BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Saturn V Performance -- Effect of Engine Thrust Increase on Weight in Earth Orbit - Case 330

DATE: July 29, 1968

FROM: J. J. Schoch

ABSTRACT

A preliminary study was made to determine the potential increase in weight in earth orbit obtainable by uprating the Saturn V first and second stage engines.

A 10% thrust augmentation of the Saturn V first stage increases the weight in earth orbit by about 10,000 lbs. If both the first and second stage thrust are increased by 10%, the result is about 16,000 lbs. The corresponding figures for a 30% increase in thrust are about 24,000 and 30,000 lbs, respectively.

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MEMORANDUM FOR FILE

Introduction

Present Saturn V vehicles have a lift-off thrust to weight ratio of 1.2. It is believed that for an unmanned version of the vehicle such as may be used for planetary missions to carry spacecraft modules or propellant to earth orbit a larger $q\alpha$ limit than presently specified would still be acceptable.

Computer runs were made with the thrust of the first (F1) and second (J2) stage engines increased to evaluate the potential gain in weight in earth orbit.

Vehicle Performance

The vehicle performance analysis is based on the mass characteristics given in Reference 1 for vehicle 506 and following. It was assumed that the increased thrust does not change the mass or drag characteristics of the vehicle. Each run is characterized by:

a) a vertical rise for 12 sec., the kicking maneuver, and a gravity turn flight for the rest of the first stage;

b) second and part of third stage: linear tangent ($tg\ \psi = A+B\ t$) flight until reaching orbital conditions.

For each run the linear tangent parameters A and B and the third stage burning time are adjusted in such a manner as to satisfy the earth orbital conditions. Besides this the kick angle was optimized so as to give minimum third stage burning time, i.e., maximum weight in earth orbit.

Results and Conclusions

The results are plotted on Graph 1. The curves show the increase in payload as a function of increase in thrust. One curve is applicable to an increase in thrust in the first stage only while an equal thrust increase in both stages was used for the second curve. The lower two curves show q_{max}. The independent variables are both thrust increase in percent and thrust to weight ratio at lift-off. A ten percent increase in first stage thrust provides an increase in weight in earth orbit of 10,000 lbs. This figure becomes 16,000 lbs. if the thrust increase is applied to both stages. The corresponding figures for a 30% thrust increase are 24,000 and 30,000 lbs.

For a 30% increase in thrust the value for q_{max} is nearly twice as large as for the conventional Saturn vehicle. This large q_{max} value cannot be decreased significantly by flying the trajectory with a non optimum kick angle.

A corresponding thrust increase in the third stage does not provide any additional increase in weight in earth orbit.

J. J. Schoch

1013-JJS-kle

Attachments

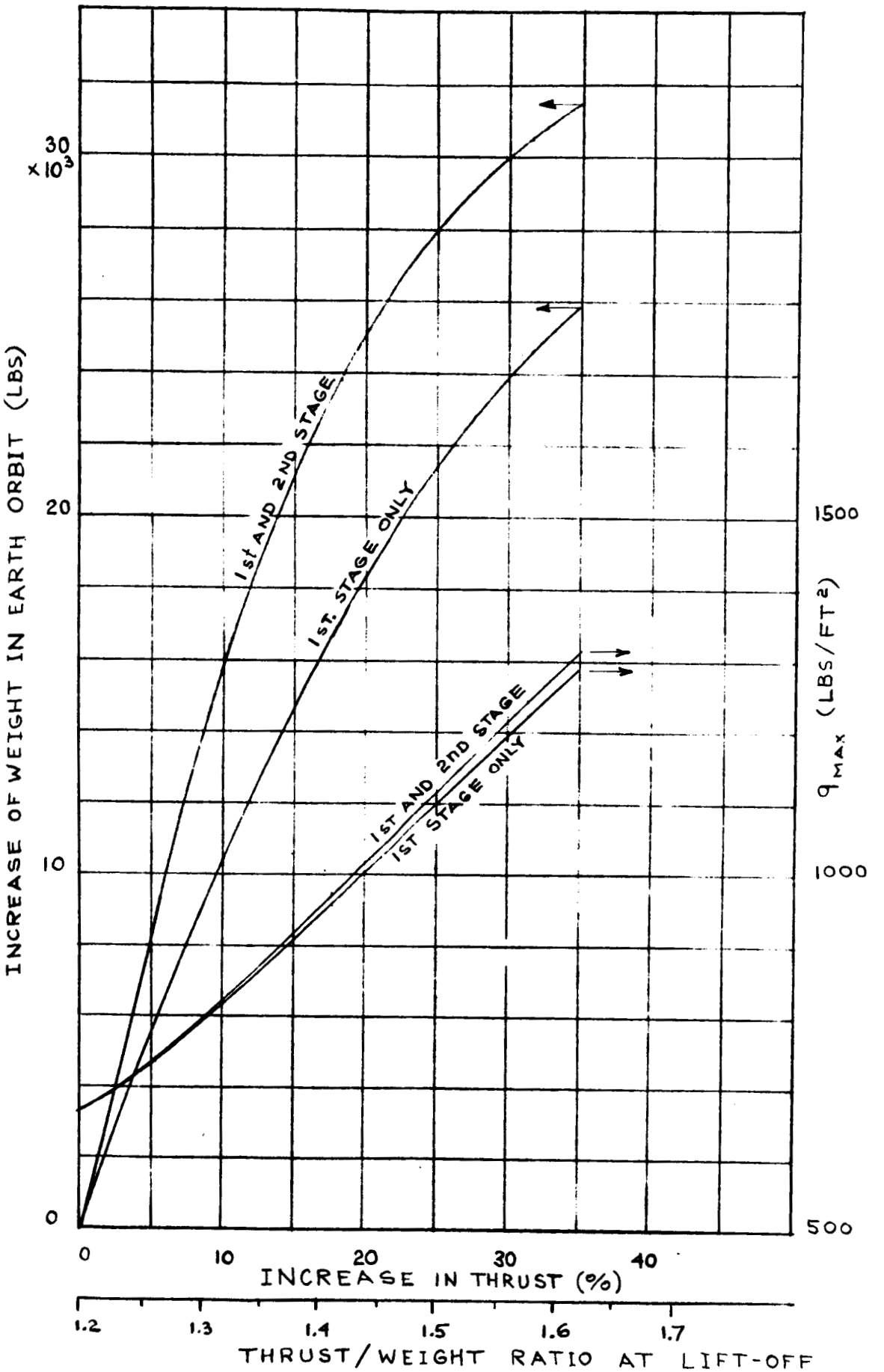
INCREASE OF WEIGHT IN EARTH ORBIT (LBS)
30
x 10³
20
10
0
1ST AND 2ND STAGE
1ST. STAGE ONLY
1ST AND 2ND STAGE
1ST STAGE ONLY
1500
1000
500
q MAX (LBS/FT²)
0
10
20
30
40
INCREASE IN THRUST (%)
1.2
1.3
1.4
1.5
1.6
1.7
THRUST/WEIGHT RATIO AT LIFT-OFF

FIGURE 1

REFERENCES

1. Saturn V Control Weights Vehicle Definition, The Boeing Co., Aerospace Division, Launch Systems Branch, Document No. D5-11462, 1965, Confidential, BCM Classified Number 65-86. (U)

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