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PROJECT HORIZON

CLASSIFICATION CHANGED
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By authority of DA-1575
Date 18 Aug 70
Amsmi - KB

Volume I
SUMMARY

& Non technical Supporting considerations

UNITED STATES ARMY

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

GROUP 4
Downgraded at 3 year intervals
declassified after 12 years

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C-207457
18 Jun 59

8 June 1959

The attached study has been conducted in accordance with a directive from the Chief of Research and Development, Department of the Army. Elements of all of the Technical Services of the Army participated in the technical investigation and in the preparation of the report. Each volume has been reviewed by a duly authorized representative of each Technical Service and approved this date.

J. B. Medaris

J. B. MEDARIS
Major General, USA
Commanding General
Army Ordnance Missile Command

10,000 lives.

1959
NASA announced the selection of America's first seven astronauts: **Scott Carpenter, Gordon Cooper, John Glenn, Gus Grissom, Wally Schirra, Alan Shepard** and **Donald Slayton.**

1965
The newly built Houston Astrodome featured its first baseball game, an exhibition between the Astros and the New York Yankees. (The Astros won, 2-1.)

April 9 1959

PROJECT HORIZON, PHASE I REPORT

A U. S. ARMY STUDY FOR THE ESTABLISHMENT OF A LUNAR ~~MILITARY~~ OUTPOST

VOLUME I

SUMMARY (U)

8 JUNE 1959

SECURITY NOTE

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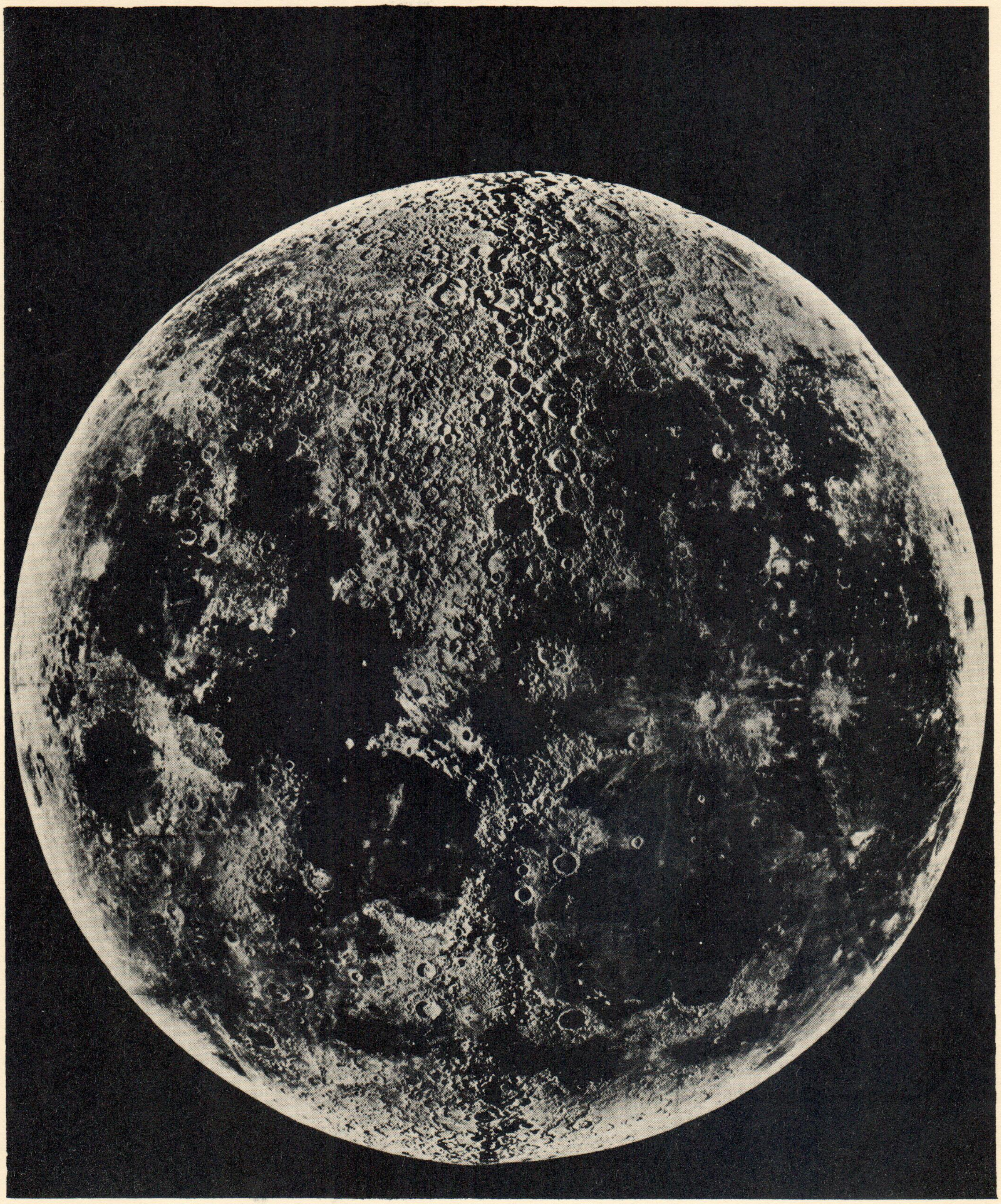

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VOLUME I

(S) CHAPTER I: INTRODUCTION

A. GENERAL

HORIZON is the project whose objective is the establishment of a manned lunar outpost by the U. S. Army. This study was directed by letter dated 20 March 1959 from the Chief of R&D, Department of the Army, to the Chief of Ordnance. Responsibility for the preparation of the study was subsequently assigned to the Commanding General, Army Ordnance Missile Command. Elements of all technical services praticipated in the investigation. This report is a limited feasibility study which investigates the methods and means of accomplishing this requirement and the purposes it will serve. It also considers the substantial scientific-political implications which the prompt establishment of a lunar outpost will have for the United States.

B. CONCLUSIONS

Three major conclusions summarize the more detailed deductions which may be drawn from the entire report:

1. Military, political, and scientific considerations indicate that it is imperative for the United States to establish a lunar outpost at the earliest practicable date. The objectives include, but are not limited to:

a. Extended and improved communications and surveillance

b. Tangible demonstration of U. S. military and scientific superiority

c. Establish and protect U. S. interests on the moon

d. Support scientific investigations of the moon as required

e. Provide a facility with unique physical and environmental characteristics for scientific studies and special tests

f. Development of a site to support other U. S. space operations

2. Project HORIZON represents the earliest feasible capability for the U. S. to establish a lunar outpost. By its implementation the United

States can establish an operational lunar outpost by late 1966, with the initial manned landings to have taken place in the Spring of 1965. The accomplishment of this undertaking requires three major technical systems - the lunar outpost, space vehicles, and communications, and in addition a number of special subsystems and unusual supporting technical talents. Significantly, the U. S. Army possesses the nation's outstanding capability for the coordinated design and management of each of these elements of the program. Specifically:

a. The SATURN rocket booster, currently under development by the von Braun team of the U. S. Army Ordnance Corps, is the only U. S. booster with the necessary performance which will be available in the time frame required.

b. The design and construction of the lunar outpost proper, as well as the supporting earth installations, will be under the direction of the U. S. Army Corps of Engineers which has an unmatched record of accomplishment and experience in the development of both "usual" and "unusual" facilities under extremes of environment.

c. The paramount requirement in this operation for reliable communications will be satisfied by the U. S. Army Signal Corps. In meeting their current responsibilities for world-wide communications, the Signal Corps has established an unexcelled capability for the development and operation of conventional equipment and is already actively engaged in major development programs for an advanced satellite-based communication system and for a U. S. world-wide space surveillance net.

d. Other special technical capability is available in the Army Technical Services (Medical, Quartermaster, Transportation, Chemical, Signal, Engineers and Ordnance Corps) to provide such necessary elements as medical data, specialized nutrition, unique transportation, unusual personal equipment and lunar-based weapons.

3. The importance of an early decision to proceed with the program, coupled with adequate funding, must be clearly understood. Inordinate delay will have two inescapable results:

a. The program's ultimate accomplishment will be delayed, thus forfeiting the chance of defeating the USSR in a military-technological race which is already openly recognized as such throughout the world.

-4 The U.S. Army possesses the capability of making significant contributions in all aspects of such a program.

b. Delayed initiation, followed later by a crash program, which would likely be precipitated by evidence of substantial Soviet progress in a lunar outpost program, will not only lose the advantage of timeliness, but also will inevitably involve significantly higher costs and lower reliability. The establishment of a U. S. lunar outpost will require very substantial funding whether it is undertaken now or ten years hence. There are no developments projected for the predictable future which will provide order of magnitude type price reductions.

~~C~~ D. ORGANIZATION AND CONTENT OF THE REPORT

The Project HORIZON report has been divided into ~~four~~ three volumes which are entitled as follows:

Volume I - Summary
Volume II - Technical Considerations and Plans
Volume III - ~~Operational Aspects~~ ← Chul
~~Volume IV~~ - (Technical Services Capabilities and Support)

Volume I is, as indicated, a document which gives a short summary of the other volumes and provides certain conclusions and recommendations therefrom. It also includes a funding summary.

Volume II is a technical investigation of the problem. It includes practical preliminary concepts for all elements of the program and, in many cases, relates actual hardware available from current programs to the solution of specific problems. It includes a broad development approach and a funding breakout by fiscal year. This volume was prepared by a unique working group which was comprized of a special segment of the Future Projects Design Branch of the Army Ballistic Missile Agency which was augmented by highly qualified representatives of each technical service of the Army. These representatives were carefully selected for the specific task and, during the course of the study, became resident members of the aforementioned ABMA group. The resident representatives of the technical services were each in turn supported by their respective services with a group of the highest caliber specialists in their fields who were made available exclusively to support the project. Thus, it is believed that the depth of experience, knowledge and judgement which has been brought to bear on the problem by this group is ~~unexcelled in the nation.~~ commensurate with the task of accomplishing the report objectives. Note #1

Throughout the preparation of the entire report, and especially within this technical volume, the guiding philosophy has been ~~the same one which has characterized the unusual degree of success of Army~~

development programs -- one of enlightened convervatism of technical approach. Briefly stated, this philosophy dictates that one must vigorously pursue research to "advance the state of the art", but that paramount to successful major systems design is a conservative approach which requires that no item be more "advanced" than required to do the job. It recognizes that an unsophisticated success is of vastly greater importance than a series of advanced and highly sophisticated failures that "almost worked". Established engineering principles, used in conjunction with the best available design parameters, have been applied throughout in order to remove the elements of science fiction and unrealistic planning which have detracted from many earlier studies which have been presented from various sources.

Volume III investigates the military and political effects and implications of the establishment of a lunar outpost. It outlines a concept of operations for the project, including the lunar outpost and its supporting facilities. Personnel training requirements for all segments of the operation are discussed as are defense requirements and future operational capabilities. There are also annexes concerned with legal and policy matters.

Volume IV illustrates the applicable technical skills, facilities and operational capacity which all of the technical services of the Army have available and could ~~to~~ devote to the program. It outlines their current capacity and projects this capacity as required to support HORIZON. There is a discussion of applicable related accomplishments. All of the above capabilities are considered as they apply to both R&D and operational activities.

(S) CHAPTER II: TECHNICAL CONSIDERATIONS & PLANS

A. OBJECTIVES & SCOPE OF THE STUDY

This part of the study presents applicable technical information which substantiates the feasibility of the expedited establishment of a lunar outpost and it relates ~~Army~~ capabilities and developments to the accomplishment of the task. It is comprehensive in its scope, covering the design criteria and requirements for all major elements of the program including the lunar outpost, the Earth-Lunar transportation system, the necessary communications systems and the considerable earth support facilities and their operation. The technical assumptions concerning design parameters for this program are realistic yet conservative. Likewise the assumptions which concern the scope and magnitude of other U. S. programs which will support HORIZON are reasonable and in line with current and projected programs.

B. RESUME OF THE TECHNICAL PROGRAM

The basic carrier vehicles for Project HORIZON will be the SATURN I & II. The SATURN I, currently being developed under an ARPA order, will be fully operational by October 1963. ~~The first R&D booster is in fabrication at the Army Ballistic Missile Agency.~~ The SATURN II, which is an outgrowth of the SATURN I program, will be developed during the period 1960-64. SATURN II will utilize improved engines in the booster and oxygen/hydrogen engines in all of its upper stages.

By the end of 1964 a total of 72 SATURN vehicles should have been launched in U. S. programs, of which 40 are expected to contribute to the accomplishment of HORIZON. Cargo delivery to the moon begins in January 1965. The first manned landing by two men will be made in April 1965. The build-up and construction phase will be continued without interruption until the outpost is ready for beneficial occupancy and is manned by a task force of 12 men in November 1966.

This build-up program requires 61 SATURN I and 88 SATURN II launchings through November 1966, the average launching rate being 5.3 per month. During this period some 490,000 pounds of useful cargo will be transported to the moon.

During the first operational year of the lunar outpost, December 1966 through 1967, a total of 64 launchings have been scheduled. These will result in an additional 266,000 pounds of useful cargo on the moon.

The total cost of the eight and one-half year program presented in this study is estimated to be $6.014 billion dollars. This is an average of approximately $700 million per year. These figures are a valid appraisal and, while preliminary, they represent the best estimates of experienced, non-commercial, agencies of the government. Substantial funding is undeniably required for the establishment of a U. S. lunar outpost; however, the implications of the future ~~military~~ importance of such an operation should be compared to the fact that the average annual funding required for Project HORIZON would be less than two percent of the current annual defense budget.

C. OUTPOST

The lunar outpost proposed for Project HORIZON is a permanent facility capable of supporting a complement of 12 men engaged in a continuing ~~military~~ operation. The design of the outpost installation herein is based on realistic requirements and capabilities, and is not an attempt to project so far into the future as to lose reality. The result has been a functional and reliable approach upon which men can stake their lives with confidence of survival.

1. Location

The exact location of the outpost site cannot be determined until an exploratory probe and mapping program has been completed. However, for a number of technical reasons, such as temperature and rocket vehicle energy requirements, the area bounded by $\pm$ 20° latitude/longitude of the optical center of the moon seems favorable. Within this area, three particular sites have been chosen which appear to meet the more detailed requirements of landing space, surface conditions, proximity to varied lunar "terrain" and communications.

A rather extensive lunar mapping program is already underway ~~by the Army Map Service~~ in order to satisfy existing requirements in Astro-Geodesy. Maps to a scale of 1:5,000,000 and 1:1,000,000 are planned for completion by December 1960 and August 1962, respectively. Larger scale mapping will then be undertaken for several specific site selections.

2. Design Criteria

The design of the lunar outpost facilities will, of course, be dominated by the influence of two factors - the lunar environment and the space transportation system capabilities. A few of the more pronounced primary lunar environmental parameters are listed below:

a. Essentially no atmosphere

b. Surface gravity approximately 1/6 earth gravity

c. Radius of approximately 1,000 miles is about 1/4 that of earth. (This results in a significant shortening of the horizon as compared to earth).

d. Surface temperature variations between a lunar day and night of +248°F to -202°F

e. Subsurface temperature, maximum, at equator, -40°F. These and many other unfamiliar environmental conditions require that every single item which is to be placed on the lunar surface have a design which is compatible with these phenomena. However, a careful determination has been made of man's requirements to live in this environment, and it appears that there is no area which cannot be adequately solved within the readily available state of the art.

3. Outpost Facilities and Their Installation

The first two men will arrive on the lunar surface in April 1965. They will be guided to an area in which the cargo build-up for future construction has already begun. Their landing vehicle will have an immediate return-to-earth capability; however, it is intended that they remain in the area until after the arrival of the advance party of the construction ~~detachment~~ crew. During their stay, they will live in the cabin of their lunar vehicle which will be provided with necessary life essentials and power supplies. For an extended stay, these will be augmented by support from cargo previously and subsequently delivered to the site by other vehicles.

The mission of the original two men will be primarily one of verification of previous unmanned environmental investigations and confirmation of the site selection and cargo delivery.

Figure I-1 shows the HORIZON outpost as it would appear in late 1965, after about six months of construction effort. The basic building block for the outpost will be cylindrical metal tanks ten feet in diameter and twenty feet in length. (Details of typical tanks are shown in Figure I-2). The buried cylindrical tanks at the left-center of Figure I-1 constitute the living quarters of the initial construction detachment of nine men who will arrive in July 1965. (Details in Figure I-3). During the construction period this force will be gradually augmented until a final complement of twelve men is reached. The

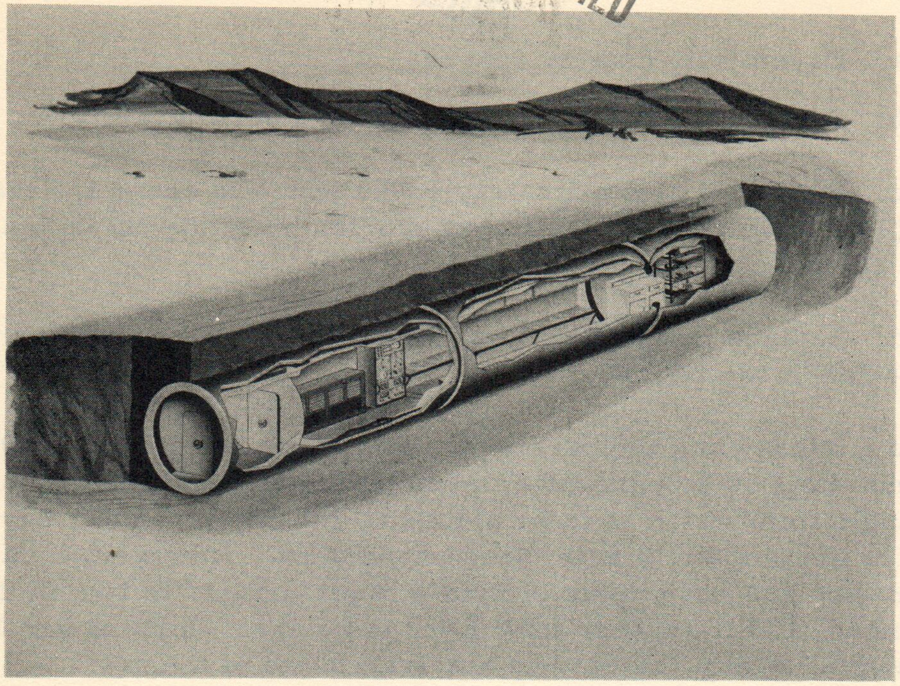

Fig. I-2. Cross Section of Typical Outpost Compartments

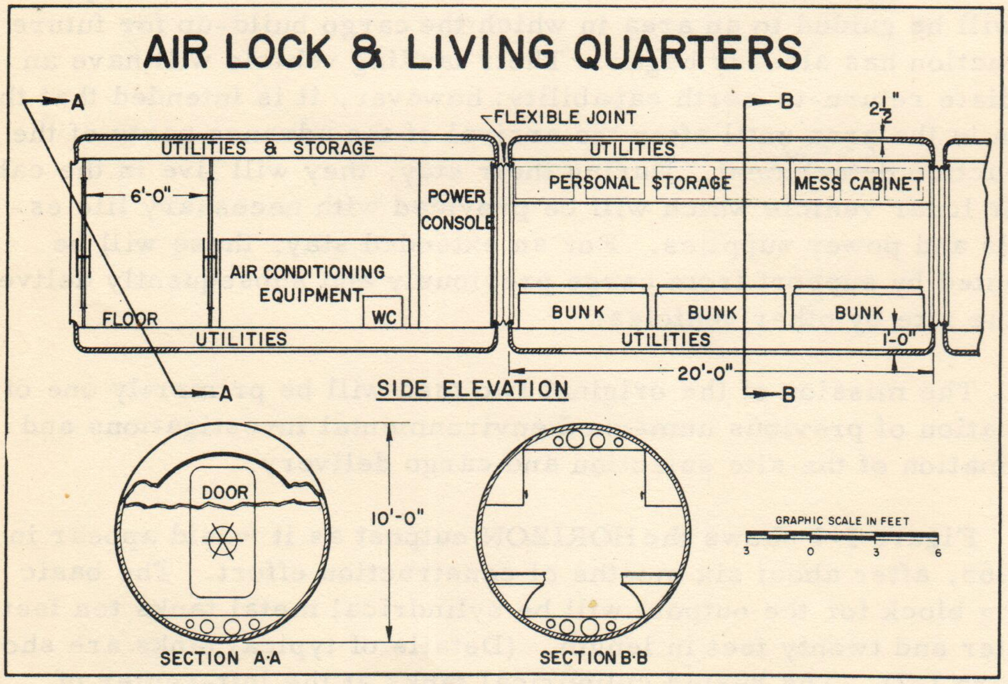

Fig. I-3. Overall View of Initial Construction Camp

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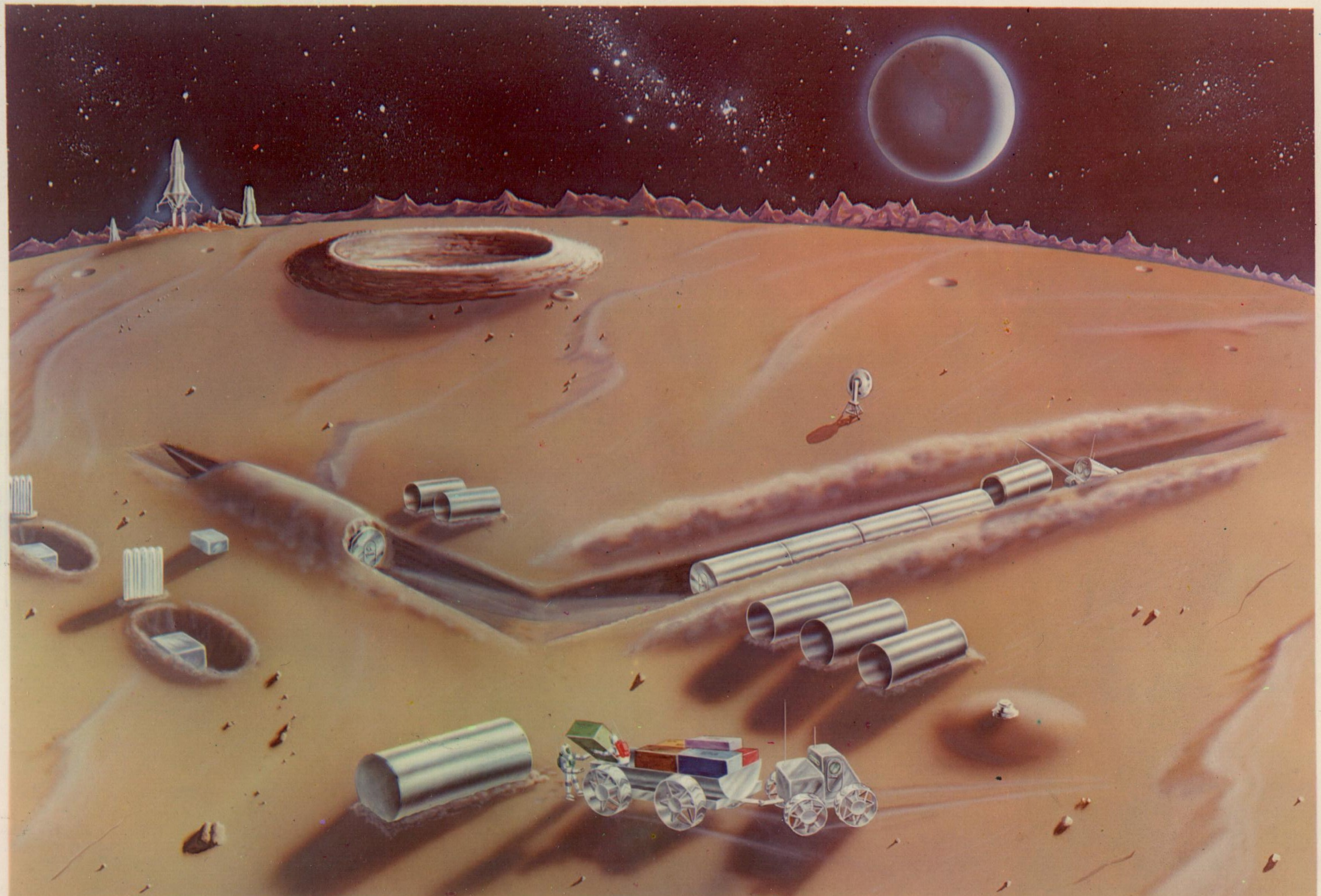

FIGURE I-1

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construction camp is a minimum facility and will be made operational within 15 days after the beginning of active work at the outpost site. Two nuclear reactors are located in holes as shown in the left portion of Figure I-1. These provide power for the operation of the preliminary quarters and for the equipment used in the construction of the permanent facility. The main quarters and supporting facilities are shown being assembled in the open excavation to the right-center of the figure. These cylinders will also ultimately be covered with lunar material. Empty cargo and propellant containers have been assembled and are being used for storage of bulk supplies, weapons and life essentials such as insulated oxygen/nitrogen tanks. Two typical surface vehicles are shown: one is a construction vehicle for lifting, digging, scraping, etc., the other is a transport vehicle for more extended distance trips needed for hauling, reconnaissance, rescue and the like. In the left background, a lunar landing vehicle is settling on the surface. A light weight parabolic antenna has been erected near the main quarters to provide communications with earth.

The basic completed outpost is shown in Figure I-4. Significant additions beyond the items illustrated in Figure I-1 are two additional nuclear power supplies, cold storage facility, and the conversion of the original construction camp quarters to a bio-science and physical-science laboratory.

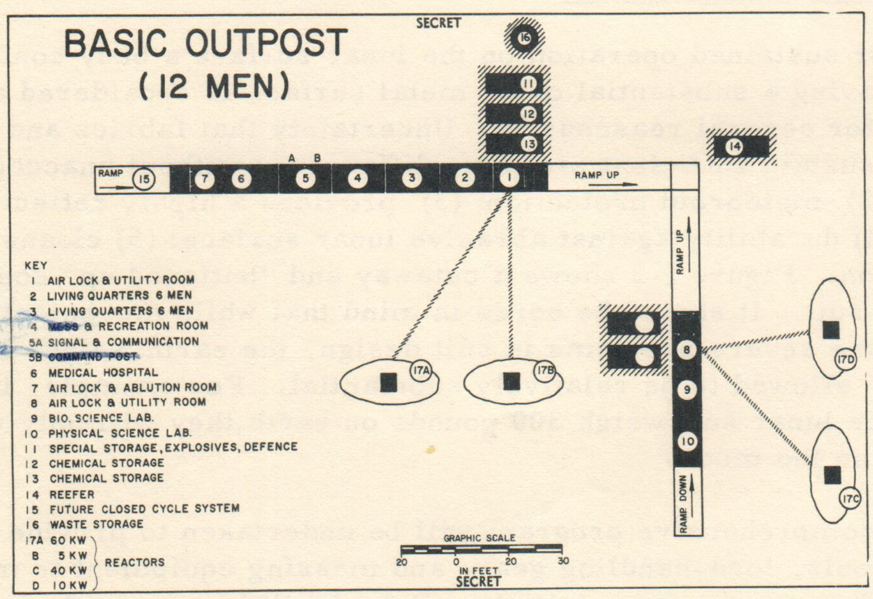


Fig. I-4. Layout of Basic 12-man Outpost

A number of factors influenced the decision to locate the main structures beneath the surface. Among these were the uniform temperature available (approximately -40°F), protection from meteoroids, military security, good insulating properties of the lunar material, and radiation protection. Each of the quarters and cylinders will be a special double-walled "thermos bottle type" vacuum tank with a special insulating material in the space between the walls. (Vacuum is easily maintained simply by venting the tank to the lunar void.) Despite the ambient subsurface temperature of -40°F, the heat losses from these special tanks will be remarkably low. Investigations show that the incidental heat given off by an adequate internal lighting system will nominally supply essentially all of the heat required to maintain comfortable "room" temperature in the outpost quarters.

A suitable atmosphere will be provided within the quarters. The basic gas supply will stem from special insulated tanks containing liquid oxygen or nitrogen. The nitrogen supply needs only to provide for initial pressurization and replacement of leakage losses; whereas, the oxygen is, of course, continuously used to supply bodily needs. However, the weights and volumes of both gases are quite reasonable and presents no unusual problem of supply. Carbon dioxide and moisture will be controlled initially by a solid chemical absorbent and dehumidifier. Such a scheme requires considerable amounts of material; therefore, a carbon dioxide freeze-out system will be installed later.

4. Personnel Equipment

For sustained operation on the lunar surface a body conformation suit having a substantial outer metal surface is considered a necessity for several reasons: (1) Uncertainty that fabrics and elastomers can sustain sufficient pressure differential without unacceptable leakage ; (2) meteoroid protection; (3) provides a highly reflective surface; (4) durability against abrasive lunar surface; (5) cleansing and sterilization. Figure I-5 shows a cutaway and "buttoned up" concept for such a suit. It should be borne in mind that while movement and dexterity are severe problems in suit design, the earth weight of the suit can be allowed to be relatively substantial. For example, if a man and his lunar suit weigh 300 pounds on earth, they will only weigh 50 pounds on the moon.

A comprehensive program will be undertaken to provide special hand tools, load-handling gear, and messing equipment to meet the unusual requirements. Initially all food will be pre-cooked; however, as water supplies increase with the introduction of a reclaiming

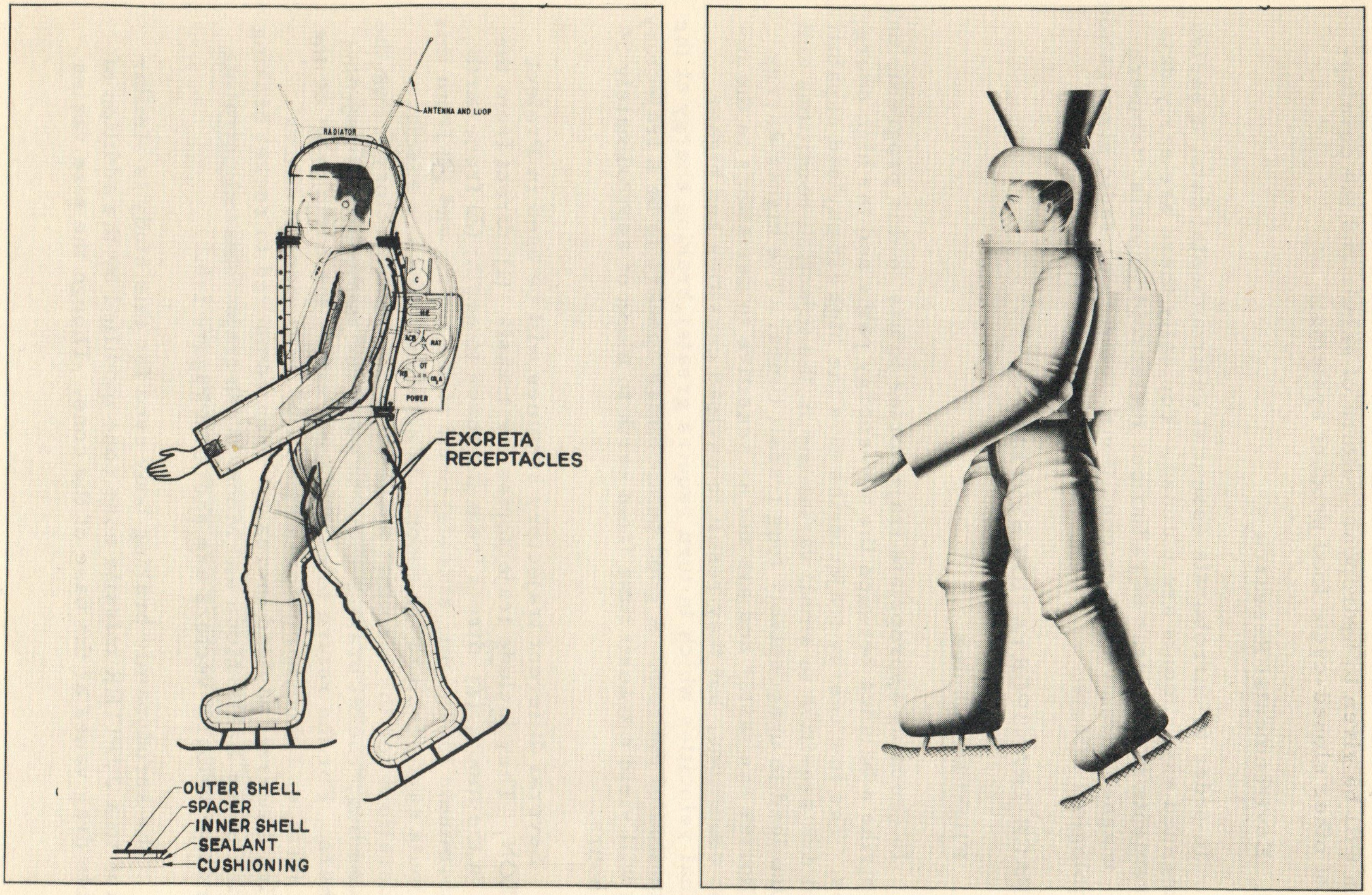


Fig. I-5. Typical Lunar Suit

system, dehydrated and fresh-frozen foods will be used. Early attention will be given to hydroponic culture of salads and the development of other closed-cycle food product systems.

5. Environmental Research

In order to corroborate essential environmental data, a series of unmanned experiments are planned. Topically there are early data requirements in the areas of radiation, meteoroid impacts, temperatures, magnetic field, surface conditions, ionization, radio propagation and biological effects.

D. SPACE TRANSPORTATION SYSTEM

1. Flight Mechanics

In choosing appropriate trajectories to use in this program, one must strike a balance between the low-energy paths and the high energy curves. The low energy trajectories give the highest payload capability, but are sensitive to small variations in the injection conditions and can also lead to unacceptably long transit times. The higher energy trajectories are faster and are not as sensitive to deviations in the injection conditions, but they result in payload penalties and higher terminal velocities which in turn require greater braking energy at the termination of the trip. A good compromise appears to be a trajectory which will yield a transit time from earth to moon of approximately 50 to 60 hours.

Several different trajectory schemes will be used in Project HORIZON. They include trajectories for transit: (1) direct from the earth to the moon, (2) direct from the moon to earth; (3) from earth to a 96-minute (307 n. mi. altitude) orbit of the earth, and (4) from this 96-minute earth orbit to the moon. In addition there are special considerations for the terminal phase of each type trajectory. For the lunar landing, rocket braking must be used due to the lack of any atmosphere. For the return to earth, from either the earth orbit or the lunar surface, aerodynamic braking will be used since it allows significant overall payload increases when compared to rocket braking. Sketches of the Earth-Moon and Moon-Earth trajectories illustrating the relative velocity vectors are shown in Figure I-6.

The aerodynamic braking body used for this study is similar in shape to a JUPITER missile nose cone modified by the addition of movable drag vanes at the base of the cone. Though the size varies,

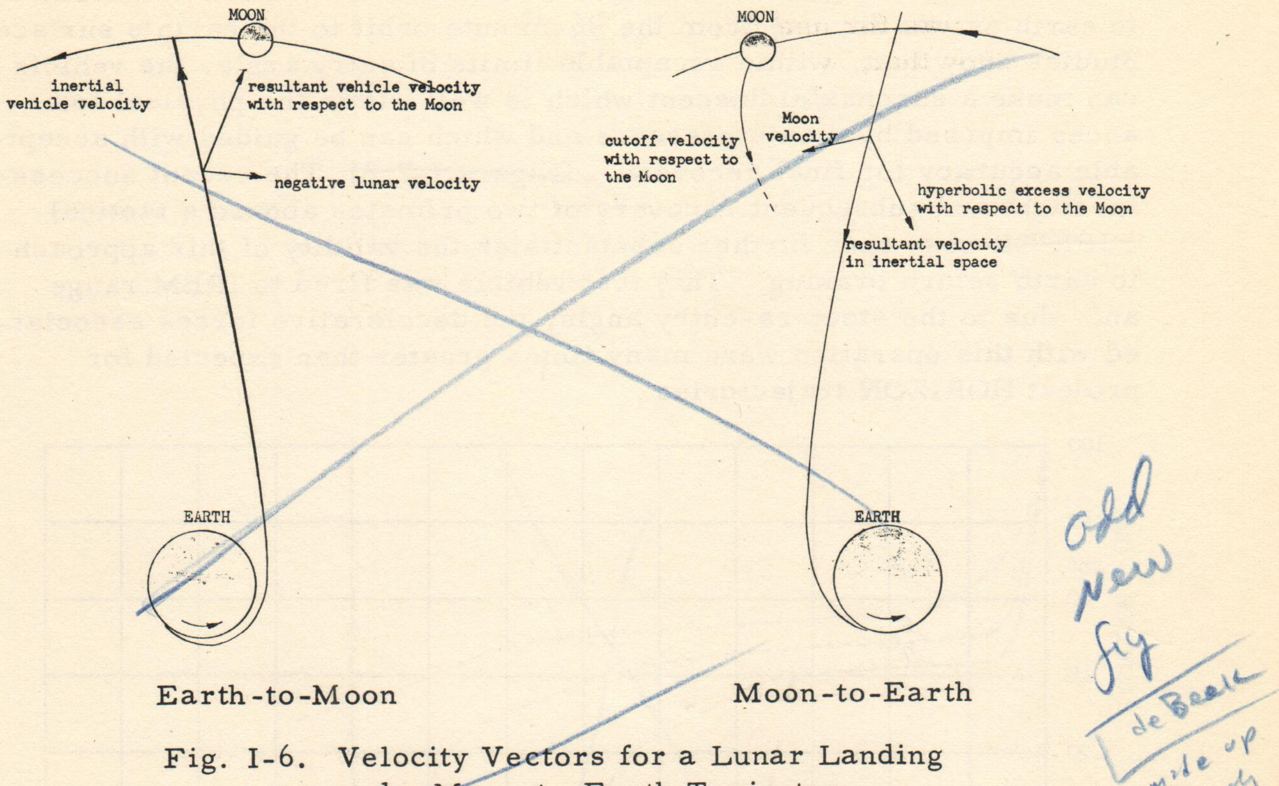


Fig. I-6. Velocity Vectors for a Lunar Landing and a Moon-to-Earth Trajectory

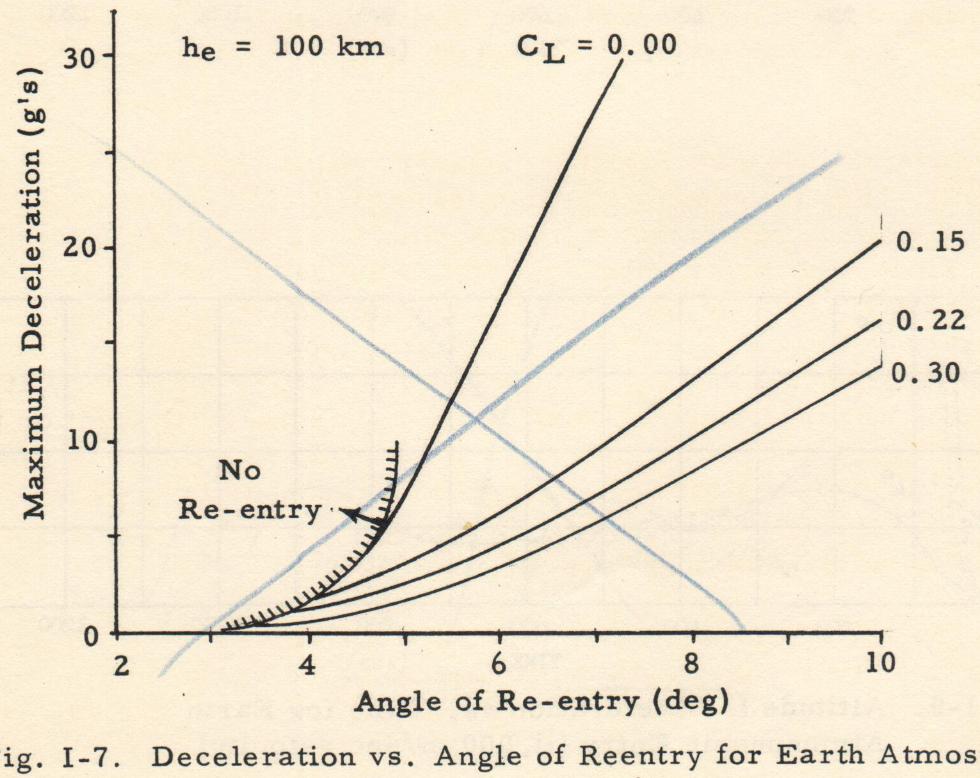


Fig. I-7. Deceleration vs. Angle of Reentry for Earth Atmosphere the same basic shape was considered for use from the lunar surface to earth as was for use from the 96-minute orbit to the earth's surface. Studies show that, within acceptable limits of entry angle, the vehicle can make a successful descent which is well within the physical tolerances imposed by man's presence and which can be guided with acceptable accuracy for final recovery. (Figure I-7, 8) The recent successful flight and subsequent recovery of two primates aboard a tactical JUPITER nose cone further substantiates the validity of this approach to earth return braking. This test vehicle was fired to IRBM range and, due to the steep re-entry angle, the decelerative forces associated with this operation were many times greater than expected for project HORIZON trajectories.

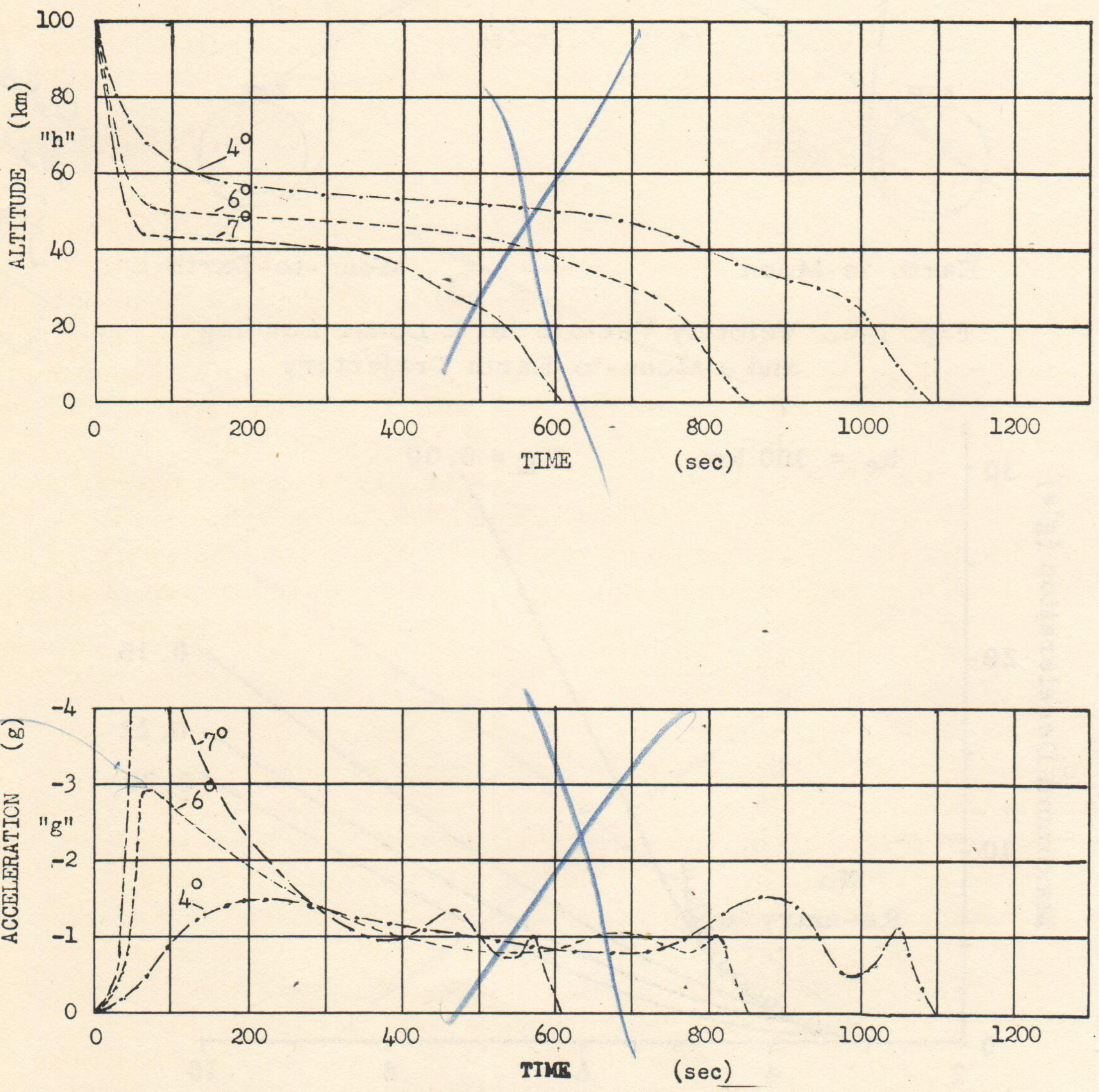


Fig. I-8. Altitude & Acceleration vs. Time for Earth Atmospheric Entry (11,000 m/sec velocity)

2. Orbital Carrier and Space Vehicles

Only two basic carrier vehicles are required to carry out Project HORIZON - SATURN I and a further development, SATURN II.

The SATURN I vehicle, shown in Figure I-9 & I-10 consists of a clustered booster with a lift off thrust of 1,504,000 pounds, a twin engine second stage of about 360,000 pounds of thrust, and a lox/hydrogen (O_2/H_2) third stage of 30,000 pounds of thrust. The initial performance of this vehicle will enable it to place 30,000 pounds of net payload in a 96-minute orbit and 7,500 pounds of net payload to earth escape velocity. It will be powered by eight North American H-1 engines which are a greatly simplified version of the engine used in JUPITER, THOR and ATLAS. The second stage is a modified version of the TITAN booster. The third stage is a modified CENTAUR vehicle currently under development by Pratt & Whitney and Convair.

The SATURN II vehicle (Figures I-11 & I-12) is based on a modified SATURN I booster. The North American H-1 engines of the original version will be replaced by H-2 engines which will up-rate the total thrust by 1/3 to a sea level value of 2,000,000 pounds. The second stage will incorporate two 500,000-pound thrust H_2/O_2 engines, a third stage will utilize two 100,000-pound thrust H_2/O_2 engines and the fourth stage will use one such engine. Present feasibility studies indicate a SATURN II payload capability of 70,000 pounds into a 96-minute orbit using three stages and 26,750 pounds to earth escape velocity using four stages. The development of such a vehicle will provide the nation a near-optimum vehicle for the utilization of the SATURN Booster. The prime requirement for the development of such a vehicle is an expansion of current high-energy O_2/H_2 engine programs to include development of 100 K and 500 K engines.

Two modes of transit from the earth to the moon will be used in Project HORIZON. The first of these is a direct trip from the earth's surface to the lunar surface. Six thousand pounds of useful cargo can be soft-landed on the moon with the direct method. As presented herein, only cargo will be transported in this manner, although there is a discussion of how personnel could also be transported to and from the moon utilizing the direct method. The second form of conveyance requires two steps. Initially the required payloads, which will consist of one main lunar rocket vehicle and several additional propellant tankers, will be placed in a 96-minute orbit of the earth. At this time the propellants in orbit will be transferred to the main lunar rocket vehicle.

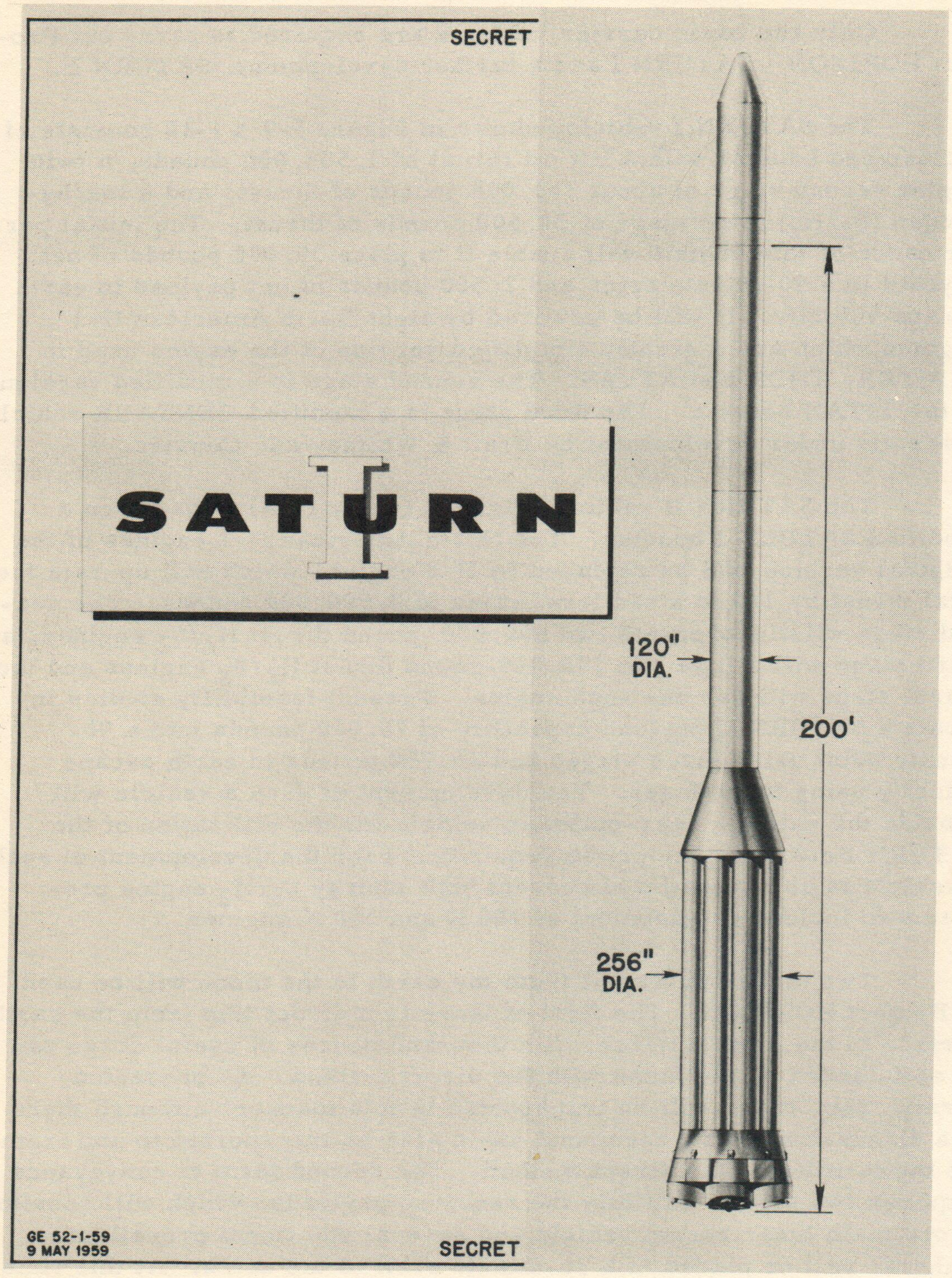
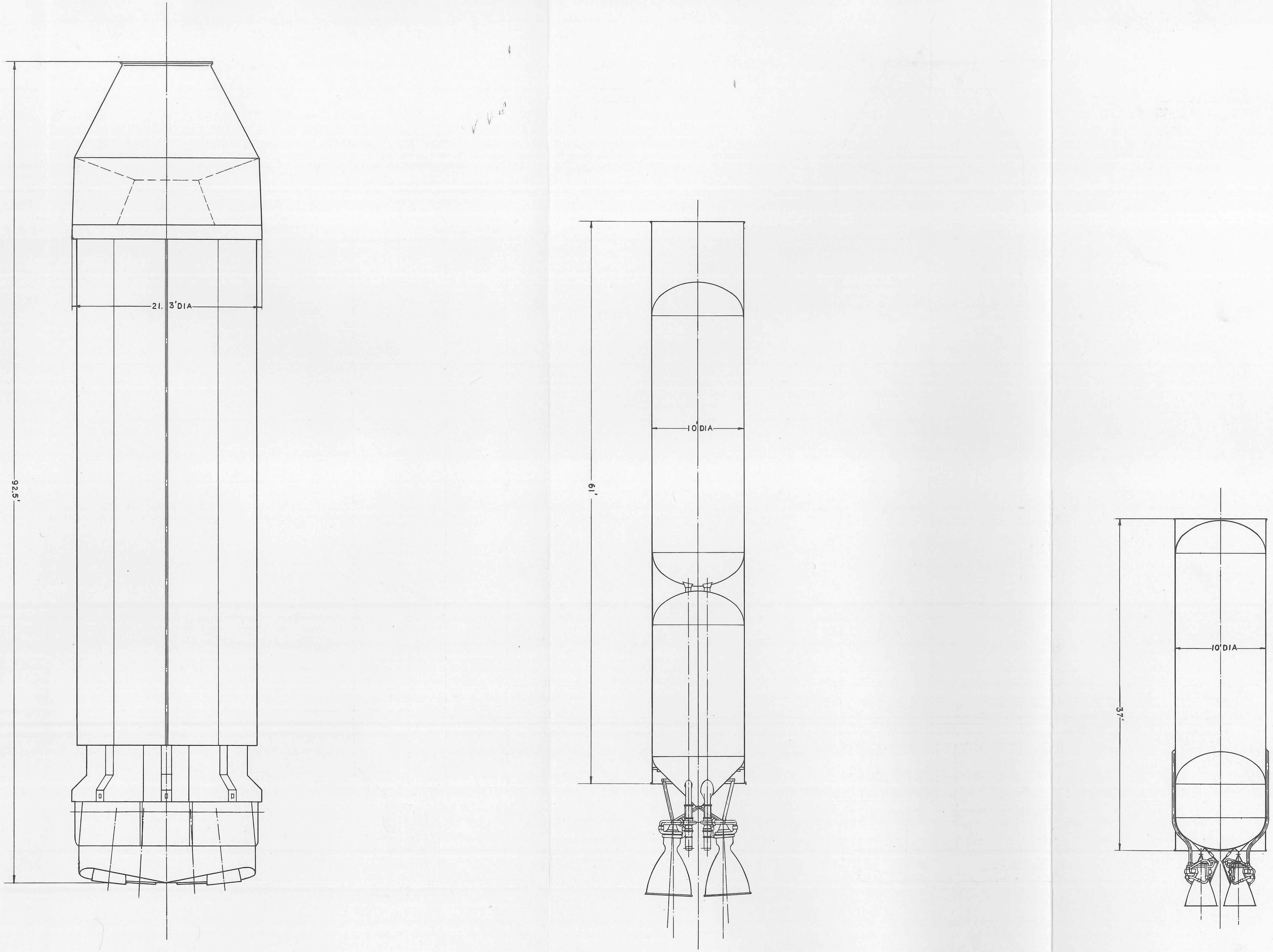


Fig. I-9. SATURN I



First Stage (Booster)

Second Stage

Third Stage

Fig. I-10. SATURN I, Stages 1 through 3

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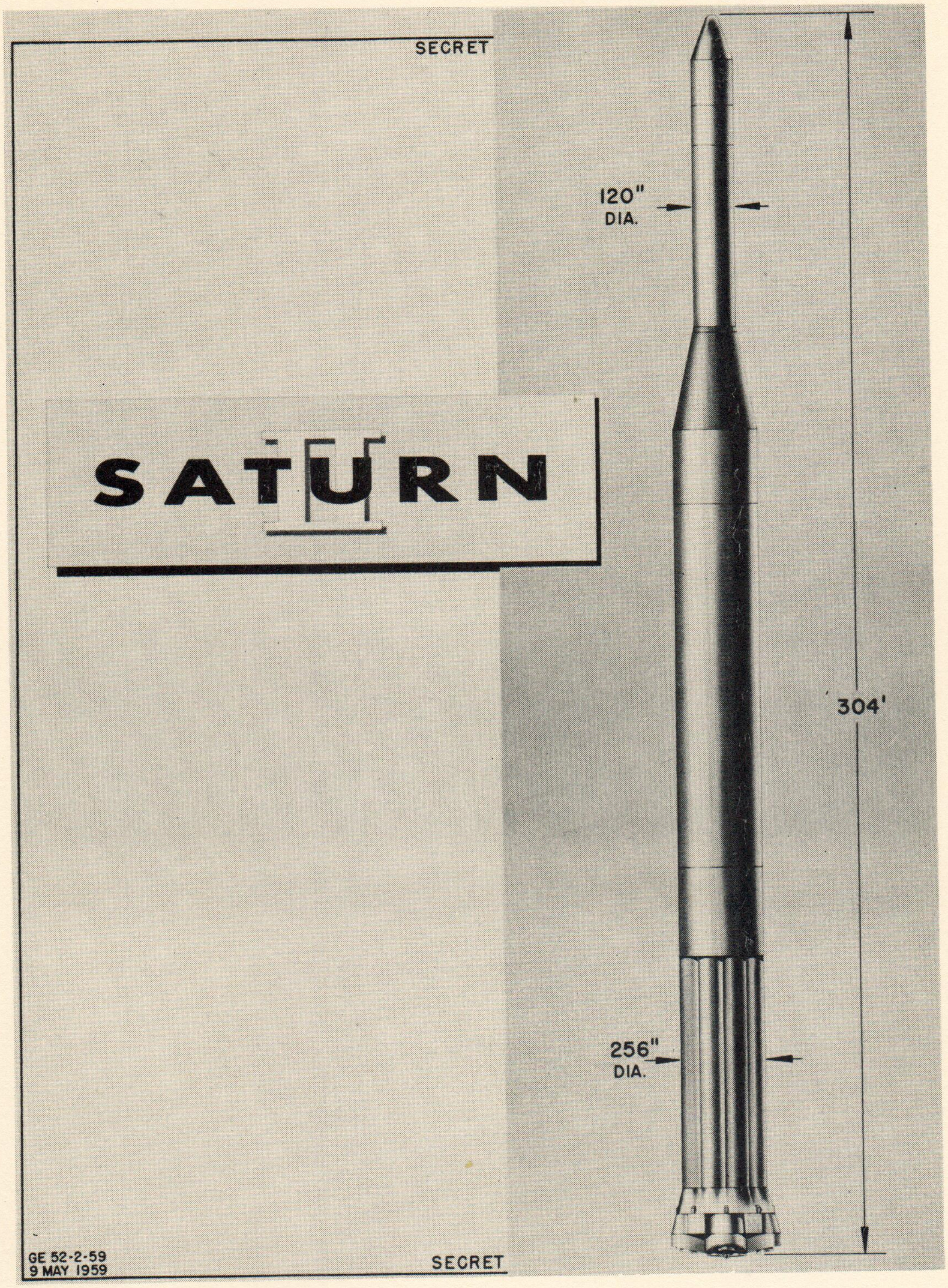
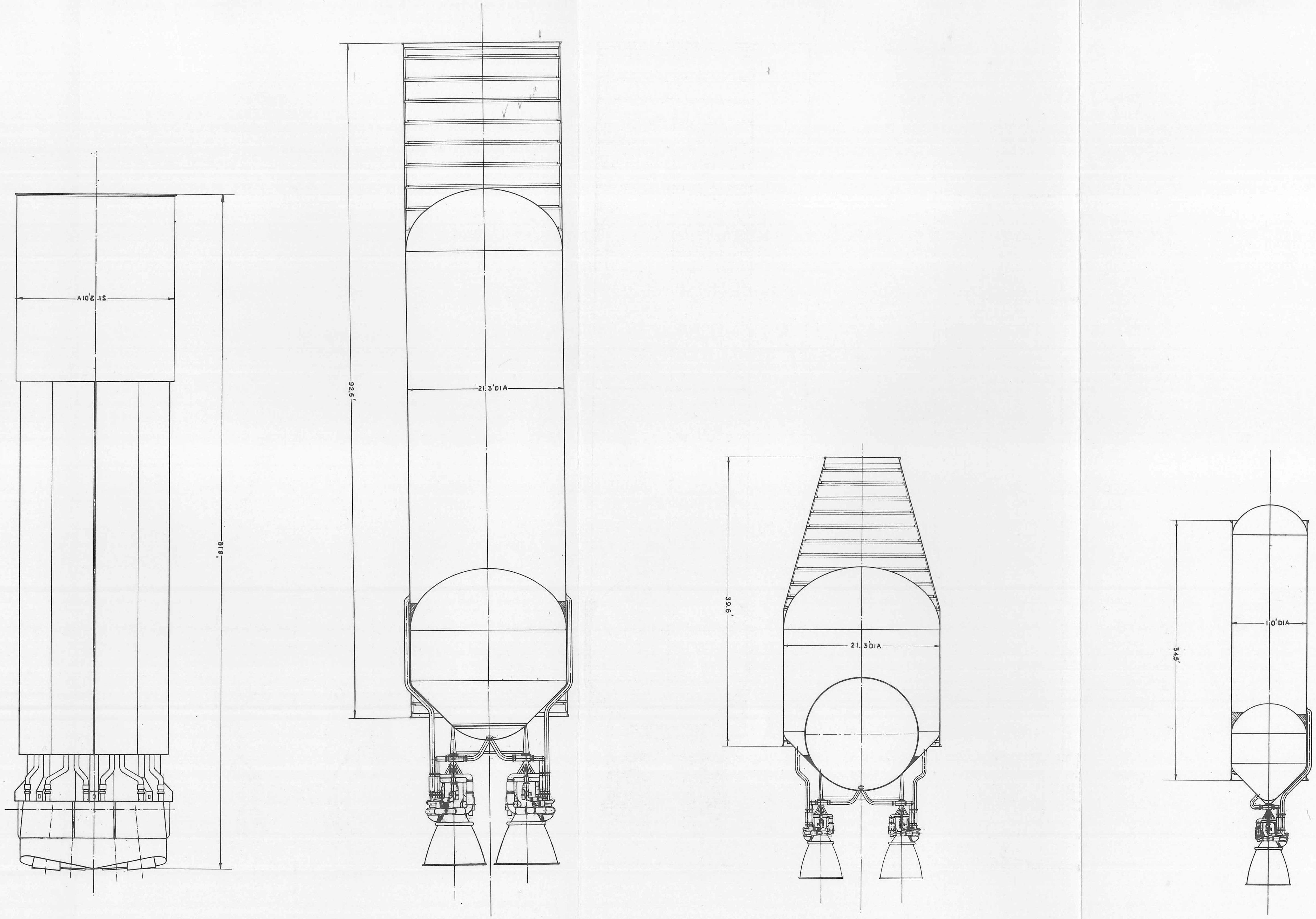


Fig. I-11. SATURN II



First Stage (Booster) | Second Stage | Third Stage | Fourth Stage

Fig. I-12. SATURN II, Stages 1 through 4

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Figure I-13 is a conceptual view of the operations in the equitorial earth orbit. The operation in orbit is principally one of propellant transfer and is not an assembly job. The vehicle being fueled is the third stage of a SATURN II with a lunar landing and return vehicle attached. The third stage of the SATURN II was used in bringing the combination into orbit and has thus expended its propellants. This stage is fueled in orbit by a detachment of approximately ten men after which the vehicle then proceeds on the moon. It is planned to send all personnel and approximately 1/3 of the cargo to the moon by the orbital method.

Using this orbital system, individual payloads of 48,000 pounds may be soft-landed on the moon. This value is especially significant since it represents the approximate minimum weight required for a complete earth return vehicle which is already assembled and loaded with propellants and is capable of returning several men. Thus, in order to provide a preassembled return vehicle on the lunar surface during the time frame under consideration, it is mandatory to go through an initial earth orbit. Studies show that, in order to provide such a capability via the direct flight method, a booster of approximately 12,000,000 pounds of thrust is required. In addition to providing a large individual payload capability, the orbital transportation system offers other important advantages. Among these are that the total number of firings to deliver the same amount of payload to the moon is significantly less and payloads may be fired for orbital rendezvous at any given pass very day of the month. This alleviates the launch site scheduling problems which are associated with the restricted firing times of direct flights.

There are two versions of the lunar landing vehicle. The first type will be used for direct trips from earth to the lunar surface. This vehicle has a gross weight of 26,750 pounds and will soft land some 6000 pounds of payload. The second vehicle will be used for flights via orbit. It will have a gross weight of 140,000 pounds which gives it a capability of soft landing approximately 48,000 pounds of payload on the moon. Each type of vehicle will have suitable payload compartments to accomplish different mission requirements. The lunar landing vehicle shown in Figure I-14 has an earth return vehicle as a payload. For such return vehicle payloads, the structure of the expended braking stage will serve as a launching platform when it is time to begin the return journey to earth.

To sustain the orbital station detachment and to provide for

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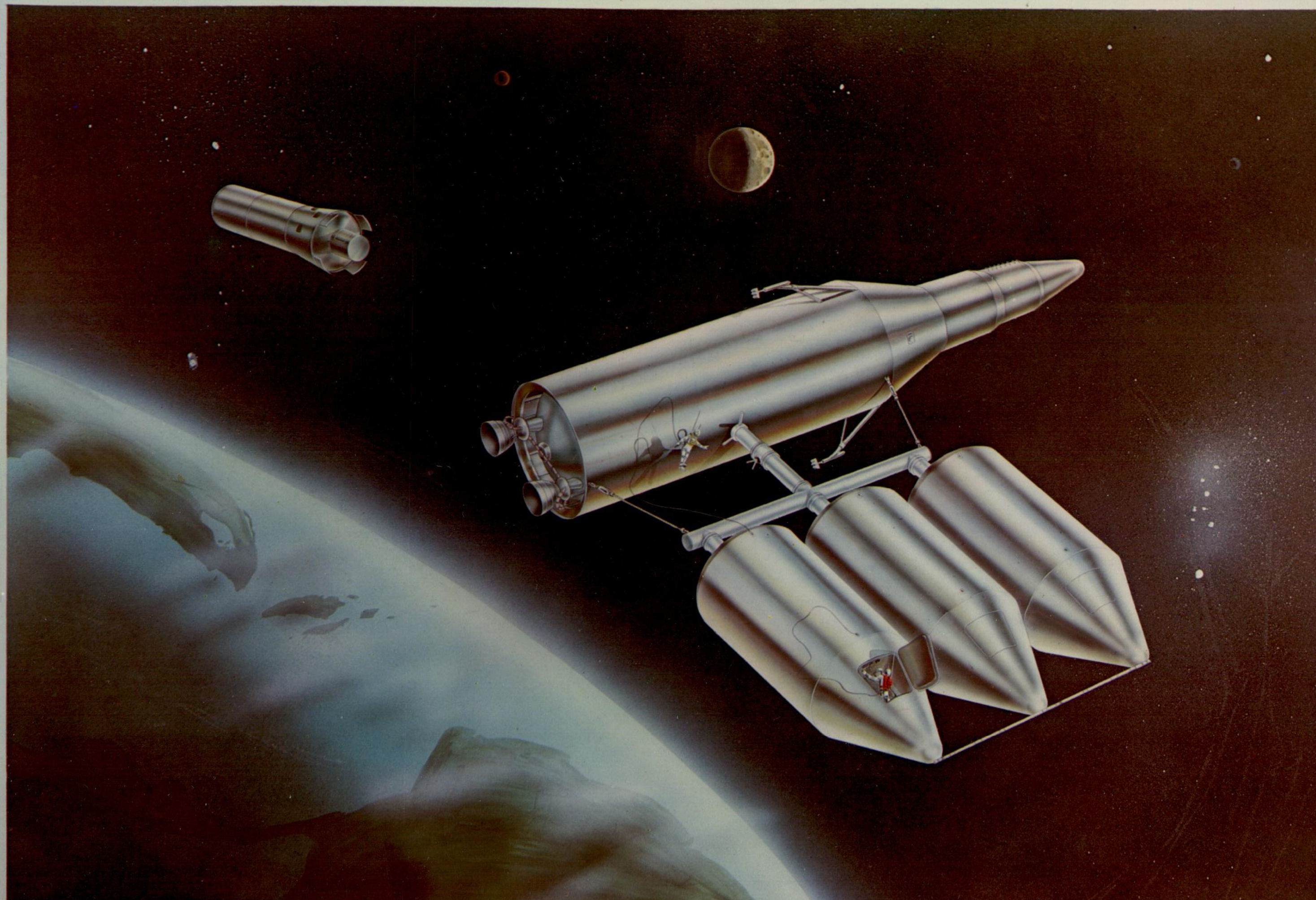

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FIGURE I-13

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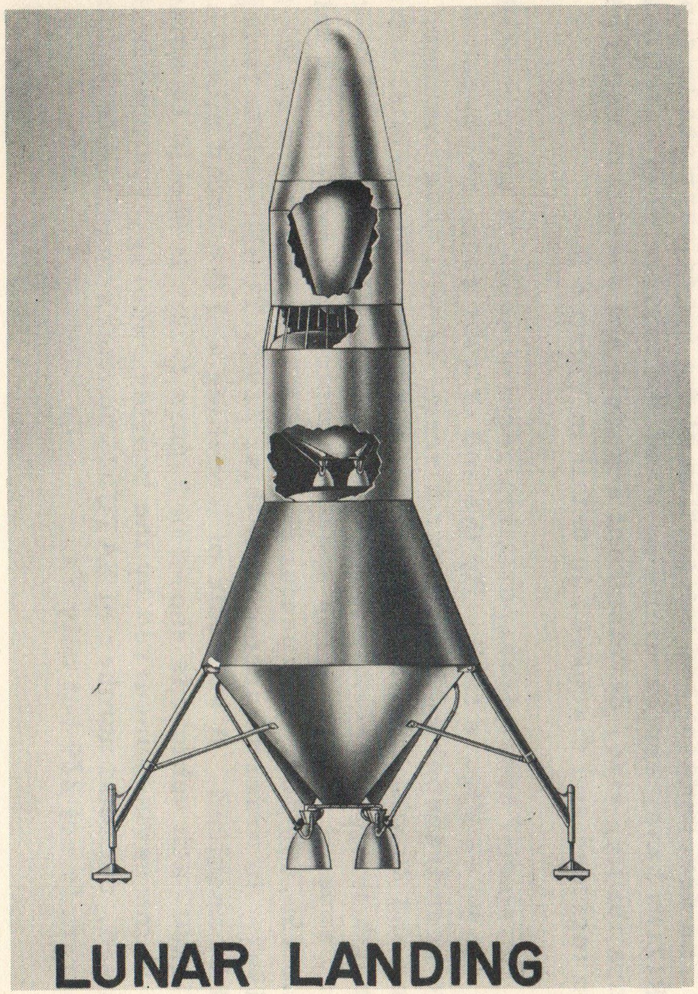

Fig. I-14. Lunar Landing Vehicle

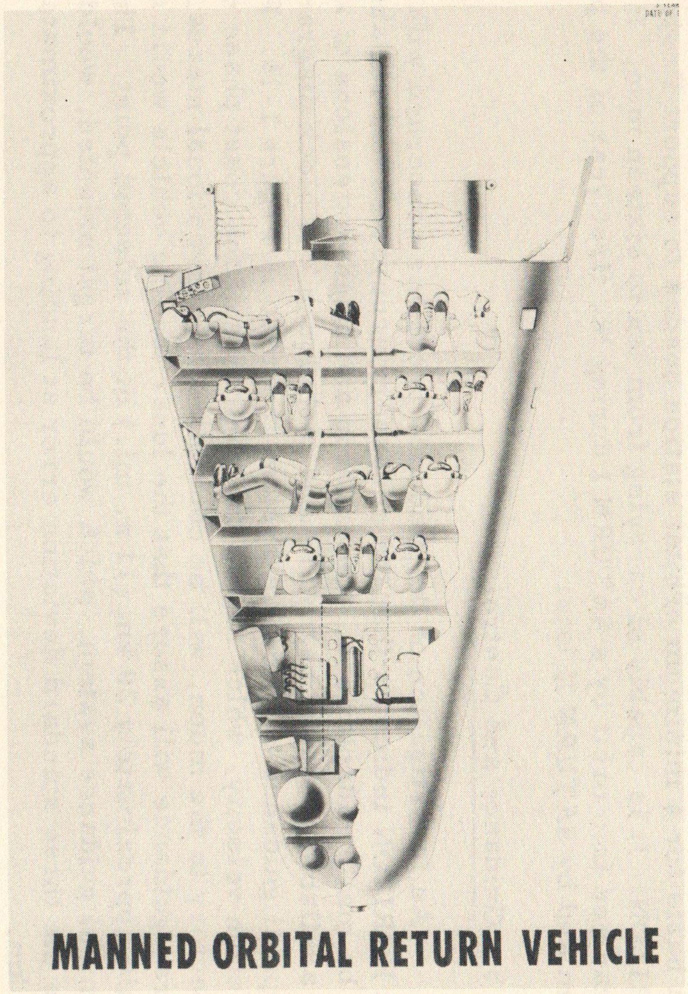

Fig. I-15. Orbital Return Vehicle

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their safe return to earth, an orbital return vehicle such as shown in Figure I-15 will be provided. This vehicle may be used in conjunction with another established U. S. orbital station, or it may be used as a basis for a minimum orbital station needed to support Project HORIZON. It is capable of carrying from ten to sixteen men. It will be carried into orbit by a SATURN I during the first year of the program and by SATURN II later.

3. Guidance and Control

An investigation of the guidance problems concerned with Project HORIZON indicates that the necessary accuracies and reliabilities can be met by adaptations, combination and slight extensions of known and available guidance hardware and techniques. A block diagram of a typical guidance and control system is shown in Figure I-16. Final injection velocity, which marks the beginning of the coast phase of the trajectory to the moon, will be controlled by conventional means. Mid-course guidance will assure that the lunar landing vehicle would come within approximately 20 km (11 n. mi.) of the selected point. The terminal guidance system, which would be target oriented, would reduce the three standard deviation error at landing to approximately 1.5 km.

E. TRANSPORTATION SYSTEM INTEGRATION

The development and integration of the space carriers to support HORIZON have been carefully outlined and various considerations as to compatibility, size, development schedule and overall mission have been included and discussed in detail in Volume II.

Personnel space transportation requirements to support HORIZON are shown on Figure I-17. By the end of 1967 some 252 persons will have been transported into an earth orbit, 42 will have continued to the moon and 26 will have returned from the moon. The orbital station strength is approximately ten; however, the detachment will be rotated every several months. The space transportation system will deliver some 756,000 pounds of useful cargo to the lunar surface by the end of 1967. In order to accomplish this, 229 SATURN vehicle firings will be required. A schedule of launching and the broad mission assigned each vehicle is shown in Figure I-18. It should be noted that, due to the savings incurred by the booster recovery system which will be used, the total number of SATURN boosters required to support the program is not 229 but only 73.

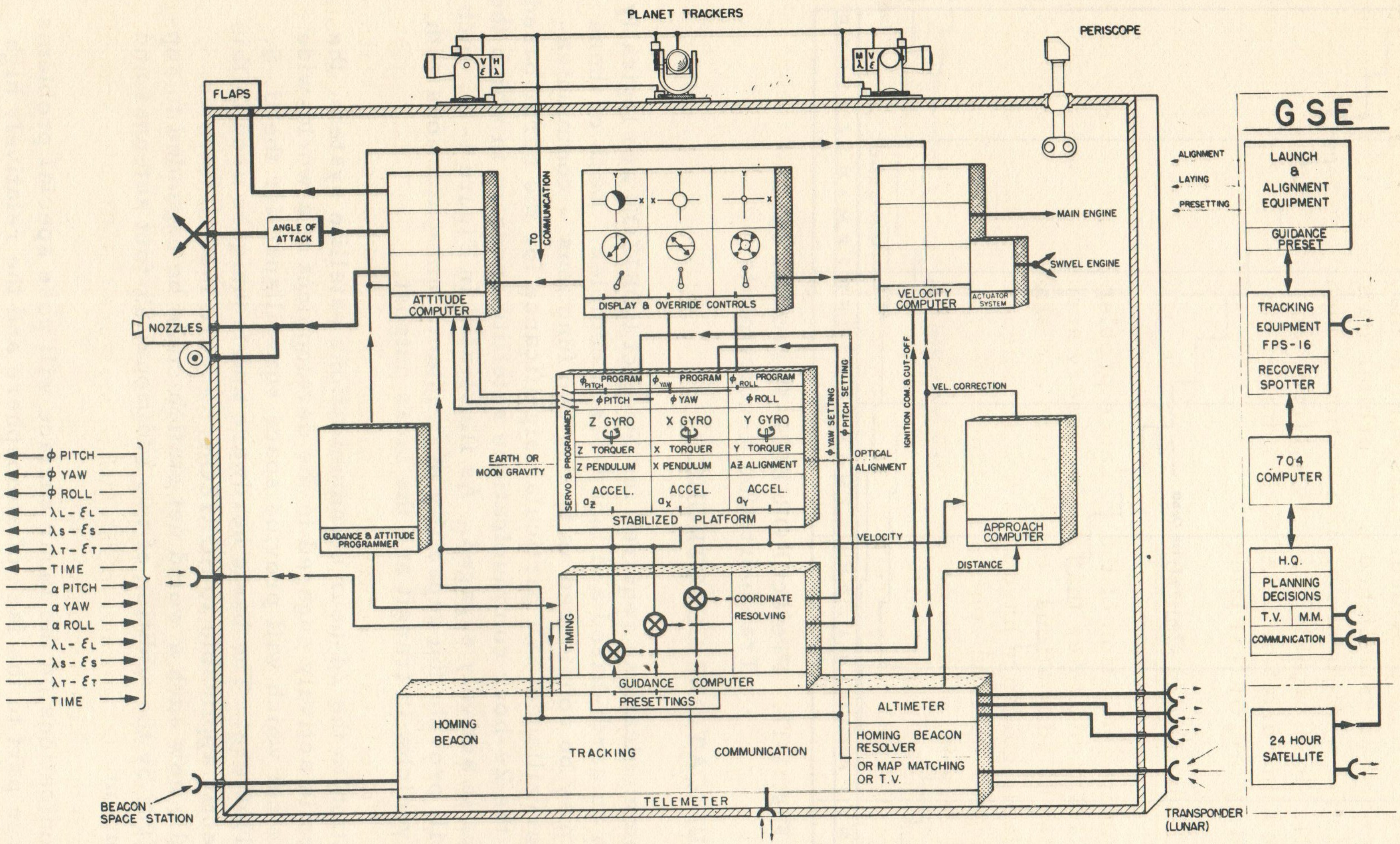

Fig. I-16. Block Diagram of Typical Guidance and Control System

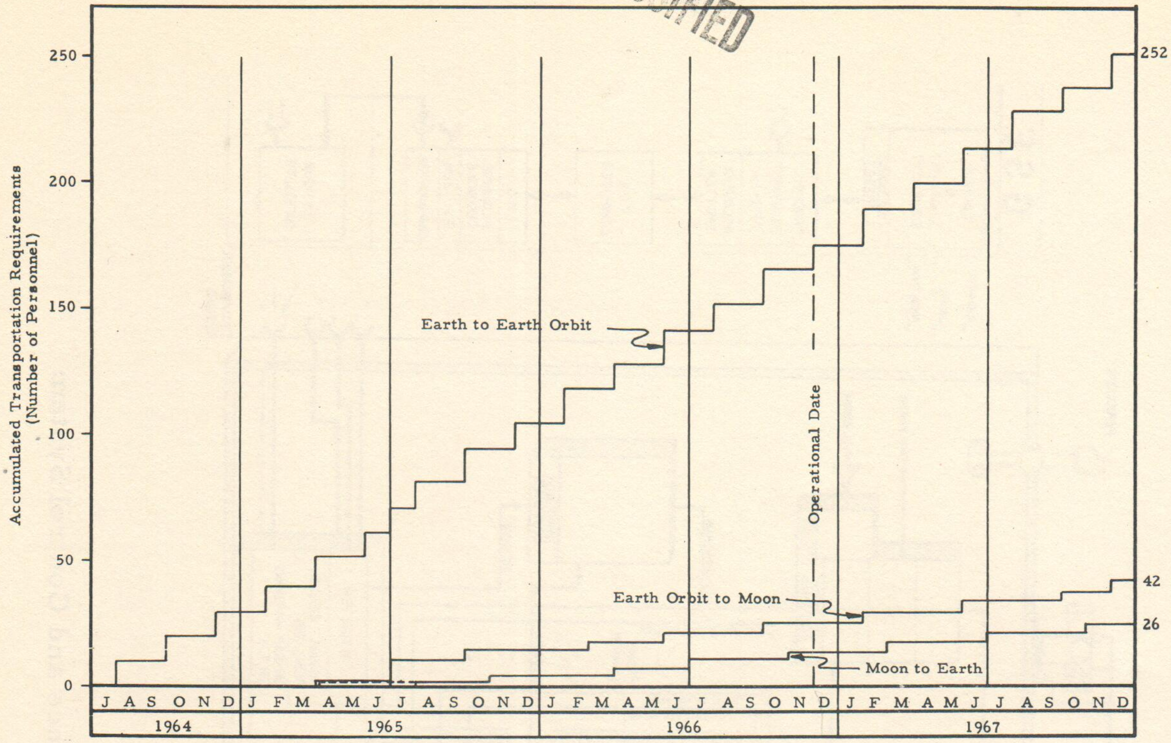

Fig. I-17. Project HORIZON Personnel Space Transportation Requirements

F. COMMUNICATIONS ELECTRONICS

The communications required for Project HORIZON are logically divided into an earth-based and lunar-based complex. Each of these complexes may be considered as having two functions - communications and surveillance. Of particular significance for the earth-based complex is the 24-hour communications satellite program in which the Signal Corps is actively engaged. As illustrated in Figure 1-19, such a system will provide the capability of constant communications with both space vehicles in transit and the lunar outpost.

In addition to the 24-hour communications satellite system, the Signal Corps is actively engaged in the development of a world-wide surveillance net which will provide space surveillance for the U. S. during the 1960 era. The basic hardware and techniques used in this net are directly applicable to HORIZON. Figure I-20 illustrates schematically how such a world net station could be expanded to support HORIZON by the addition of two additional 85-foot antennas and other equipment.

Communications on the lunar surface will pose special problems due in a large part to the lack of atmosphere and the relatively high

PROJECT HORIZON VEHICLE REQUIREMENTS AND LAUNCHING SCHEDULE

Number of Flights for Designated Dates

Vehicle and Mission	1964						1965												1966												1967												Total Flights
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Lunar Soft Landing Vehicle (Direct)																																											
SATURN II							1	1	1	1	1	2	2	2	2	1	2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	3	2	2	3	2	2	3	2	2	73
Earth-Orbit and Return (Manned)																																											
SATURN I		1		1		1		1		1		1	1	1		1		1		1		1		1		1		1		1													16
SATURN II																																1		1		1		1		1		1	6
Earth-Orbit (Cargo)																																											
SATURN I		1	3	1	3	3	4	3	3	2	2	3	2	3	3	2	2	1	1	1		1		1		1				1													47
SATURN II				1				1	1	1	1			1	1	1	1	2	2	3	3	2	3	2	3	3	3	3	3	2	2	2	3	2	2	3	2	2	3	2	2	3	71
Emergency Vehicles																																											
SATURN I							1	1			1							1					1				1																6
SATURN II													1				1		1			1		1				1				1			1			1			1		10
Orbit-Lunar Soft Landing (Cargo)							1												1							1				1													4
Orbit-Lunar Soft Landing (Manned)										1			1			1					1			1				1					1			1			1			1	10
Lunar-Earth Return														1			1					1			1			1						1			1			1			8
Total																																											
SATURN I		2	3	2	3	4	5	5	3	3	3	4	3	4	3	3	2	3	1	2		2	1	2		2	1	1		2													69
SATURN II				1			1	2	2	2	2	2	3	3	3	2	4	4	5	5	5	5	5	5	6	5	6	6	6	4	5	6	5	6	5	6	5	6	5	6	5	6	160
Total Carrier Vehicles for Project HORIZON		2	3	3	3	4	6	7	5	5	5	6	6	7	6	5	6	7	6	7	5	7	6	7	6	7	7	7	6	6	5	6	5	6	5	6	5	6	5	6	5	6	229

OUTPOST OPERATIONAL DATE

Fig. I-18. Project HORIZON Vehicle Requirements and Launching Schedule

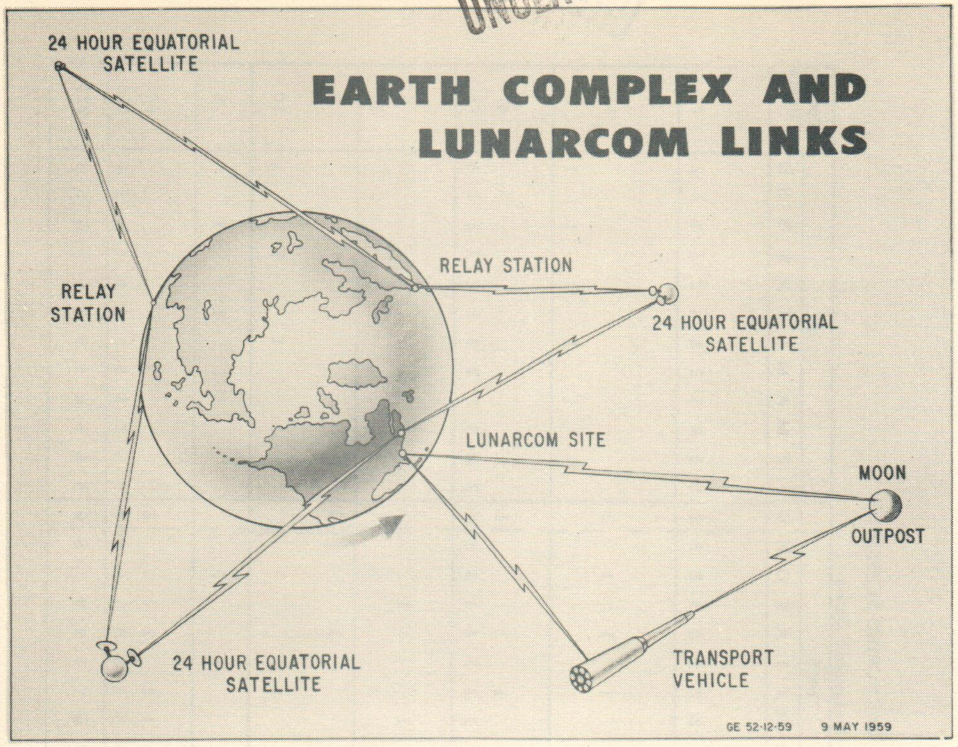

Fig. I-19. Earth Complex and Lunarcom Links

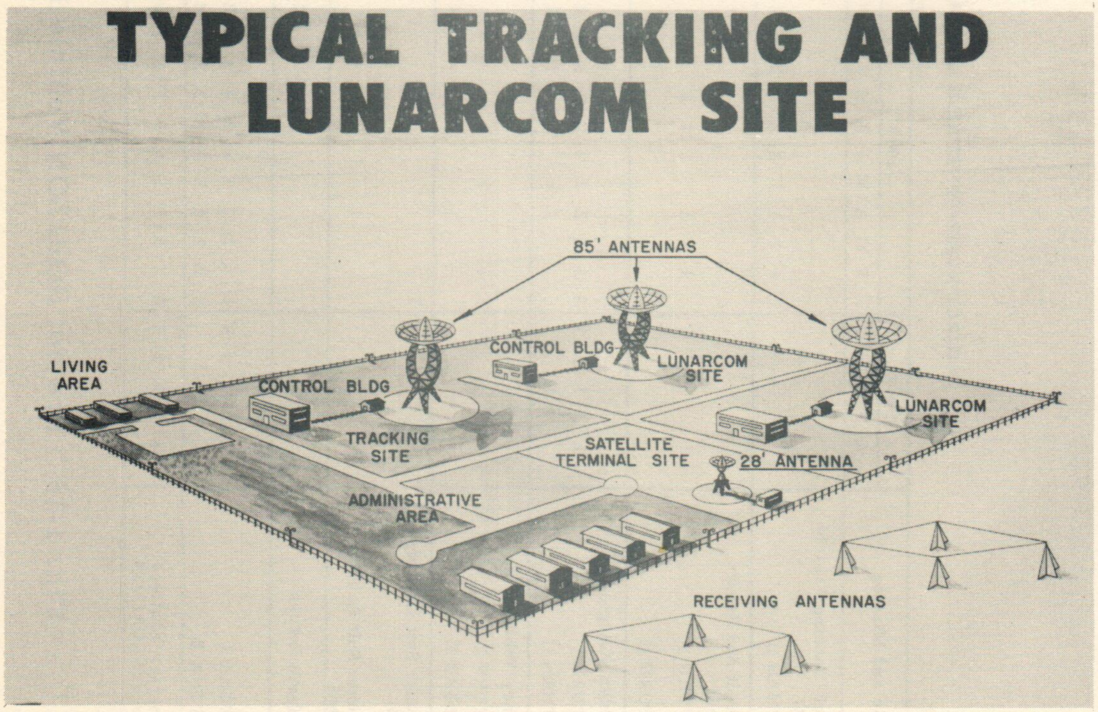

Fig. I-20. Typical Tracking and Lunarcom Site curvature of the surface. However, careful investigation reveals no problems which cannot be solved by an appropriate research program. In a number of areas current developments appear almost directly applicable; for example, the small helmet-mounted radio, a Signal Corps item currently in production, and also a microminiturized version in advanced development will provide a basis for personal communication between individuals clad in lunar suits. As the lunar outpost expands, radio relay stations will extend the radio horizon as conceived in Figure I-21.

In addition to voice communication between members of the lunar party, a number of other electronic devices will be used at the outpost. These include TV receipt and transmission, transmission of still photographs, homing and location devices, instantaneous self-contained emergency communications packs (for distress signals to earth), infra-red detectors, radar detectors, and Elint receivers.

G. EQUATORIAL LAUNCH SITE

The launching facility which will be used for Project HORIZON is illustrated in Figure I-22. A total of eight launch pads are required. This facility will support the requirements of HORIZON and would provide some additional capacity for additional firings that might be required for other U. S. programs.

The equatorial location of the site provides very real advantages in terms of payload capability, guidance simplicity and operational launching schedules in terms of increased latitude of appropriate firing times. Two sites stand out when compared to others - Brazil and Christmas Island. Both of these locations appear feasible; however, a more detailed criteria will have to be set up to make the best choice. Cost and early availability may ultimately be the governing factors. It is emphasized that site acquisition and initiation of launch site construction is one of the most critical items in the program with respect to leadtime. For the purposes of this study it has been assumed that the Brazil site would be used.

H. PROGRAM LOGISTICS

The Army's experience in technical and community support of overseas areas will be utilized to support the Project HORIZON equatorial launch site.

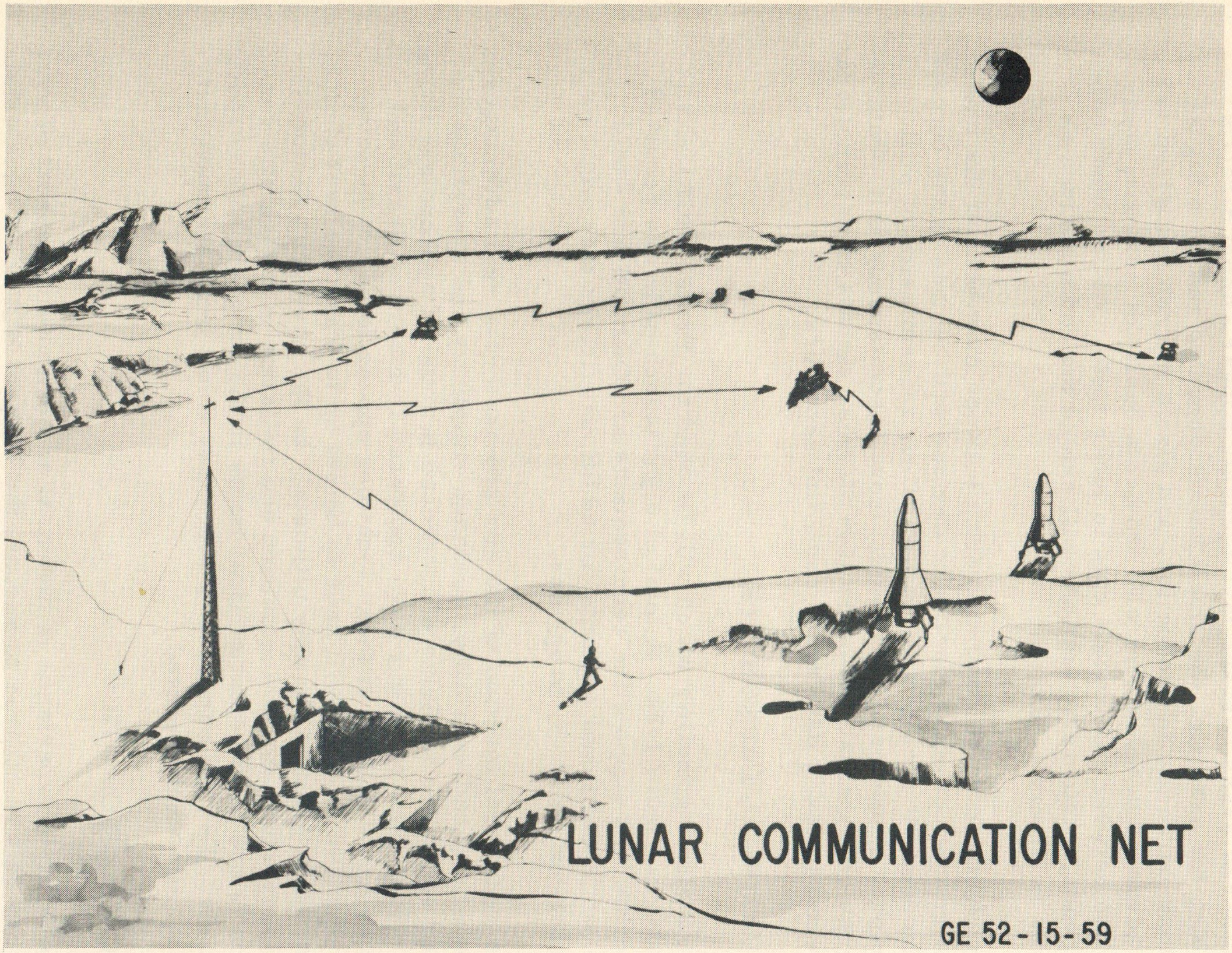

Fig. I-21. Lunar Communication Net

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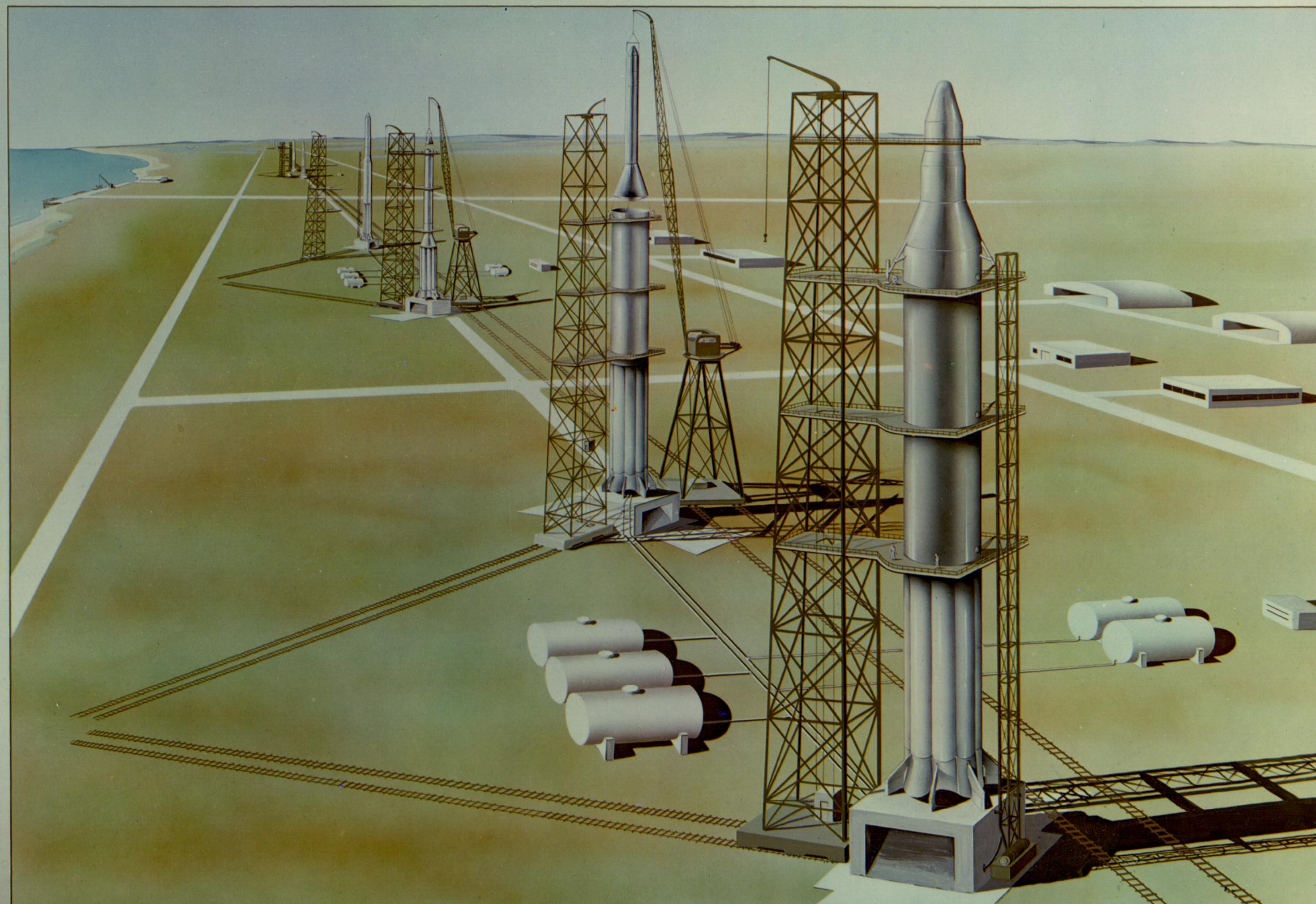

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FIGURE I-22

A consideration of the manufacturing and transportation aspects of the program indicates that the production capacity required is well within available U. S. industrial resources; however, the size of many of the components emphasize the desirability of ready access from manufacturer's plants to water transport.

I. RESEARCH AND DEVELOPMENT

1. Organization

There are three major systems developments needed to accomplish the initial capability for this program, each with progressively more restrictive modifications and dependence upon a former system. The interdependence of these systems and the technical service with prime responsibility for their development are shown below.

TABLE I - 1

MAJOR SYSTEMS RESPONSIBILITY

System	Limiting Design Factors	Technical Service Responsibility
Space Vehicle System	State of Rocketry Art	Ordnance Corps
Outpost System	Available Space Vehicles	Corps of Engineers
Communications System	Space Vehicles & Outpost Design	Signal Corps
Supporting Subsystems & Components	Compatibility with all of above	Appropriate Technical Service

Table I-1. Major Systems Responsibility

The foregoing assignments of system responsibility fall naturally within the Army's framework of development responsibility. They also represent logical assignments in the light of current development responsibilities as assigned by the Department of Defense. Specifically, the Department of Defense has assigned responsibility for (1) the large space vehicle booster (SATURN) to the U. S. Army Ordnance Corps; (2) construction to the Corps of Engineers, and (3) long-range communication to the Signal Corps.

An overall systems manager will be designated during or at the conclusion of Phase II of project HORIZON (see Par I-2). The responsibilities of the overall systems manager will be to:

a. Assure the full technical integration and compatibility of the three major systems - space vehicles, outpost and communications and all subsystems as they might affect other major systems.

b. Provide central programming capability.

c. Render progress reports and allied communications.

d. Coordinate scheduling of tests, facilities, etc.

e. Provide a central point of technical contact for the operational elements of the Army for operational preparations.

2. Program Phases

This program may be depicted in six logical phases as indicated in Figure I-23 and discussed below.

a. Phase I. The first phase, the conduct of a preliminary integrated study of the problem by all technical services of the Army and preparation of this four-volume report, has been completed.

b. Phase II. The second phase requires more detailed studies and limited experimentation and would result in a detailed development and funding plan. Preparation of this plan should be coordinated by the Army Ordnance Missile Command (AOMC) in a manner similar to that accomplished during Phase I.

c. Phase III. This phase illustrates major systems responsibility and the individual systems development period. The continuous coordination of the space vehicle, outpost, communications and subsystems developments into an overall integrated system takes place throughout this period.

d. Phase IV. This phase involves the actual construction of the lunar outpost, as well as active assumption of operational control by the field command.

e. Phase V. The outpost has been established at its initial level and is operated and maintained at essentially that level for a year.

f. Phase VI. The initial capability of the outpost may be expanded if events indicate such a plan to be desirable and feasible.

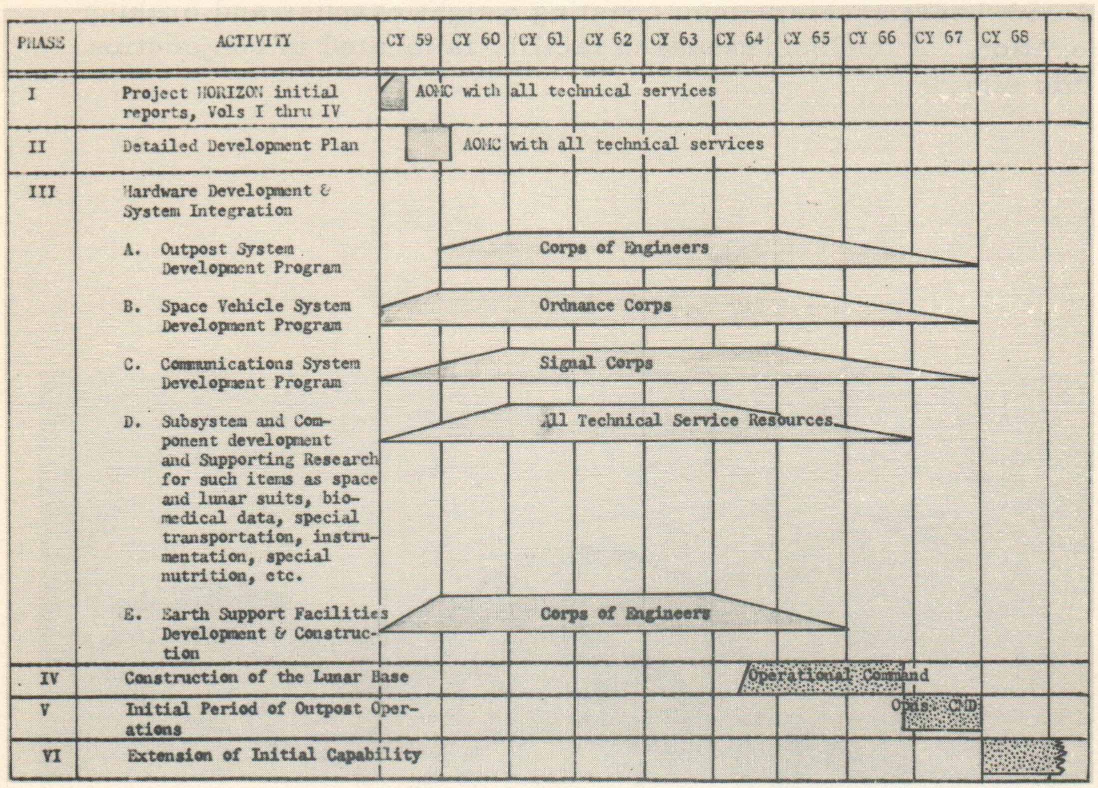

Fig. I-23. Organization for Research and Development

3. Supporting Research

The importance of a strong supporting research effort in support of a project of the nature of HORIZON cannot be overstated. Typical areas requiring attention are food and oxygen, clothing, chemical, biological, radiological, bio-medical, vacuum conditions, weightlessness, meteoroids, lunar-based weapons systems, moon mapping, explosives in lunar environment, power generation, material and lubricants, liquid hydrogen production and handling, and lunar "soil" mechanics.

4. Research Facilities

Several unique facilities will be required to support HORIZON. Figure I-24 is a view of a large lunar environmental simulator which will provide a capability for research, development, testing and training for national space programs. Figure I-25 illustrates a space flight simulator which will provide for research and training of effects associated with boost acceleration, coasting weightlessness and braking deceleration. A medical research facility is located in conjunction with this site.

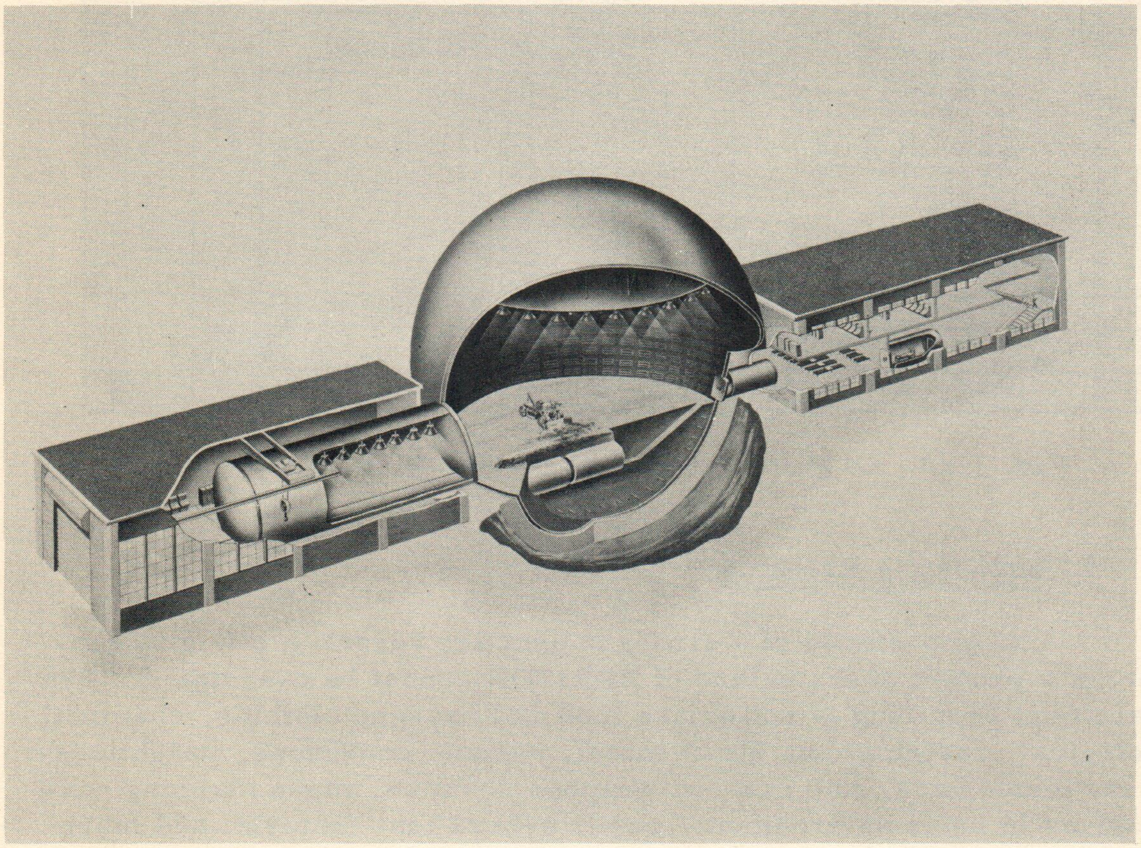

Fig. I-24. Cross Section Through Main Facility LERUT

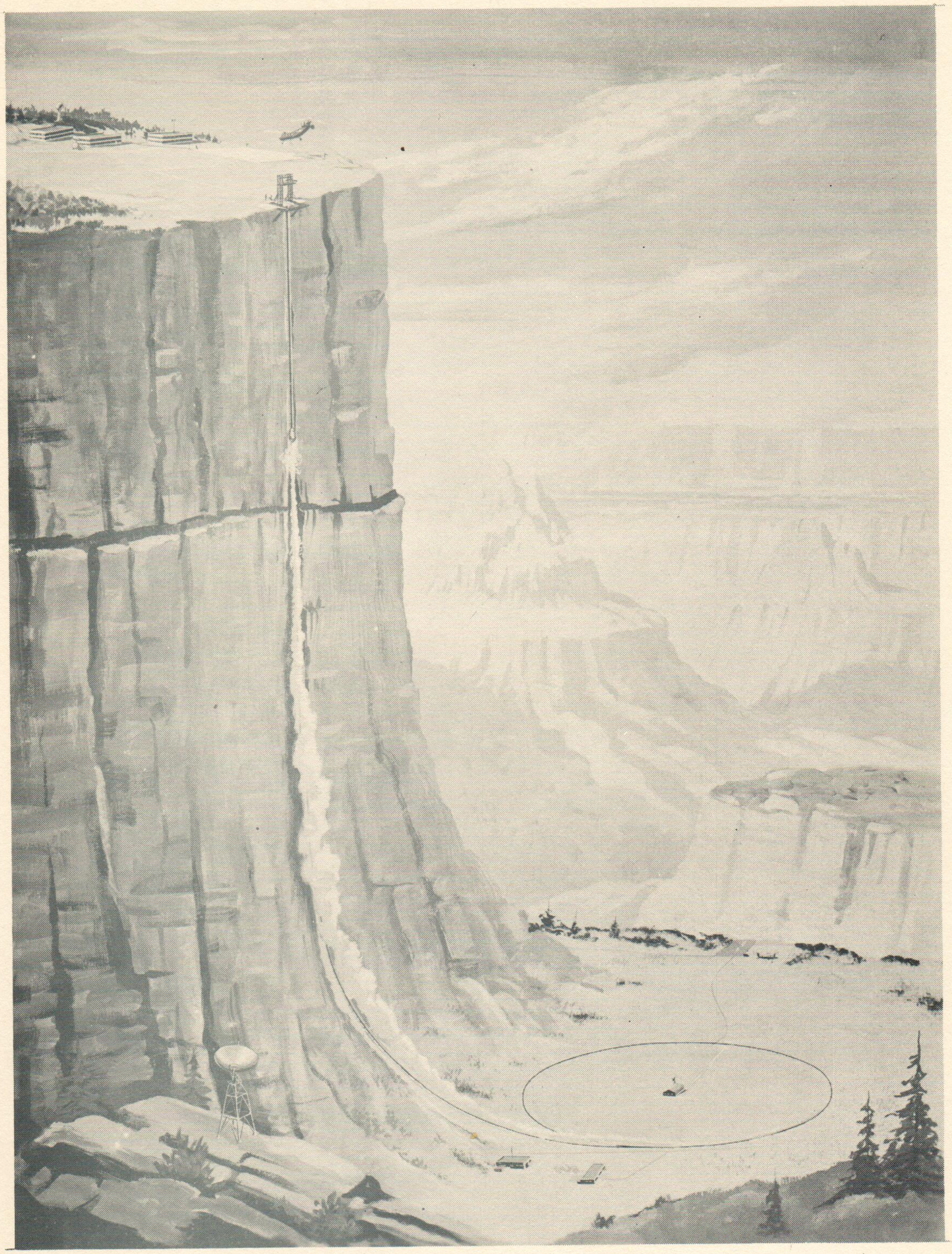

Fig. I-25. View of Flight Simulator

(S) CHAPTER III: OPERATIONAL ASPECTS

A. REQUIREMENTS

It is in the national interest to exploit this nation's space capability as necessary to achieve military, political and scientific purposes. The establishment of a base of military operations in the lunar environment will demonstrate United States military and scientific leadership in space. It will also provide a basis for further operations on the lunar surface as well as a supporting capability for other U. S. operations in space.

There is an Army requirement for a lunar outpost to:

1. Demonstrate the United States military and scientific leadership in outer space.

2. Establish a permanent Army outpost in space to extend and improve the accomplishment of certain military operations on earth and to support combat operations on the moon.

3. Support scientific and military explorations and investigations.

4. Extend and improve space reconnaissance and surveillance activity and control to translunar space.

5. Extend and improve military communications and serve as a communications relay station.

6. Provide a basic and supporting research laboratory for all military and civil space research and development activity.

7. Develop a stable, low-gravity outpost for use as a launch site for deeper space exploration.

8. Provide a proving ground for test of effects of weapons designed to be too dangerous for test elsewhere or designed specifically for space applications.

9. Provide military, as well as scientific, exploration and development of a military mapping and survey system.

10. Provide dispersion, concealment of activity, and reduction of vulnerability of certain weapons for future application against earth or space-based military targets.

11. Provide emergency staging areas, rescue activity or navigational aid for other space activity.

12. Provide local security to protect U. S. interests.

13. Provide "International Law Enforcement" or protection of national interests by basing weapons on the lunar surface.

B. HISTORICAL MILITARY PRECEDENT

Throughout history the military outpost has served as a hub around which evolved the social, economic and political structure of civilization. Modern traffic still flows over the Roman Appian Way and in the more recent history of the United States the early military outposts provided the framework for the technological achievements which were necessary for ecomomic and social growth. Advanced military installations have traditionally evolved a struggle between man and a hostile environment. Where others had failed, the U. S. Army Corps of Engineers and Medical Service conquered the elements of nature to build the Panama Canal.

C. POLICY

There is a requirement for an early determination of both general and specific policy guidance on the national level on the subject of this study. A considerable volume of general policy guidance on the overall subject of space has evolved from both Legislative and Executive action. This policy, while general in nature, is nevertheless clear in stating the urgency of the military situation. The intelligence estimates which support statements of national policy credit the Soviet Union with a capability of accomplishing the objectives of this study anytime after 1965. Therefore, the military requirement is inferred from national policy.

D. MILITARY, POLITICAL & SCIENTIFIC IMPLICATIONS

From the viewpoint of national defense, the primary implication of the feasibility of establishing a lunar outpost is the importance of being first. Clearly we cannot excercise an option between peaceful and military applications unless we are first. The establishment of the initial twelve-man lunar outpost may not in itself provide a realistic military capability for operations on the lunar surface; however, it is the first giant step in that direction. The political implications of our failure to be first in space are a matter of public record. This failure has reflected adversely on United States military, scientific and political leadership. Having been second best in man's first endeavors in space, we cannot afford to be second on any other major achievements.

A wealth of scientific data and experiments can be obtained from a lunar outpost. A number of these are documented elsewhere in the report. Without doubt the scientific community will generate many new and unique applications as man's actual arrival on the moon draws nearer reality. The very absence of knowledge about the moon and outer space is scientific justification to attempt to breach this void of human understanding.

E. MILITARY OBJECTIVES AND STAFF PLANNING

The technical aspects of the three areas of operations for Project HORIZON have been outlined in this volume and are detailed in Volume II. In Volume III these areas are treated in more of an operational context. This complete coverage of the study is not summarized herein in that the necessarily broad scope of the discussion does not lend itself to further condensation.

After considering the elements which affect the choice of operational organizational structure, it is concluded that an Army Space Command is required to control all operational Army activities in space. Staff organization, personnel and administration, intelligence and security, operations and training, logistics and technical service operations are discussed.

F. DEFENSE CONSIDERATIONS

The defense problems associated with Project HORIZON have been divided to correspond to the three principal areas of operation, earth site, orbital station and lunar outpost. Investigations have been made concerning each of these areas.

For this study, some 1,000 pounds of defense weapons were allotted for use at the lunar outpost. While the lunar environment undoubtedly poses difficult problems to many weapon concepts, there are some remarkable extensions of earth capabilities. For instance, DAVY

CROCKETT which has an earth range of 2,190 yards would have a lunar range of 17,000 yards. Unique hand-held versions of Claymore mines offer considerable potential in the non-nuclear field. (Figure I-26.) These and other systems appear to provide the lunar outpost with an adequate early defense capability.

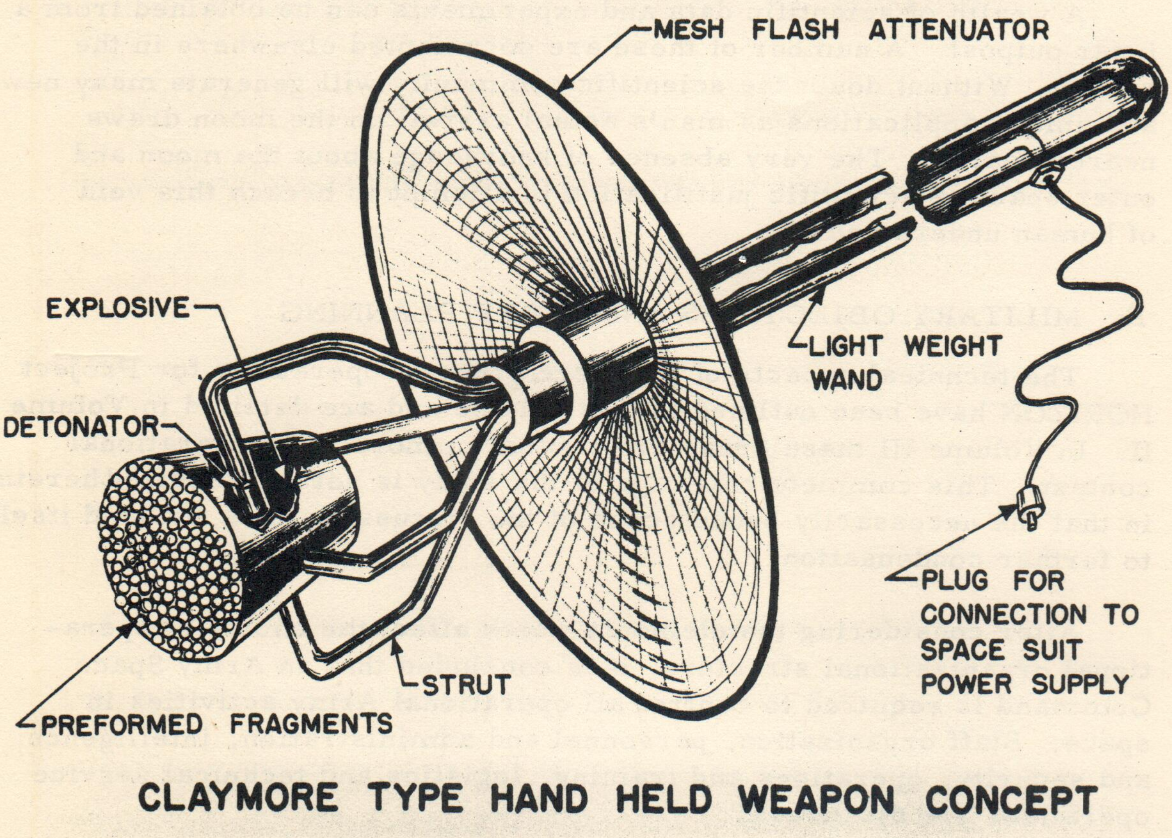

Fig. I-26. Hand Held Claymore Mine

(S) CHAPTER IV: TECHNICAL SERVICES CAPABILITIES AND SUPPORT

A. GENERAL

The success of the Army has always been dependent to a great extent upon the quality of its technical judgement, as well as its tactical judgement. The scientific and engineering resources of the technical services which underlie this technical judgement have developed with the Army's technological requirments. In balanced combination with American industry and the scientific institutions of this country, these government resources have consistently demonstrated their technological and management capability. This is especially evident in the extent to which the Army has contributed to the national space program. The many missile and space "firsts"accomplished by the Army demonstrate its ability to meet the most advanced scientific and engineering challenges within minimum time and dollar limits. There is historic proof of the Army's ability to understand fully the problems in technology and to solve those problems with assurance.

On many occasions this country has been faced with decisions on space projects such as HORIZON, although on a smaller scale. Most of these projects have demanded the shortest possible development time, requiring maximum compression of lead times. These stringent demands have imparted risks not only in time requirements and estimated costs, but in the reliability of the product of the project.

The establishment of a lunar outpost presents challenges of greater magnitude than any other single space project heretofore attempted. Such a program demands the highest reliability in its technical approach, and, equally important, in estimates of its time and cost.

B. RESEARCH AND DEVELOPMENT RESOURCES

The Army technical services presently own and operate approximately $1 billion worth of research and development facilities. With the normal improvement and replacement of facilities projected for the future, Project HORIZON requires an increase in facilities of approximately 10% over current worth.

The R&D resources of the Army include approximately 40,000 personnel, with a high percentage of scientific and engineering personnel, who are capable of conducting and controlling the most advanced effort in the R&D field. These personnel and facilities represent an annual operating expense of over $400 million, and are supported during the current FY by approximately $3/4 billion effort from industry and private institutions.

The combination of skilled personnel and modern facilities in the R&D activities of the Army has kept pace with the requirements of the modern Army and the other services they support, and have made outstanding contributions to the National Space Program. Examples of this competency are found in such areas as:

1. The provision of missiles for land combat, air and missile defense. Included in the Army's missile resources is the large-missile design, fabrication, testing, check-out and launching capability of the Army Ordnance Missile Command. With the proven technical proficiency in this area, maximum reliability can be given to self-contained space vehicles upon which space travelers must rely for existence.

2. Research and development to maintain man's operating effectiveness, unimpaired by any conditions. Extensive effort is spent by the Army on a continuing basis on environmental research and provision of man's needs, where the effects of heat, cold and other environmental conditions upon human physical and psychological performance are studied. Men have been isolated under extreme conditions for up to 40 days in the Quartermaster's large climatic chambers. This effort relates directly to the design of lunar suits, space vehicle and lunar shelter requirements and feeding systems, including the preparation, preservation and production of food under space and planetary conditions.

Many facilities are available for the study of man and the conditions he may face, such as:

a. The Army Medical Services' eleven specialized laboratories from Washington to Puerto Rico to Malaya, where research is conducted in areas such as environmental physiology, radiation, infectious diseases and nutrition, and which includes a complete germ-free laboratory and a whole body radiation counter.

b. The Wound Ballistics Laboratory at the Army Chemical Center, operated by Chemical, Medical, Ordnance and Quartermaster can serve as a means of obtaining design data for space station defense weapons, studying injury occurring with decompression, defensive weapons design data and many other areas.

c. The Quartermaster solar furnace, largest in the free world, capable of delivering 10 K cal/sec.

d. The extensive facilities of the Chemical Corps in the protection of man from biological, chemical and radiological hazards including large land test areas, plants for large-scale production of micro-organisms and a Norton sphere to test exposure of animals to biological aerosol clouds.

3. Electronic research at the Signal Corps R&D Laboratory is carried forward in more than 30 fields. Hardly a missile system or space system has been completed without significant contributions from the Signal Corps' 3500-man laboratory at Fort Monmouth. In such fields as electronic parts and materials, electron tubes, solid state devices, power sources, frequency control and radar, the electronic skills of the Army have been called upon to develop greater performance and reliability in equipment with accompanying reduction in size.

4. Construction Mapping and Engineering Materiel

In its principal laboratory at Ft. Belvoir, augmented by such specialized laboratories as Nuclear Power Laboratory and an Artic Construction Laboratory and others, the Corps of Engineers has developed construction techniques and engineer materiel for application to extremes of environment and for high performance in support of the missile and space field and related activities.

C. MISSILE AND SPACE PROGRAMS

The Army technical services are conducting a significant portion of the U. S. missile and space programs. These programs are being conducted for the Army, for other elements of the Department of Defense, and for non-military government agencies. Although the major share of these programs currently falls within the mission of the Ordnance, Engineer, and Signal Corps, these programs are supported by the applicable resources of the remaining technical services. The programs include:

1. Ordnance Corps

a. As prime developer of Army missile systems, Ordnance has conducted a broad program of rocket and missile development since 1944. Seven Ordnance-developed systems -- CORPORAL, NIKE AJAX, NIKE HERCULES, HONEST JOHN, LITTLEJOHN, REDSTONE and JUPITER -- have been deployed or are ready for deployment. Systems now in R and D include: **MAULER, HAWK REDEYE, LACROSSE, NIKE ZEUS, SERGEANT. and PERSHING.**

b. Ordnance programs being conducted in support of the national space program have an estimated value of some $300 million. These programs began with the launching of EXPLORER I, the first U. S. satellite, and have expanded to include:

(1) SATURN Program - development of a 1.5 megapound booster, the basic element of the first U. S. space vehicle with significant lunar payload capability.

(2) Project MERCURY - a project to place a man in space by means of a ballistic vehicle. Ordnance participation includes manufacture of eight REDSTONE and two JUPITER boosters, mating the payload capsules with the boosters and launching of the capsule which contains the first human passenger.

(3) JUNO II - eleven satellite and space probe firings with the JUNO II vehicle (JUPITER plus upper stages).

(4) Research Projects - Ordnance is directing study programs in virtually every area of missile and space systems development. These projects include research in the fields of radar, propellants, heat rejection, space intercept systems, and ballistic missile defense.

2. Corps of Engineers

a. As the largest single construction organization in the world today, the Corps of Engineers is constructing missile bases and launching sites and facilities wherever the requirement exists.

b. The Army Map Service is currently working on a project to map the moon.

c. Research, development, and procurement projects totaling almost $9 million are being conducted in support of Ordnance missile systems development programs. This effort includes development of such items as propellant generation, storage and transfer equipment, power plants, shelters and other system components.

3. Signal Corps

The Signal Corps is conducting eleven missile and space projects for Department of Defense agencies and for NASA. The projects have a projected gross value of some $70 million.

a. Satellite projects

(1) Completed - Signal Corps has contributed to VANGUARD, Project SCORE (the first communications satellite), and other U. S. satellite and space probe projects.

(2) Current - The Signal Corps is conducting a number of satellite and satellite systems programs for the Army, for NASA, and for ARPA. These include: Project TIROS (TV and infrared scanning), the Courier communications satellite, and a communications system much larger in scope than Courier.

b. Surveillance - The Ordnance and Signal Corps are jointly sponsoring a contract to prove the feasibility of placing a television camera and transmitter in the warhead of a missile for surveillance missions.

D. OPERATIONAL RESOURCES

It is the mission of the technical services to provide continuing support to the peace-time operations of the Army, and to maintain a readiness to extend that operational support to the demands of national emergencies. This mission is complete, extending from research and development through field support.

This will involve not only the Army technical services but also the Navy and Air Force in areas such as recovery operation for personnel and boosters, and for more conventional transportation. Construction of the launch site and other facilities will be within the normal mission of the Corps of Engineers. The assurance of the health of personnel at the launch site, and the special provisions for the departing and arriving space travelers, will call for direct support from the Army Medical Service. This will be of great importance, particularly if the selection of the equatorial launch site is in an area of tropical climate with its attendant disease and sanitation problems.

The global missions of the Signal Corps for world-wide communications and the Corps of Engineers for construction and mapping are extended to provide the earth-lunar communication link and the inclusion of the lunar surface as base for the Corps of Engineers.

(S) CHAPTER V: PROGRAM SCHEDULE AND COST

A. A summary of the projected HORIZON technical accomplishments is illustrated in Figure I-27. This schedule is realistic and fully achievable if adequate and timely fiscal support is given. The Army has established an exceptional record for its ability to meet development schedules as promised. Army developmental agencies are proud and jealous of this record. The proposed development schedule is presented after careful analysis of the problem by these agencies and in full realization of the importance to the nation of the accuracy of time estimates in the program.

SUMMARY OF HORIZON ACCOMPLISHMENTS

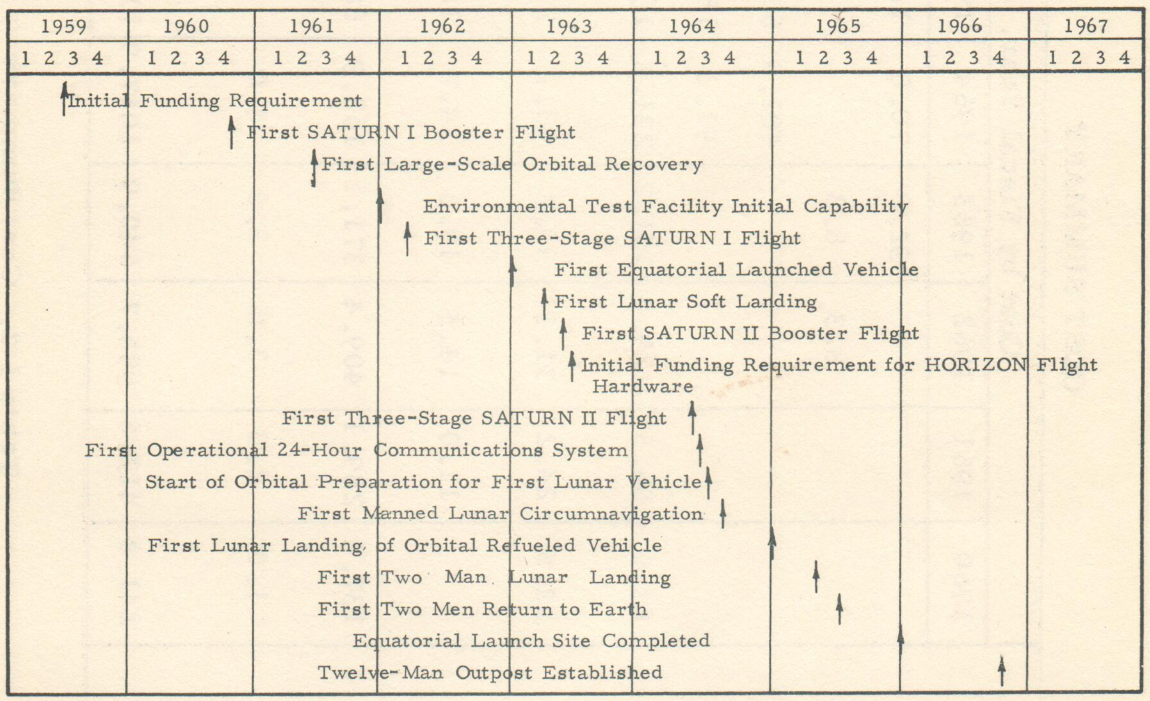

Fig. I-27 HORIZON Technical Accomplishments

B. Table I-2 is an overall cost summary of the entire program. The details may be found in Volume II. Every effort has been made to make the cost data present a complete package which includes all essential elements of the program and not a misleading partial program extract. Where assumptions are made concerning other supporting developments, they are clearly stated.

COST SUMMARY

Item	Cost by Fiscal Year, in millions of dollars									
	1960	1961	1962	1963	1964	1965	1966	1967	1968	Total
Outpost				52.0	70.0	10.0				132.0
Orbital Station			8.3	8.3						16.6
Vehicles					401.8	636.8	747.2	382.0	20.0	2187.8
Payload Containers					91.2	151.8	151.5	60.4	5.0	459.9
Launching Site and Operation	81.0	86.5	129.4	151.2	221.2	191.1	182.8	180.1	85.8	1309.1
Communications and Electronics	22.8	24.2	31.1	35.7	43.1	27.0	21.7	18.6	9.4	233.6
Personnel Training		11.0	14.5	19.6	24.7	18.7	10.7	10.2	4.7	114.1
Research and Development	137.0	289.1	409.4	371.1	162.9	68.2	47.2	35.1	19.7	1539.7
Program Management	1.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	1.0	21.0
TOTAL	241.8	412.8	595.7	640.9	1017.9	1106.6	1164.1	688.4	145.6	6013.8

Table I-2. Cost Summary

(S) CHAPTER VI: RECOMMENDATIONS

It is recommended that:

1. Project HORIZON be approved in concept and the Army be directed to proceed with the program. Funds for the program should be from sources other than the established Army budget.

2. Phase II of the program be immediately authorized and funded. This will lead to a comprehensive Development and Funding Plan for the program. Preparation of this plan will take eight months from date of receipt of authorization and necessary fiscal support. A total of $5.4 million dollars is required to complete this phase of the program.

3. Further appropriate funding as shown be provided to support design, construction or procurement of long leadtime items, especially launch facilities and R&D test facilities.