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CONFIDENTIAL

PRELIMINARY CONSIDERATIONS FOR MILITARY SPACE SYSTEMS

VOLUME I

ADVANCED WEAPON SYSTEMS STUDY
PART II

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Preliminary Considerations for Military Space Systems

Volume I

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I. AIR FORCE SPACE MISSION REQUIREMENTS

A. Introduction

The basic Air Force space missions are indicated in Table 1. The primary one, at the present time is "Reconnaissance", both visual and electromagnetic. The second application for satellite vehicles will be "Communications", where satellite vehicles can serve as transponders for multiple military purposes. The third requirement, "Manned Space Flight", is listed as a means of supporting the Reconnaissance and Communications missions mentioned previously, and is a necessary step in the development of a future space superiority capability. The fourth area lists "Technical Development and Experimental Support", and covers the general areas of basic and exploratory research involving space flight where the Air Force presently has the unique capability to carry on research, and in the future will have military need of the knowledge to be obtained by such space explorations. A more detailed consideration of each area in Table 1 is appropriate here.

Table 1. Air Force Space Mission Requirements

1. Reconnaissance
2. Communications
3. Manned Space Flight
4. Technical Development and Experimental Support

B. Reconnaissance

The obvious application of satellites is for reconnaissance, just as it was the initial obvious application of the airplane. The current Air Force 117-L program is the first step in this direction, directed at continuously obtaining visual surveillance, and, in later versions, providing electromagnetic surveillance on a continuous basis of any desired area in the world.

Visual reconnaissance, of course, can best be conducted from low altitude satellites. Besides the direct military value obtained from surveys of ground installations, the weather data obtainable from such continuous mapping of world cloud patterns should prove of inestimable value from both a military and civil standpoint.

Primary requirements in the reconnaissance area involve establishing an initial limited capability as soon as possible, followed by a later, higher quality system. Special emphasis needs to be placed on satellite recovery systems, especially information recovery systems, the means of operating at lower altitudes for better resolution, and on the immense problems of relaying and properly using the large quantities of data obtained.

Another aspect of reconnaissance is the early warning capability that could be obtained with high altitude satellites. The promising possibility is the stationary, or 24-hour satellite which goes around the earth once per 24-hours, or at the same rate as the earth rotates. Satellites of this type, if placed in suitable spots could see all of the USSR and, using an infrared detection scheme, could ascertain whenever a large rocket was launched. Further, it might, with suitable adaptations, provide tracking information, indicate velocities gained, trajectories, and even predict impact points. The use of infrared and visual techniques would be perfectly feasible because such a satellite would be operating above the atmosphere where clouds and such interference would be non-existent. Adequate information on location, observation, tracking, and warning of such launchings could certainly be obtained with an automatic system, but the significance of such early warning data, and the potential complexity of the equipment, indicate that a manned capability existing for such a mission is highly desirable. Manned monitoring would then permit a check on any rocket launching of sufficient duration to be an ICBM, or even an IRBM. This would make possible some 25 to 30 minutes warning of ICBM launchings, as compared to the 15 minutes promised by presently proposed large ground radars. Such a space station could also provide data to aid the anti-ICBM problem, since the conditions at burn-out determine precisely the impact position of an ICBM. Hence, measurement of, and transmission of, this information to a defending area would greatly facilitate separation of the true nose cone from possible decoys. While adequate tracking would require at least two satellite stations using an infrared means, it would appear that, since the base line or separation between the two satellites could be very large, accurate impact prediction is inherently possible. In view of the need for better early warning, the very great difficulties involved in detecting differences between decoys and true nose cones after missile burn-out, and the impracticability of obtaining reconnaissance data by other means, it would appear that intensive development of both low and high altitude satellites for reconnaissance missions is of the greatest importance.

C. Communications

A major military problem, especially for the Air Force which deals with rapidly moving vehicles, is that of world-wide communications. It is of the utmost importance that reliable communications be available at all times to a widely distributed system of Air Force bases throughout the world, and to the numerous aircraft which are in the air at any particular time. While the emphasis in this plan is on space missions, it must not be forgotten that with the development of ICBM's and equivalent deterrent systems, the potential enemy will likely turn to limited or small scale wars to achieve his objectives, and that the Air Force must therefore be ready with aircraft systems capable of handling the limited war problem. A primary requirement for both limited and general war is adequate world-wide communications. At the present time such communications are quite unsatisfactory, multiple frequency bands are required, atmospheric difficulties cause serious interference, and jamming is usually not difficult. Investigations*, which will not be detailed here, have indicated that suitable radio relay stations placed in 24-hour satellites could provide reliable, jam-free communications between the United States and all other parts of the world, and particularly between the United States and all aircraft or space vehicles in flight. Much of the complication of low altitude reconnaissance satellites could be eliminated by suitable high altitude satellite relay stations. Problems of recalling or diverting a Strategic Air Command mission once launched, might be handled through communications with such a satellite. Conceivably even an ICBM mission could be set up for destruction prior to re-entry, if desired. Intercontinental television, including television from aircraft or space vehicles in flight on a real time basis would be available. With the addition of suitable electronic scrambling, noise and directional techniques already under development, effective world-wide visual and verbal communication could become a reality. The space stations would also be of enormous assistance to aircraft navigation. Intensive effort is indicated here to develop the vehicles required for the communication satellites, providing the guidance system to operate them effectively, and finally to equip them with the payloads that will make possible the achievement of the military objectives.

D. <u>Manned Space Flight</u>

At the present time no military space mission can be said to have been defined which absolutely requires the presence of a man for its fulfillment. In general, the missions outlined previously under reconnaissance and communications can, at least in theory, be remotely controlled and automatically operated. However, as one considers more advanced

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* Advanced Military Satellites, GM-TR-59-0000-00604.
AFDAP Advanced Weapons Systems Study, Part III

reconnaissance and communications missions which will doubtlessly have to be conducted in the future, it becomes increasingly apparent that the presence of men to repair and maintain the equipment, to observe and monitor questionable results, and to make available the human judgment factor as close as possible to the data source, will become increasingly desirable as our space capability grows. Thus, essentially, while all missions can in theory be done by machines alone, it appears that the time will come when maximum military effectiveness in space missions will probably be achievable only with manned vehicles. It must be realized that our current view of the utility of space vehicles and, particularly of manned space flight, is necessarily extremely narrow and limited. It may, by analogy, be compared with the concept of the usefulness of the airplane as a military vehicle in 1907 when Orville Wright made his first demonstrations at Fort Myers, Virginia. At that time it was conceived that the airplane would have great military value for reconnaissance, but it was doubted that it would have any other uses. While bombing was considered, what were then believed to be payload limitations, precluded its general recognition as a major aircraft application. The concept of an air battle was generally conceived to be ridiculous, with the result that aircraft entered World War I completely unarmed. As history has shown, this condition lasted for only a few days before weapons appeared on aircraft of both sides. It is, of course, debatable as to the validity of the analogy between the airplane and the space vehicle, but the many aspects of similarity during the initial period of man's venture into space would indicate that we should anticipate a need for manned space flight, and should expect new and unforeseen military exploitations of our space capability to be invented. While developments in automation may tend to reduce the number of men required for space flight, it must be recognized that automation so far has been most useful when we know exactly what we want to do, when we want to repeat the same operations many times, and when nothing unexpected is anticipated. The Air Force must always be prepared to deal with the unexpected and, while it should be planned to use automation to the maximum extent possible in dealing with the routine and expected occurrences, the flexibility of the man may still be the most advantageous way of handling highly intermittent random or unanticipated operations. In particular, in considering manned space flight there exists some small possibility that establishment of retaliatory launching stations on high altitude satellites might be desirable. Such stations, if placed at 100,000 miles altitude, would be at least 24 hours removed from any earth launched means of destruction. Hence, if they carried small ballistic missiles, they would in effect present a launching base system that could not be destroyed without the launchings against them giving 24 hours' warning of the imminent attack. Thus, while ICBM's can complete their missions in 30 minutes and conceivably, if a sufficient number were launched nearly simultaneously, they might destroy all United States launching sites in this time, the high altitude satellite vehicles would still be in place 23 hours later, and could launch retaliatory weapons. An enemy therefore would be unable to condense his war effort into a single half hour, even theoretically. He would be forced either to launch an attack against the satellites 24 hours before he launched missiles against the United States, thereby giving away his intent, or he would be faced with accepting the consequences of the retaliatory action of the space vehicles. It must be emphasized here that this discussion deals with high altitude retaliatory satellites which give an additional expansion of the time dimension to a ballistic missile war. The low altitude offensive satellite has been set aside in planning this program as inferior in most respects to the straight ICBM.

The early accomplishment of manned space flight would, of course, have tremendous military prestige value, and would assist in re-establishing United States technological leadership. While the value in the "hot" or active war sense of this accomplishment in the immediate future might be minimal, its value in achieving superiority in the cold war is unquestioned.

In view of the probable eventual military importance of a manned space flight capability, it is urgent that the current programs directed at solving the problems of manned space flight be expanded, and that the development of vehicles and hardware to make possible extended manned space missions be expedited.

E. Technical Development and Experimental Support

In order to accomplish the basic military space missions of the next decade and to be suitably prepared for the next level of developments, it is essential that the Air Force have an adequate program of basic research, research applications, and technical development in space technology. This activity must have an adequate experimental program to support the basic technical developments. As a result of the ICBM and IRBM developments, the Air Force is equipped with the basic booster vehicles to make possible the initial phases of reconnaissance, communications, and manned space flight. In addition, these vehicles can be adapted to explorations of the moon, of the nearer planets, and of the sun. The present military value of such explorations of our planetary system, except from a prestige standpoint is not clear. The scientific value, however, is enormous. Any time new scientific information is acquired it quickly turns out to have a military value, usually long before it has significant value to civilian life. Hence, the Air Force will have the vehicles and technology to make the initial explorations of our planetary system, and it is probable that the information initially gathered will be of maximum use to the Air Force and the military. Hence, the Air Force should devote a significant portion of its space effort to exploring our solar system and obtaining basic data on the moon, Mars, Venus, Mercury, and the sun. The military prestige of such accomplishments in the cold war would alone justify this effort, but the unforeseen military applications that would arise from the information obtained from the explorations and from the developments required to carry them out would assist greatly in maintaining our continued military superiority. Hence, an intensive program of space technology development, including interplanetary explorations, should be carried on by the Air Force during the next decade.

F. Technical Approach to Astronautics Development

From the technical standpoint an astronautics development plan must treat four areas:

1) The vehicles for traveling to and from space;

2) The guidance systems for controlling the vehicles;

3) The payloads carried in the vehicle for either military or scientific missions;

4) The plans for using the vehicles.

Using basic sub-system components from these areas, systems can be assembled to handle a wide variety of potential Air Force space missions. In many respects, the Air Force is well on its way towards having these space systems. The missiles presently in the Air Force ballistic missile programs can provide the basic boosters for most of the space missions. All that is needed in the vehicle area, as will become apparent from a later section, is the development of new upper stages and minor adaptations of the booster stages. In the guidance area, the ballistic missile guidance program can provide systems which, in general, can be adapted to the launch phase of space missions, and which will provide components for the later phases of space operation. However, in the cases of mid-course guidance, recovery and re-entry guidance, satellite positioning guidance, manned flight guidance, and similar areas, complete new sub-system developments will be required. Of particular significance in this area will be the requirement for attitude control systems which can operate for many months, and for other auxiliaries, such as stabilization equipment, power supplies, orbital tracking systems, and satellite positioning systems, all of which will require new developments.

In the payload area, very major developments are required. While some development with respect to the low altitude satellites has been conducted under the 117-L program, and limited thinking has been done, as indicated under the section on Mission Requirements, on other applications, very little really has been defined in the past in the way of the developments needed to make the Air Force space vehicles useful military systems. In this respect, the present program on visual and electromagnetic reconnaissance techniques for low altitude satellites needs to be greatly expanded. Extensive programs should be established for communications systems and early warning systems to operate from high altitude satellites, and possibly for retaliatory missiles to operate from space launchers. The requirements for, and possibilities of, the anti-satellite-satellites need investigation, and it can be expected that numerous other applications requiring development of special space payloads will be invented when the vehicle systems become available. In addition to the payloads for the immediate military applications, development of payloads for scientific missions must be undertaken. Payloads for explorations of the moon, Mars, Venus and the sun must be developed, including means of transmitting the data in suitable form back to earth. Many types of measurements will have to be made with very little weight for instrumentation, and transmitted effectively with low powers over great distances. Payloads are not, as mentioned, discussed in this report. Dates are indicated for what are expected to be the earliest applications. Formulation of plans for payloads for other applications can be expected as the basic vehicle and guidance capability comes into existence.

II. ASTRONAUTICS VEHICLE DEVELOPMENT PLANS

A. Equivalent Velocity Requirements for Space Vehicles

Figure 1 shows the equivalent velocity required for various space missions. By "equivalent velocity" is meant the velocity that would be achieved by the payload if the entire vehicle were used to carry the payload to as high a velocity as possible. In reviewing the figures it will be noted that a 5,000-mile ICBM must reach approximately 22,000 ft./sec., while the most severe mission listed on the charts is a soft landing on the moon and return to earth, which requires 53,000 ft./sec., or a little over twice as much as an ICBM. Impact on the moon, flight around the moon and return to earth, or flight to Mars or Venus, require velocities of only thirty-five to forty thousand feet per second, or a little more than 50% increase over an ICBM. To reach an ICBM capability, the Air Force has had to increase flight speeds from the Mach 2 to 3 range of air-breathing vehicles and early air-launched rockets to approximately Mach 23, a gain in velocity of about one order of magnitude. To perform the most difficult space mission listed in Figure 1 requires only double the ICBM velocity and, hence, is not nearly the development problem from the vehicle standpoint it might initially appear to be. As will be seen from a later discussion, this relative easing of the development problem is true only if the space capability is derived by the use of the Air Force ballistic missiles as boosters of new upper stages, and if the Air Force ballistic missile technology is fully applied to the development of the astronautics capability.

B. Space Capabilities of Existing Air Force Boosters

Formulation of a vehicle plan for astronautics begins with the study of what can be done using the existing Air Force ballistic missiles adapted to space applications.* The three basic vehicles considered for this application are the

* Many of the vehicles discussed in this section are analyzed in detail in Appendix A.

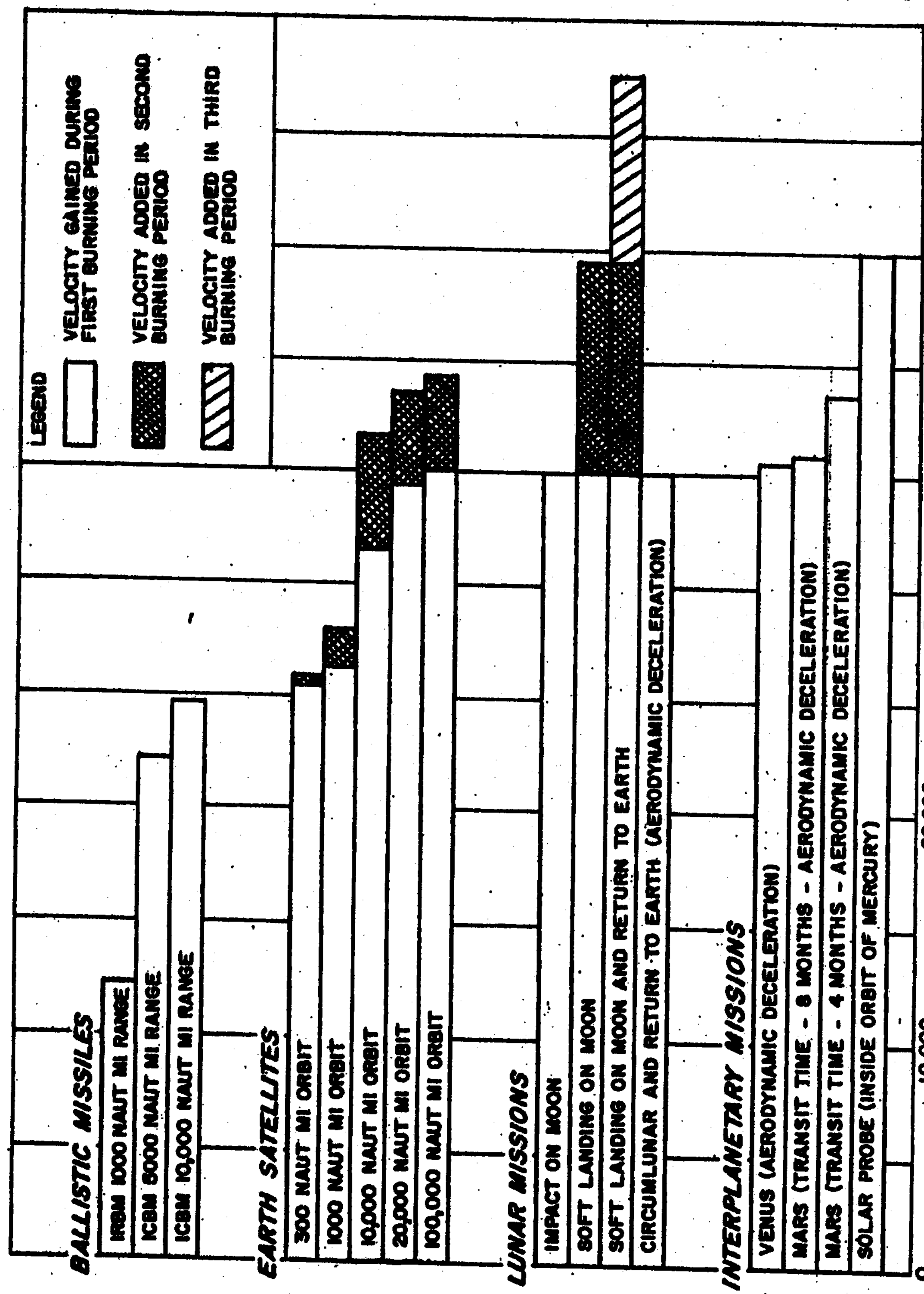
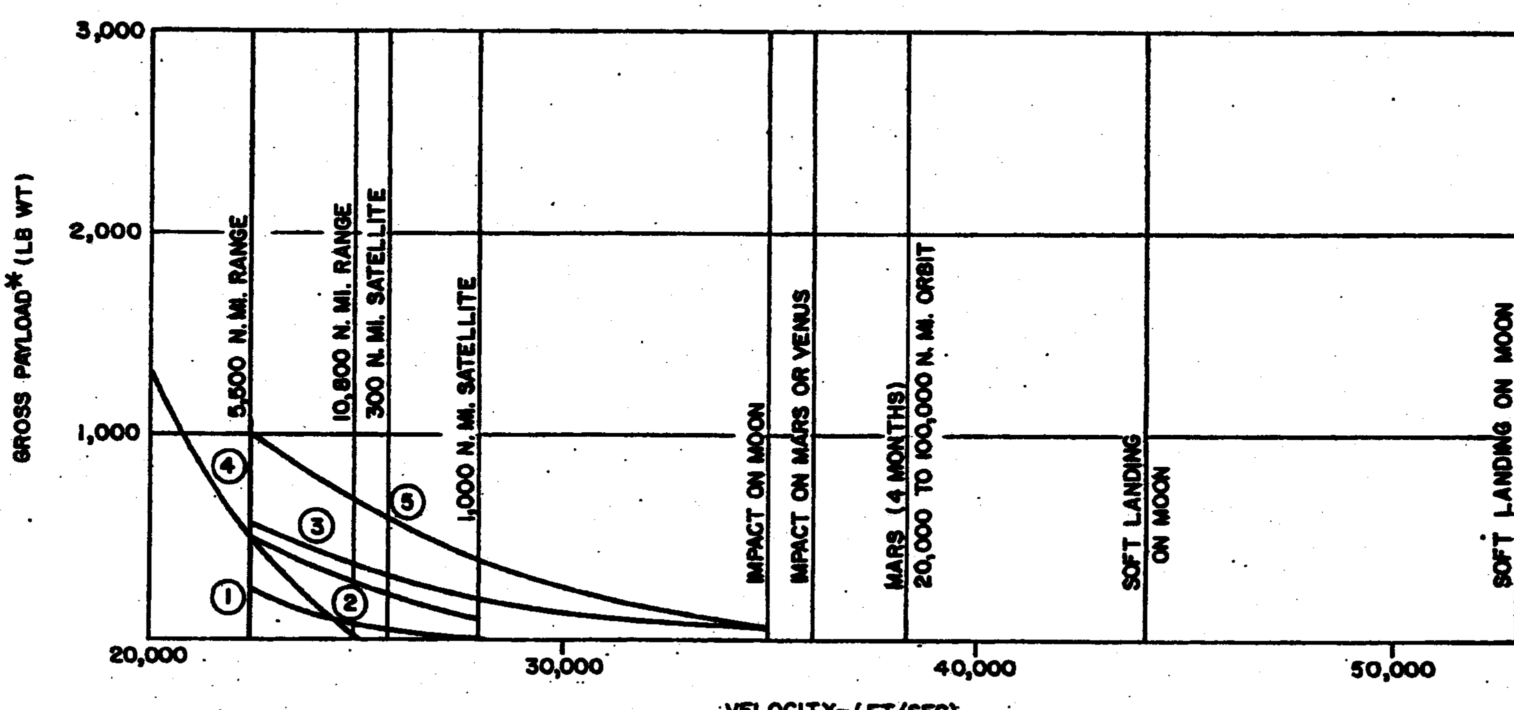


Figure 1. Equivalent Velocity Required for Various Missions.

Thor, the Atlas and the Titan. Each has been studied with added stages and with modifications of its existing stages in an attempt to cover the major spectrum of space potential for these vehicles. The studies for each vehicle have included combinations with additional stages of gradually improving performance capability consistent with availability of the basic vehicle, the development time for added stages and refinements, and with optimization of the total vehicle system. The study of Thor capabilities is perhaps most representative of the range covered, and the results of the study are indicated by Figures 2 and 3, Figure 2 showing the Thor capabilities with added stages of solid propellant, while Figure 3 indicates the capability obtained with liquid propellant added stages. Nine additional stage combinations have been treated, and the payload versus equivalent velocity determined, from which the applicability to various possible missions can be readily evaluated. The added stages considered range from a single Vanguard third stage solid rocket of the type that exists today, through a 15,000 lb. gross weight pressurized fluorine** stage that would require nearly 20 months for development. A similar chart is shown in Figure 4 for the Atlas. Structural limitations presently preclude more than 9,300 lbs. in a stage on top of the Atlas and, hence, the study was limited to this weight. This limit could be raised most efficiently by changing the tank shape from its present tapered nose to a cylindrical nose, which would require new tooling and design modifications. Alternatively, the allowable upper stage weight could be increased by thickening the forward skins and providing for higher pressurization of the LOX tank.

** Fluorine has been used in this report as a basic high performance oxidizer to be used with various fuels. Other high performance propellant combinations have been evaluated. Some were not considered satisfactory for theoretical reasons and others, including the extremely high performance H_2-O_2 combination, were unsatisfactory for practical reasons. Therefore, if substantial engineering advances are made, some combinations may become much more attractive.

	1ST STAGE	2ND STAGE	3RD STAGE
1	THOR	1 VANGUARD-3RD STAGE	—
2	THOR	4 VANGUARD-3RD STAGE	—
3	THOR	4 VANGUARD-3RD STAGE	1 VANGUARD-3RD STAGE
4	THOR	SERGEANT	—
5	THOR	XM-34	1 VANGUARD-3RD STAGE



*GROSS PAYLOAD INCLUDES ALL FIXED EQUIPMENT, GUIDANCE, ETC, BUT DOES NOT INCLUDE THE BARE STRUCTURE OF THE FINAL STAGE

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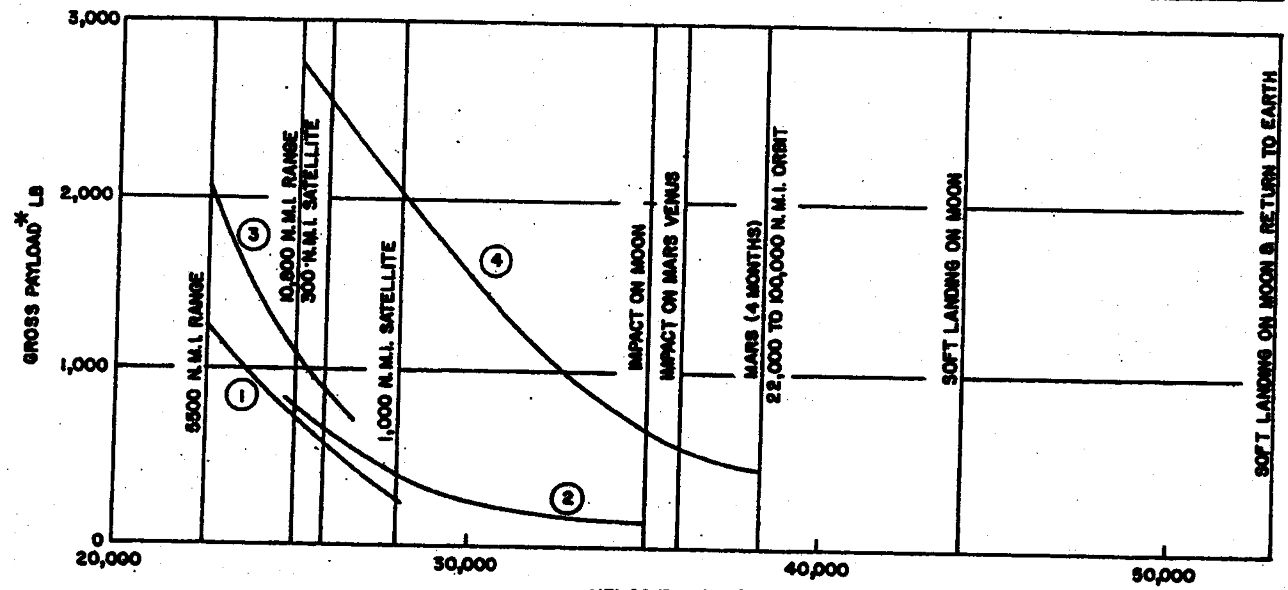
Figure 2. Thor Capability with Added Solid Propellant Stages.

	1ST STAGE	2ND STAGE	3RD STAGE
1	THOR	VANGUARD 2ND STAGE	—
2	THOR 175,000 LB THRUST	VANGUARD 2ND STAGE	VANGUARD SOLID 3RD STAGE
3	THOR 175,000 LB ENGINE REDUCE FUEL TANK MILLING	15,000 LB STORABLE YLR-81 ENGINE	—
4	THOR 175,000 LB ENGINE REDUCE FUEL TANK MILLING	15,000 LB F_2-NH_3 WEIGHT 15,000 LB	—



*GROSS PAYLOAD INCLUDES ALL FIXED EQUIPMENT, GUIDANCE, ETC, BUT DOES NOT INCLUDE THE BARE STRUCTURE OF THE FINAL STAGE

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Figure 3. Thor Capability with Liquid Propellant Second Stages.

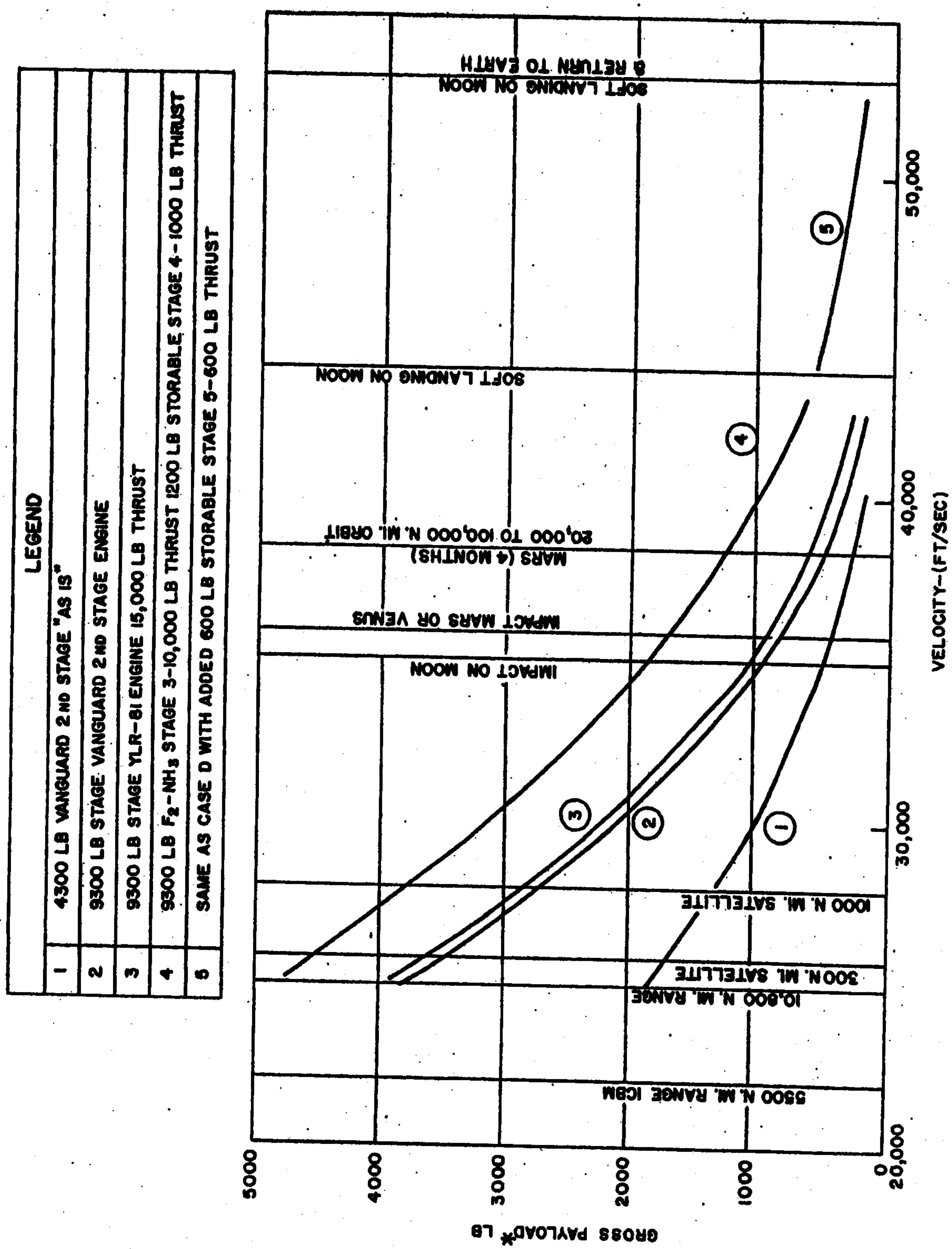

Figure 4. Atlas Capability with Added Stages.