D-Von Braun

35

B-12

~~SECRET~~

CONFIDENTIAL

Copy No. 9 of 35 copies

VIII.1

REPORT TO THE ADMINISTRATOR, NASA

ON

SATURN DEVELOPMENT PLAN

BY

SATURN VEHICLE TEAM

Classification Changed
To: UNCLASSIFIED
By Authority of ACG-6
Date 3/5/64 By [illegible]

GROUP 4
Downgraded at 3 year intervals;
declassified after 12 years

CONFIDENTIAL

~~SECRET~~

December 15, 1959

C 270363
15 Dec 59

Reg # 306471

VIII-B-1

INTRODUCTION

The President of the United States, on 2 November 1959, announced his intention to transfer the Development Operations Division of the Army Ballistic Missile Agency (ABMA) and the Saturn project to NASA. In anticipation of this transfer, the NASA and Department of Defense have established an interim working agreement that provides for immediate assumption by NASA of responsibilities for technical management of the Saturn vehicle development. On 17 November 1959, the Associate Administrator of NASA requested the Director of Space Flight Development to

> "form a study group with membership from NASA, the Directorate of Defense Research and Engineering, ARPA, ABMA, and the Air Force from the Department of Defense to prepare recommendations for guidance of the development, and specifically, for selection of upper stage configurations.
>
> Attention in the study should be directed toward
>
> 1. Missions and payloads,
> 2. Technical development problems,
> 3. Cost and time for development, and
> 4. Future growth in vehicle performance."

A Saturn vehicle team was established with the following membership:

Dr. Abe Silverstein, Chairman	NASA
Col. N. Appold	USAF
Mr. A. Hyatt	NASA
Mr T. C. Muse	ODDR&E
Mr. G. P. Sutton	ARPA
Dr. W. von Braun	ABMA
Mr. E. Hall, Secretary	NASA

The results and recommendations of the Saturn vehicle team are summarized in this report and the more detailed findings are presented in Appendices A, B, and C, which are attached.

The Saturn project was initiated on 15 August 1958 by an order from the Advanced Research Projects Agency to the Army Ordnance Missile Command to develop a large booster vehicle of approxima tely 1.5 million pounds of thrust using available engines. Authorization was given for construction of test facilities, development and early captive firing of the first stage, launchings of three first stages with dummy upper stages, and one with a live upper stage. A brief chronology of important actions relative to the Saturn project are contained in Appendix A.

For the past several months technical studies have been conducted by ABMA, ARPA, and NASA to establish the performance characteristics of the Saturn vehicle with various upper stages. The results of these independent studies were in close agreement and form a basis for this evaluation.

Presentations were made to the Saturn vehicle team on missions for the Saturn vehicle by both NASA and the Department of Defense. The following missions, listed in their order of importance, were established for the Saturn vehicle (Appendix B).

a. Lunar and deep space missions with an escape payload of about 10,000 pounds.

b. Payloads of about 5,000 pounds in a 24-hour equatorial orbit.

c. Manned spacecraft missions such as Dyna Soar, with a weight of about 10,000 pounds in a low orbit (two-stage launch vehicle)

These missions were established for the initial Saturn vehicle configuration. It is recognized that the initial Saturn configuration must provide for growth to permit increased payload capability in the lunar, deep space, and satellite missions. Early capability with an advanced vehicle and possibilities for future growth were accepted as elements of greatest importance in the Saturn vehicle development.

The current Saturn first stage with eight engines giving a total thrust of nearly 1,500,000 pounds was reviewed. The many problems associated with its development and operation were discussed. Attention was given to alternate configurations for the first stage including the use of solid propellant rockets, a cluster of four 400,000-pound thrust engines, and a single engine of 1,500,000 pounds of thrust. The problems of clustered tanks as compared with those of a single large tank were also considered.

A wide variety of upper stages utilizing conventional and high-energy propellants and of various weights were compared on the basis of performance, technical feasibility, growth potential and probable time and cost to develop. Various tank configurations, including clusters of existing IRBM's, which were independently analyzed by ABMA and NASA, were also studied by the group. A discussion of the technical items covered is contained in Appendix C.

SUMMARY OF RESULTS

After a review of the many possible configurations of Saturn vehicles, the team reduced its detailed considerations to those shown in Table I.

The payload capabilities of the configurations shown in Table I for the most important missions listed in the Introduction are given in Table II.

Vehicle A-1, with upper stages consisting of a modified Titan stage 1 and Centaur upper stage, makes maximum utilization of existing hardware and would most likely have earliest flight availability and lowest cost. It fails, however, to meet the mission requirements for the lunar and 24-hour missions and, because of its slenderness (120-inch diameter upper stages), vehicle A-1 is a structurally marginal configuration. Development of a 160-inch diameter second stage similar in construction to the Titan first stage was reviewed and eliminated from detailed consideration because it limited the growth potential of the Saturn.

The A-2 vehicle, with a cluster of IRBM's as the second stage, is similar to the A-1 configuration in its use of existing hardware. Vehicle A-2 fails to meet the requirements for lunar and deep-space missions and for the 24-hour equatorial orbit.

Vehicle B-1 meets the requirements of the missions, but requires the development of a new conventionally fueled second stage that is approximately twice the size of our current ICBM's. The cost and time to develop this large second stage which seemed to be interim in character for advanced missions raised doubts as to the desirability of developing this vehicle.

In examining vehicles A-1, A-2, B-1, and others, it became apparent that the highest priority missions for the Saturn vehicle could not be accomplished in a reasonable design without the use of high-energy propellants in the top stages. If these propellants are to be accepted for the difficult top-stage applications, there seems to be no valid engineering reasons for not accepting the use of high-energy propellants for the less difficult

CONFIDENTIAL

~~SECRET~~

TABLE I

DESCRIPTION OF POSSIBLE
SATURN VEHICLE CONFIGURATIONS

STAGE	1	2	3	4
A-1	LOX/RP EIGHT H-1 ENGINE CLUSTER	LOX/RP TITAN 120" DIA.	CENTAUR 120" DIA. TWO 15K ENGINES	
A-2		CLUSTER OF IRBM'S	CENTAUR 120" DIA. TWO 15K ENGINES	
B-1		LOX/RP 220" DIA.* FOUR H-1 TYPE ENGINES	LOX/LH 220" DIA.* FOUR 15-20K ENGINES	CENTAUR 120" DIA. TWO 15K ENGINES
C-1		LOX/LH 220" DIA.* FOUR 15-20K ENGINES	CENTAUR 120" DIA. TWO - 15K ENGINES	
C-2		LOX/LH 220" DIA.* TWO 150-200K ENGINES	LOX/LH 220" DIA.* FOUR 15-20K ENGINES	CENTAUR 120" DIA. TWO 15K ENGINES
C-3	LOX/RP 2.0/ MILLION POUND THRUST ENGINE CLUSTER	LOX/LH 220" DIA.* FOUR 150-200K ENGINES	LOX/LH 220" DIA.* TWO 150-200K ENGINES	LOX/LH 220" DIA.* FOUR 15-20K ENGINES

*Nominal tank diameter
H-1 Engine - 165,000 to 188,000 lb. thrust

~~SECRET~~

CONFIDENTIAL

TABLE II

PERFORMANCE OF POSSIBLE SATURN VEHICLE CONFIGURATIONS

	*DRY GROSS PAYLOAD, POUNDS (AMR LAUNCH)		
MISSION	LUNAR CIRCUMNAVIGATION	DYNA SOAR-TYPE (2 STAGE)	24 HR. SATELLITE
A-1	6,800 (3)	12,500 (2)	3,800 (3)
A-2	7,000 (3)	8,500 (2)	3,500 (3)
B-1	11,000 (3) 15,000 (4)	12,600 (2)	5,000 (3) 9,000 (4)
C-1	9,000 (3)	24,000 (2)	5,500 (3)
C-2	15,500 (3)	40,000 (2)	9,000 (3)
C-3	25,000 (3) 34,000 (4)	54,000 (2)	12,000 (3) 21,800 (4)

*DRY GROSS PAYLOAD includes net payload, shrouds, instrument compartment and instrumentation, and guidance and control. (Does not include flight reserve propellant) application to intermediate stages. Of course, the maximum payload capability with the Saturn first stage booster will be achieved if high-energy propellants are used in all the upper stages. Current success in the Centaur engine program substantiates the choice of hydrogen and oxygen for the high-energy propellants.

The C-1 configuration (Tables I and II) is the first phase in the development of a vehicle using all hydrogen and oxygen upper stages (see figures 1 and 2). Succeeding phases are C-2 and C-3 with progressively increasing payload capability. As the development proceeds from phase to phase, a new stage is added to the vehicle. Stages developed for early phases continue to be used in all latter phases (see figure 2). Thus all developments lead to increased flight capability and reliability.

Configuration C-1 permits early flights and essentially meets the established mission requirements. The upper stages consist of a four engine hydrogen-oxygen second stage (S IV) and a Centaur upper stage (S V) as a third stage. The engines for the second and third stage are the same. Uprating of the 15K Centaur engine to 20K is necessary for the second stage.

Configuration C-2 is adapted from C-1 by the addition of a new hydrogen-oxygen second stage (S III). The development of a 150K - 200K pounds of thrust hydrogen-oxygen rocket engine is required to power the new stage.

Configuration C-3 increases the payload capability by adding a second stage (S II) with four 150K - 200K pound thrust engines. The thrust of the first stage is also increased to over two million pounds. This thrust may be obtained by replacing the four center engines with one F-1 engine or by uprating all eight H-1 engines.

RECOMMENDATIONS

It is recommended that:

1. A long-range development plan for the Saturn vehicle be established that will provide, through a consecutive development of building-block upper stages, a substantial early payload capability and a final configuration that exploits the maximum capability of the Saturn first stage. Vehicle reliability will be emphasized in the building-block program through a continued use of each development stage in later vehicle configurations.

2. All upper stages be fueled with hydrogen-oxygen propellants.

3. The initial vehicle configuration, C-1, consists of the following:

a. The eight engine first stage currently under development at ABMA,

b. A newly developed second stage using four of the current Centaur engines uprated to 20,000 pounds of thrust.

c. The third stage using the current Centaur stage modified only as required for vehicle and payload attachments.

4. The following developments be initiated immediately:

a. A 150-200K hydrogen-oxygen fueled rocket engine for stages S II and S III.

b. A design study of hydrogen-oxygen upper stages S II and S III using the 150-200K engines.

5. The development schedule shown in Table III be adopted.

Submitted by:

Abe Silverstein, NASA (Chairman)

Abraham Hyatt, NASA

George P. Sutton, ARPA

T. C. Muse, ODDR&E

Norman C. Appold, Col., USAF

Wernher von Braun, ABMA

Eldon Hall, NASA (Secretary)

FIGURE I
SATURN VEHICLE BUILDING BLOCKS

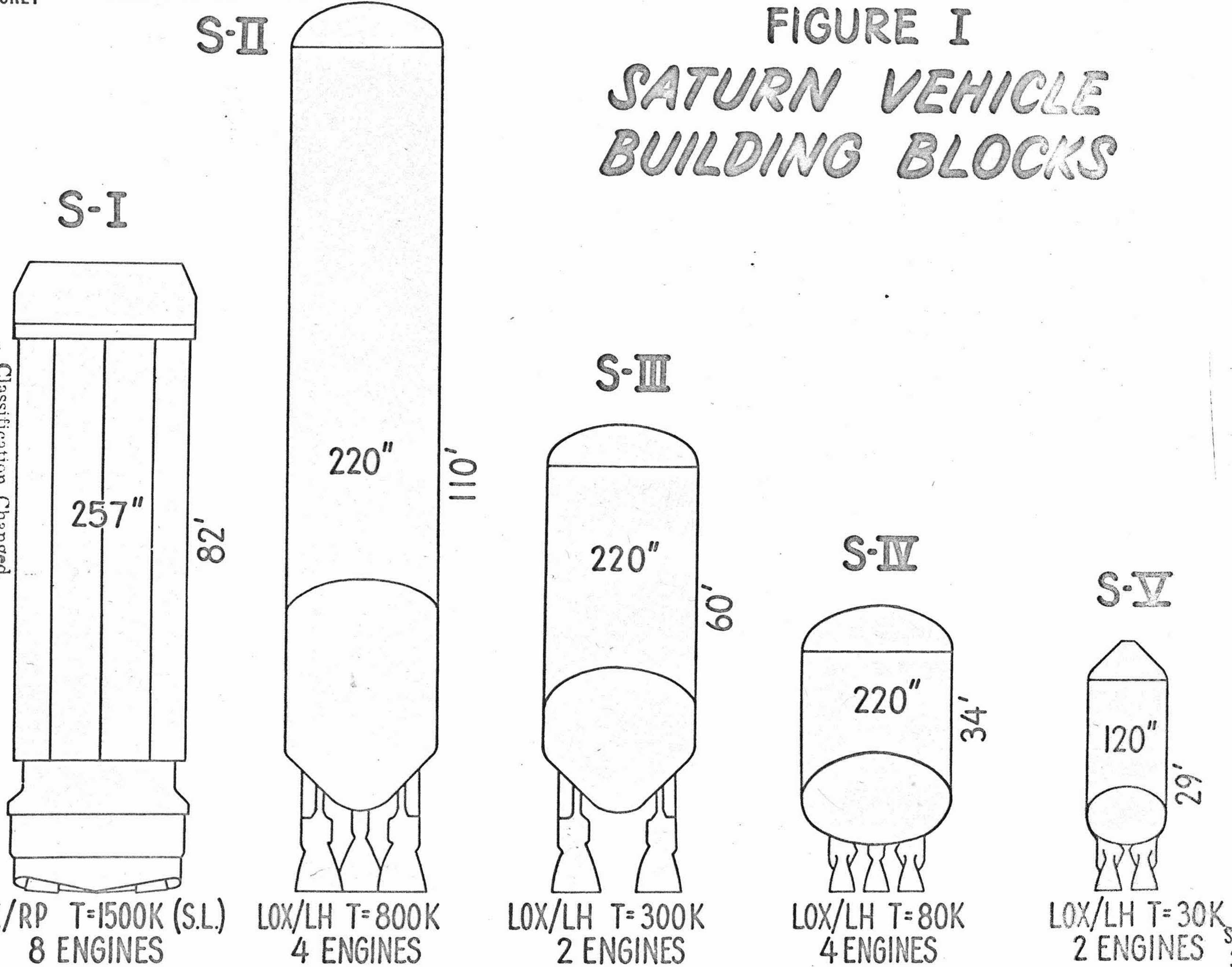
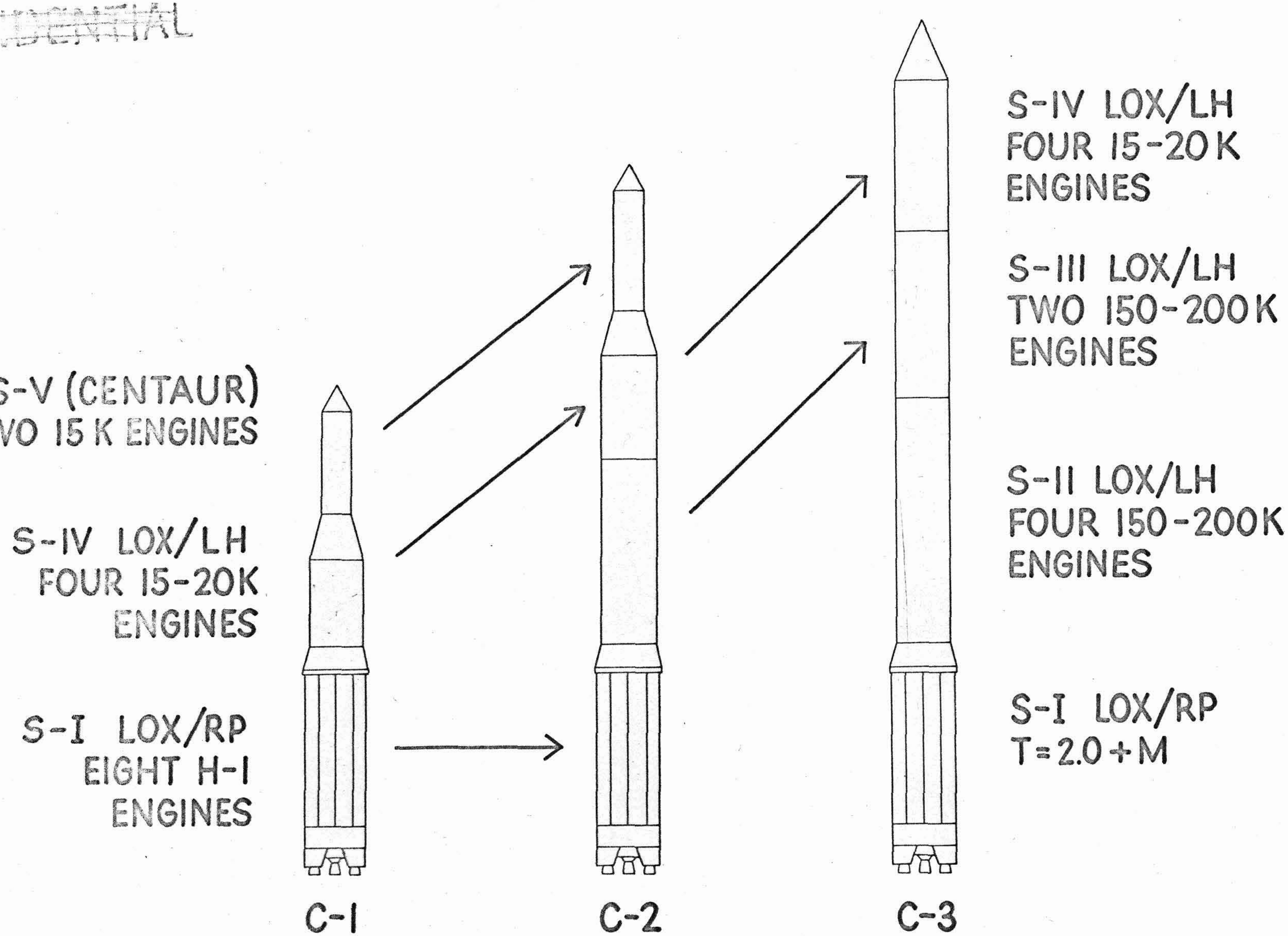


Figure 1

~~SECRET~~

SATURN CONFIGURATIONS

~~CONFIDENTIAL~~



~~SECRET~~ 3074

~~CONFIDENTIAL~~

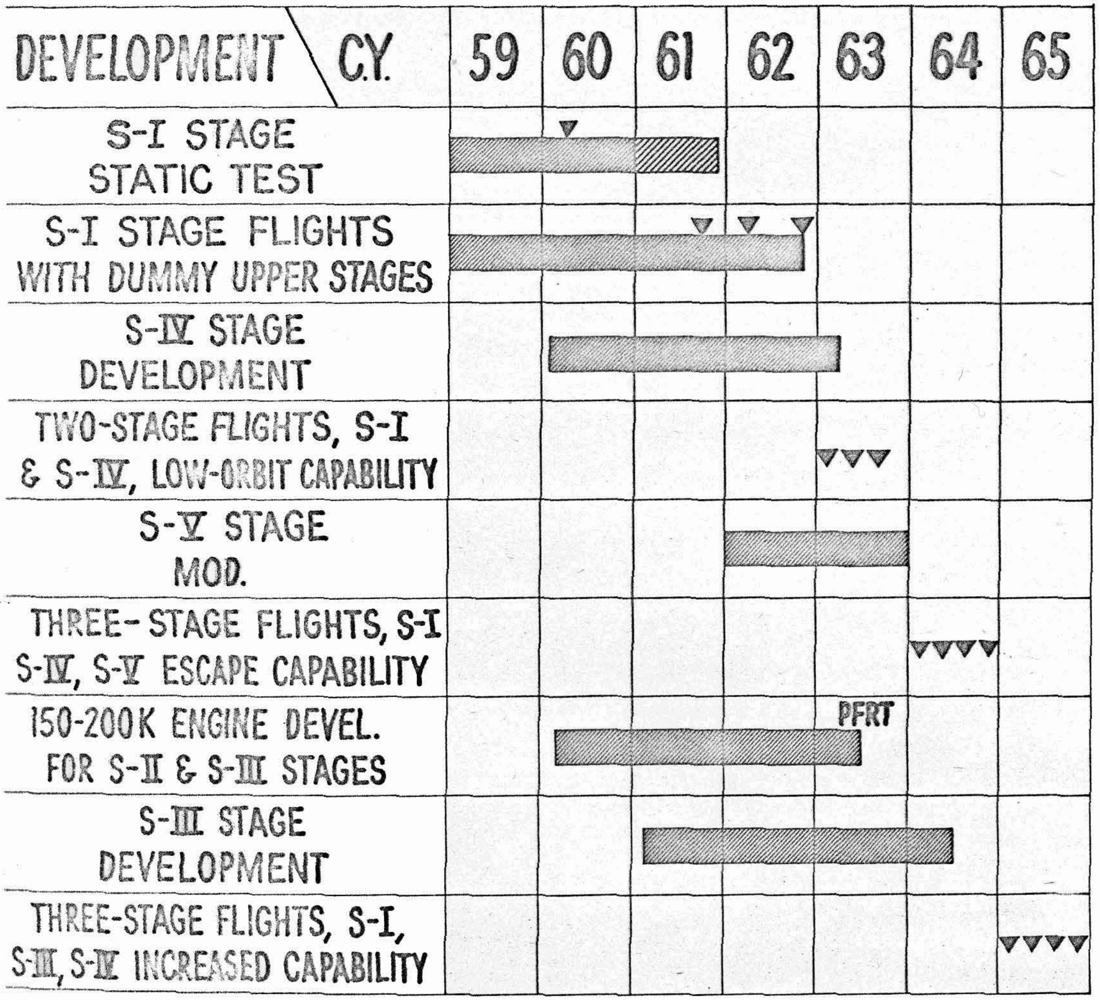
Figure 2

-SECRET

CONFIDENTIAL

TABLE III

SATURN DEVELOPMENT SCHEDULE*



FUNDING:

1. SCHEDULE BASED ON FUNDING OF $70M IN FY 60, $140 M IN FY 61, AND ANTICIPATED FUNDING OF $150 M TO $200 M IN SUBSEQUENT YEARS AT A NOMINAL FIRING RATE OF 4 PER YEAR.

2. FUNDING INCREASES OF $15 M IN FY60 AND $30M IN FY61 WOULD PROVIDE INCREASED RELIABILITY AND EXPEDITE SCHEDULE 3 MONTHS FOR 2-STAGE FLIGHTS AND 6 MONTHS FOR 3-STAGE FLIGHTS.

3. COST OF 150-200K ENGINE NOT INCLUDED IN FUNDING

4. COST OF PAYLOADS NOT INCLUDED.

* FURNISHED BY ABMA

CONFIDENTIAL

SECRET 3073