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USES OF SATURN

by

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USES OF SATURN

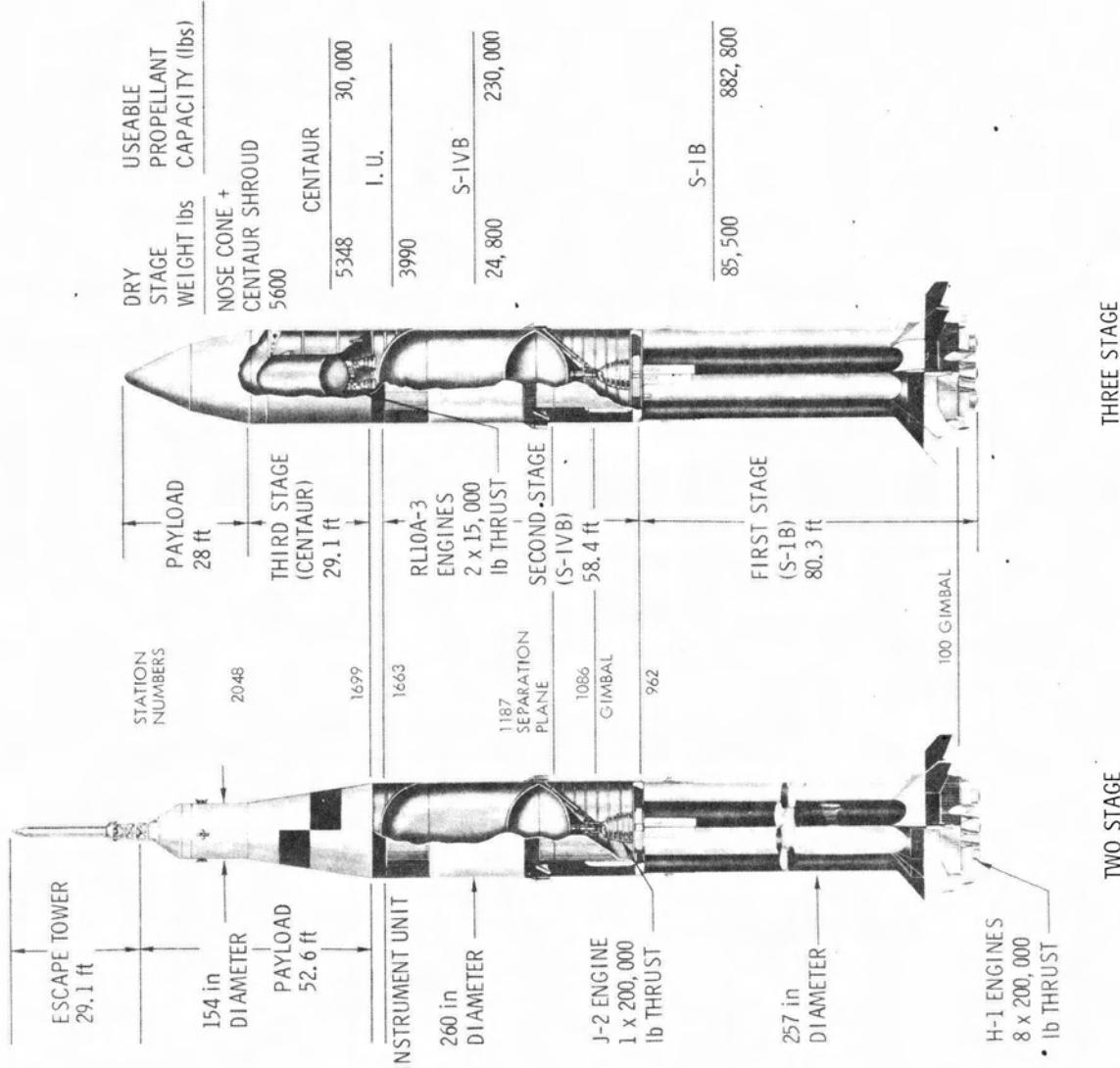
Abstract

Saturn and Apollo hardware will not have realized their ultimate potential for space exploration after the project lunar landing is complete. To accomplish the Apollo lunar landing program, an immense backlog of technology, facilities, and booster capability will have been built up, and we believe proper utilization of this resource will fill the needs for planetary, lunar, and earth orbital space exploration for years to come. In achieving the Apollo lunar objective, large investments will have been made in launch facilities, tracking systems, propulsion technology, re-entry systems, lunar landing systems, and rendezvous technology, to name only a few. Although these specialized areas have been pointed toward the lunar exploration mission, numerous studies by NASA and industry have demonstrated the feasibility of using the spacecraft, vehicles, and operating techniques for missions far beyond the lunar landing. In this paper, I will discuss some of these Saturn/Apollo missions which lie beyond the Apollo lunar landing program. By identifying these advanced uses of Saturn/Apollo hardware to meet important national goals, we can amortize the large cost of the Saturn/Apollo program across a much wider spectrum of missions.

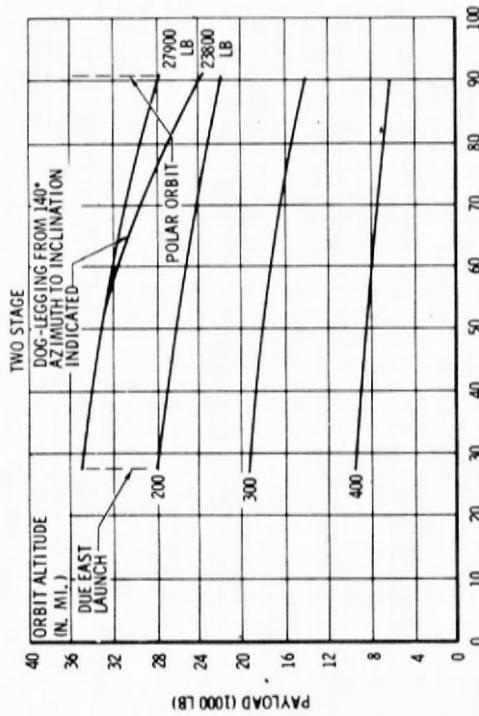
Saturn, the vehicle designed for one mission, will meet the needs of the country in space exploration for many years to come. Since both the Saturn IB and Saturn V versions were designed for manned application from the outset, we can expect the continuation of the outstanding reliability record already begun by the Saturn I vehicle. By using Saturn over the widest base of missions, cost per unit will decrease and the nation's investment in the future will pay rich dividends in new knowledge, prestige, and world leadership.

Saturn has a future in space.

SATURN IB CONFIGURATIONS



SATURN IB PERFORMANCE

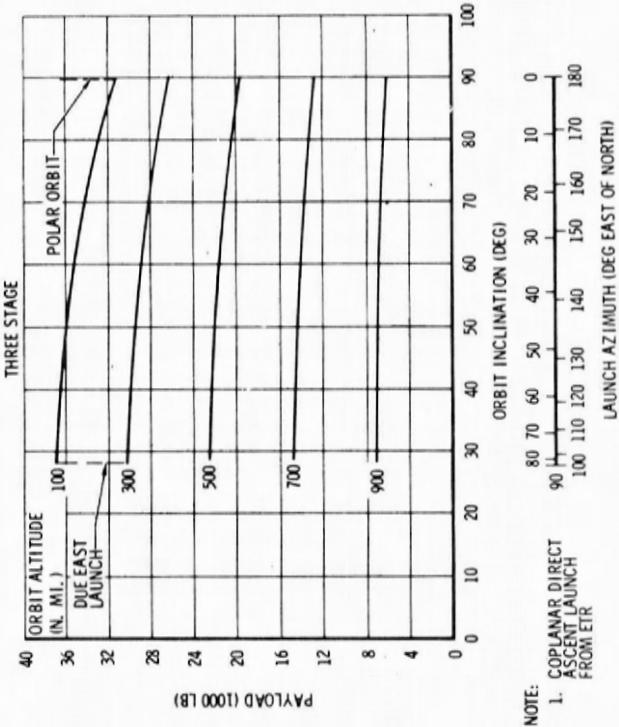


NOTES:

- COPLANAR DIRECT ASCENT LAUNCH FROM ETR
- RANGE SAFETY

LAUNCH AZIMUTH (DEG EAST OF NORTH)

ORBIT INCLINATION (DEG)

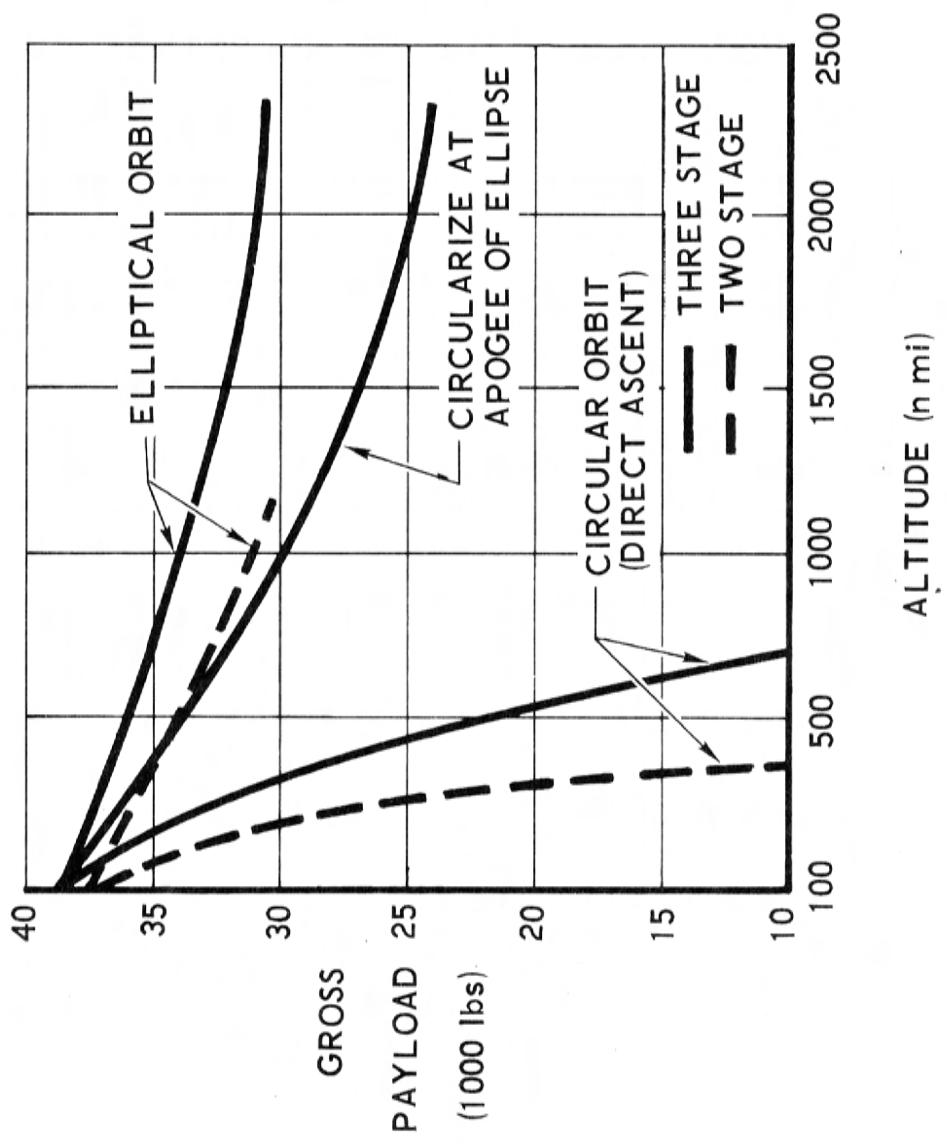


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SATURN IB PERFORMANCE



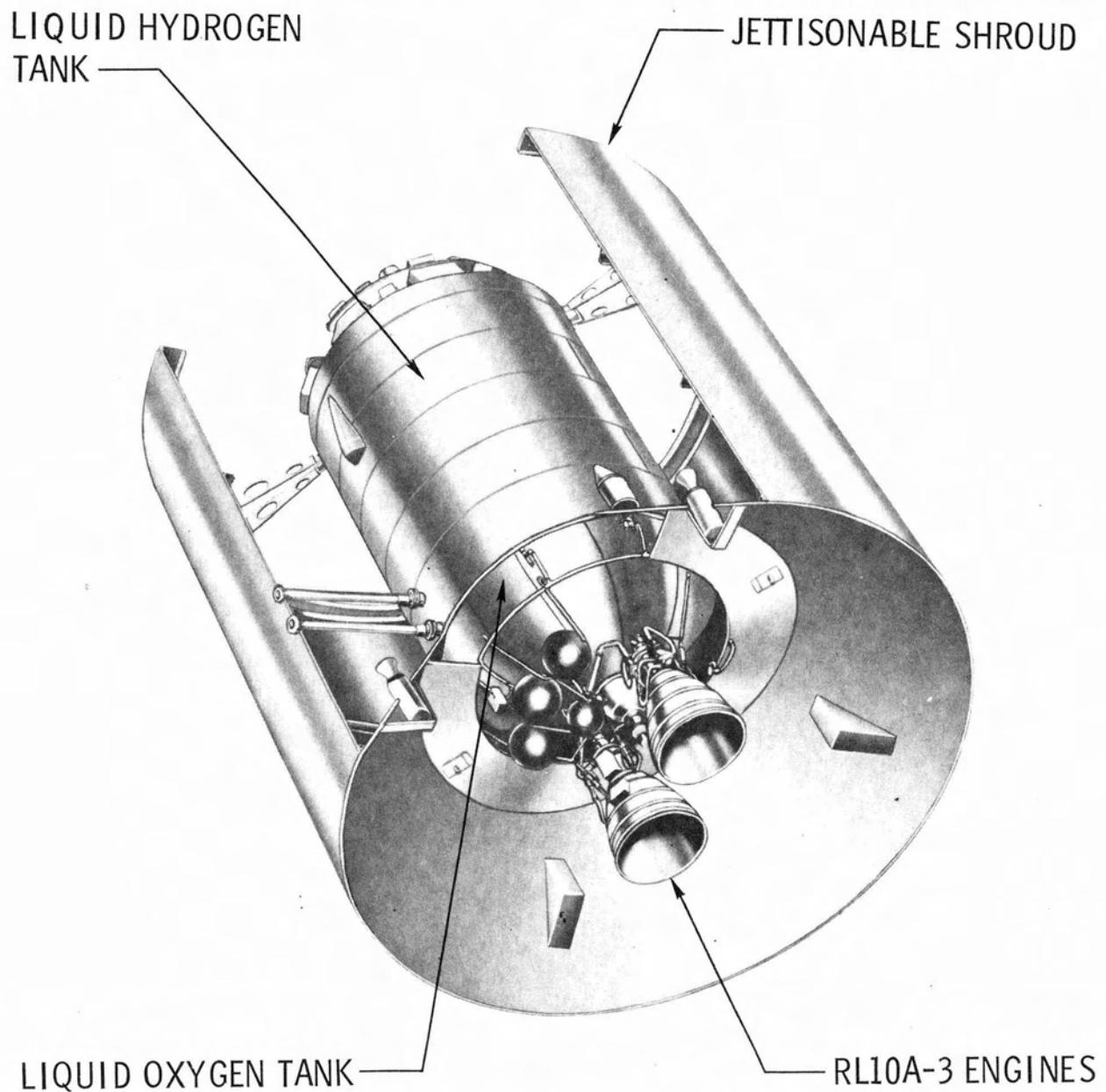
USES OF SATURN

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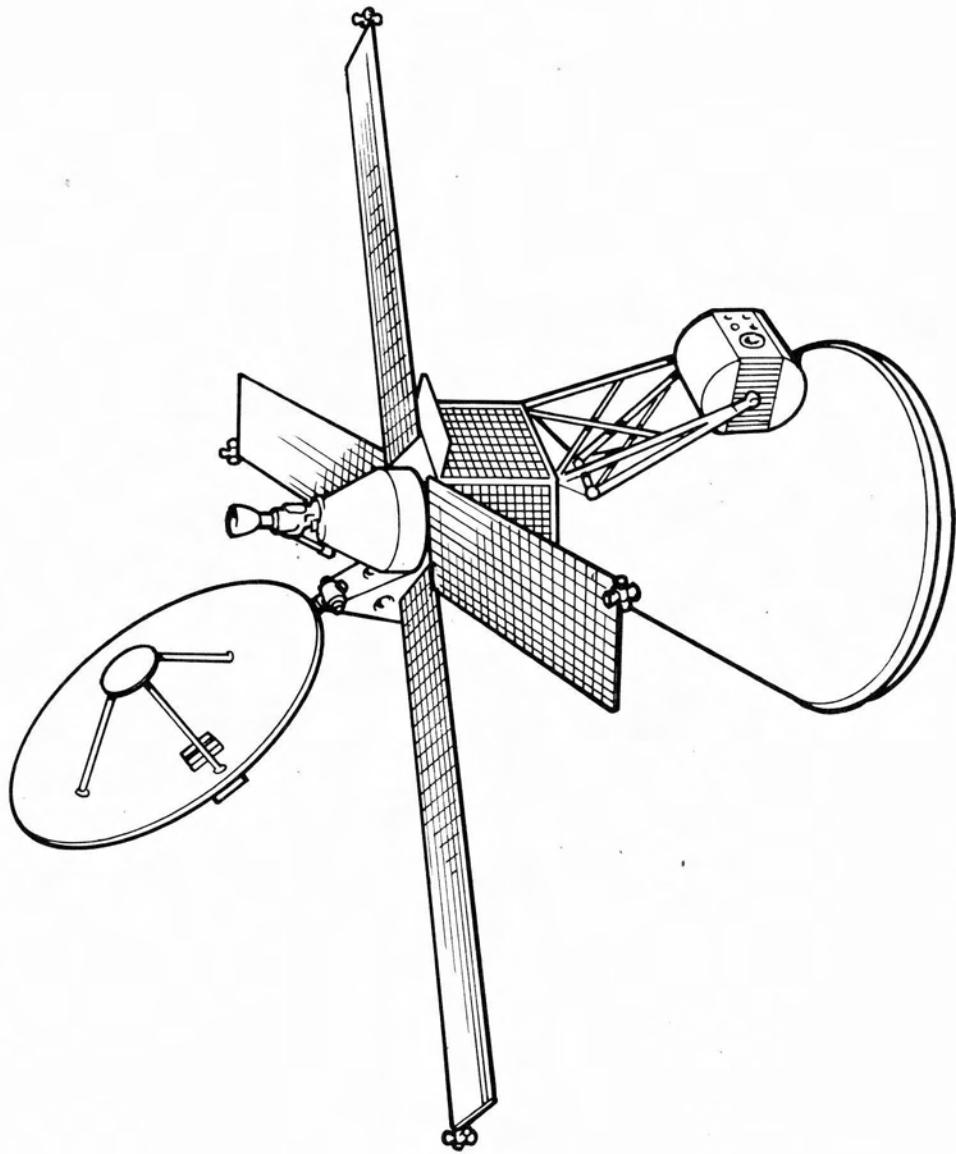
The Saturn IB vehicle (Figure 1) has been designed to place the Apollo command module, service module (partially loaded) and lunar excursion module in earth orbit for practice rendezvous, re-entry tests, and command and control system operations. The vehicle has the capability of placing 35,000 pounds into a 100 nautical mile orbit. The S-IVB stage itself can provide attitude control for 4-1/2 hours after injection. If a Centaur third stage is added to this two stage configuration, the Saturn IB vehicle has an escape capability of approximately 12,000 pounds. Figure 1 also shows the three stage vehicle. Performance of the Saturn IB is shown in Figures 2 and 3, both for the two stage and three stage versions.

The third stage being considered for use with the Saturn IB vehicle is the Centaur. This stage can be used essentially as it is designed for the Atlas Centaur application and only minor changes are required to the basic Saturn IB vehicle to accept it. The Centaur stage itself is shown in Figure 4. It uses

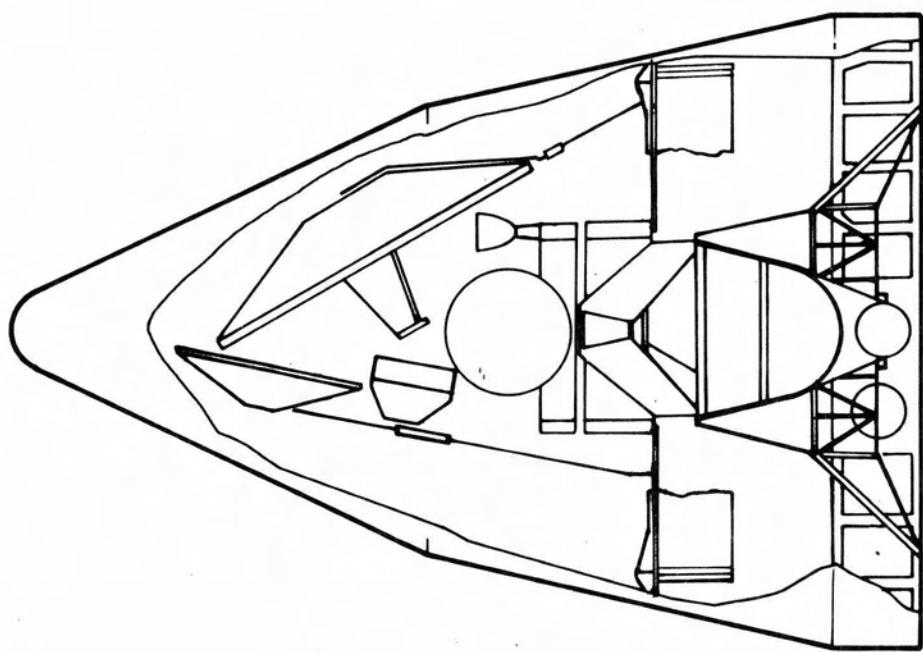
THIRD STAGE (CENTAUR)



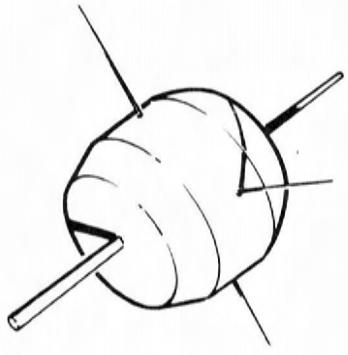
VOYAGER



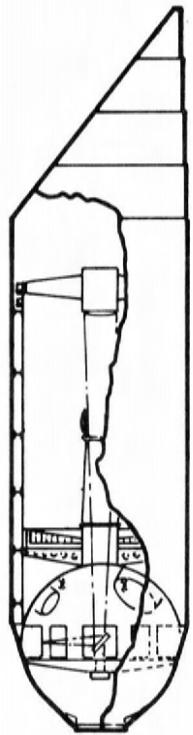
VOYAGER



SYNCHRONOUS ORBIT OPERATION 22,000 S MILES



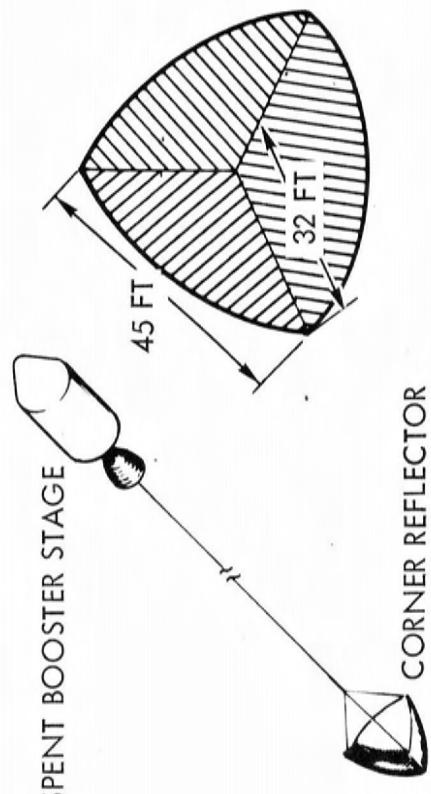
GLOBAL COMSAT SYSTEM



SPACE OBSERVATORY 60 INCH TELESCOPE



OPERATIONAL WEATHER SATELLITE



NAVIGATIONAL AID SATELLITE

two Pratt and Whitney RL10 LOX/LH₂ engines, which are the same engines that are used in the Saturn S-IV vehicle. As shown in Figures 1 and 4; the Centaur vehicle is surrounded by an outer shroud which carries a portion of the payload structural loads to the S-IVB. The shroud itself provides insulation to the Centaur and is jettisoned during second stage burning. Because the Centaur possesses capability for multiple restarts and has a very high mass fraction, it is well suited for this third stage application.

The National Science Foundation has recently recommended to Mr. Webb that NASA consider Martian exploration as an important high priority program. To this end, the Jet Propulsion Laboratory has recently issued request for proposals for the Voyager payload (Figures 5 and 6). This unmanned probe of Mars will be launched sometime in the early 1970's on the three stage Saturn IB vehicle. Specific experiments to be performed by Voyager include:

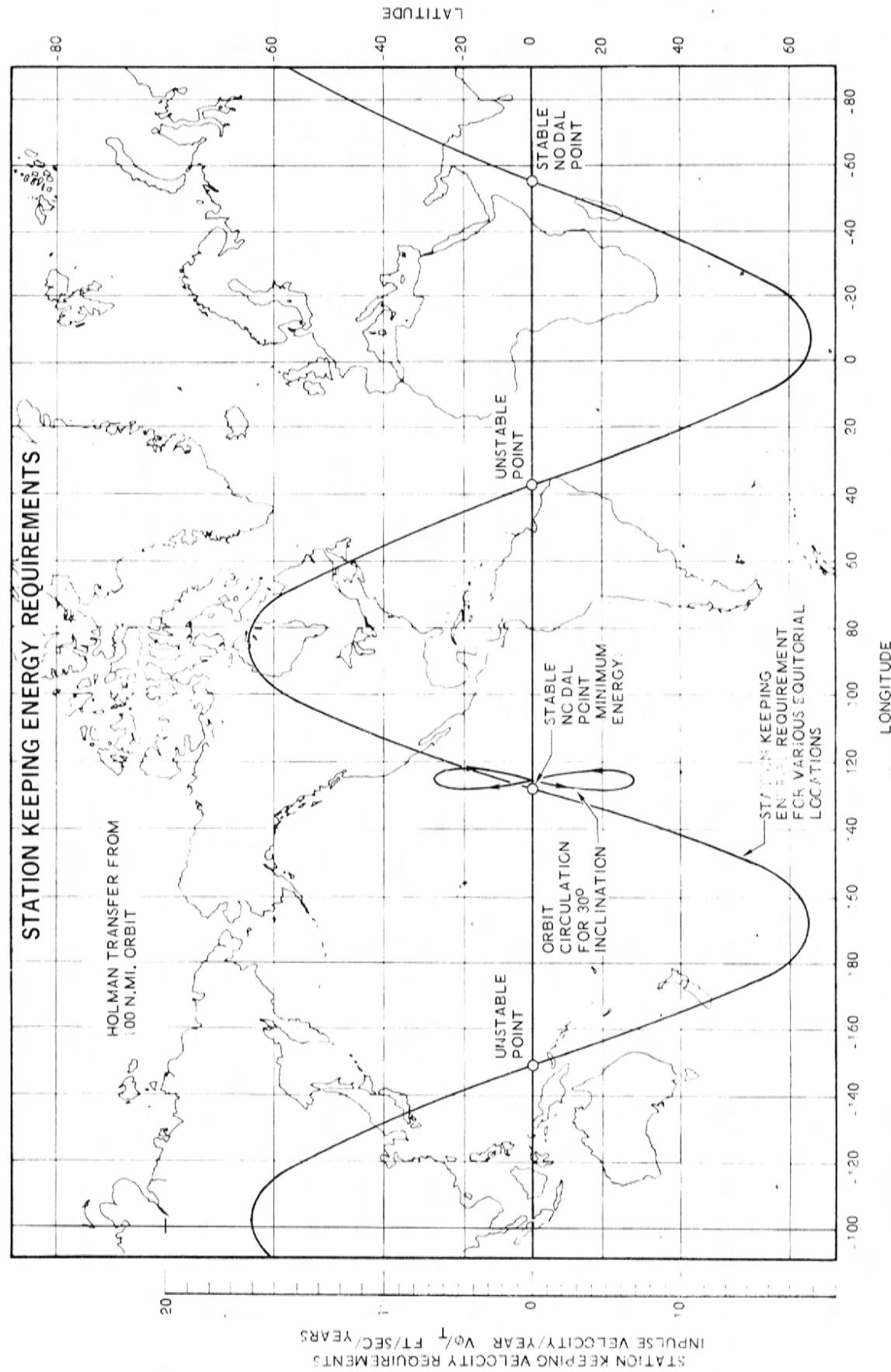
1. Sensing space environmental conditions during the transfer orbit
2. Determination of Mars atmospheric constituents
3. Interaction of energetic particles with planetary atmospheres and fields, electric, magnetic, and gravitational fields
4. Investigation of planetary structure and surface features, as well as extraterrestrial life.

When Voyager reaches the vicinity of Mars, a small retro rocket will place it in orbit around the planet. From this Martian orbit, it will release probes to the surface of Mars. These probes will sample geological and microbiological features and relay their findings back up to the orbiting spacecraft for transmission to earth.

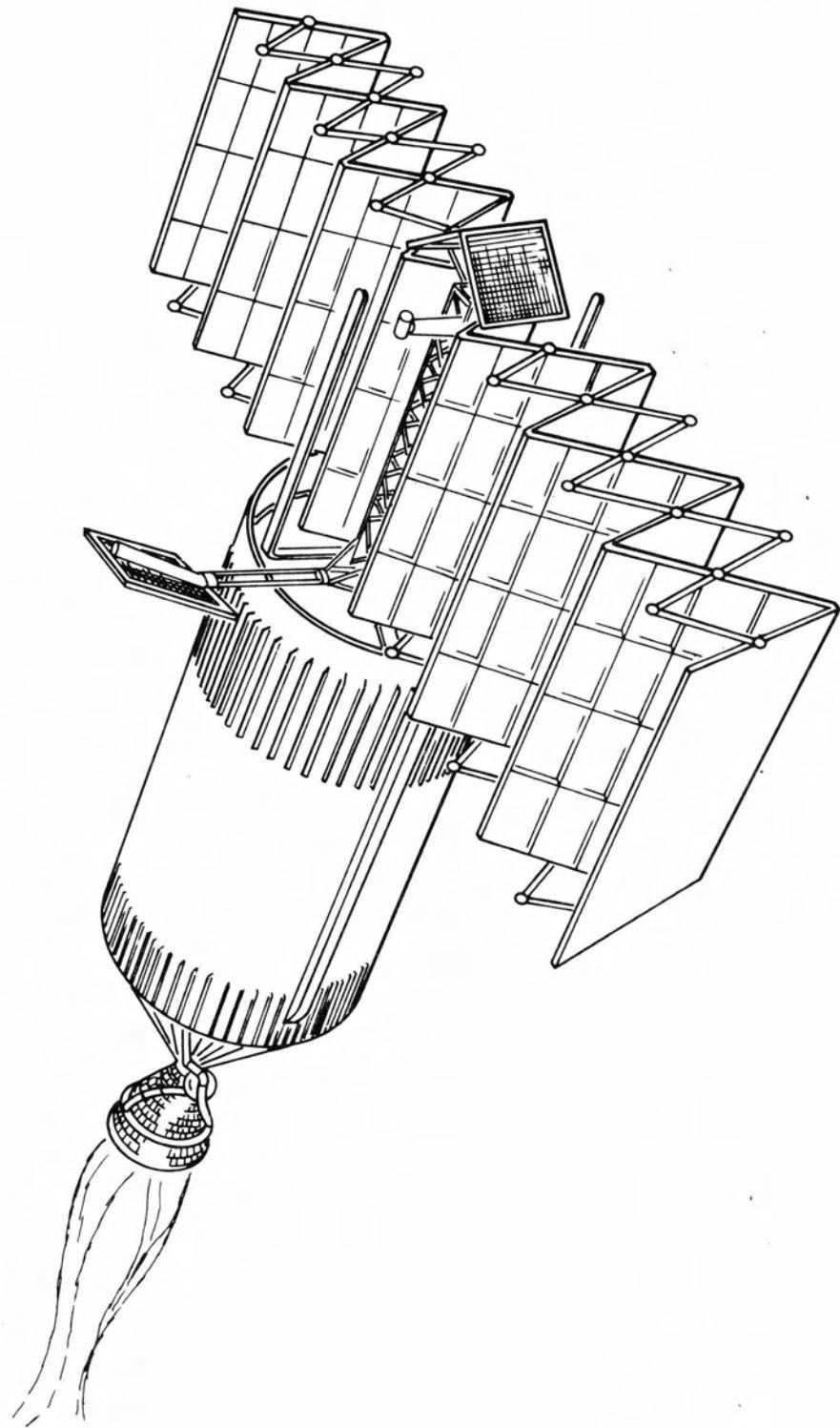
But the three stage Saturn IB has capabilities which go even beyond the Voyager application. For example, this vehicle can carry 9800 pounds of payload to synchronous orbit. With payloads of this magnitude available, Saturn IB can be considered for such missions as large orbiting telescopes, very large synchronous communication satellites, navigational aids, and weather surveillance from a fixed point above the earth (Figure 7). In each of these cases, previous mission analyses have placed these types of payloads in low earth orbit because of vehicle performance limitations.

SATURN IB LAUNCH TO 24 HR SYNCHRONOUS ORBIT

S-IVB-1660



CIRCUMLUNAR PEGASAS
S-IVB STAGE



Now, the three stage Saturn IB can place these payloads in synchronous orbit and obtain the advantage of fixing the payload with respect to a geographical point over the earth. It is interesting to note that at an altitude of 22,000 miles, the synchronous orbit altitude, there exist two nodal points where a satellite will be in stable orbit. This results from the fact that the shape of the earth is distorted from a perfectly symmetrical, oblate spheroid. At these points, which are longitude 130W and 55E, theoretically, no propellants are required for orbit keeping and the satellite will remain stationary. At all other points on this orbit over the equator, some station keeping propellants are required, but even at worst, these requirements are quite small, as shown in Figure 8.

The three stage Saturn IB could also be used for other high energy missions of interest in planetary exploration. For example, with a high energy fourth stage, 4000 pounds of payload can be sent on a solar probe, far planet exploration with a payload of 1000 pounds, and out-of-the-ecliptic probes with payloads of 2000 pounds. In each of these missions, the solid propellant engines could be the same as that carried in the Voyager for retro impulse at Mars.

Another mission being considered for the three stage Saturn is the circum-lunar Pegasus flight. The Saturn I vehicle has launched a Pegasus into low earth orbit and two more are planned. However, after these flights, the question of micrometeoroid environment in translunar and circumlunar flight will still remain unanswered. The Saturn IB provides an ideal platform for this mission, since it can boost 12,000 pounds to a lunar escape velocity. With this escape capability, a modified Pegasus (Figure 8A) could be sent into a figure eight mission around the Moon and provide advanced data on the environment which Apollo will encounter in its lunar flight.

Of course, there are advanced assignments for the Saturn IB vehicle which will occur after lunar exploration has been initiated. The vehicle can be used for lunar logistics supply or it can furnish a communications satellite to orbit around the Moon in support of extended lunar exploration and backside communication.

Thus, it appears that the Saturn IB with a third stage can satisfy a host of planetary exploration missions. Because this vehicle will operate from launch pads 34 and 37 already in existence at KSC, these missions can be mounted without interference to the parallel Saturn V operations at pad 39. Furthermore, the continued use of the Saturn vehicle will reduce the cost per vehicle flight to something on the order of \$500 per pound for low earth orbit (two stage), or \$1300 per pound to escape velocity. These figures include vehicle cost and launch operation cost, but do not include tracking, data acquisition, payload or research and development amortization.

NASA is considering a series of missions with the Saturn IB and Saturn V vehicles known as AES (Apollo Extension Systems). In this series of missions, the Saturn vehicles would boost Apollo and LEM hardware with special accessory equipment into orbit and space exploration missions primarily for collection of near earth translunar and lunar scientific and engineering data. The concept is basically this: The family of flight-proven and manrated hardware developed for the Apollo landing program can be used in a broader spectrum of missions to accomplish national goals in the most timely and economical way. An Apollo spacecraft with a partially loaded service module would, for example, be boosted into low earth orbit to accomplish scientific research on the effect of high vacuum and weightlessness on engineering materials or biological specimens. The partially loaded service module could provide propulsion or orbital maneuvering with the spacecraft. This maneuvering capability could permit orbital plane changes or Hohman transfer from one orbital altitude to another. It might also be used to permit the Apollo module to rendezvous with other spacecraft in orbit.

National press media reporting on this program have also discussed typical assignments for AES. These include:

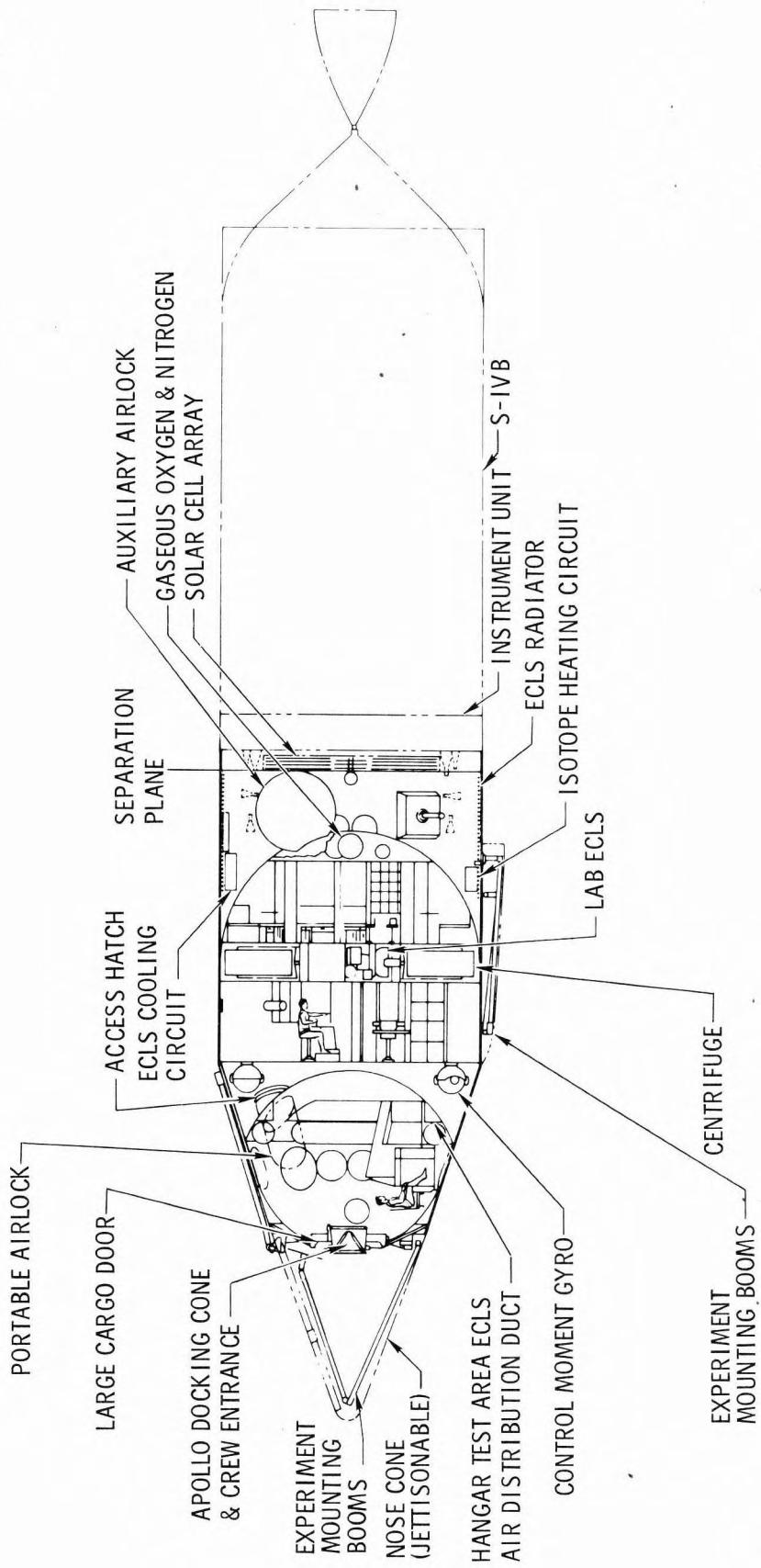
1. Transmission of TV pictures directly to homes on earth
2. Mapping and observation of the earth's surface by Apollo spacecraft in polar orbit
3. Testing of new propulsion systems and space suits
4. Retrieval of Echo balloons
5. Astronomical observations
6. Studies of lunar surface topography and surface composition using multispectral photography and selenodesy

This program will use hardware which is unmodified from the basic Apollo design. The program could involve the use of six Saturn V vehicles and six Saturn IB vehicles per year with the first manned orbital flights coming as early as 1968. The uses of this type of hardware are extremely varied. For example, one application envisioned is the employment of several Surveyor spacecraft to the surface of the Moon from an orbiting command module without the LEM stage. The Surveyors could be placed so that their path on the lunar surface converged to one spot, where an Apollo crew could collect them without need for long term shelter.

This concept has given rise to a call from NASA/Headquarters to potential experimenters. Throughout the country, universities and members of industry have been asked to propose scientific and engineering experiments for flight aboard Apollo missions. Some experiments have already been accepted for use on Apollo, and we understand that the interest among the scientific community for space on these missions is quite high.

After AES, NASA may elect to provide space stations of the MOL class. This type of space station will house approximately six men. Its major purpose will be to accomplish larger scale scientific and technological experimentation in space (Figure 9). The MOL can be launched by the Saturn IB into low inclination orbits and into polar orbits by Saturn IB or Saturn V. Since each MOL will remain in orbit for very long periods,

MORL SPACE STATION



logistic resupply will be necessary. In these logistic missions, Saturn IB vehicles can provide the booster impulse required. Crew changes will also be required, and Saturn IB vehicles can boost Apollo to rendezvous with the MOL. A large space station in orbit is a logical next step after the AES program, because it provides for longer stay times and more complex experimental apparatus, particularly for those types of experiments involving more than one man.

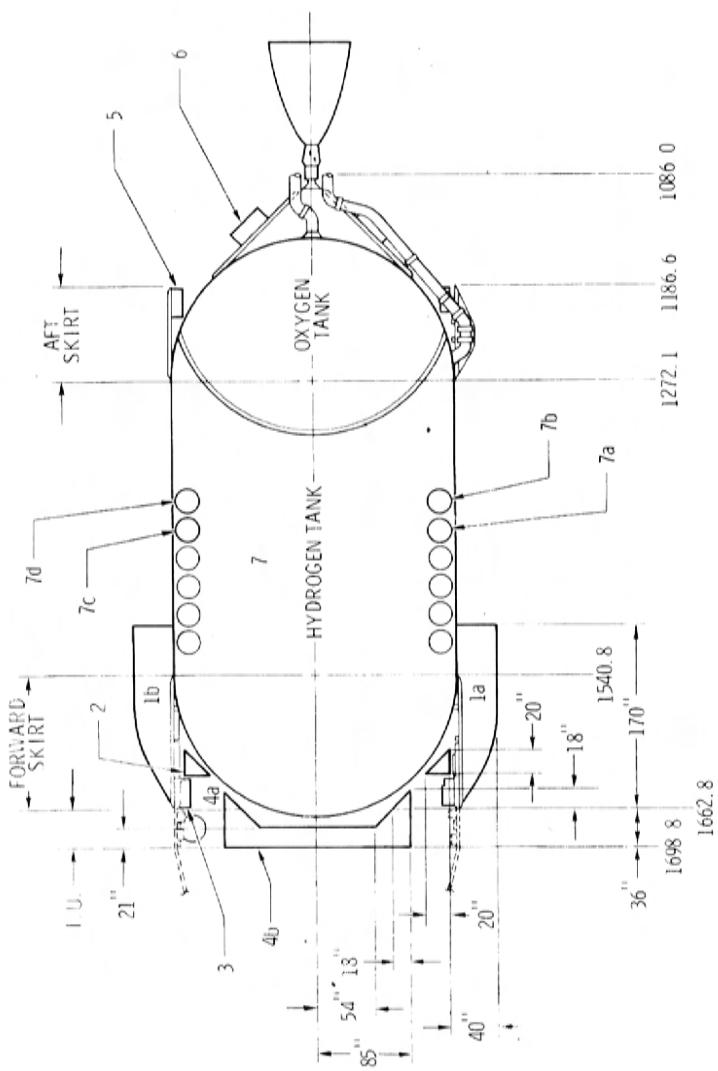
Many Saturn flights will be able to accommodate auxiliary experiments or payloads. Similar to studies presently being focused on the auxiliary payload carrying capability of the command, service, and lunar excursion modules, we are investigating and defining a variety of experiment volumes on the S-IVB stage (Figure 10) which are suitable for auxiliary payloads. In addition, we are publishing a Saturn IB Payload Planner's Guide to assist the sponsor of an auxiliary payload in placing his payload on Saturn vehicles much the same as our Aircraft Division conducts aircraft route studies to meet the airline's requirements.

Our forthcoming orbital hydrogen experiment is one example of an auxiliary engineering payload which will be flown on Saturn IB. The objective of this experiment is to study the behavior of liquid hydrogen under zero g conditions under low accelerations that can be required to manage the propellant for stage relight.

The Saturn V vehicle represents the largest booster available to the world. It can place 250,000 pounds in low earth orbit and escape payloads in excess of 95,000 pounds. With this type of capability available, very large scale solar system exploration may be undertaken. For example, the Saturn V vehicle on a direct ascent mission can send 90,000 pounds to the Moon and 60,000 pounds to Mars (Figure 10A). With an optimally sized fourth stage, the performance to the far planets can be significantly increased. For example, Saturn V in this case can send 7000 pounds to Pluto. Incidentally, this fourth stage is quite close to the Centaur and the problems of mating the Centaur with the S-IVB and IU will, of course, have been solved in the three stage Saturn IB vehicle. Use of the fourth stage (Figure 11) will not only permit quite large payloads to be sent to the far planets, but will reduce trip times significantly to the near planets.

SPACE - PAC CONCEPT

SPACE-PAC CONCEPT
SIVB AUXILIARY PAYLOAD VOLUMES



VOL. NO	LOCATION	VOLUME	PAYOUT WEIGHT, LBS
1a	FWD. SKIRT - EXT.	78 FT ³	1,100
1b	FWD. SKIRT - EXT.	78 FT ³	1,100
2	FWD. SKIRT - INT.	109 FT ³	1,000
3	FWD. SKIRT - INT.	24 FT ³	900
4a	FWD. SKIRT - INT.	45 FT ³	2,500
4b	I.U. - INT.	380 FT ²	-
5	AFT SKIRT - INT.	8 FT ³	-
6	THRUST STRUCTURE	INDEF.	-
7	HYDROGEN TANK	-	-
7a-d	HYDROGEN TANK	3.5 FT ³ EA.	-

SATURN V PERFORMANCE

THREE STAGE LAUNCH VEHICLE

90,000 POUNDS PAYLOAD TO THE MOON IN 72 HOURS

60,000 POUNDS PAYLOAD TO MARS IN 100 DAYS

FOUR STAGE LAUNCH VEHICLE

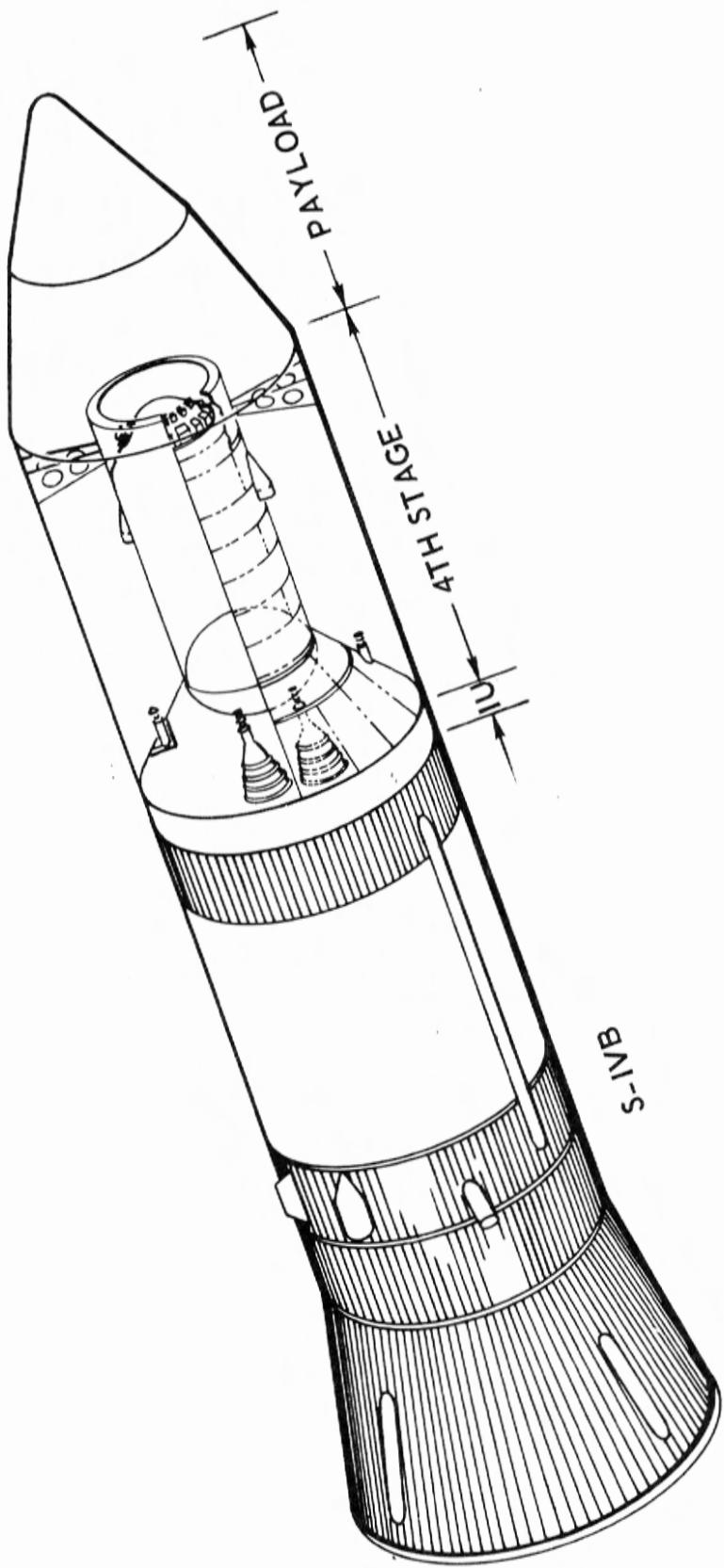
7,000 POUNDS PAYLOAD TO SATURN

7,000 POUNDS PAYLOAD TO SATURN IN 2 YEARS

7,000 POUNDS PAYLOAD TO PLUTO IN 10 YEARS

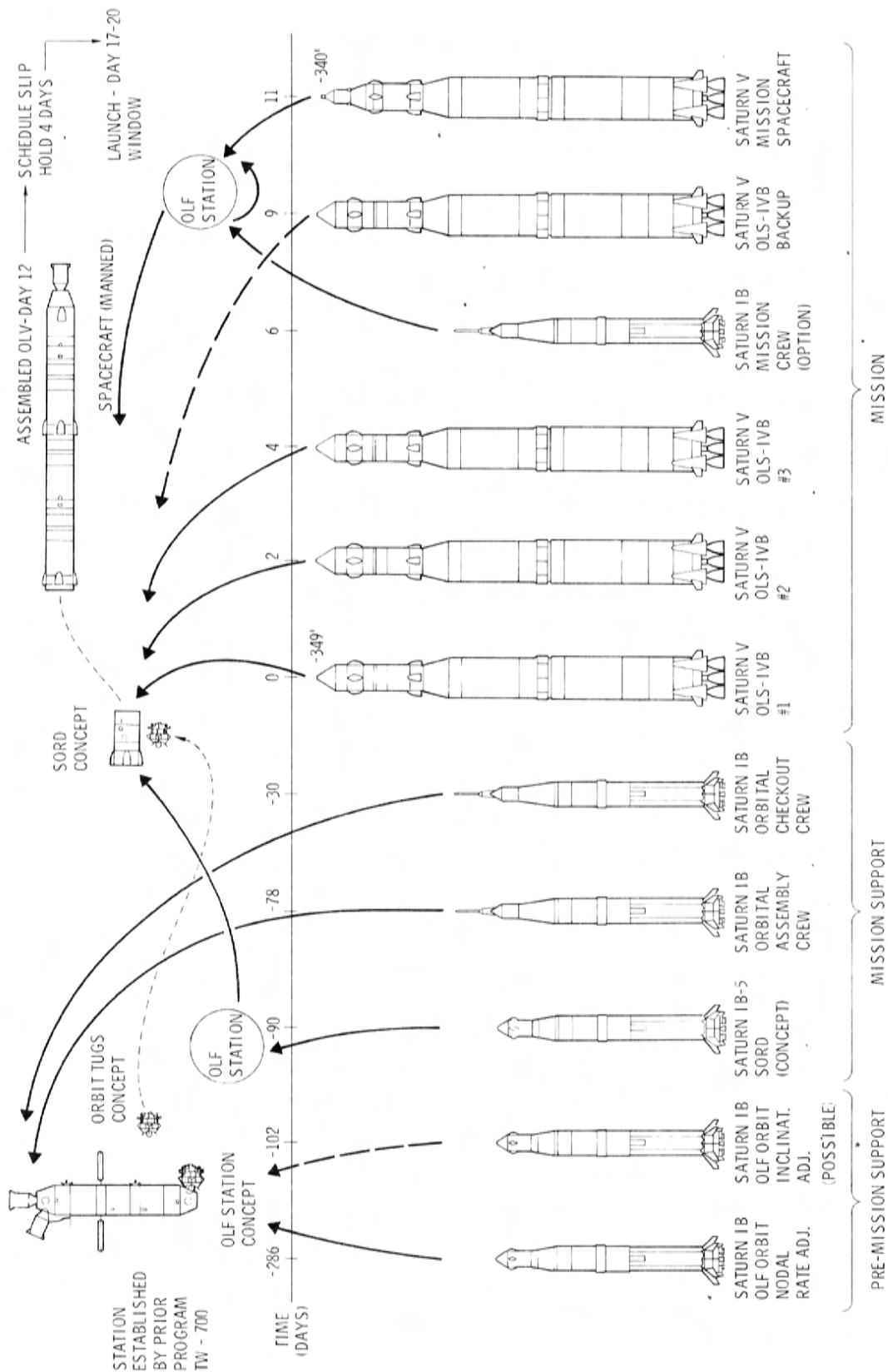
7,000 POUNDS PAYLOAD TO 1/10 Δ.U. PROBE IN 150 DAYS

4th STAGE FOR SATURN V FOR DEEP SPACE MISSIONS

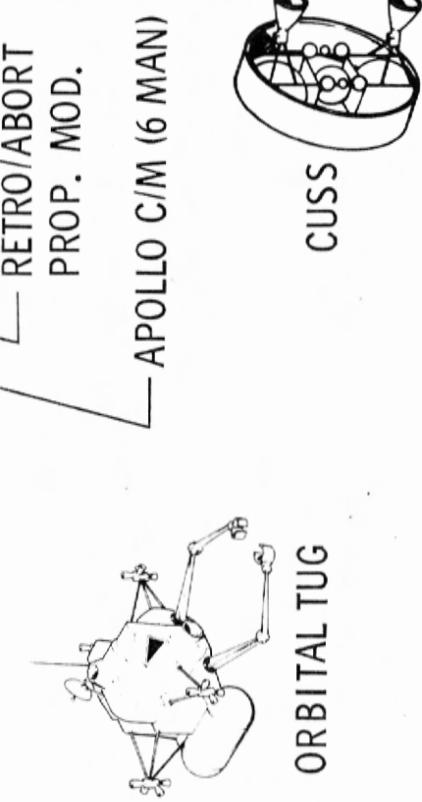
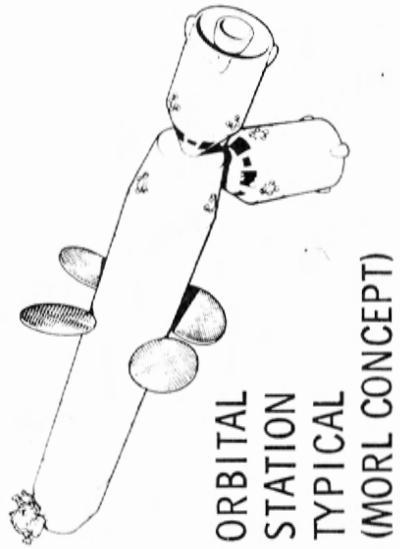
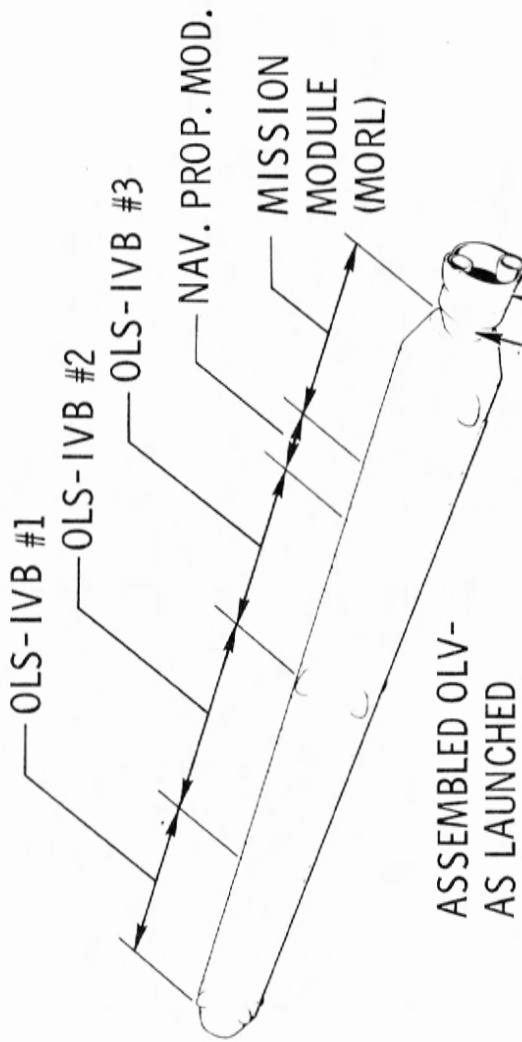


We have studied the use of the Saturn V in manned planetary exploration missions. We have studied a mission in detail, for example, which involves the flight of a six-man spacecraft past the planet Mars in the 1977 time period. This mission involves earth orbit assembly of fueled S-IVB's with a spacecraft whose design is evolved from a MOPL space station module and an Apollo command module with suitable mid-course and retro propulsion added. In the mission envisioned (Figure 12), two Saturn V vehicles launch fueled S-IVB's into earth orbit. The S-IVB's are docked with a "SORD" which serves as an orbital dock and checkout station. When the S-IVB needs to vent, the SORD provides forward acceleration for propellant settling. The maneuvering of the S-IVB to rendezvous is accomplished by a jettisonable cryogenic stage made up of hydrogen/oxygen propellant containers and two RL10 engines. After the first S-IVB has entered orbit, the CUSS is removed and the second S-IVB is launched and mated with the first. A third Saturn V launch places the mission spacecraft into orbit. This unit is maneuvered to rendezvous and docking by a third CUSS. Thus, the stack assembled in orbit is an S-IVB, an S-IVB, a MORL mission module, and the spacecraft. The hardware in orbit is shown in Figure 13. The spacecraft itself is based on the MORL work which DAC accomplished for Langley Research Center and is shown in Figure 14. It may be seen that the spacecraft is composed of a probe room, from which Martian experiments are launched during the passage of the planet, a control room containing a bio-shield for protection against solar flares during transit, a centrifuge for producing periodic gravity exercise for each crewman during flight, and an auxiliary propulsion system for providing mid-course corrections. The Apollo itself is carried with the spacecraft for eventual return through the earth's atmosphere. A retro module attached to the Apollo provides braking in the vicinity of the earth. The mission itself is depicted in Figure 15. Flight time is approximately 670 days. The scientific observations are conducted throughout the entire flight; the most intensive period of Mars exploration is accomplished during the several days of twilight fly-by. After passing Mars, the spacecraft swings out toward the asteroid belt. The recovery sequence of the Apollo spacecraft is similar to that planned for the lunar flight.

ELEMENTS OF THE MANNED MARS FLYBY PROGRAM

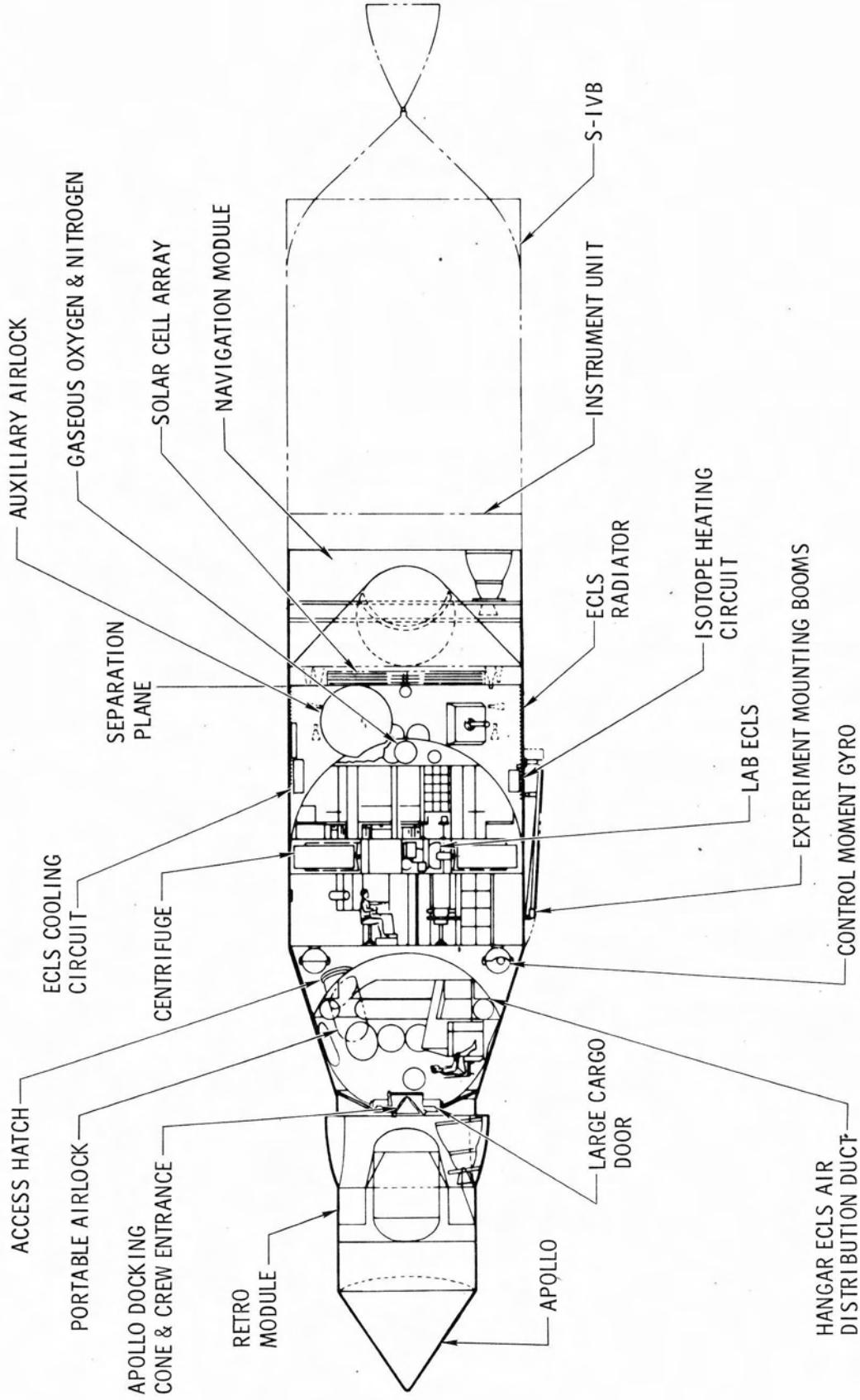


ORBIT LAUNCH VEHICLE AND SUPPORT ELEMENTS



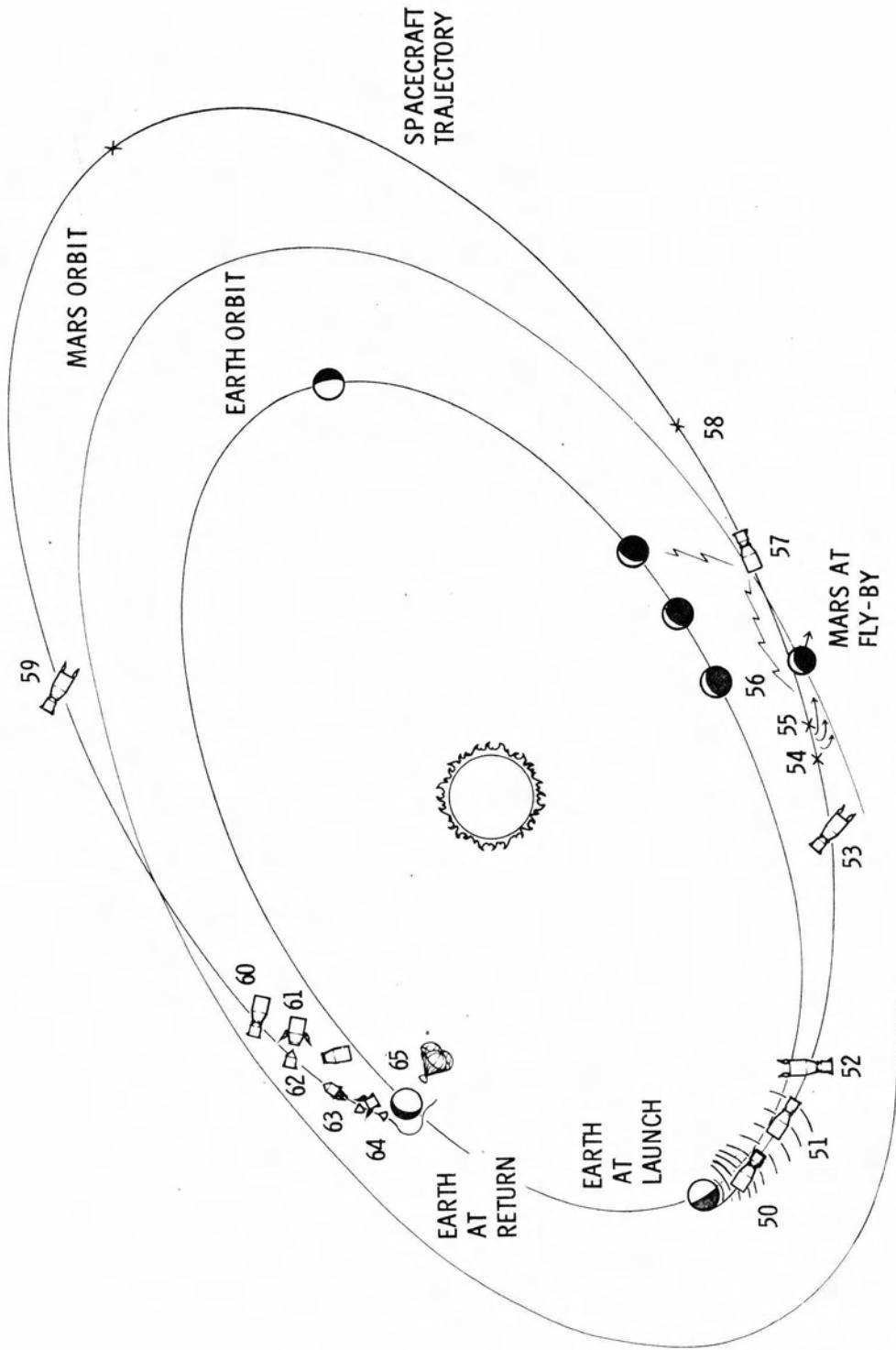
MISSION MODULE SPACECRAFT

S-IVB-1618



INTERPLANETARY MISSION PROFILE

S-IVB-1594



It is significant to note that in the 1977 time period, the mission described can be accomplished, even with spacecraft weights approaching 200,000 pounds. Through the introduction of earth orbit rendezvous techniques, Saturn V can provide a very significant contribution to manned solar system exploration. The future growth of both the Saturn IB and Saturn V launch vehicles is important to future space programs and studies have identified a number of possible improvements, including enlarged propellant tanks, uprated engines, new engines, improved component designs, new stages such as the 260-inch solid stage, and strap-on solid stages similar to the Thrust Augmented Delta (TAD) and the Titan IIIC techniques.

The Saturn IB uprating vehicles of interest shown in Figure 16 include increased stage propellant in the Saturn IB-1 and -2 vehicles; strap-on 120 inch solids with and without increased liquid propellants in Saturn IB-8 and -7; and the solid-liquid Saturn of the -5 and -6 version, where a 260-inch solid first stage lifts a liquid S-IVB second stage. The relative performance of these variations is shown in Figure 17. It can be seen here that the two stage Saturn IB performance of 35,000 pounds of payload can be nearly quadrupled if desired.

The Saturn V booster growth potential is likewise extensive. The more probable versions are shown in Figure 18 and are primarily obtained by combinations of propellant additions or engine variations. The performance to be expected from such growth is shown in Figure 19.

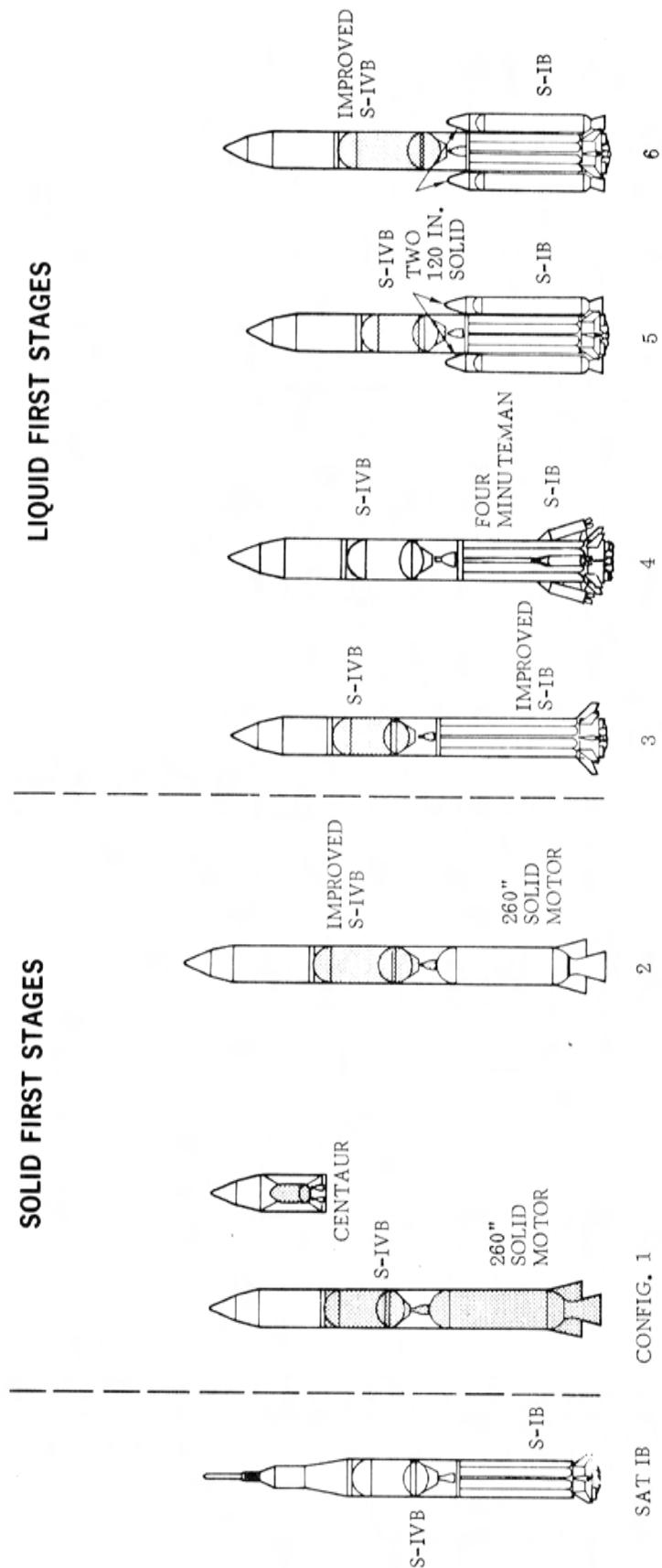
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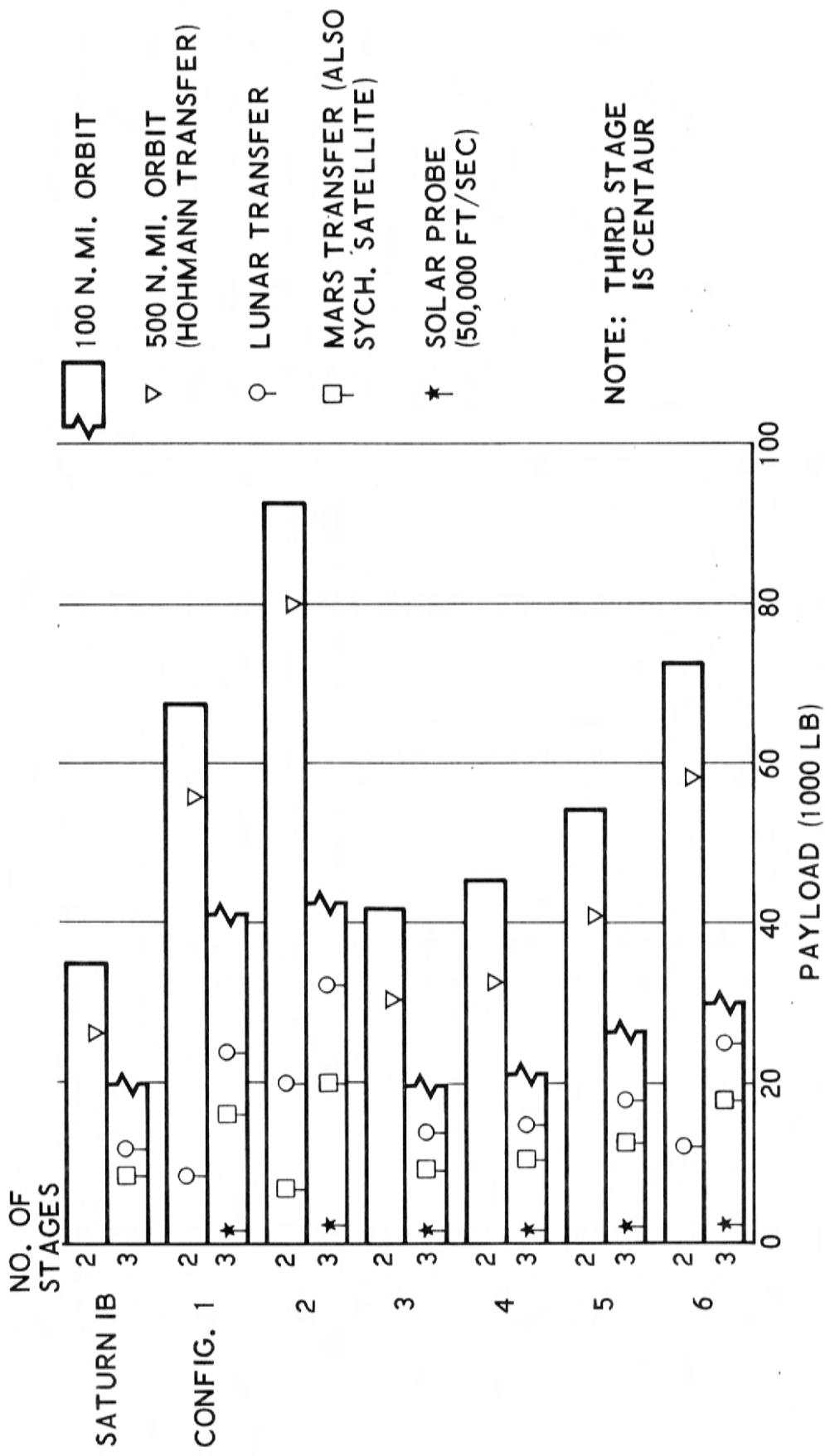
SATURN IB UPGRADING CONFIGURATION

SOLID FIRST STAGES

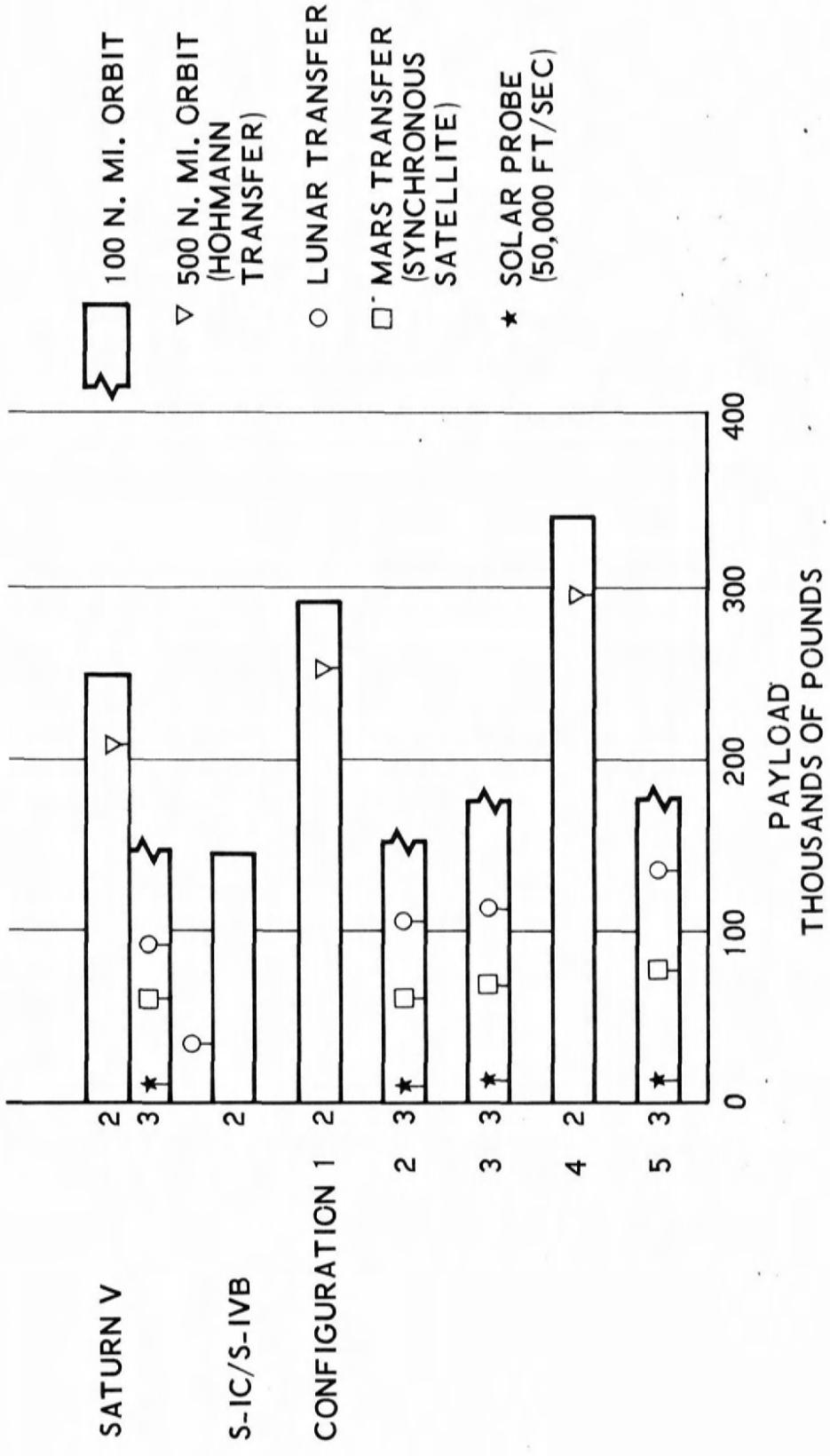
LIQUID FIRST STAGES



SATURN IB UPGRADING PERFORMANCE



SATURN V UPGRADING PERFORMANCE



SATURN V UPGRADING CONFIGURATION

