F.L. Williams

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REPORT
TO THE
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

SPECIAL COMMITTEE ON SPACE TECHNOLOGY

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a national integrated missile and space vehicle development program

GROUP 3
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By

THE WORKING GROUP ON VEHICULAR PROGRAM

18 July 1958

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FOR AERONAUTICS

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A NATIONAL INTEGRATED MISSILE AND SPACE VEHICLE DEVELOPMENT PROGRAM

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ABSTRACT

This report, the third in a series of reports by the Working Group on Vehicular Program to the NACA Special Committee on Space Technology, outlines a plan for a national integrated missile and space vehicle development program.

In the introduction to the report, the overall economy of United States space flight is discussed, and a chronological listing of milestones in the proposed U.S. integrated program is given and compared with anticipated Soviet capabilities. The report proper is divided into two parts: Part I gives an overall view of the proposed vehicle program together with conclusions and recommendations, and Part II contains supporting technical information in the form of detailed charts and tables. A review of the military missile program is presented in Appendix A.

Based on the study reported herein, it is concluded that a national missile and space flight program is not only feasible but mandatory for national security, and it is recommended that such a program be initiated immediately.

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INTRODUCTION

A. THE NEED

The recent launchings of satellites by the Soviet Union and the United States have made it apparent that the people of the earth are entering into the age of space travel, and possibly, of space warfare, unless the present world tension can be reduced or eliminated. A comparison of present accomplishments shows emphatically that the state-of-the-art of the Soviet Union is considerably more advanced than that of the United States in both space travel and space warfare. Although the United States is advancing rapidly in the field of space vehicles, there appears to be an excessive amount of duplication of effort and a lack of complete coordination among the numerous organizations involved. This is not only an unnecessary burden on the national economy but also a waste of man-power in what could be considered a national emergency.

In view of the above, the need for a national integrated missile and space vehicle program withing the United States is considered mandatory if this nation expects to equal the accomplishments of the Soviet Union and ultimately surpass them in the race for space supremacy. Such a program should utilize all available research, development, and production capabilities in the accomplishment of a common, well-defined single plan designed to assure national security and space supremacy.

The realization of the need for this program led to the establishment of a Special Committee on Space Technology by the National Advisory Committee for Aeronautics. The several working groups of this committee are charged collectively with the responsibility of developing a plan for a national integrated missile and space development program.

B. PROGRAM OBJECTIVES

This plan must properly define a national integrated missile and space vehicle development program which will ultimately lead to:

1. The reaffirmation of national scientific and technological supremacy.

2. The provision for an adequate defense against hostile capabilities in space warfare.

3. The extension of the national deterrent capability to include space warfare techniques.

4. The evolution of a national capability for space exploration.

These objectives must be accomplished on a national basis devoid of the interests of any individual, military or civilian group, or organization, and without upsetting the nation's economic stability, disrupting the manpower balance, or draining the national resources.

C. REPORT OBJECTIVES AND SCOPE

This report is the third in a series of reports to be submitted to the NACA Special Committee on Space Technology by the Working Group on Vehicular Program. The primary considerations of this report are given to the space vehicles proper; however, it has been necessary to consider other aspects of an overall national program to give the vehicular program in the proper perspective. This report, therefore, reviews the United States missile program and outlines a feasible plan for a national integrated missile and space vehicle development program.

The report is divided into two parts: Part I presents an overall view of the national program, together with conclusions and recommendations, and Part II contains the supporting technical details.

Part I describes 15 different vehicles which could be utilized in a United States space flight program. These vehicles, many of which have several possible missions, are divided into five generations or classes defined as follows:

First Generation - Based on SRBM boosters
Second Generation - Based on IRBM boosters
Third Generation - Based on ICBM boosters
Fourth Generation - Based on 1.5 million-pound-thrust boosters
Fifth Generation - Based on 3 to 6 million-pound-thrust boosters

Several other possible configurations, comprised of various existing and proposed components, were reviewed but not included since they appeared less attractive from a performance, availability, and cost standpoint than the vehicles presented.

The vehicles required for the proposed national program are described and illustrated in pictorial form. Payload capabilities - for individual vehicles and for all vehicles combined - are considered briefly. Several missions are anticipated for many of the proposed vehicles, and a typical mission requirement has been established for all vehicles covering the period 1958 through 1980. Based on the proposed missions and the supporting program requirements, a typical expenditure forecast has been estimated and presented. These expenditures exclude the present national missile program without space flight missions.

Part II consists of the detailed charts and tables required to support the information presented in Part I.

The information utilized in preparing this report was obtained from several government and non-government sources. It was found in comparing much of the data that inconsistencies existed, primarily due to use of different nomenclature or definitions and method of solution for such problems as performance and payload capabilities. Since the function of this report is to present the facts on possible United States capabilities and not to evaluate existing and proposed programs, no effort has been made to verify some of the data presented herein. Although these effects would not substantially modify the proposed program, it would be very desirable to minimize the inconsistencies by the use of common terminology and methods of solution.

D. ECONOMIC FEASIBILITY

One of the overriding parameters in the developing of space vehicles, as in other means of transportation, is overall economy. The parameter commonly used in surface and air transportation is dollars per ton-mile. For space flight, this parameter should be modified since distance is not a convenient mea-

TABLE 1: **TRENDS IN ORBITAL TRANSPORTATION**

NO.		DESCRIPTION	OPER YEAR	*SINGLE PAYLOAD CAPABILITY	TOTAL PAYLOAD CAPABILITY	TOTAL PROGRAM COST	PAYLOAD IN ORBIT COST (100% RELIB)	REALB. FACTOR	EFFECTIVE PAYLOAD IN ORBIT COST	PERCENT OF VANGUARD COST	GROWTH FACTOR
-				POUNDS	POUNDS	MILLIONS	$/LB		$/LB		W_o/W_{payl}
1	IA	VANGUARD PROGRAM	1958	4@3.5 7@21.5	165	145	880,000	0.25	3,520,000	100	1000
2	IB	JUNO I PROGRAM	1958	3@18.5 2@25	105	8	76,000	0.67	113,500	3.25	1750
3	IIA	JUNO II PROGRAM	1959	2@72 2@10	164	21	128,000	0.67	191,000	5.45	1500
4	IIC	JUNO IV PROGRAM	1959	102@2400 4@130	245,320	825	3360	0.75	4500	0.15	57
5	IIIC	MODIFIED ATLAS	1959	36@8500 5@1900	315,500	340	1080	0.75	1400	0.05	36
6	IIIF	MODIFIED TITAN	1960	271@11500 6@3400	3,183,000	1577	495	0.75	660	0.02	30
7	IV A or B	APPROX 1500 K BOOSTER	1962	210@34000 370@14000 **	12,320,000	3695	290	?	---	---	29
8	V A	3000 K BOOSTER	1968	262@200000 78@35000	55,130,000	2812	50	?	---	---	12

*90 MINUTE ORBIT FOR ORBITAL MISSIONS AND ESCAPE FOR LUNAR AND INTERPLANETARY MISSIONS
**COMMERCIAL FLIGHTS ARE NOT INCLUDED

sure, especially under the absence of gravity. It, therefore, seems advisable to utilize cost per unit payload delivered into a specific orbit or to escape velocity as a parameter for overall economy.

If the present and future trends of the proposed space flight transportation systems are investigated, the position of each vehicle in the overall economic picture will become apparent. Table 1 compiles a few characteristic figures of present and anticipated orbital carrier vehicles which illustrate clearly the trend in the overall economy. Included in this table are operational dates, single missile payload capability, and total program payload capability, as well as total program cost. Dividing the total program cost by total payload and assuming 100% reliability, the payload-in-orbit cost can be obtained (Column 6). By introducing a reliability factor for the probability of successful flights, an effective payload-in-orbit cost is determined (Column 8) which gives the desired parameter for overall economy. Since the mission of a carrier vehicle is to deliver a given payload into orbit, the proper economic perspective can be given each vehicle by comparing the values given in Column 8 of Table 1.

Since it is not the function of this report at this early stage of investigation to decide which of the possible future space vehicle development programs should be initiated, no specific recommendations have been made. However, the following comment is considered in order: The need for at least one vehicle in each generation is considered necessary in order to provide a systematic advancement in the state-of-the-art and the steadily increasing orbital and space mission payload capability required to achieve U.S. space supremacy.

E. CHRONOLOGY, RECOMMENDED U.S. SPACE FLIGHT PROGRAM

To provide some understanding of the program as a whole, milestones of the recommended U.S. space flight program are listed chronologically in Table 2. One of the outstanding milestones in the U.S. space flight program should be that of performing a manned lunar landing in advance of the Soviets, and it has, therefore, been established as one point on the capability chart.

BLE NO. 2

MILESTONES OF THE RECOMMENDED U.S. SPACE FLIGHT PROGRAM

ITEM	DATE	EVENT	VEHICLE GENERATION
1	JAN 1958	FIRST 20 lb SATELLITE (ABMA / JPL)	I
2	AUG 1958	FIRST 30 lb LUNAR PROBE (DOUGLAS / RW / AEROJET)	II
3	NOV 1958	FIRST RECOVERABLE 300 lb SATELLITE (DOUGLAS / BELL / LOCKHEED)	II
4	MAY 1959	FIRST 1500 lb SATELLITE	II
5	JUN 1959	FIRST POWERED FLIGHT WITH X-15	
6	JULY 1959	FIRST RECOVERABLE 2100 lb SATELLITE	II and/or III
7	NOV 1959	FIRST 400 lb LUNAR PROBE	II and/or III
8	DEC 1959	FIRST 100 lb LUNAR SOFT LANDING	II and/or III
9	JAN 1960	FIRST 300 lb LUNAR SATELLITE	II and/or III
10	JULY 1960	FIRST WINGLESS MANNED ORBITAL RETURN FLIGHT	II and/or III
11	DEC 1960	FIRST 10000 lb ORBITAL CAPABILITY	III
12	FEB 1961	FIRST 2800/600 lb LUNAR HARD OR SOFT LANDING	III
13	APR 1961	FIRST 2500 lb PLANETARY OR SOLAR PROBE	III
14	SEP 1961	FIRST FLIGHT WITH 1500 K BOOSTER	IV
15	AUG 1962	FIRST WINGED ORBITAL RETURN FLIGHT	III
16	NOV 1962	FOUR MAN EXPERIMENTAL SPACE STATION	III
17	JAN 1963	FIRST 30000 lb ORBITAL CAPABILITY	IV
18	FEB 1963	FIRST 3500 lb UNMANNED LUNAR CIRCUMNAVIGATION AND RETURN	IV
19	APR 1963	FIRST 5500 lb SOFT LUNAR LANDING	IV
20	JUL 1964	FIRST 3500 lb MANNED LUNAR CIRCUMNAVIGATION AND RETURN	IV
21	SEP 1964	ESTABLISHMENT OF A 20 MAN SPACE STATION	IV
22	JULY 1965	FINAL ASSEMBLY OF FIRST 1000 TON LUNAR LANDING VEHICLE (EMERGENCY MANNED LUNAR LANDING CAPABILITY)	IV
23	AUG 1966	FINAL ASSEMBLY OF SECOND 1000 TON LUNAR LANDING VEHICLE AND FIRST EXPEDITION TO THE MOON	IV
24	JAN 1967	FIRST 5000 lb MARTIAN PROBE	IV
25	MAY 1967	FIRST 5000 lb VENUS PROBE	IV
26	SEP 1967	COMPLETION OF 50 MAN-500 TON PERMANENT SPACE STATION	IV
27	1972	LARGE SCIENTIFIC MOON EXPEDITION	V
28	1973/1974	ESTABLISHMENT OF A PERMANENT MOON BASE	V
29	1977	FIRST MANNED EXPEDITION TO A PLANET	V
30	1980	SECOND MANNED EXPEDITION TO A PLANET	V

The best available information on the U.S.S.R. target date for such an accomplishment is prior to September 1967. After careful consideration of the anticipated U.S. space vehicle capability, it is believed that the U.S. will be capable of performing this feat not later than August of 1966 with a back-up vehicle to insure maximum possible human safety. There is a possibility that a manned lunar landing, on an emergency basis without a back-up vehicle, could be accomplished as early as July 1965.

The milestones listed in Table 2 are considered feasible and obtainable as indicated by the supporting information presented in the body of the report.

Satellite capability is considered a good yardstick in measuring the space vehicle state-of-the-art for a given nation. The anticipated U.S. and U.S.S.R. satellite capabilities are compared in Figure 1. The indications are that at least five years will be required for the U.S. to overtake and surpass the U.S.S.R. if proper action is initiated in the very near future. This comparison, together with the comparison of U.S. and U.S.S.R. lunar landing capabilities given in Figure 2, reiterates the need for rapid U.S. advancement.

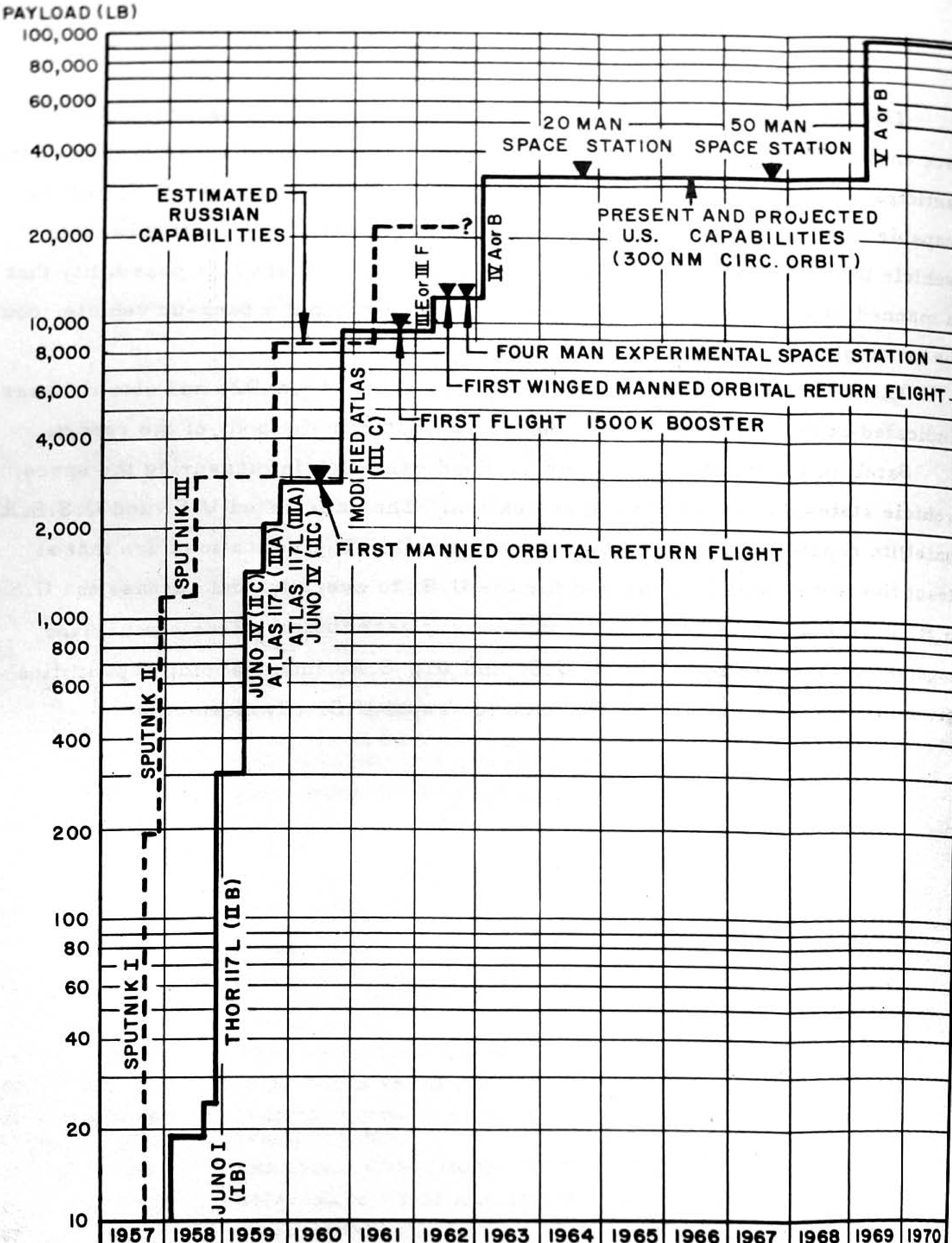

FIG. 1 COMPARISON OF U.S. AND U.S.S.R. SATELLITE CAPABILITY

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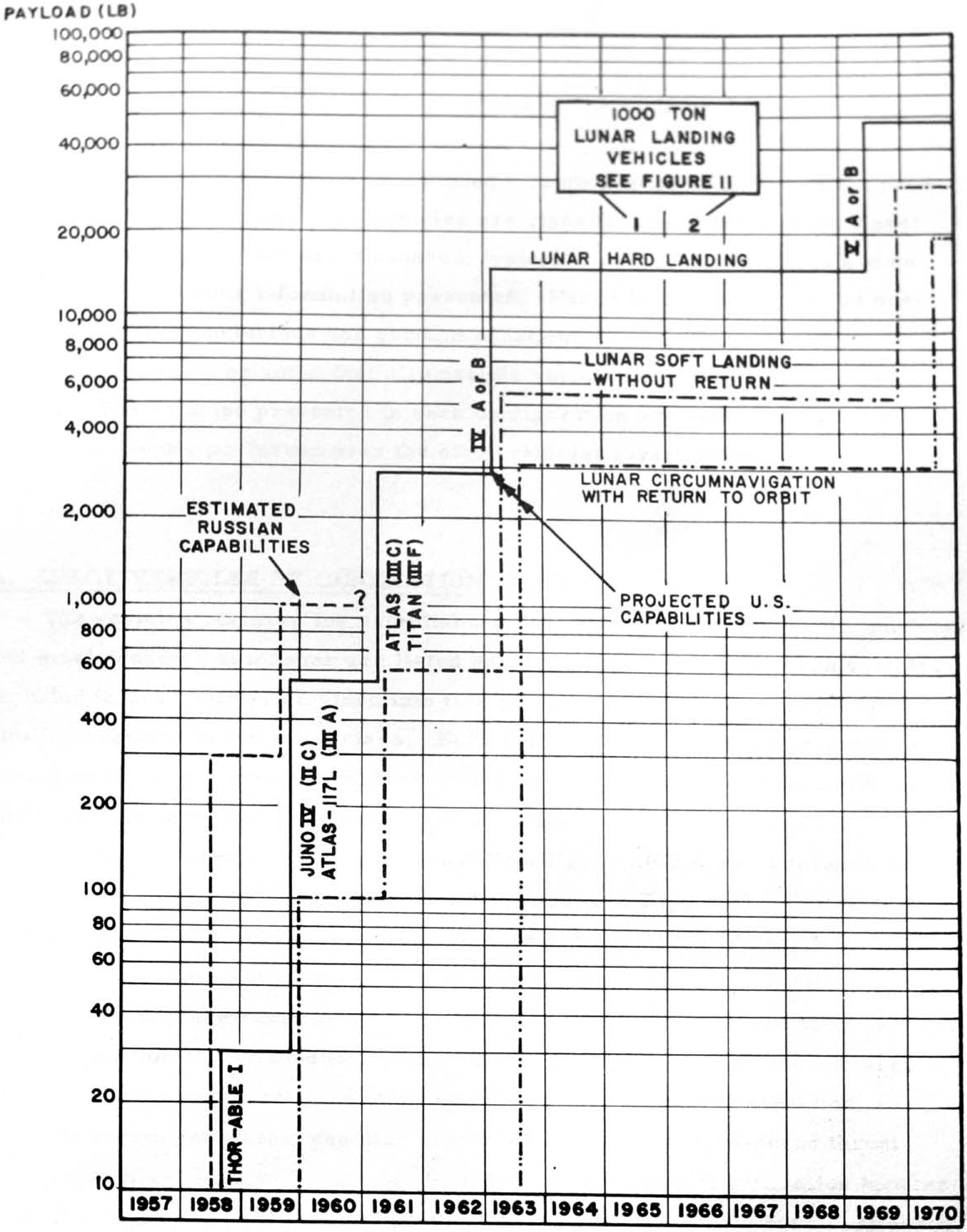

FIG. 2 COMPARISON OF U.S. AND U.S.S.R. LUNAR CAPABILITIES

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PART I

PROPOSED VEHICULAR PROGRAM: AN OVERALL VIEW

This division of the report is designed to give an overall view of the proposed vehicular program. The vehicles are classified by generation or class; their payload capabilities are discussed; typical mission requirements are established; and funding information presented. Part I is culminated by the presentation of the conclusions and recommendations.

It should again be noted that all possible vehicle configurations are not included. The vehicles presented in each configuration are considered typical and are presently preferred over the other vehicles investigated.

A. SPACE VEHICLES BY GENERATION (CLASS)

The vehicles required for establishing U.S. space supremacy in the quickest and most economical manner are listed and described in Table 3. The vehicles included in this table are divided into five generations in an effort to group similar vehicles in the same class. Each vehicle in the proposed program has been given a Roman numeral and letter designation indicating generation (class) and vehicle within each generation, respectively.

The first generation vehicles, VANGUARD and JUNO I, are presently in existence and are based on SRBM class boosters (see Figure 3). The second generation vehicles, JUNO II, THOR-117L (ABLE I), JUNO IV, are based on the IRBM boosters and are illustrated in Figure 4.

The third generation vehicles are based on the ICBM boosters or in the case of configuration III E a modified ICBM booster. Figure 5 shows the external views of the six configurations being considered for the third generation.

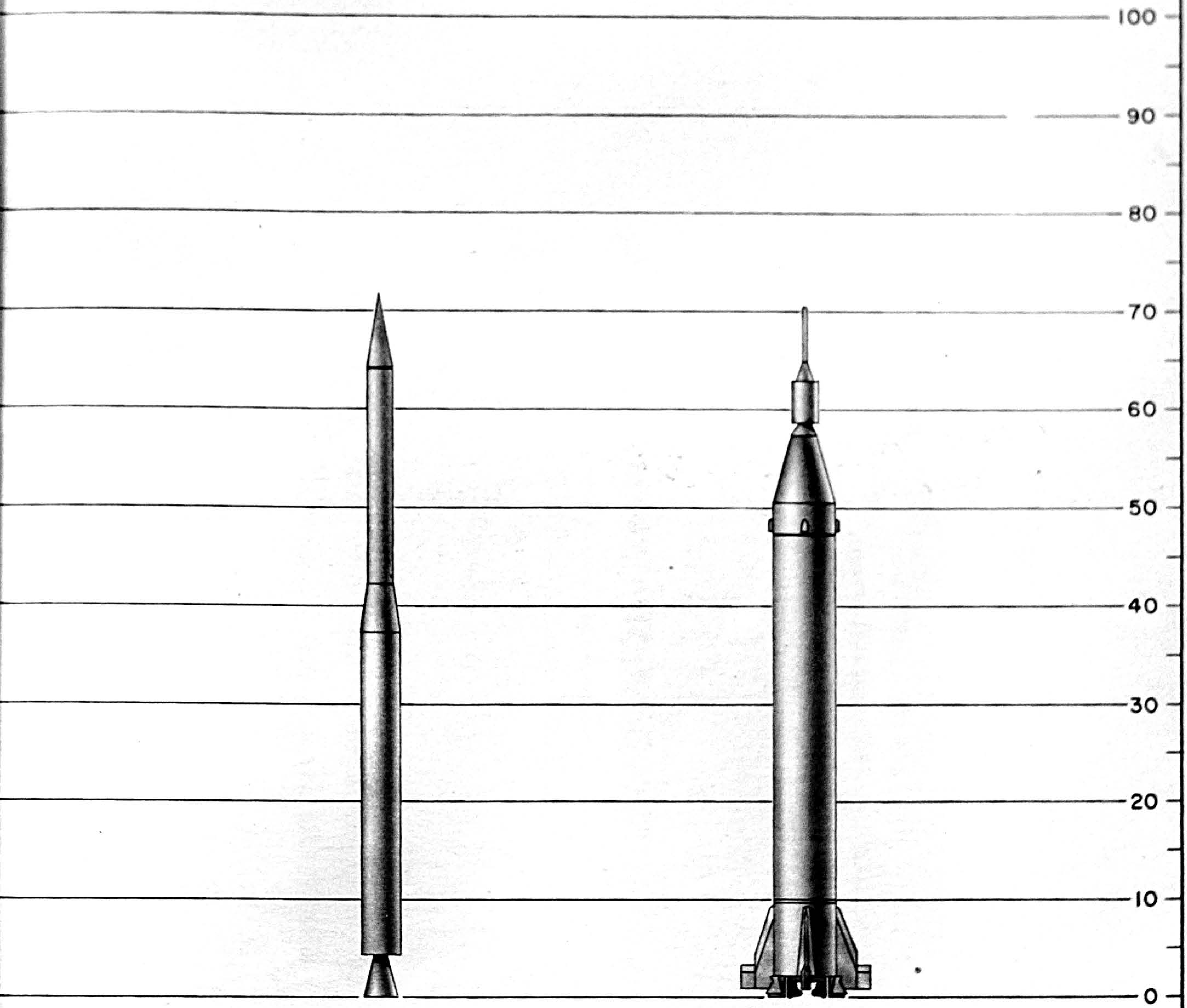
The fourth generation vehicles are based on a 1.5 million-pound thrust booster as illustrated in Figure 6. In order to have a fourth generation booster available beginning 1961, only clusters of smaller engines have been considered. Configuration IV A would be based on a cluster of four 380K engines, presently

TABLE NO. 3: DESCRIPTION OF CARRIER VEHICLES BY GENERATION

GEN	DESIGNATION	DESCRIPTION	STAGE	Fo (POUNDS)	Wo (POUNDS)	PAYLOAD CAPABILITY
I	IA	VANGUARD - WELL KNOWN ORBITAL CARRIER VEHICLE	I II III	28 K 7.75 K	22 K 5 K	3.5 21
	IB	JUNO I - REDSTONE BOOSTER WITH (11+3+1) 6" SERGEANTS	I II III IV	80.4 K 14.6 K 0.42 K 0.16 K	62.5 K 10.3 K 0.29 K 0.09 K	18- 35
II	II A	JUNO II - JUPITER BOOSTER WITH (11+3+1) 6" SERGEANTS	I II III IV	150 K 14.6 K 0.42 K 0.16 K	110.5 K 11 K 0.29 K 0.16 K	100- 200
	II B	THOR BOOSTER WITH 117L AS SECOND STAGE (TEST VEHICLE FOR PIED PIPER)	I II	150 K 15 K	115 K 8 K	200- 400
	II C	JUNO IV - JUPITER BOOSTER (LOX/RP-1) WITH GE 405 SECOND STAGE AND JPL THIRD STAGE	I II III	150 K 45 K 6 K	136 K 30 K 11 K	500- 2500
III	III A	ATLAS BOOSTER WITH 117L SECOND STAGE PIED PIPER VEHICLE	I II	360 K 15 K	275 K 9.3 K	2000- 3000
	III B	UNCHANGED TWO-STAGE TITAN AS ORBITAL VEHICLE	I II	300 K 80 K	220 K 50 K	1000- 3000
	III C	BEEFED-UP ATLAS BOOSTER WITH HIGH PERFORMANCE UPPER STAGE (H_2O_2 PRESSURE-FED ENGINE)	I II	390 K 45 K	303 K 30 K	3000- 9000
	III D	THREE-STAGE VEHICLE CONSISTING OF 1st & 2nd STAGE TITAN WITH FLUORINE/HYDRAZINE THIRD STAGE	I II III	300 K 80 K 12 K	227 K 57 K 6 K	3000- 6000
	III E	MODIFIED ATLAS BOOSTER (LOX/N_2H_4) WITH LOX/N_2H_4 AND LOX/H_2 AS SECOND AND THIRD STAGES	I II III	495 K 84.7 K 20 K	370 K 65 K 15 K	5000- 12000
	III F	FIRST STAGE RECOVERABLE TITAN BOOSTER, SECOND AND THIRD STAGES USE HIGH-PERFORMANCE PROPELLANTS SUCH AS LF_2 AND HYDRAZINE	I II III	400 K 81 K 12 K	304 K 62 K 10 K	5000- 10000
IV	IV A	FIRST STAGE RECOVERABLE 4 x 380 K WITH LOX/JP. SECOND STAGE IS 380 K LOX/JP. THIRD STAGE IS ATLAS SUSTAINER WITH LF_2/HYDRAZINE	I II III	1520 K 440 K 80 to 100 K	1000 K 285 K 72 K	25000 35000
	IV B	FIRST STAGE 3 x 495 K ATLAS MODIFIED BOOSTER CLUSTER WITH MODIFIED ATLAS AS SECOND STAGE AND LOX/H_2 AS THIRD STAGE	I II III	1485 K 390 K 40 K	1120 K 260 K 60 K	25000- 35000
V	VA	FIRST STAGE RECOVERABLE 2(OR 4)x 1500 K (LOX/JP) CLUSTER WITH 1500 K AS SECOND STAGE	I II	3000- 6000 K 1500 K	2400- 4400 K 950-1075 K	40000- 150,000
	VB	FIRST STAGE RECOVERABLE 2(OR 4)x 1500 K (LOX/JP) CLUSTER WITH 750 K NUCLEAR SECOND STAGE	I II	3000- 6000 K 750 K	2400- 4400 K 460-550 K	100,000 300,000

FIG. 3

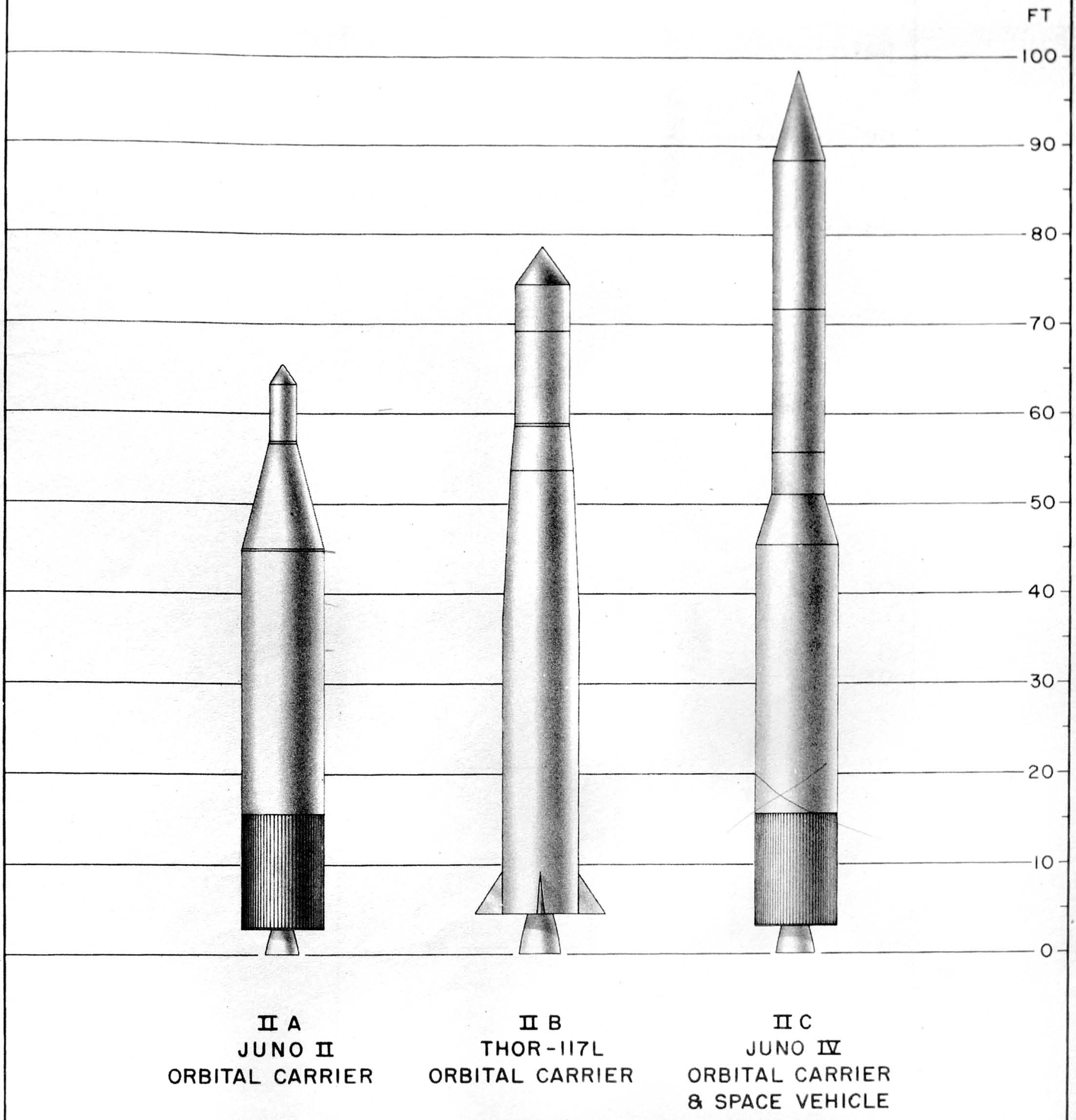
FIRST GENERATION VEHICLES



I A
VANGUARD
ORBITAL CARRIER

I B
JUNO I
ORBITAL CARRIER

FIG. 4
SECOND GENERATION VEHICLES



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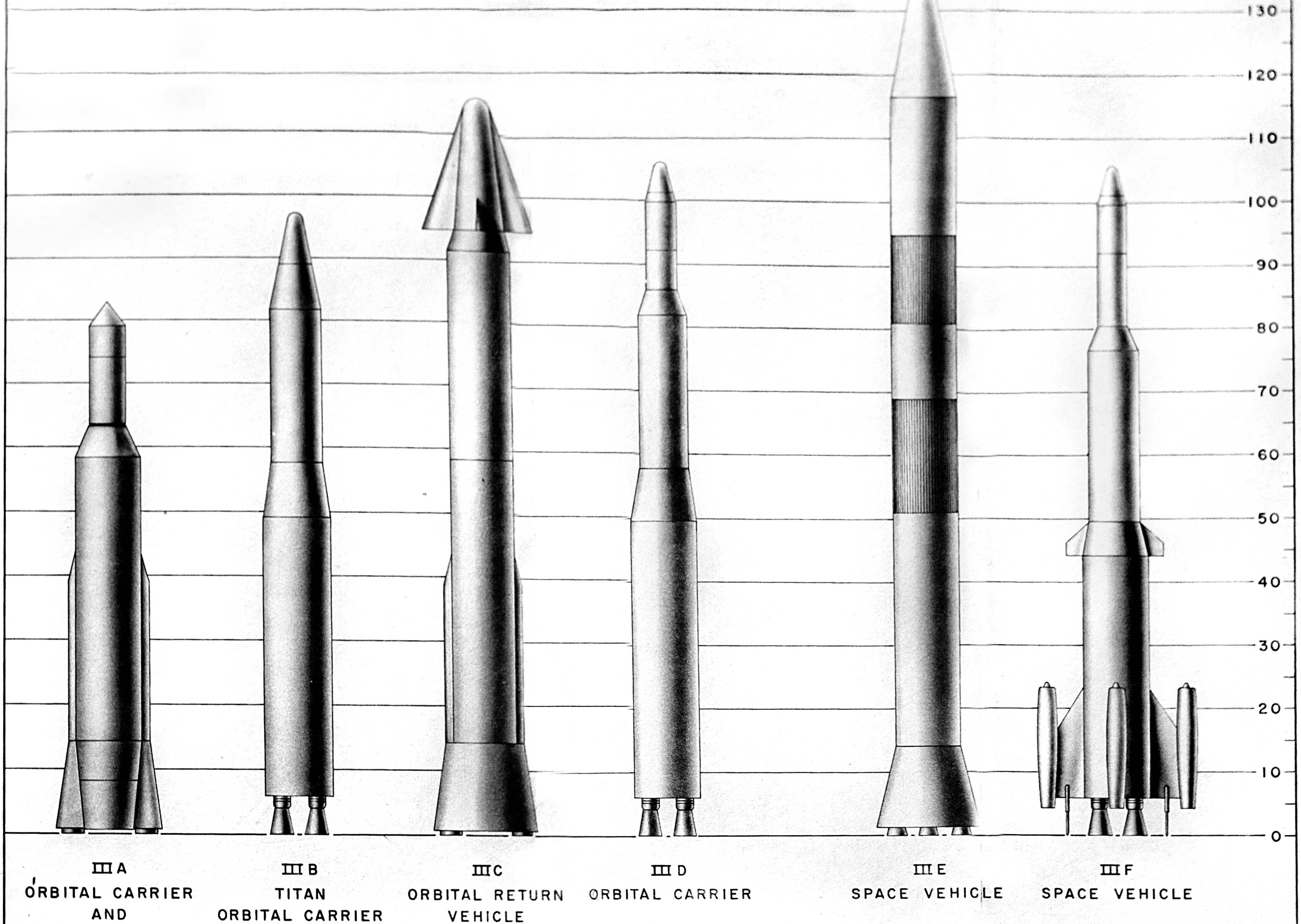
THIRD GENERATION VEHICLES
FIG. 5



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IV A
SPACE VEHICLE

IV B
SPACE VEHICLE

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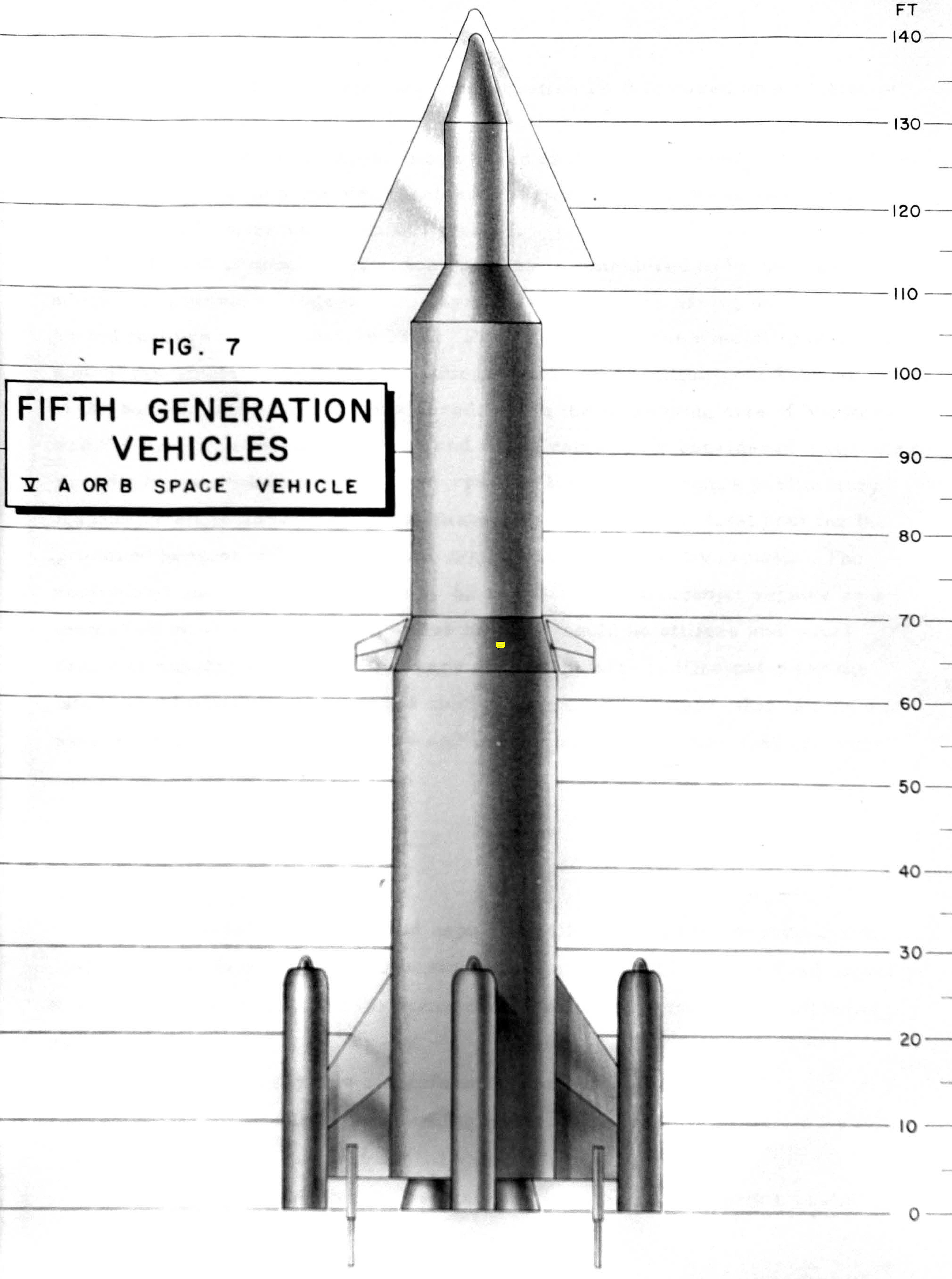

FIG. 7

FIFTH GENERATION VEHICLES

V A OR B SPACE VEHICLE

being developed, and the alternate configuration IV B is based on a cluster of nine 165K engines.

The fifth generation vehicles are based on the development of a single barrel 1.5 million-pound engine. A cluster of two to four of these engines will be used in each booster as shown in Figure 7.

The fourth generation of space vehicles is considered to be an interim solution providing a large orbital payload capability and having an operational period through approximately 1970. For this reason, the possiblity of conversion of the clustered booster for a single barrel 1.5 million-pound thrust engine in the booster has not been considered. With the increasing size of boosters and the resulting increase in cost and firing rates, it is considered mandatory that the boosters be recovered and reused Indications from a preliminary feasibility study show that approximately 40 percent of the total cost for the proposed booster vehicle program can be saved if recovery is used. The configurations shown in Figures 5, 6, and 7 illustrate turbojet engines as a method of recovery; however, other methods could be utilized and would result in similar savings. Recovery of the top stage is illustrated for the later vehicles by use of a winged configuration. Here again, this is only one possibility for satellite recovery and is included only to show that recovery should be accomplished.

B. PAYLOAD CAPABILITIES

The estimated useful payload capabilities for each of the proposed vehicle configurations is presented for various missions in Table 4. Payload capbilities have not been included for some configurations for one of the following reasons:

1. Vehicle not capable of performing the subject mission.
2. Vehicle capable of performing mission, but the useful payload would be too small to be of practical value.
3. Vehicle payload capability would be too large to perform a useful function.

TABLE 4
U.S. SPACE FLIGHT PAYLOAD CAPABILITY

VEHICLE		EARTH SATELLITE		LUNAR CIRCUMNAV.	LUNAR SATELLITE	LUNAR LANDING		PLANETARY		AVAILABILITY
DESIGNATION	DATA	ONE WAY	RETURN			HARD	SOFT	PROBE	SATELLITE	
I A	VANGUARD	3.5 – 21	—	—	—	—	—	—	—	MAR 1958
I B	JUNO I	18 – 35	—	—	—	—	—	—	—	JAN 1958
II A	JUNO II	100 – 200	—	15	—	15	—	—	—	OCT 1958
II B	THOR – ABLE	200 – 400	—	50	—	50	—	—	—	SEPT 1958
II C	JUNO IV	500 – 2,500	1,000	140	120	200	70	140	—	MAY 1959
III A	ATLAS + 117L	2,000 – 3,000	1,000	—	—	—	—	—	—	JULY 1959
III B	TITAN	1,000 – 3,000	1,000	—	—	—	—	—	—	JAN 1961
III C	ATLAS + H_2/O_2 UPPER STAGE	3,000 – 9,000	3,000	1,500	1,400	2,000	600	1,500	600	OCT 1960
III D	TITAN + F_2/N_2H_4 UPPER STAGE	3,000 – 6,000	2,000	800	750	1,100	400	800	300	JAN 1961
III E	MODIFIED ATLAS	5,000 – 12,000	4,000	3,000	2,700	3,500	1,100	3,000	1,300	OCT 1961
III F	MODIFIED TITAN	5,000 – 10,000	3,000	2,000	1,800	2,500	800	2,000	900	JULY 1962
IV A	THREE STAGE VEHICLE WITH 4 – 380 K ENGINES IN BOOSTER	25,000 – 35,000	8,000	5,300	4,800	—	2,500	5,300	2,600	JAN 1963
IV B	THREE STAGE VEHICLE WITH 9 – 165 K ENGINES IN BOOSTER	25,000 – 35,000	8,000	12,000	10,000	—	4,000	12,000	5,000	JAN 1963
V A	TWO STAGE VEHICLE (CHEMICAL) WITH 2 OR 4 – 1500 K BOOSTER	40,000 – 150,000	15,000 – 50,000	—	—	—	—	—	—	JAN 1967
V B	TWO STAGE VEHICLE 2 OR 4 – 1500 K BOOSTER 750 K NUCLEAR 2nd STAGE	100,000 – 300,000	—	20,000 – 25,000	18,000 – 21,000	—	10,000 – 15,000	—	10,000 – 13,000	JAN 1968

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C. TYPICAL MISSION REQUIREMENTS

Table 5 lists the typical mission requirements, by vehicle, for the proposed national program through 1980. The missions listed for items 21 through 26 could be accomplished by either of the three vehicles shown; therefore, it may be possible to eliminate one or two of the third generation configurations. Likewise, the missions listed for the fourth generation vehicles could be accomplished by either configuration IV A or IV B and the necessity for both vehicles does not appear justifiable. The missions for the fifth generation vehicles could also be accomplished by either V A, an all-chemical configuration, or V B, a chemical-nuclear configuration. However, it would be premature to consider eliminating either of the fifth generation vehicles at this time.

Based on the timetable used in preparing this report and the overall economy of space transportation by 1970, the requirement for vehicles for commercial use has been included as a mission for the fifth generation vehicles. These vehicles, beginning in 1970, are not considered part of the development program but are added to indicate the first probable date that commercial space transportation will become available and the approximate quantity of vehicles required.

One factor not included in Table 5 which should be considered in planning vehicle requirements for the future space flight program is that of using military vehicles for non-military missions as they are replaced by more advanced configurations. For example, as the POLARIS and MINUTEMAN replace the JUPITER and THOR, the boosters of both these missiles could be used as a basic space transportation system for numerous space missions and at very little additional expense, assuming the vehicles would be made available by the military.

The number of vehicles listed in Table 5 indicate firing requirements for the proposed program. There is, however, one possible exception: that of the space defense vehicles. These vehicles could be stockpiled if there is no immediate need for them. For vehicles utilizing booster recovery, and in some cases top stage recovery, the production requirements for the recovered components would be substantially less than the numbers listed.

In reviewing the various missions and the overall program listed on Table 5, the requirement for each generation of vehicles is considered necessary to accomplish the objectives of the program. It should be possible, however, to eliminate two or three of the listed vehicles, as discussed above, without affecting the results of the program.

Since the mission of the carrier vehicles discussed in this program is to provide orbital and space transportation, a good measure of the magnitude of the vehicular program would be that of the total accumulated payload capability. Figure 8 presents a graphical representation of the accumulated payload capability for escape missions, orbital missions, and the total of all planned missions. It is interesting to note that if the proposed vehicle program is accomplished, the U. S. would have the capability of delivering into space 40, 000 tons (80, 000, 000 lb) of useful payload. This value would be over and above that of the payload-stage vehicle, which could also have some practical application. The existing requirement for military vehicles has not been included in Table 5 since the purpose of this report is to present a space vehicle development program with maximum use of military hardware. In order to accomplish this study, however, it was necessary to review the military program, and the results are presented in Appendix A.

D. FUNDING

As mentioned earlier in the report, one of the overriding parameters in the development of a space vehicle program is the overall economy. The budget requirements for the proposed program have been listed by components for each year through 1980 and result in a grand total of $17.21 billion, which is an average of $750 million per year for the 23-year period.

In evaluating the data presented, consideration should be given to the following:

1. The unit cost for the vehicles is based on the cost of existing vehicles and the extrapolation of these values for later vehicles. The vehicle

TABLE NO. 5: TYPICAL SPACE FLIGHT MISSION CHART

No	Gen	VEHICLE	MISSION	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	TOTAL	
1	I	I A VANGUARD	IGY - SPACE RESEARCH	1 3 3 3																							10	15
2		I B JUNO I	SPACE RESEARCH	2 0 2 1																							5	
3		II A JUNO II	SPACE RESEARCH SATELLITE		1 1																						2	4
4			LUNAR & SPACE PROBES	1	1																						2	
5		II B (1) ABLE	LUNAR & SPACE PROBES	2 1																							3	28
6		II B (2) ABLE I	117L TEST VEHICLE	2	1 2																						5	
7			BIOLOGICAL SATELLITES		2 1 2 1																						6	
8	II		SPACE RESEARCH SATELLITE		2	3 3 3 3																					14	
9		II C JUNO IV	METEORAL & SPACE RESEARCH SATELLITE		1 1	1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1	1 1	1 1											38	186
10			COMMUNICATIONS SATELLITE		1 1	1	2 2 2	2 2 2 2	1 1 1 1																		21	
11			ORBITAL RE-ENTRY TEST VEH.		1	1 1 1 1	1																				6	
12			SATELLITE INTERCEPTION MISSILE			1 · 2	3 3 3 3	3 3 3 3	(4) (4) (4) (4)	(5) (5) (5) (5)	(5) (5) (5) (5)	(5) (5) (5) (5)	(2) (2) (2) (2)	(1) (1)	(1) (1)	(1) (1)											117	
13			LUNAR AND SPACE PROBE		1	1 1	1																				4	
14		III A ATLAS 117L	RECONNAISSANCE		1 2	2 1 1 2	2 3 3 3	3 3 3 3	3 3 3 3																		44	70
15			ORBITAL RECOVERY		1	1 2 2 3	3 3 3 2																				20	
16			LUNAR AND SPACE PROBES		1	1 1 1 1	1																				6	
17	III	III B TITAN	ORBITAL RECOVERY (DYNA-SOAR I)				2 3 3 3	3 3 3 2																			22	22
18		III C MODIFIED ATLAS	GLOBAL SURVEILLANCE SYSTEM				1	2 1 1	1 2 3 3																		14	41
19			ORBITAL SUPPLY CARRIER AND RESEARCH			1	2 2 2 2	2 2 4 3	1 1																		22	
20			LUNAR AND SPACE PROBE				1 1 1	1	1																		5	
21		III D / III E / III F OPTIMUM TITAN or ATLAS	ORBITAL CARRIER (SUPPLY & RESEARCH & DYNA-SOAR)				1 1 2 3	3 3 2 2	2 2 2 2	2 2 2 2	2 2 2 2	2 1 2 1	1 1 1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	77	277
22			GLOBAL SURVEILLANCE SYSTEM							2 2 2 2	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	72	
23			COMMUNICATION SATELLITE						1 1 1 1	2 2 2 2	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	76	
24			MET. & RESEARCH SATELLITE						1 1 1 1		1 1 1 1	1 1	1 1 1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	40	
25			SPACE OBSERVATION VEHICLE					1 1	1 1 1 1																		6	
26			LUNAR AND INTERPLANETARY PROBE				1 1	1 1 1 1																			6	
27		IV A OR IV B	SPACE DEFENSE MISSILE						1 3 6	9 9 9 3																	40	596
28			EMERGENCY LUNAR LANDING (VEHICLES)						3 5 5 5	5 5 . 15	16 16 21 21	21 21 21 21															212	
29			20 MAN INTERIM SPACE STATION							3 6 3 3	3 3 3 3	3 3 3 3	3 3 3 3														54	
30	IV		50 MAN PERMANENT SPACE BASE										16 16 16 6	3 3 3 3	3 3 3 3	3 3 3 3											88	
31			ORBITAL SUPPLY CARRIER (R & D)			1*	1* 1* 2* 2*	2* 2* 3* 3*	2 2 3 3	3 3 3 3	3 3																44	
32			LUNAR & INTERPLANETARY PROBE						1 2 1 1	1 1 2			3 3 5 16	21 21 21 21	12 12 6 6												158	
33		V A AND/OR V B	ORBITAL SUPPLY CARRIER								1* 1* 1* 1*	2* 2* 2* 2*	2 2 2 2	2 2 2 2	3 3 4 4	5 5 5 5	6 6 6 6	3 3 3 3	3 3 3 3	3 3 3 3	5 5 5 5	5 5 5 5	5 5 5 5	5 5 5 5	5 5 5 5	5 5 5 5	242	584
34			LUNAR SUPPLY CARRIER										1 1 1 1				1 1 1 1	3 3 3 3	3 3 3 3	3 3 3 3	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	68	
35	V		SPACE DEFENSE MISSILE											3 3 3 3	2 2 2 2	2 2 2 2	1 1 1 1										32	
36			INTERPLANETARY RESEARCH VEHICLE											1 1 1 1	1 1		1 1 1 1										10	
37			COMMERCIAL SPACE FLIGHT MISSIONS **													1 1 1 1	3 3 3 3	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6	232	
			TOTAL	3 3 7 8	5 5 6 9	9 10 10 15	20 18 22 22	22 22 22 22	23 27 29 32	36 36 36 36	36 36 36 36	36 36 36 36	34 34 34 34	34 34 34 34	25 25 19 19	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15	15 15 15 15		1823

*TEST VEHICLE WITH ORBITAL CAPABILITY ONLY

**NOT TO BE FUNDED BY GOVERNMENT

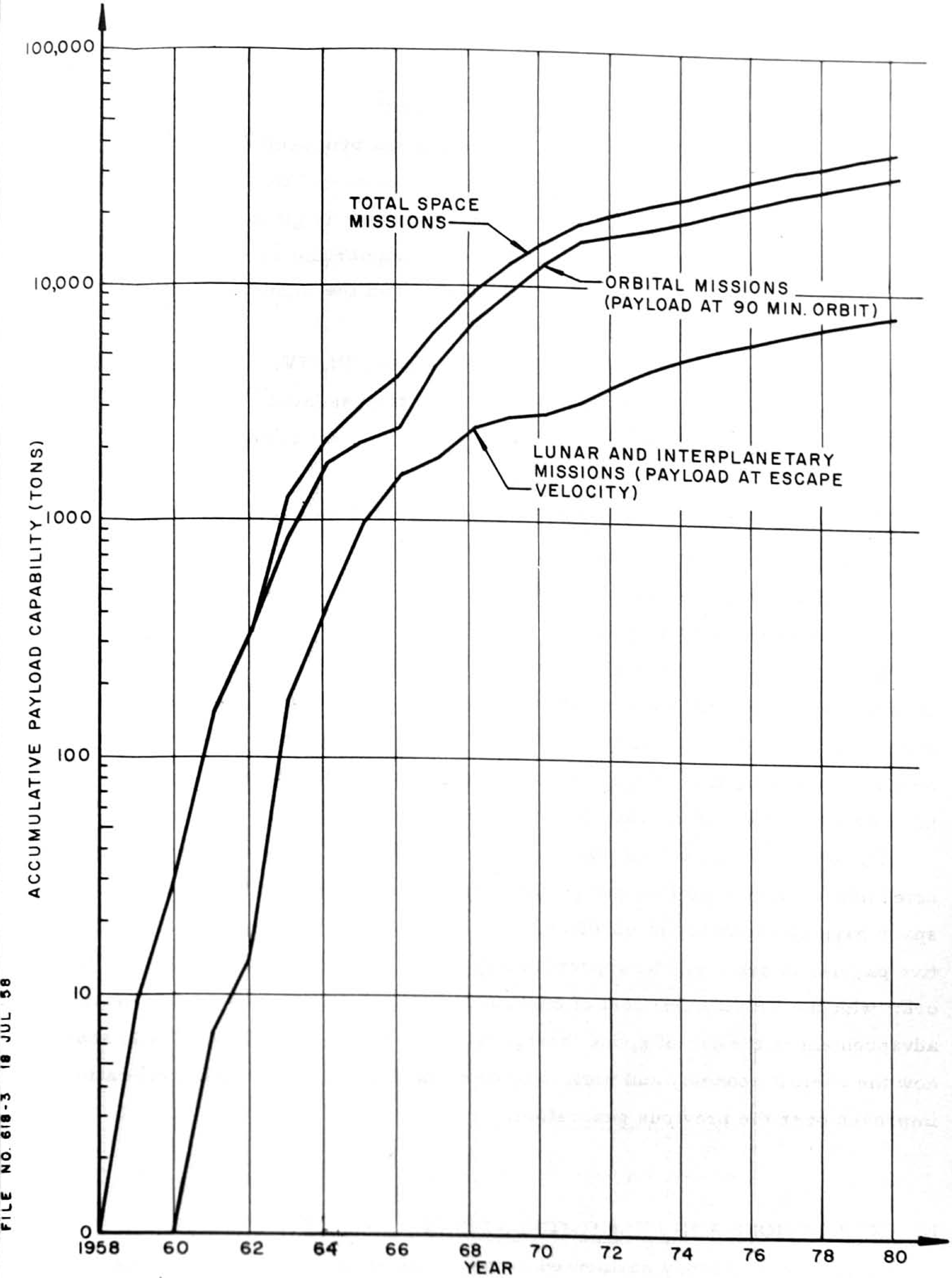

FIG. 8 ACCUMULATIVE PAYLOAD CAPABILITIES FOR TYPICAL SPACE FLIGHT PROGRAM

cost presented also include the payload cost.

2. Development costs are based on existing and proposed development programs and estimates from several sources on later developments. A detailed breakdown for all development costs is given in Part II.
3. Program administration, operation, and supporting research costs are based on present expenditure levels and the expected expansion required for the proposed program.
4. Booster recovery is assumed in generations III, IV, and V and the resulting savings are reflected in the data presented.
5. The cost of the present military program has not been included in the cost information presented.
6. The cost of the commercial vehicles included as a mission for the fifth generation is not included.
7. All cost figures are based on the present dollar value and no inflation rate has been included.

It should be understood that the costs for individual vehicle programs, as well as overall general and supporting research costs, are approximate and are presented in an effort to indicate an order of magnitude for the integrated space vehicle program. Figure 9 gives a graphical representation of the information presented in Table 5.

The overall unit payload transportation cost for the program should be noted here. With a total budget requirement of $17.21 billion and a total space payload capability of 40,000 tons, the average cost per pound of effective payload in orbit will be approximately $215. A comparison of $215/lb in orbit with the VANGUARD cost of $820,000/lb in orbit indicates a tremendous advancement in the art of space transportation. A review of Table 1 will show how the overall economy and performance of each proposed vehicle generation improves over the previous generation.

E. CONCLUSIONS AND RECOMMENDATIONS

On the basis of study performed in the preparation of this report, the

TABLE NO. 6: EXPECTED EXPENDITURES FOR TYPICAL SPACE FLIGHT PROGRAM

GEN	VEHICLE	MISSION	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	TOTAL
I	I A VANGUARD	IGY SPACE RESEARCH	135	10																						145
	I B JUNO I	SPACE RESEARCH	3.5	4.3																						8
II	II A JUNO II	SPACE RESEARCH SATELLITE																								
	II A JUNO II	LUNAR AND SPACE PROBE		20.6																						21
	II B THOR-ABLE	LUNAR AND SPACE PROBE	5	7																						12
	II B THOR-ABLE	117L TEST VEHICLE	16	24																						40
	II B THOR-ABLE	BIOLOGICAL SATELLITE		30																						30
	II B THOR-ABLE	SPACE RESEARCH SATELLITE		11	60																					71
	II C JUNO IV	METEOROLOGICAL & SPACE RESEARCH		24	13	16	16	16	16	16	16	67	8	8	8											224
	II C JUNO IV	COMMUNICATIONS SATELLITE		24	9	24	32	16																		105
	II C JUNO IV	ORBITAL RE-ENTRY TEST VEHICLE		12	28	4																				44
	II C JUNO IV	SATELLITE INTERCEPTION MISSILE			24	72	48	48	60	60	60	24	6	6	6											414
	II C JUNO IV	LUNAR AND SPACE PROBE		12	19	7																				38
III	III A ATLAS-117L	RECONNAISSANCE		38	72	66	72	72																		320
	III A ATLAS-117L	ORBITAL RECOVERY		25	52	66																				143
	III A ATLAS-117L	LUNAR AND SPACE PROBE		10	42	10																				62
	III B TITAN	ORBITAL RECOVERY (DYNA-SOAR I)				125	99																			224
	III C MOD ATLAS	GLOBAL SURVEILLANCE SYSTEM				25	40	81																		146
	III C MOD. ATLAS	ORBITAL SUPPLY CARRIER & RESEARCH			7	56	66	12																		141
	III C MOD ATLAS	LUNAR AND SPACE PROBE				33	10	10																		53
	III D, III E, III F: OPTIMUM TITAN OR ATLAS	ORBITAL CARRIER				63	90	44	44	44	29	19	10	10	10	10	10	10	10	10	10	10	10	10	10	463
		GLOBAL SURVEILLANCE SYSTEM							60	30	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	495
		COMMUNICATIONS SATELLITE						18	36	18	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	297
		METEOROLOGICAL & RESEARCH SATELLITE						22	0	22	10	20	10	10	10	10	10	10	10	10	10	10	10	10	10	204
		SPACE OBSERVATION SATELLITE					18	22																		40
		LUNAR & INTERPLANTARY PROBES				26	52																			78
IV	IV A OR IV B	SPACE DEFENSE MISSILE						150	185																	335
	IV A OR IV B	EMERGENCY LUNAR LANDING VEHICLE						189	160	390	336															1075
	IV A OR IV B	20 MAN INTERIM SPACE STATION							135	90	78	78														381
	IV A OR IV B	50 MAN PERMANENT SPACE BASE										390	78	78	78											624
	IV A OR IV B	ORBITAL SUPPLY CARRIER			5	30	72	120	78	39																344
	IV A OR IV B	LUNAR & INTERPLANETARY PROBES						100	26	0	0	150	462	198												936
V	V A OR V B	ORBITAL SUPPLY CARRIER								80	160	104	56	56	80	96	30	30	30	50	50	50	50	50	50	1022
	V A OR V B	LUNAR SUPPLY CARRIER										52	0	0	0	16	30	30	30	10	10	10	10	10	10	218
	V A OR V B	SPACE DEFENSE MISSILE											240	104	104	52										500
	V A OR V B	INTERPLANETARY RESEARCH VEHICLE											64	26	0	52										142
	V A OR V B	COMMERCIAL SPACE FLIGHT MISSIONS	NOT FUNDED BY GOVERNMENT																							
VEHICLE AND PAYLOAD PROGRAM COST			160	252	331	623	615	920	800	789	731	946	976	538	338	278	122	122	122	122	122	122	122	122	122	9395
PROPULSION SYSTEMS DEVELOPMENT PROGRAM COST			68	98	132	157	179	187	198	209	184	170	163	150	140	130	120	70	50	35	30	30	20			2520
CREW ENGINEERING DEVELOPMENT PROGRAM COST			4	7	8	8	8	9	11	6	5	3	3	2	2	1	1	1	1	2	1	1				83
NAVIGATION SYSTEMS DEVELOPMENT PROGRAM COST			10	10	10	10	10	10	10	10	5															85
GROUND AND FLIGHT TEST FACILITY COST			33	140	154	160	115	75	65	75	60	10														887
SUPPORTING RESEARCH			30	50	70	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	2140
PROGRAM ADMINISTRATION AND OPERATION			20	40	60	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	2100
TOTAL			325	597	765	1128	1127	1401	1284	1289	1185	1329	1342	890	680	609	443	393	373	358	353	353	342	322	322	17, 210

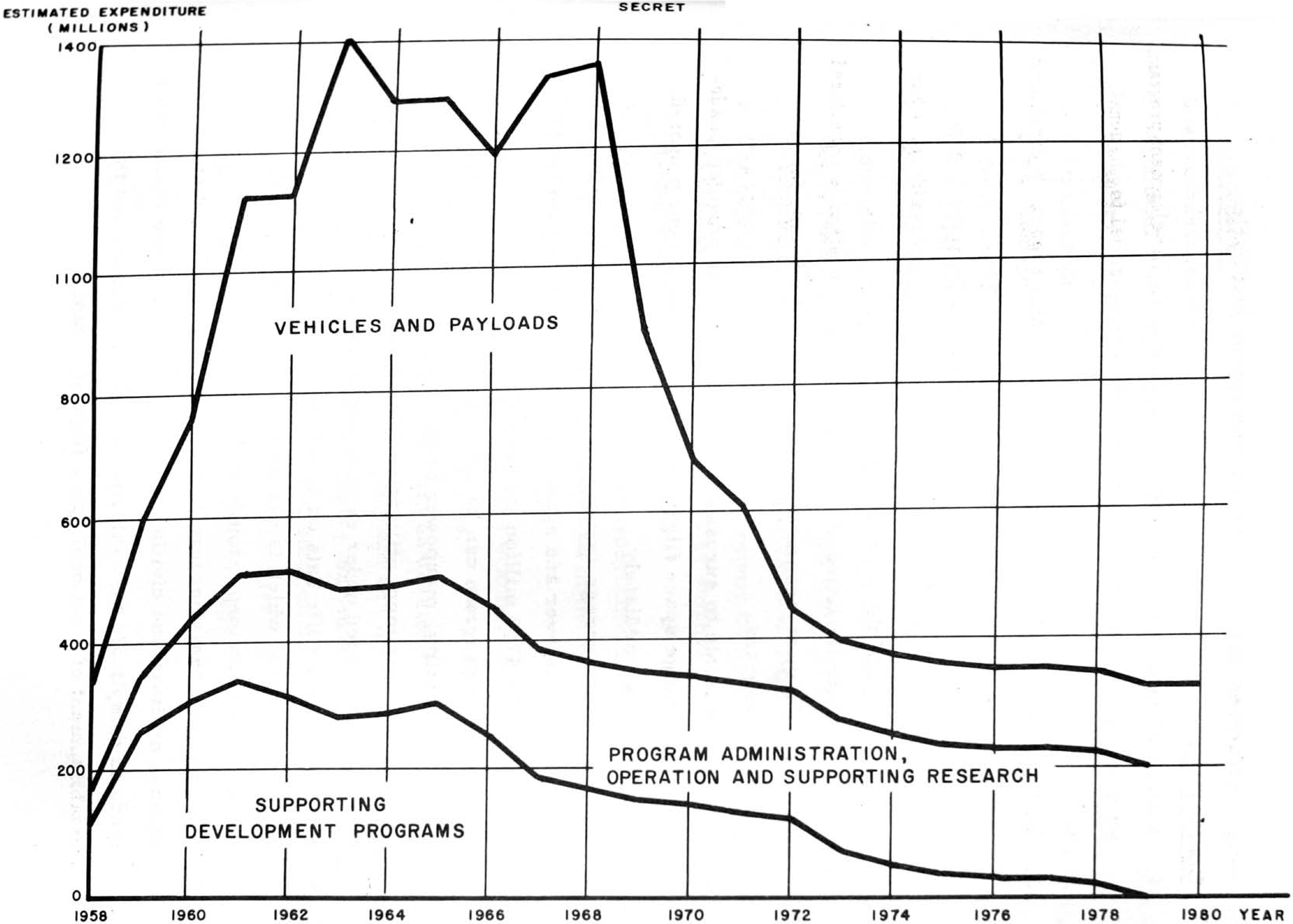

FIG. 9 EXPECTED EXPENDITURES SUMMARY

following conclusions and recommendations appear justifiable:

Conclusions

1. A national integrated missile and space vehicle development program, as described in this report, is feasible and essential for national survival.
2. Each generation of vehicles, as defined by this report, is considered necessary to accomplish the program objectives.
3. The immediate initiation of a development program for a large booster, in the 1.5 million-pound thrust class, is considered a key to the success of the proposed program.
4. The immediate initiation of a booster recovery system is considered necessary,from an economic and reliability standpoint, for the proposed program.
5. It will be possible to surpass the Soviet capability provided an adequate long-range space flight program, such as the one proposed, is instituted immediately.
6. The estimated average annual cost of the program described in this report (which is over and above the present missile program) will be approximately $750 million for the next 23 years.
7. The proposed program can be achieved without upsetting the nation's economic stability, manpower balance, or draining the national resources if maximum utilization is made of existing teams and of hardware developed under existing and future missile programs.
8. Most of the scientific data on upper atmosphere, space, and celestial body environment which is needed to solve the problems of space travel can be obtained through this program.
9. The use of inconsistent terminology and methods of solution by various military and civilian groups involved in space vehicle work tends to complicate the evaluation of various vehicles and the establishment of a national space flight program.

Recommendations

It is recommended that:

1. A national integrated missile and space vehicle development program be authorized and initiated immediately.
2. A development program be initiated immediately for a booster in the 1.5 million-pound thrust class, with emphasis on early availability.
3. A development program for booster recovery be initiated immediately for at least the third, fourth, and fifth generation vehicles.
4. Long-range vehicle responsibility be assigned without delay to individual development teams, working under the direction and coordination of the NATIONAL AERONAUTICS AND SPACE AGENCY in conjunction with the ADVANCED RESEARCH PROJECTS AGENCY.
5. The objectives established by this report be accepted as goals for the national program, with particular emphasis on a manned lunar landing within the next nine years.
6. Maximum use be made of the transportation provided by the program for all types of scientific exploration of the upper atmosphere, space environment, and celestial bodies.
7. Necessary action be taken to make obsolete military vehicles available for space flight missions.
8. A scientific exploration program be developed at an early date in order that the space vehicle program and the scientific exploration program can be coordinated during individual development phases.
9. That terminology and methods of solution be standardized for use by all groups involved in space vehicle work, to enable the authorized agency to evaluate and select proposed space vehicles.

PART II

PROPOSED VEHICULAR PROGRAM: TECHNICAL SUMMARY

This part of the report is devoted to the presentation of background data required to support the information included in Part I. The schedule for each item presented below is compatible with the availability date required to fulfill the missions established in Part I.

Table 7 presents the schedule of each vehicle, by missions, and is broken down into preliminary design, engineering, R and D firing, and operational. The recommended satellite vehicle, payload stage, is given in Table 8 and includes the R and D and operational schedule, payload weights, number of vehicles required and the total cost for each configuration. All satellite vehicles required to accomplish the program objectives are included in this breakdown. The TERRA family of manned space stations is illustrated in Figure 10 and is included to indicate possible configurations. Table 9 presents the recommended lunar flight program and Figure 11 illustrates payload and budget requirements vs. time for performing a manned lunar landing via orbital refueling. The recommended interplanetary flight program required to support the national space effort is listed in Table 10 and indicates R and D and operational schedules, number of vehicles required and total mission cost. The required carrier vehicles to perform the program objectives are listed in Table 11 together with R and D and operational schedules and number of R and D vehicles required.

The payload capability envelopes for the five generations of carrier vehicles are plotted on Figure 12, with specific vehicles indicated within each envelope. This figure gives the proper perspective to each generation and indicates the necessity for each in order to cover the full payload spectrum with maximim utilization of each vehicle.

Table 12 gives the propulsion systems required to support the carrier vehicles listed in Table 11 and also includes additional systems which will be required for later generation vehicles as well as space-to-space vehicles. The navigation systems required to perform the space missions are listed on Table 13 together with schedules and system costs. Tables 14A and 14B give problem areas and expected expenditures for various aspects of the crew engineering phase of space flight which are required to enable man to survive and to perform a useful function in space. The ground and flight test facilities required to perform the program outlined in this report are listed in Table 15 in terms of the funds necessary to establish these facilities.

Although some of the information presented in Part II of this report is not within the intended scope of the working group, it was necessary to consider these items to make the proper assumptions on the vehicular portion of the program. Since this information was available it has been included to clarify the assumptions made and possibly be of assistance to other working groups of the committee.

TABLE NO. 7: SPACE VEHICLE DEVELOPMENT PROGRAM SCHEDULE

No.	VEHICLE	MISSION	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	I A-VANGUARD	IGY RESEARCH																							
2	I B-JUNO I	IGY RESEARCH																							
3	II A-JUNO II	SATELLITE AND LUNAR RESEARCH																							
4	II B-THOR ABLE	ORBITAL CARRIER AND SPACE VEHICLE																							
5	II C-JUNO IV	SPACE RESEARCH AND COMMUNICATIONS SATELLITE																							
6	II C-JUNO IV	ORBITAL RE-ENTRY TEST VEHICLE																							
7	II C-JUNO IV	SPACE RESEARCH																							
8	II C-JUNO IV	SATELLITE INTERCEPTION																							
9	III A-ATLAS-117L	RECONNAISSANCE AND ORBITAL RECOVERY																							
10	III A-ATLAS-117L	LUNAR AND SPACE PROBES																							
11	III B	ORBITAL RECOVERY																							
12	III C	GLOBAL SURVEILLANCE SYSTEM																							
13	III C	ORBITAL SUPPLY CARRIER																							
14	III C	LUNAR AND SPACE PROBE																							
15	III D, E OR F	ORBITAL CARRIER																							
16	III D, E OR F	GLOBAL SURVEILLANCE SYSTEM																							
17	III D, E OR F	COMMUNICATION, SPACE OBSERVATION & RESEARCH SAT.																							
18	III D, E OR F	LUNAR AND SPACE VEHICLE																							
19	IV A OR IV B	SUPPLY AND SPACE DEFENSE VEHICLES																							
20	IV A OR IV B	ESTABLISHMENT OF SPACE STATIONS																							
21	IV A OR IV B	LUNAR AND INTER-PLANETARY PROBE																							
22	V A OR V B	SUPPLY AND SPACE DEFENSE VEHICLES																							
23	V A OR V B	LUNAR AND INTER-PLANETARY PROBE																							
24	V A OR V B	COMMERCIAL SPACE FLIGHT MISSIONS																							
25	TERRA I	EXPERIMENTAL SPACE STATION-4 MEN & INSTRUMENTS																							
26	TERRA II	INTERIM SPACE STATION-20 MEN AND INSTRUMENTS																							
27	TERRA III	PERMANENT SPACE STATION 50 MEN AND INSTRUMENTS																							
28	FERRY I	INTERORBIT RESCUE FERRY VEHICLE																							
29	LUNA I	LUNAR SHIP WITH LANDING CAPABILITY																							
30	LUNA II	LUNAR SHIP WITH LANDING CAPABILITY																							
31	MARS I	MARS SPACE SHIP WITH SURFACE EXPLORATION																							
32	VENUS I	RESEARCH																							

Legend:
- ········ PRELIMINARY DESIGN
- – – – ENGINEERING
- ——— R & D FIRINGS
- —·—·— OPERATIONAL

SECRET

TABLE NO. 8: RECOMMENDED SATELLITE VEHICLE PROGRAM

NO.	CIV. MIL.	CARRIER VEHICLE	MISSION	R & D PHASE	OPER. PHASE	SINGLE WEIGHT (POUNDS)	NUMBER OF VEHICLES	COST OF SINGLE SAT. or PAYLOAD (MILLIONS)	TOTAL PAYLOAD CAPABILITY (POUNDS)	TOTAL COST (MILLIONS)	TEAM
1	CIV	I A	RESEARCH (VANGUARD)	1955/58	1958	3.5-21.5	2 + 6 = 8	1	136	8	NRL
2	CIV	I B	RESEARCH (EXPLORER)	1956/57	1958	18.5-35	5	1	120	5	JPL/ABMA/UNIVERSITY OF IOWA
3	MIL	II B (2)	RECONNAISSANCE	1957/59	1959	300	5	5	1,500	25	LOCKHEED/PHILCO
4	CIV	II B (2)	BIOLOGICAL RESEARCH	1958/59	1959	300	5	2	1,500	10	AF BIOLOGICAL DIVISION
5	CIV	II A	RESEARCH	1958/59	1959	130	2	1.5	260	3	ABMA/JPL/NACA
6	CIV	II B (2)	RESEARCH	1958/59	1959/60	300	14	2.5	4,200	35	AIR FORCE/NAVY
7	CIV	II C	METEOROLOGICAL & RESEARCH	1959/60	1960/70	2000	38	1	76,000	38	ABMA/RCA/SIGNAL CORPS
8	MIL	II C	COMMUNICATION SATELLITE	1959/61	1962/63	2000	21	1	42,000	21	SIGNAL CORPS
9	MIL	II C	RE-ENTRY TEST VEHICLE	1959/60	1960/61	2500	6	1	15,000	6	ABMA/COOK
10	MIL	II C	SATELLITE INTERCEPTION	1958/60	1961/70	2000	117	1	234,000	117	ABMA/AVCO
11	MIL	III A	RECONNAISSANCE	1957/62	1961/63	2500	44	2	110,000	88	LOCKHEED/PHILCO
12	MIL	III A	ORBITAL RECOVERY	1958/60	1960/61	3000	20	2	60,000	40	CONVAIR + ?
13	MIL	III B	WINGED ORBITAL RECOVERY (DYNA-SOAR I)	1958/62	1961/62	6000	22	5	126,000	110	MARTIN/BELL OR BOING/NAA
14	MIL	III C	GLOBAL SURVEILLANCE	1959/61	1961/63	9000	14	5	126,000	70	CONVAIR + ?
15	CIV	III C	SUPPLY AND RESEARCH	1959/61	1961/63	9000	22	2	198,000	44	CONVAIR + ?
16	MIL/CIV	III F	SUPPLY AND DEVELOPMENT	1960/62	1963/80	10000	77	2	770,000	154	
17	MIL	III F	GLOBAL SURVEILLANCE	1962/64	1965/80	10000	72	4	720,000	288	
18	MIL	III F	COMMUNICATION	1962/63	1964/80	10000	76	1	760,000	76	
19	CIV	III F	METEOROLOGICAL & RESEARCH	1962/63	1963/80	10000	40	2	400,000	80	
20	MIL	III F	SPACE OBSERVATION	1961/63	1963	10000	6	2	60,000	12	
21	MIL	IV	SPACE DEFENSE	1961/63	1964/70	25000	40	5	1,000,000	200	
22	MIL/CIV	IV	INTERIM SPACE STATION	1962/64	1964/80	25000	54	3	1,890,000	162	
23	MIL/CIV	IV	PERMANENT SPACE BASE	1965/67	1967/80	35000	88	3	3,080,000	264	
24	MIL/CIV	IV	SUPPLY AND DEVELOPMENT	1959/63	1963/65	35000	44	2	1,540,000	88	
25	MIL	V	SPACE DEFENSE	1964/68	1969/80	100000	32	10	3,200,000	320	
26	CIV	V	ORBITAL SUPPLY	1963/67	1968/80	150000	242	1	36,100,000	242	
27	CIV	V	COMMERCIAL TRAVEL	1967/71	1972/80	150000	232	-	34,800,000	0	

TABLE NO. 9: RECOMMENDED LUNAR FLIGHT PROGRAM

No.	CARRIER VEHICLE	MISSION	R & D PHASE	OPERATIONAL PHASE	SINGLE PAYLOAD WEIGHT	NUMBER OF VEHICLES	COST OF SINGLE PAYLOAD	TOTAL PAYLOAD CAPABILITY	TOTAL COST	TEAM
1	II B (1)	LUNAR PROBE	1958	1958	32	3	$ 1 Mill.	96	$ 3 Mill.	NOTS
2	II A	LUNAR PROBE	1958/59	1958/59	15	2	1 Mill.	30	2 Mill.	JPL
3	II C	LUNAR LANDING	1958/59	1959/60	400	4	5 Mill.	1,600	20 Mill.	JPL
4	III A	LUNAR LANDING	1959/60	1959/60	2000/500	3	6 Mill.	2,000	18 Mill.	
5	III C	LUNAR SOFT LANDING	1959/61	1961/62	800	3	6 Mill.	2,400	18 Mill.	
6	III F	LUNAR LANDING	1959/61	1961/62	1000	2	6 Mill.	2,000	12 Mill.	
7	IV	EMERGENCY LUNAR LANDING	1960/64	1965/66	25000	212	0.5 Mill.	53,000,000	106 Mill.	
8	IV	LUNAR PROBES	1961/63	1963/64	5000	5	10 Mill.	25,000	50 Mill.	
9	V	LUNAR SUPPLY CARRIER	1964/69	1970/80	50000	68	1 Mill.	3,400,000	68 Mill.	

FIG. 10
TERRA FAMILY

FIG. 11

TYPICAL MANNED LUNAR LANDING PROGRAM
VIA ORBITAL REFUELING

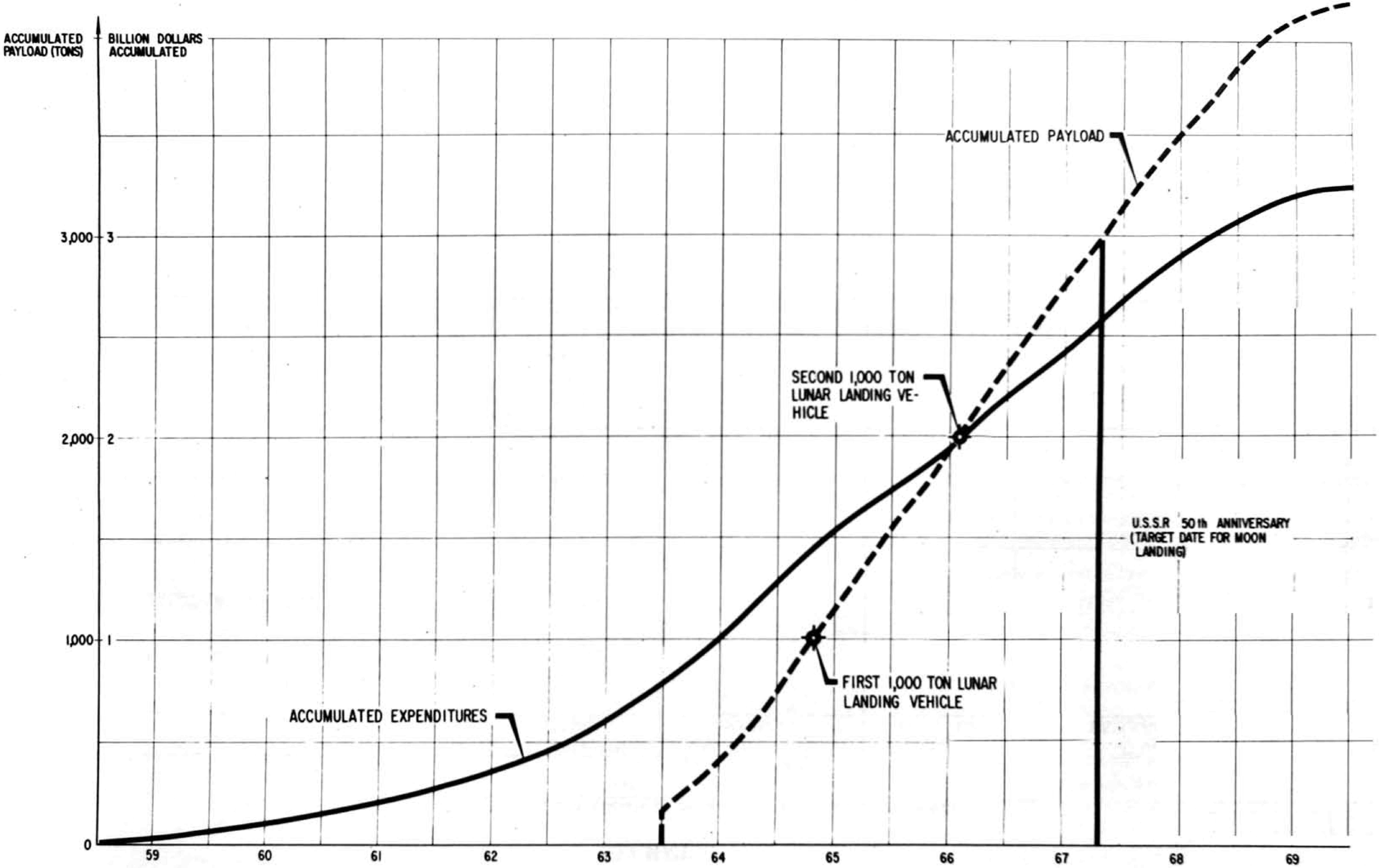

CHART NO. 6

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FILE NO. 606-9 | 23 JUNE 1958

TABLE NO. 10: RECOMMENDED INTERPLANETARY PROGRAM

No.	CARRIER VEHICLE	MISSION	R & D PHASE	OPERATIONAL PHASE	SINGLE PAYLOAD WEIGHT	NUMBER OF VEHICLES	COST OF SINGLE PAYLOAD	TOTAL PAYLOAD CAPABILITY	TOTAL COST
1	III A	INTERPLANETARY PROBE	1959/60	1960/61	2,000	3	$ 6 Mill.	6,000	$ 18 Mill.
2	III C	INTERPLANETARY PROBE	1960/61	1961/62	2,500	2	6 Mill.	5,000	12 Mill.
3	III F	INTERPLANETARY PROBE	1959/61	1961/62	4,000	4	6 Mill.	24,000	24 Mill.
4	IV	INTERPLANETARY PROBES	1961/63	1963/64	4,000	153	2 Mill.	16,000	306 Mill.
5	V	INTERPLANETARY RESEARCH VEHICLE	1965/68	1968/71	30,000	10	10 Mill.	300,000	100 Mill.

TABLE NO. 11 RECOMMENDED SPACE VEHICLE DEVELOPMENT PROGRAM

GENERATION	TYPE	NAME	R & D PHASE	OPER. PHASE	NO. OF R&D MISSILES	SIN. PAYLOAD CAPABILITY	DEVELOPMENT TEAM	REMARKS
I	I A	VANGUARD	1955/58	1958	6	3.5 - 21.5	MARTIN/AEROJET GE/GRAND C.	FOR INITIAL IGY PROGRAM
	I B	JUNO I	1956/57	1958	(3)	18 - 35	ABMA/JPL	THREE JUPITER-C (3 STAGES) FLIGHTS FOR JUPITER NOSE CONE PROGRAM
II	II A	JUNO II	1958	1958/59	0	100 - 200	ABMA/JPL	OPERATIONAL MISSIONS BEGINNING WITH THE FIRST FLIGHT TEST
	II B	THOR - 117L	1957/58	1958/59	0	200 - 400	DOUGLAS/LOCKHEED BELL/RW	TEST VEHICLE FOR 117L PAYLOADS AND BIOLOGICAL PAYLOADS
	II C	JUNO IV	1958/59	1959/80	0	500 -2500	ABMA/JPL	OPERATIONAL MISSIONS BEGINNING WITH THE FIRST FLIGHT TEST
III	III A and/or	ATLAS - 117L	1956/59	1959/63	0	2000 - 3000	CONVAIR/LOCKHEED	DEVELOPMENT COST PAID BY MILITARY PROGRAM
	III B	TITAN	1955/59	1960/62	0	1000 - 3000	MARTIN	DEVELOPMENT COST PAID BY MILITARY PROGRAM
	III C and/or	MODIFIED ATLAS WITH HI-E PROPELLANT	1958/60		10	3000- 9000	CONVAIR	H_2/O_2 20K POWER PLANT HAS TO BE DEVELOPED (LISTED IN ENGINE PROGRAM)
	III D	MODIFIED TITAN WITH HI-E PROPELLANT	1959/61	1962/64	10	3000 - 6000	MARTIN	F_2/N_2H_4 12K POWER PLANT IS ALREADY UNDER ACTIVE DEVELOPMENT (LISTED IN ENGINE PROGRAM)
	III E and/or	OPTIMUM ATLAS FOR MAXIMUM PAYLOAD	1959/61	1962/80	5	5000 - 12000	CONVAIR	MODIFICATION FROM 2 x 150K + 80K BOOSTER TO 3 x 165K BOOSTER + HIGH ENERGY UPPER STAGES
	III F	OPTIMUM TITAN (HE) WITH BOOSTER RECOVERY	1960/62	1963/80	5	5000 - 10000	MARTIN	ECONOMY CARRIER WITH BOOSTER RECOVERY WITH MAXIMUM FLEXIBILITY IN MISSIONS
IV	IV A or	RECOVERABLE 1500K BOOSTER + 500K + 80K HI-E	1959/62	1963/70	16	25000-35000	ABMA/NAA PROPOSAL	BASIC CARRIER VEHICLE IN THE LARGE PAYLOAD CLASS
	IV B	9 x 165K ATLAS P.S. + 3 x 165K + 40K HI-E	1960/62	1963/70	?	25000-35000	CONVAIR PROPOSAL	ALTERNATE CARRIER VEHICLE IN THE LARGE PAYLOAD CLASS
V	V A and	2 (to 4) x 1500K + 1500K	1961/66	1968/80	12	50000-150000	MARTIN PROPOSAL	RECOVERABLE FIRST AND PAYLOAD STAGE
	V B	2 (to 4) x 1500K + NUCLEAR PROPELLANT	1961/68	1968/80	20	100000-250000	CONVAIR PROPOSAL	FULLY RECOVERABLE SYSTEM IF FEASIBLE

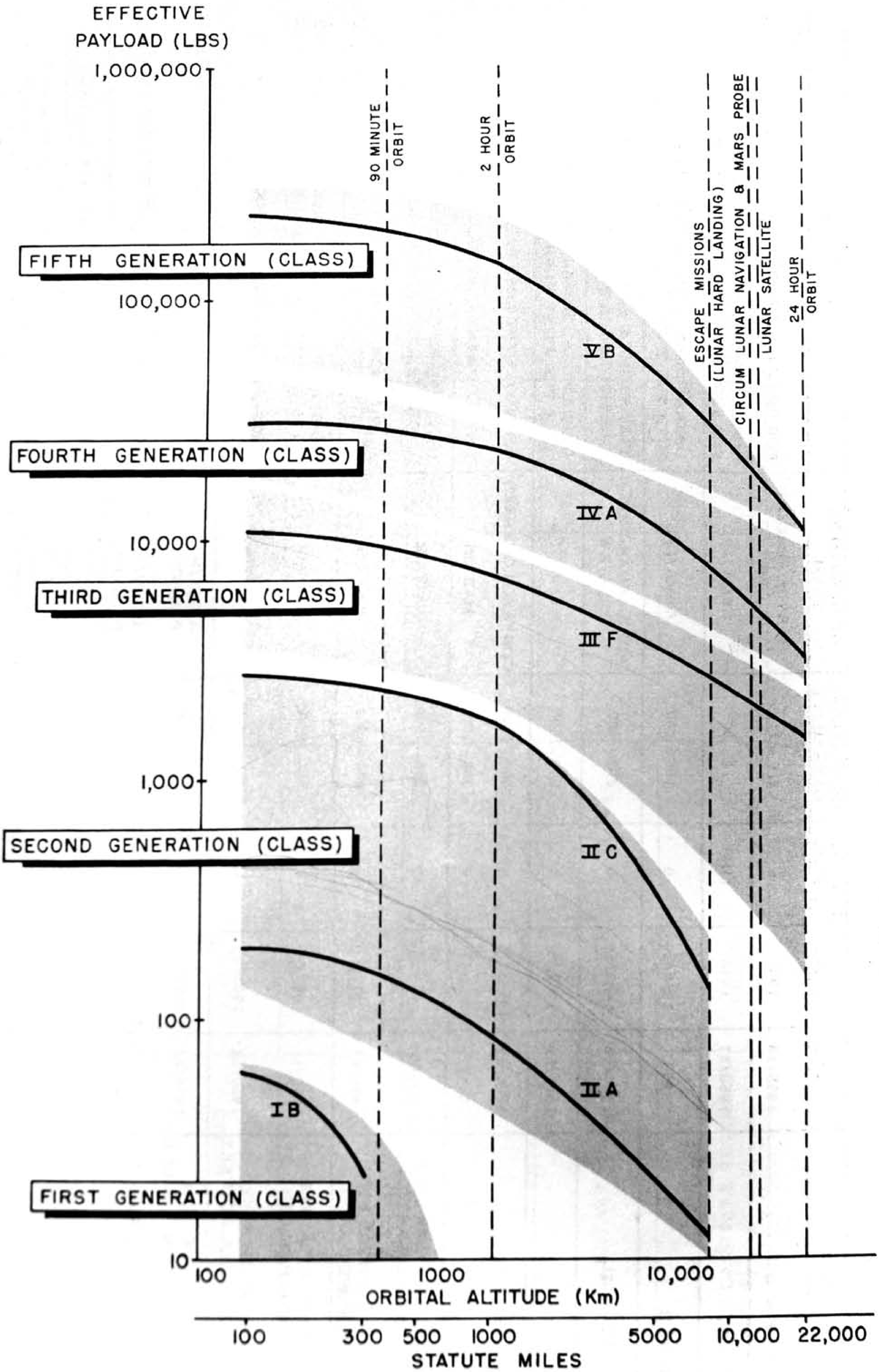

FIG. 12 - PAYLOAD VS. ALTITUDE CAPABILITY FOR RECOMMENDED SPACE VEHICLE DEVELOPMENT PROGRAM

TABLE NO. 12 RECOMMENDED PROPULSION SYSTEM DEVELOPMENT PROGRAM

PROJECT NO.	THRUST LEVEL	PROPELLANTS	R & D PHASE	OPER PHASE	R & D COST ESTIMATE
1	380K (SL) E-1	LOX/RPI	1956-61	1961-70	60
2	CLUSTER 4 x 380K (SL)	LOX/RPI	1958-61	1961-70	0
3	1500K (SL)	LOX/RPI OR HYDRAZINE	1956-64	1964-85	180
4	CLUSTER 2 OR 4 x 1500K (SL)	LOX/RPI OR HYDRAZINE	1960-65	1965-87	0
5	6K (VAC) VERNIER	SPACE STORABLE PROPELLANT	1958-59	1959-70	4
6	45K (VAC) PRESSURE FED	HIGH ENERGY PROP. (N_2O_4/N_2H_4)	1958-61	1961-70	6
7	100K (VAC)	SPACE STORABLE PROPELLANT	1960-63	1963-75	50
8	500K (VAC)	SPACE STORABLE PROPELLANT	1960-66	1966-80	50
9	12K (VAC)	LF_2/HYDRAZINE	1958-63	1963-75	25
10	20K (VAC	H_2/O_2	1959-60	1961-70	20
11	80 TO 100K (VAC)	LF_2/HYDRAZINE	1958-63	1963-75	50
12	500K (VAC)	LF_2 OR SIMILAR/HYDRAZINE	1960-65	1965-77	60
13	500 TO 1000K	NUCLEAR HYDROGEN HEAT EXCHANGER	1957-66	1967-?	360
14	0.001 TO 1K (VAC)	ION-DRIVE*	1957-?	?	200
15	0.001 TO 1K (VAC)	ARC-THERMO*	1958-?	?	200?
16	0.001 TO 1K (VAC)	MAGNETO-HYDRO*	1958-?	?	300 ?
17	0.001 TO 1K (VAC)	THERMONUCLEAR	1958-?	?	750?
*	REQUIRE ELECTRICAL POWER SOURCE		1958-?	?	200?

TABLE NO. 13 RECOMMENDED SPACE NAVIGATION DEVELOPMENT PROGRAM

No.	Mission	Gen.	Navigation Task	Time For R & D	First Application
1	TV and Communication System with Spin Stabilized Satellite No Recovery	I II	Spin rate control.	1958	1958/59
2	Close-to-Moon Path TV Mission. No Recovery.	II	Spin reduction control. RF transmission tests.	1958/59	1959
3	Moon Landing - Hard.	II III	Precise attitude control and guidance on ascending phase. No control after cutoff of last stage.	1958/59	1959
4	Moon Landing - Soft	II III IV	Ascending phase as in 3. Attitude control by jet nozzles with horizon seeker. RF altimeter for retro-rocket control.	1958/60	1959/60
5	Retrievable Instrument Satellite.	II III	Ascending phase as in 3. Attitude control by jet nozzles with horizon seeker. Ignition of retro-rockets by command signal from ground.	1958/59	1959/60
6	Retrievable Satellite. Animal Recovery.	II III	Continuous 3-axis attitude control. Partially earth- and partially space-fixed control. Horizon seeker. Star seeker. Stabilized platform with supervision. Control and guidance over re-entry as in 5.	1958/60	1959
7	Forerunner of Manned Satellites. Animal Recovery	II III	Continuous 3-axis attitude control and re-entry. Guidance as in 6.	1958/63	1960/62
8	Manned Satellite 6G Maximum Allowance.	III IV	Same as 7 above.	1963	1961
9	Space Station Establishment.	III IV V	Approach guidance and control. Space station spin control. Spin axis control. Return alignment problems.	1960/66	1964

Mission	Year	Time of weightlessness	Suits: Bail-out (B) Space (S) Moon (M)	Oxygen: Bottled (B) Regenerative (R)	Water: Bottled (B) Regenerative (R)	Waste: Stored (S) Ejected (E)	Food: Tubes (T) Kitchen (K)	Temperature: Controlled (C) Heater (H)	Air: Decontamination (D)	Protection: Cosmic rays and meteors (P)	Monitoring: TV & Tele. Continuous (C) Intermittent (I)	Air lock for vehicle exit: Hatch (H)	Food production: Algae (A)
Man in Rocket	1959	6 min	B	B	B	S	-	-	-	-	C	-	-
Man in X-15	1959	min	B	B	B	S	-	-	-	-	C	-	-
Animals in satellite	1959	hrs	-	B	B	S	T	C	-	-	C	-	-
Animals in satellite	1959	wks	-	B	B	E	T	C	D	P	I	-	-
Man in satellite	1960	hrs	B	B	B	S	T or K	C	-	-	C	-	-
Man in satellite (winged)	1962	hrs	B	B	B	S	T	C	-	-	C	-	-
4-Man satellite	1962	days	B&S	B	B	S or E	T	C	D	P	C	H	-
Man around moon	1964	days	B	B	B	E	T	H	D	P	I	-	-
20-Man satellite	1966	days-wks	B&S	R	R	E	T&K	C	D	P	I	H	-
Moon station	1967	days-mos	B&M	R	R	E	K	H	D	P	I	H	-
50-Man satellite	1968	mo-yr	B&S	R	R	E	K	C	D	P	I	H	-
Moon expedition	1972	wks	B&M	R	R	E	K	H	D	P	I	H	-
Planetary probes	1972	mo-yr	B&S	R	R	E	K	C	D	P	I	H	-
Perm. moon satellite	1973	mo-yr	B&S	R	R	E	K	H	D	P	I	H	A
Planet landing	1977	yrs	B&S	R	R	E	K	H	D	P	I	H	A

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TABLE NO. 14 B: RECOMMENDED CREW ENGINEERING PROGRAM COST ESTIMATES

No.	Task	Capsule Volume (cu ft)	Year	Total Man Years	Cost (millions)
1	Capsules for animals (hours)	1 to 10	1959	15	$ 0.3
2	Suits: bail-out		1959	5	0.1
3	Air decontamination (animals)		1959	2	0.04
4	Protection against meteors and cosmic rays (animals)		1959	5	0.1
5	TV and telemeter monitoring (preliminary)		1959	100	2.0
6	Waste (storage)		1959	20	0.4
7	Food (tubes)		1959	50	1.0
8	Temperature (control)		1959	20	0.4
9	Capsules for animals (weeks)	20 to 50	1959	50	1.0
10	Capsules for man (hours)	50	1960	50	1.0
11	TV and telemeter monitoring (complete)		1960	300	6.0
12	Capsules for man (days)	150	1962	100	2.0
13	Water regeneration		1962	50	1.0
14	Waste (ejection)		1962	200	4.0
15	Air decontamination (humans)		1962	50	1.0
16	Protection against meteors and cosmic rays (humans)		1962	100	2.0
17	Temperature (heating system)		1964	300	6.0
18	Capsules for man (weeks)	5,000	1966	300	6.0
19	Suits: work in space (bottle suit)		1964	100	2.0
20	Oxygen regeneration (chemical or biological)		1966	100	2.0
21	Food (space kitchen)		1966	500	10.0
22	Air lock for vehicle escape		1966	100	2.0
23	Suits: moon		1967	150	3.0
24	Capsules for man (mos & yrs)	5,000,000	1968	600	12.0
25	Food production (algae)		1973	500	10.0
26	Suits: planets		1977	150	3.0

TABLE NO. 15: RECOMMENDED GROUND AND FLIGHT TEST FACILITY PROGRAM

	CARRIER VEHICLE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	TOTAL
GROUND TEST FACILITIES	I B	2.5										2.5
	II C		3									3
	III A & C	18	30	12								60
	III D	2	10	10	5							27
	III E OR F	4	20	20	15	10	10	5	5			89
	IV A OR B	1	35	15	10	5	5	5	5			81
	V A OR B		10	25	25	20	15	10	5	5		115
FLIGHT TEST FACILITIES	II	2	4	2								8
	III	4	8	10	15	10	5	5	5			62
	IV			10	20	20	10	10	5	5		80
	V							20	40	40	10	110
	EQUATORIAL LAUNCHING SITE		20	50	70	50	30	10	10	10		250
TOTAL		33.5	140	154	160	115	75	65	75	60	10	887.5

APPENDIX A

In performing the background study required to outline a national integrated missile and space vehicle development program it was necessary to collect all available information on the present and proposed military missile program. A summary of this information is presented below in the form of tables on typical missile development schedules, missile firing rates, and missile production requirements for all of the present or proposed missile systems.

TABLE NO. A 1: TYPICAL MISSILE DEVELOPMENT PROGRAM SCHEDULE

No.	VEHICLE	MISSION	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	REDSTONE	SRBM																							
2	JUPITER	IRBM																							
3	THOR	IRBM																							
4	ATLAS	ICBM																							
5	TITAN	ICBM																							
6	POLARIS	IRBM																							
7	NIKE-ZEUS	ANTI-MISSILE																							
8	PERSHING	MRBM																							
9	MINUTE-MAN	2nd GEN. ICBM																							
10	NIKE-SIM																								

TABLE A 2: TYPICAL MISSILE FIRING SCHEDULE

No	VEHICLE	MISSION		1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	TOTAL
1	REDSTONE	SRBM	R & D	3 3 1 1																							20
			O		0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1																		
2	JUPITER	IRBM	R & D	1 2 1 3	4 3 3 6	6 0 00																					35
			O				0 0 1 1	0 0 1 1	0 0 1 1																		
3	THOR	IRBM	R & D	2 4 5 8	6 4 4 4	4 0 2 0																					53
			O				0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1																
4	ATLAS	ICBM	R & D	4 4 3 5	6 6 5 7	7 7 8 6	6 3 6 0																				95
			O					0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1														
5	TITAN	ICBM	R & D	0 1 0 3	3 6 5 6	6 6 6 6	4 0 4 0																				66
			O					0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1															
6	POLARIS	IRBM	R & D	0 3 3 4	9 21 15 27	33 45 39 51	42 30 42 30	14 14 14 14																			522
									1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	
7	NIKE-ZEUS	ANTI-MISSILE	R & D		0 8 0 9	9 9 9 11	14 10 15 13	14 15 11 15	15 0 16 0																		261
			O							1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	
8	PERSHING	MRBM	R & D			0 12 0 12	12 12 12 12	12 0 12 0																			168
			O						1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	
9	MINUTE-MAN	2nd GEN. ICBM	R & D						3 6 6 9	12 12 12 12	12 9 12 9																144
			O									0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	
10	NIKE-SIM	SATELLITE INTERCEPT	R & D						6 12 9 12	12 12 12 12	15 15 15 15																177
			O									0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	
			TOTAL	66	173	302	273	145	112	114	120	20	18	16	16	16	16	16	16	16	16	16	16	16	16	16	1551

NOTE- QUARTERS GIVEN AS FOLLOWS:
1st 3rd
2nd 4th

TABLE A 3: TYPICAL MISSILE PRODUCTION REQUIREMENTS

No.	TYPE	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	TOTAL
1	REDSTONE	5 7 6 6	6 6 6 6	6 6 6 6	6 6 6 6	6 6 6 6																			120
2	JUPITER	1 2 1 3	4 10 9 11	11 12 12 13																					89
3	THOR	2 4 5 8	6 6 4 8	15 15 15 15	15 15 15 15	15 15 15 15																			223
4	ATLAS	4 4 3 5	6 6 5 7	7 7 8 6	6 3 6 0																				83
5	TITAN	0 1 0 3	3 6 5 6	6 6 6 6	6 6 6 6	6 6 6 6	5 5 5 5	5 5 5 5																	136
6	POLARIS	0 3 3 4	9 21 15 27	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 0 30 0																742
7	NIKE-ZEUS		0 8 0 9	9 9 9 11	24 24 24 24	30 30 30 30	30 30 30 30	30 30 30 30	54 54 54 54	54 54 54 54	30 30 30 30														1063
8	PERSHING			0 12 0 12	12 12 12 12	12 15 12 20	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 30 30 30	30 0 30 0											1031
9	MINUTE-MAN						3 6 6 9	12 12 12 12	15 15 15 15	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	24 24 24 24	1572
10	NIKE-SIM						6 12 9 12	24 24 24 24	30 30 30 30	15 15 15 15															315
	TOTAL	80	215	336	387	407	443	524	576	492	336	216	216	156	96	96	96	96	96	96	96	96	96	96	5374

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