IB/S-IVB and Saturn V/S-IVB are given in Figures 1 and 2 respectively. The main difference in the studies are as follows:

(a) Douglas assumed an uncoupled system in pitch, yaw and roll while MSFC assumed coupling in pitch, yaw and roll.

(b) Douglas assumed $\pm 10\%$ variation in vent thrust levels and perfect thrust vector alignment, MSFC assumed $\pm 1.5\%$ variation (Ref. (c)) in vent levels and $\pm 1/2^\circ$ thrust vector tolerance.

(c) Douglas used various engine Specific Impulse (ISP) values, MSFC used only one (211).

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3. The results of both studies agree that, based on present knowledge of APS engine characteristics and anticipated vehicle disturbances, etc., the S-IVB Auxiliary Propulsion Systems can perform the desired 21 roll maneuvers ($.5^\circ/s$) in both the Saturn V and Saturn IB configurations.

J. L. Mack

J. L. Mack

2 Enc:

a/s

Approval

F. B. Moore

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

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SAT IB/V

Record copy - 105 Alagel, SAT V

FIGURE 1

SATURN IB/S-IV APS PROPELLANT ALLOCATION

OPERATION	ISP		PROPELLANT		REMARKS	
	DOUGLAS	MSFC	DOUGLAS	1bf/mod MSFC		
1. J-2 Burn	↓	↓	↓			
a. S-IB/S-IVB Separation					5.0	
b. 230 ft # exhaust gas swirl effect					20.6	
c. Lateral CG offset (guidance effect)	253	211	23.08	2.0		
2. 4 1/2 hour earth orbit ($\pm 1^\circ$ deadband)		↓		↓	The MSFC study included the coupled effect of all disturbances and thus the effect of each disturbance cannot be broken out separately.	
a. Initial convergence	253		.85			
b. LH ₂ blow-down	208		6.73			
c. LOX blow-down	208		1.09			
d. Attitude stabilization	208		8.34			
e. 21 maneuvers (.5°/s)	265	211	21.00	31.93		
3. Total propellant required per module			61.09	59.53	Total propellant available is 61.06 lb	

Enclosure 1

FIGURE 2

SATURN V/S-IVB APS PROPELLANT ALLOCATION

OPERATION	ISP		PROPELLANT 1bf/mod		REMARKS
	Douglas	MSFC	Douglas	MSFC	
1. J-2 First & second burn				5.0	
a. S-II/S-IVB separation					
b. 230 ft# exhaust gas swirl				20.6	
c. Lateral CG offset (guidance effect)	↓	↓	↓	2.0	
	208	211	24.86		
2. 4 1/2 hour earth orbit					
a. Ullage control (prior to continuous vent)	270		26.7	34.1 ↑	
b. Attitude stabilization	244		30.7		
c. 21 roll maneuvers (.5°/s)	272		27.3		
d. Continuous LH ₂ vent	208		26.3	44.6 ↓	
e. Override LH ₂	208		1.51		
f. Lox vent	208		3.51		
g. Ullage engine disturbance balance	208		3.0		
h. Chillydown & restart	270	↓	88.0	↓	
		211	120.80		

The MSFC study includes the coupled effect of all disturbances and thus cannot be broken out separately.

FIGURE 2 (continued)
SATURN V/S-IVB APS PROPELLANT ALLOCATION

OPERATION	ISP		PROPELLANT lbf/mod		REMARKS
	Douglas	MSFC	Douglas	MSFC	
3. Translunar Coast					
a. Attitude Stabilization			7.4		
b. LOX tank blowdown			Negligible		
c. LH ₂ tank blowdown	↓	↓		↓	
	208	211	8.61	7.9	
4. Total Propellant required/module			247.89	235.00	Total propellant available is ~260 lbf