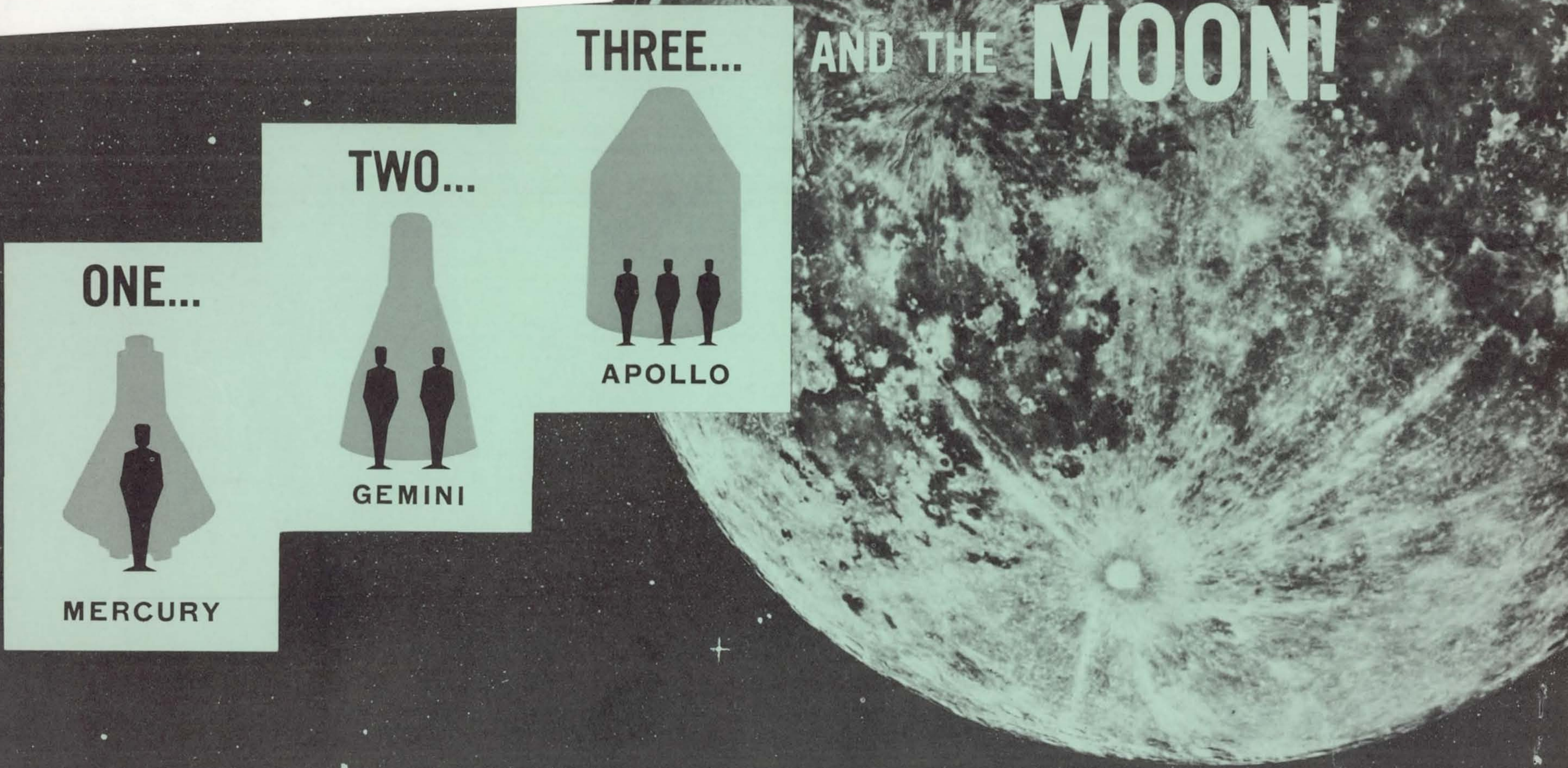
ONE... TWO... THREE... AND THE MOON!



AMERICA'S MANNED SPACE FLIGHT PROGRAM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA EP-7
(Revised 6-63)

"Those who came before us made certain that this country rode the first waves of the industrial revolution, the first waves of modern invention, and the first wave of nuclear power, and this generation does not intend to founder in the backwash of the coming age of space.

"We mean to be a part of it. We mean to lead it, for the eyes of the world now look into space, to the moon and to the planets beyond, and we have vowed that we shall not see it governed by a hostile flag of conquest, but by a banner of freedom and peace.

"We have vowed that we shall not see space filled with weapons of mass destruction, but with instruments of knowledge and understanding.

"Yet the vows of this Nation can only be fulfilled if we in this Nation are first, and therefore, we intend to be first. In short, our leadership in science and in industry, our hopes for peace and security, our obligations to ourselves as well as others, all require us to make this effort, to solve these mysteries, to solve them for the good of all men, and to become the world's leading spacefaring nation.

"We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people. For space science, like nuclear science and all technology, has no conscience of its own . . . .

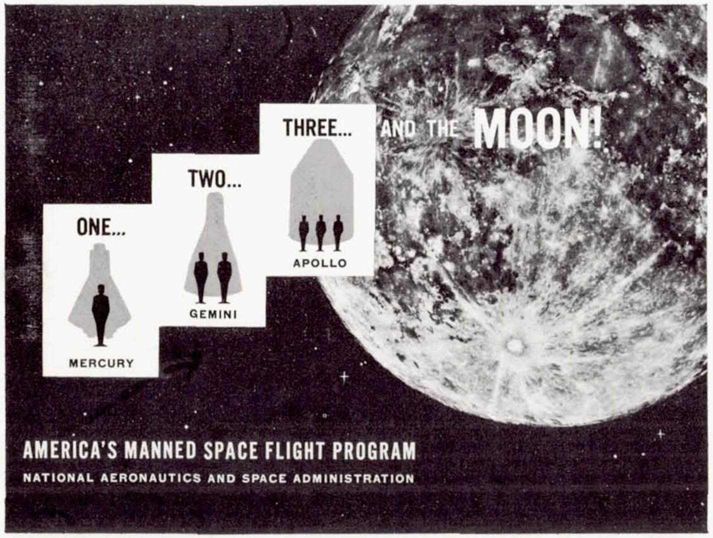
"We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

. . . Excerpts from President Kennedy's remarks at Rice University in Houston, Tex., September 12, 1962.

1–2–3 AND THE MOON

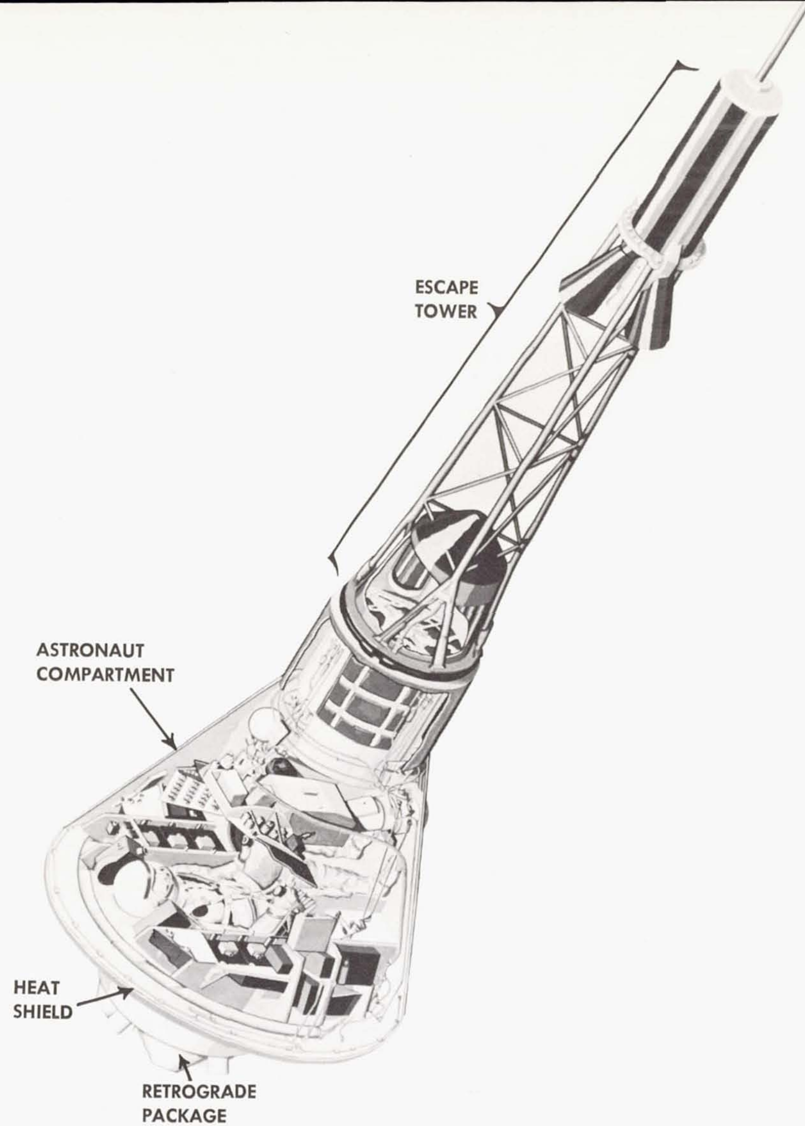
PROJECTS MERCURY, GEMINI, AND APOLLO OF AMERICA'S MANNED SPACE FLIGHT PROGRAM

NATIONAL AERONAUTICS & SPACE ADMINISTRATION



Spacecraft and crew members are symbolized in rectangles representing NASA's three projects leading to exploration of the moon and to more advanced ventures.

TABLE OF CONTENTS



Major assemblies of Mercury spacecraft.

FOR CENTURIES, man has looked to the skies and sought to break the chains which shackled him to a single planet in the vast universe. This aspiration has stemmed not only from his curiosity but also from man's fundamental thirst for knowledge and his readiness to accept a challenge. Today, he may be on the threshold of realizing this ambition.

Man has already succeeded in orbiting and returning to earth, the logical first step in space exploration. Now, he is literally reaching for the moon as the first stop on the way to more advanced ventures.

The President and Congress have set the landing of an American on the moon in this decade as a major National goal. The United States program directed toward achieving this goal includes three projects—Mercury, Gemini, and Apollo—each of which is designed to lay a sound foundation for additional progress. Together, they constitute the greatest single engineering enterprise in this Nation's history.

WHAT IS PROJECT MERCURY?

Project Mercury was organized October 5, 1958, to orbit a manned craft, investigate man's reaction to and abilities in space flight, and recover safely both man and spacecraft.

The Mercury flights have demonstrated that the high gravity forces of takeoff and entry into the atmosphere and weightlessness in flight, lasting hours, do not interfere with the ability of man to perform control tasks as efficiently as in the cockpit of a high-performance aircraft. In addition, man can conduct scientific observations and experiments in space, thus augmenting and clarifying information from instruments.

THE ONE-MAN MERCURY SPACECRAFT

is shaped like a bell. Its base is about 6 feet across. Without the escape tower, it stands nearly 10 feet high and weighs about 3,000 pounds.

SAFETY—A MAJOR DESIGN CONSIDERATION

The safety of the astronaut was a major consideration in designing the Mercury spacecraft.

The spacecraft contains a couch shaped to fit the contours of the astronaut's body. This couch helps him to endure the great pressures of launch and of entry into earth's atmosphere.

A rocket-powered escape tower mounted on the spacecraft can be triggered by conditions that foretell an impending malfunction of the Atlas booster and can promptly pull the astronaut out of danger.

Indicators on an instrument panel flash red if any vital mechanisms are failing to do their job.

Packed into the spacecraft are 7 miles of electrical wiring, hundreds of instruments, switches, radios, and lights, and electronic systems to assure proper operation and timing. Behind every vital component is at least one alternate system that can readily substitute for it. Nearly every Mercury spacecraft operation can be conducted automatically, by radio from earth, or by the astronaut with manual controls.

ASTRONAUT CAN CONTROL CRAFT'S ATTITUDE

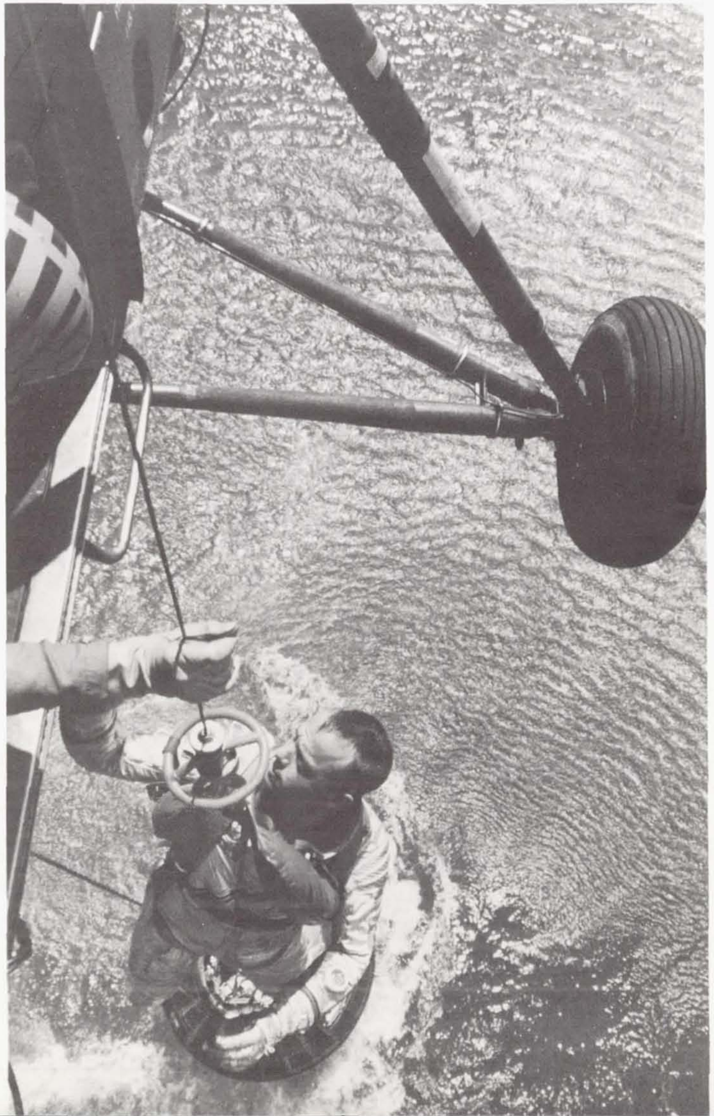
The astronaut can control the spacecraft orientation in space. He can pitch the nose up and down, yaw to the right and left, or roll around the long axis by activating hydrogen-peroxide attitude-control jets. During orbital flight, however, he cannot control the course of the spacecraft which follows the path set when the Atlas booster inserts the craft into orbit.

If the astronaut is busy with other tasks, he can also set the attitude control jets to position the craft automatically for entry into the atmosphere.

WHAT IS A MERCURY SPACE FLIGHT LIKE?

Astronauts Alan B. Shepard, Jr., and Virgil I. Grissom made Mercury suborbital flights on May 5 and July 21, 1961, respectively. Both flew as high as 115 miles above the earth and landed about 300 miles from their Cape Canaveral launch site.

Astronaut Alan B. Shepard, Jr., is recovered by helicopter after first Mercury suborbital rocket flight.



Each flight lasted about 15 minutes. Maximum speed was approximately 5,000 miles per hour. At launch and at entry into the atmosphere, Shepard and Grissom were subjected to gravity forces as high as 11 times their weight (11g). Each was weightless for about 5 minutes during flight.

The flights of Shepard and Grissom opened the way for United States manned orbital flights. On February 20, 1962, John H. Glenn, Jr., flew three times around the world. On May 24, 1962, Astronaut M. Scott Carpenter completed an almost duplicate journey. On October 3, 1962, Walter M. Schirra, Jr., carried out a six-orbit mission. And on May 16, 1963, L. Gordon Cooper, Jr., completed a 22-orbit flight.

While each Mercury mission is subject to some unique occurrences, flights are characterized for the most part by the sequence of events depicted below.

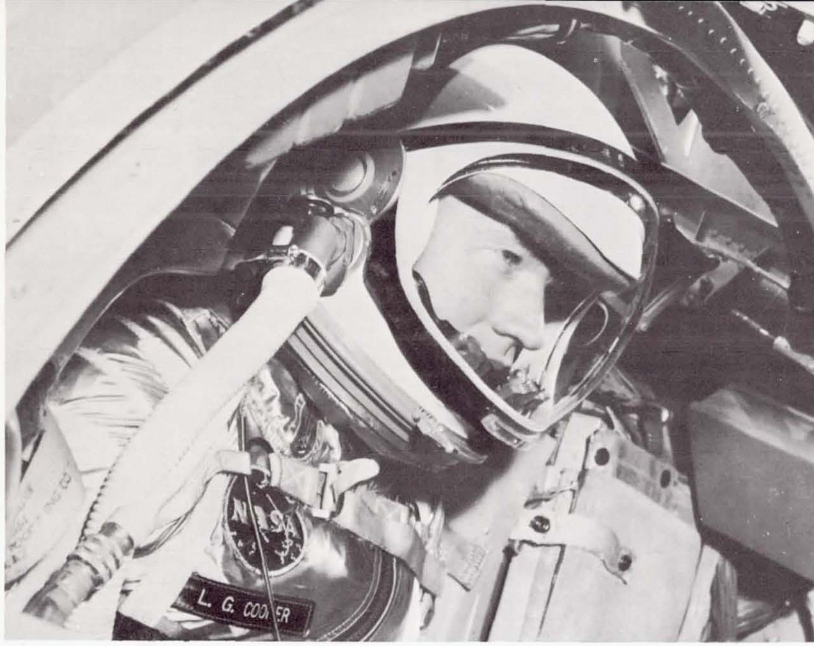
ASTRONAUT READIED

The astronaut awakens before dawn and eats a low-residue breakfast—for example: orange juice, scrambled eggs, toast, jelly, beverage, and steak. After a final medical examination during which medical sensors are taped to his body he dons his pressure suit and rides in the transfer van from his quarters to the launch pad.

An elevator carries him to a platform near the top of the service structure (gantry). From here he crosses to and enters the Mercury spacecraft, which is mounted on the great Atlas booster. Lying on his form-fitting couch, he makes final checks of instruments while launch preparations continue.

LAUNCH

At lift-off, the Atlas climbs slowly at first, then rapidly accelerates as thrust builds up. The spacecraft and booster broadcast data to ground stations which relay it to giant computers at Goddard Space Flight Center, Greenbelt, Md. The computers compare this data with the flight program established in advance; if everything is in order, Goddard flashes to Mercury

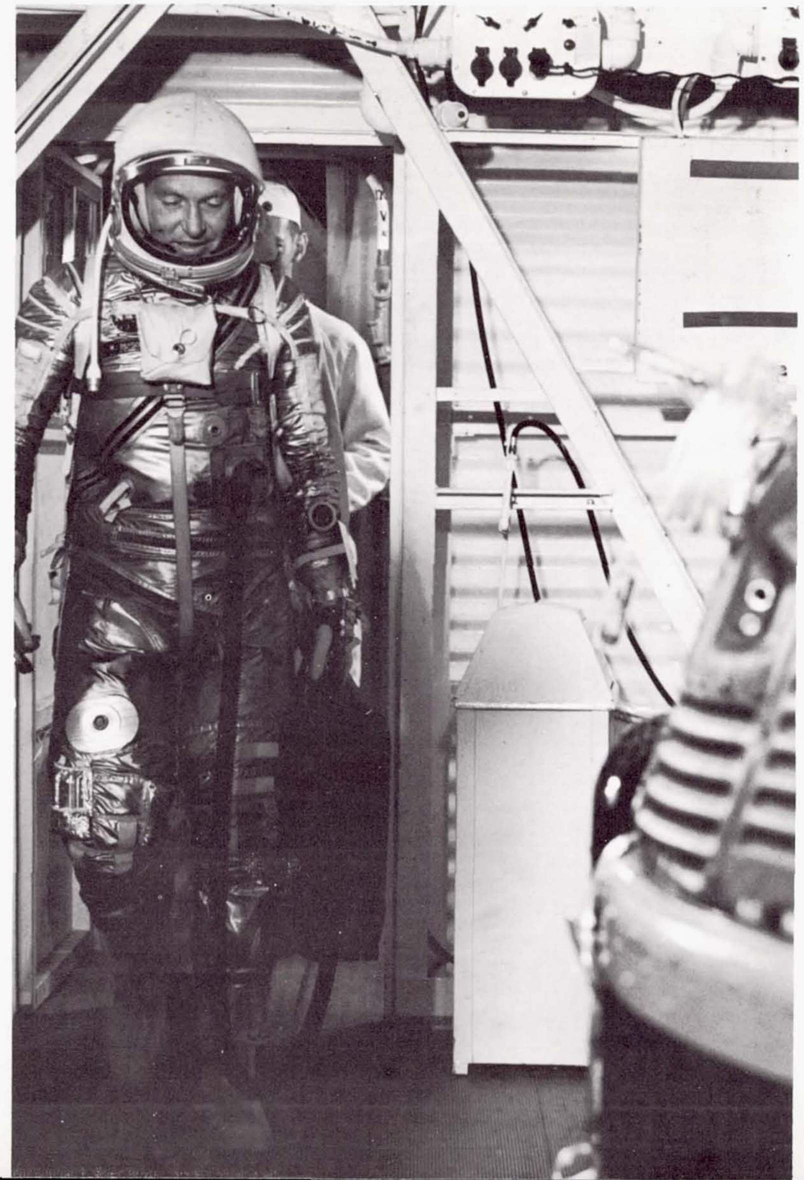


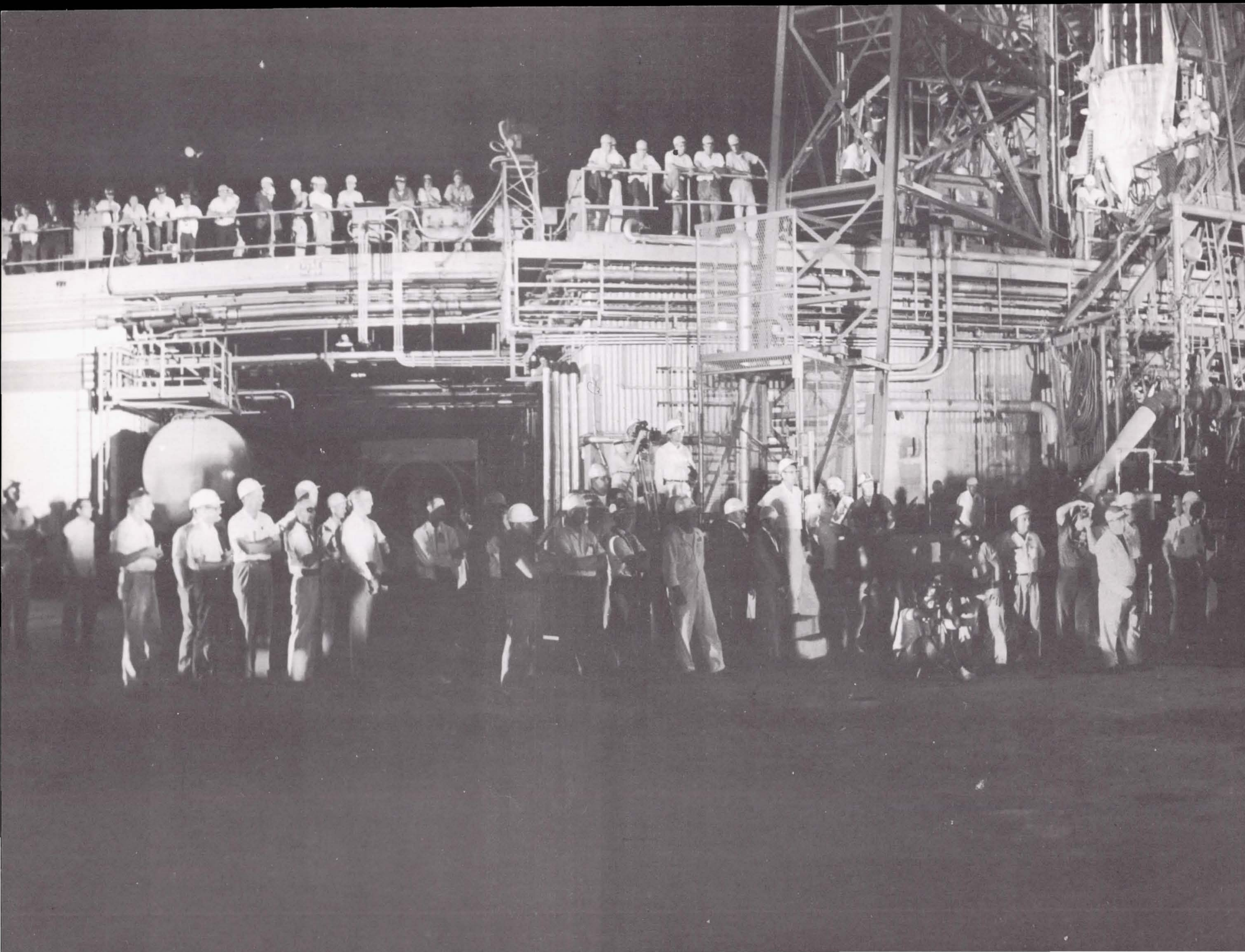
Opposite, above: *Astronaut Virgil I. Grissom prepares to enter Liberty Bell 7 for suborbital space flight.*

Opposite, below: *Astronaut M. Scott Carpenter, second American to orbit the earth, pokes his head from open top of Mercury craft.*

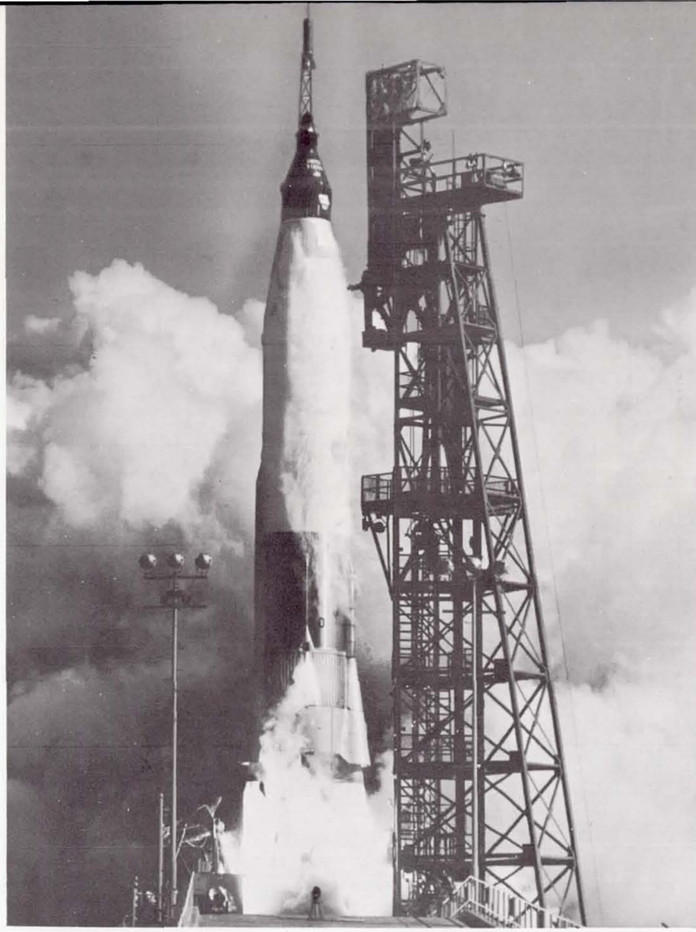
Right: *Astronaut Walter M. Schirra, Jr., enters gantry prior to his six-orbit flight of October 3, 1962.*

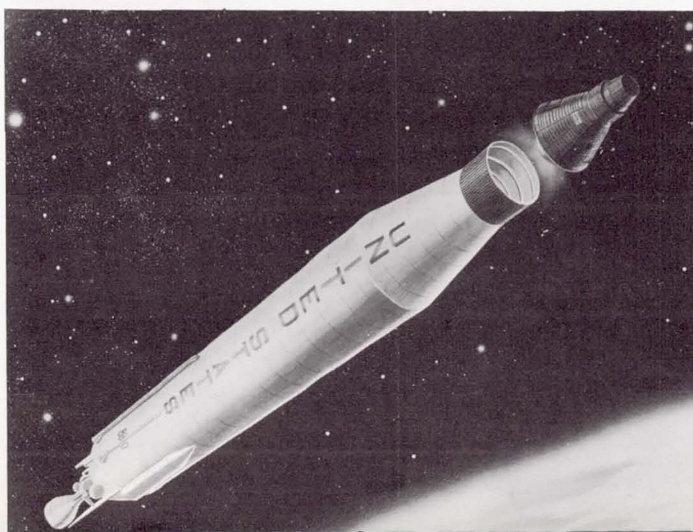
Above: *Astronaut L. Gordon Cooper, Jr., practices controlling a spacecraft during preparation for his 22-orbit 34-hour flight.*





The Mercury astronaut walks from transfer van to service tower where a waiting elevator will carry him to his spacecraft.





Control Center, Cape Canaveral, Fla., that the trajectory is "Go."

ORBITAL FLIGHT

After 5 minutes, the Atlas rocket engine is cut off. The spacecraft separates from the launch vehicle. In orbit, the orientation jets turn the spacecraft around, blunt end front. The spacecraft's altitude ranges from about 100 to approximately 160 miles. Velocity is about 17,500 miles per hour.

The pilot is weightless. Like a stone attached to a piece of string and swung in a circle, the vehicle is traveling at the exact speed where the centrifugal force of its circular motion neutralizes the pull of earth's gravity. The astronaut checks his instrument panel. At times, he manually operates the capsule's automatic system which corrects any forward, backward, or sideward roll by emitting spurts of gas. The astronaut can shut off these attitude control jets for extended periods in order to conserve fuel for return to earth.

The astronaut looks out the window to orient his position with respect to earth and make assigned scientific observations. He has two separate radio systems through which he can talk to ground personnel, including his fellow astronauts.

In each 90-minute orbit, the spacecraft flies 27,000 miles. Near the end of the final orbit, the pilot is told by ground controllers to prepare for reentry. Either automatically or under pilot control, the capsule is positioned for this critical maneuver. Three small retrorockets facing forward are fired to slow the spacecraft for return to earth.

RETURN TO EARTH

As the spacecraft drops into the atmosphere like a meteor, heat on its front end reaches about 3,000 degrees Fahrenheit

Left, above: ***Moments after zero countdown, first Mercury manned orbital flight, February 20, 1962.***

Left, below: ***Artist's conception of Mercury spacecraft separating from Atlas in orbit.***

but is dissipated by melting, evaporation, and charring of the surface of the heat shield. Velocity drops from about 15,000 to 100 miles per hour in less than 5 minutes, resulting in forces of almost eight times gravity (8g) on the spaceman.

At about 20,000 feet, a 6-foot-diameter parachute is released to slow and stabilize the craft. At about 10,000 feet, the 63-foot-diameter main parachute is deployed.

A plastic, air-filled bag is extended 4 feet below the heat shield to help absorb the shock of the landing. Upon touchdown, both chutes are jettisoned; the craft's radio beacon begins signaling.

RECOVERY

U.S. Navy vessels are waiting in the recovery area for the spacecraft and its astronaut. They are aided by helicopters and search aircraft. The Mercury spacecraft and astronaut are picked up by helicopters and/or ships.

LANDING POINT CHANGES WITH MISSION

The earth's rotation, the nature of the spacecraft's orbit, and other considerations are involved in selection of the landing area for a Mercury mission. For example, the planned landing areas for the three-orbit flights of Astronauts Glenn and Carpenter were in the Atlantic Ocean. The planned landing areas for Astronauts Schirra and Cooper at the ends of their respective 6- and 22-orbit journeys were in the Pacific Ocean.

FLIGHTS PROVIDED VALUABLE INFORMATION FOR LUNAR PROGRAM

Mercury flights have proved the technical soundness of the project and provided vital information for use in Projects Gemini and Apollo. Among other things, they have demonstrated the tremendous potential of man in space. As a result,

Right, above: ***Astronaut John H. Glenn, Jr., during his historic orbital flight.***

Right, center: ***Mercury capsule in orbit (artist's conception).***

Right, below: ***Ocean landing completes each Mercury mission.***

Nigerians watch operation of Mercury antenna at Kano. It is part of a world-wide network of Mercury tracking and data acquisition stations.

NASA is increasing emphasis on man as a controller of his spacecraft and supervisor of the operation of his automatic systems. This will permit significant improvement in the overall reliability.

Much of the pilot-training experience gained through Mercury is also directly applicable to that required by pilots of the Gemini and Apollo spacecraft.

WORLD-WIDE TRACKING NETWORK MONITORED SPACECRAFT AND ASTRONAUT

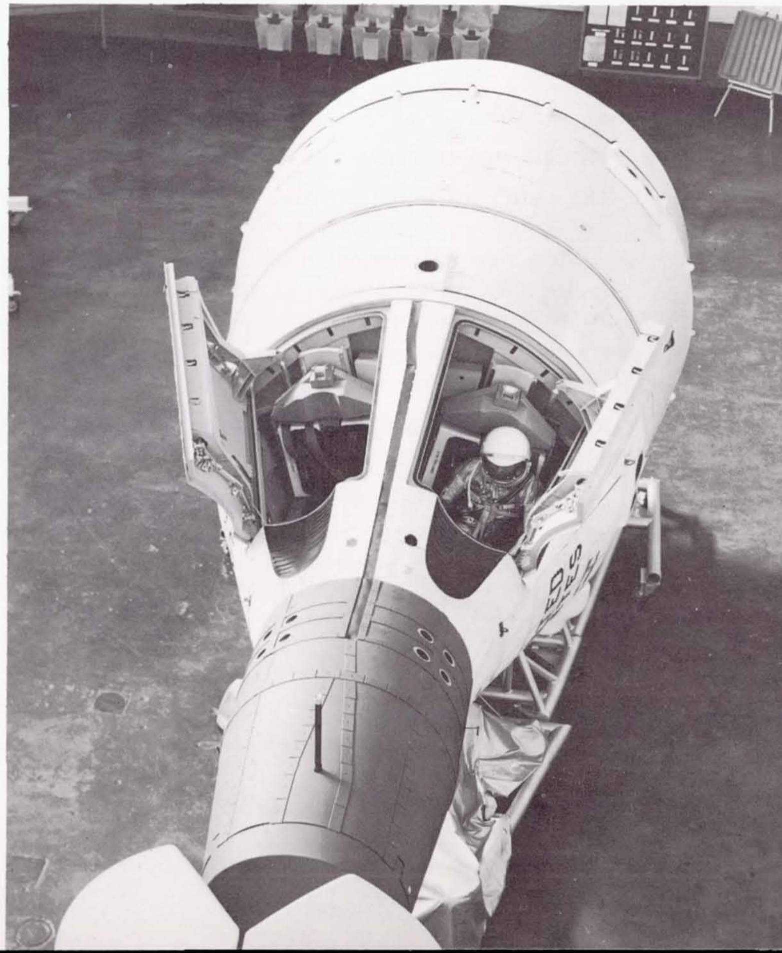
During orbital flights, 16 radio and radar stations around the world maintain voice communication with the astronaut and receive electronic data reporting on the conditions of the spacecraft and astronaut. The stations are linked by 100,000 miles of teletypewriter, 35,000 miles of telephone, and 5,000 miles of data circuits. The data are funneled into computers at NASA's Goddard Space Flight Center, Greenbelt, Md., where they are converted into usable information and flashed to Mercury Control Center, Cape Canaveral, Fla. The stations are located at or on:

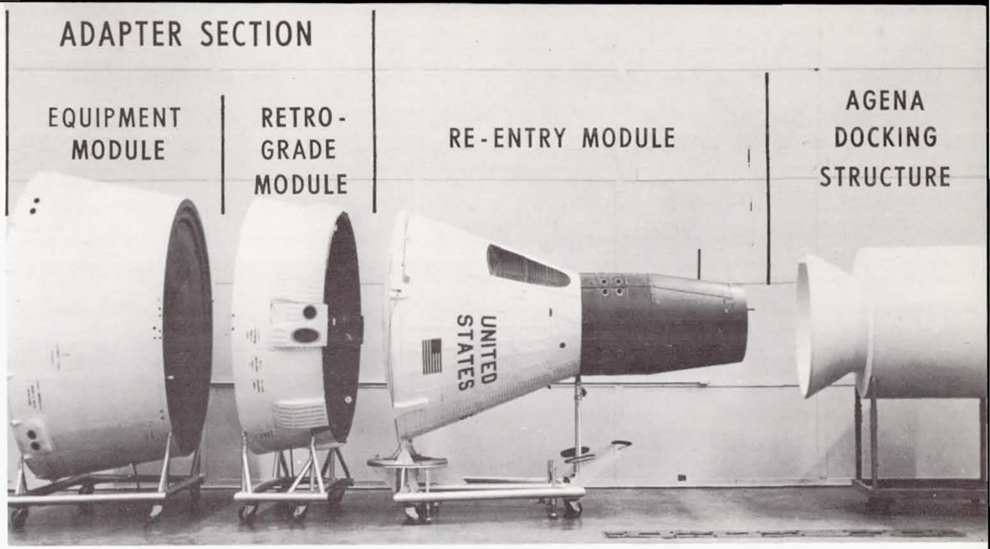
Cape Canaveral, Fla.	Muchea, Australia
Grand Bahama Island*	Woomera, Australia

Below: *Overhead view of Gemini spacecraft mock-up with doors ajar showing some of the accommodations for two pilots. In the foreground; Agena's docking structure with which Gemini will connect in orbit.*

Opposite, left: *Mock-up of Gemini spacecraft as it will appear during orbital flight.*

Opposite, right: *Separated segments of Gemini mock-up. At right is docking structure of Agena which contains apparatus for link-up of spacecraft and rocket.*





Grand Turk Island*	Canton Island
Bermuda	Kauai, Hawaii
Canary Islands	Point Arguello, Calif.
Kano, Nigeria	Guaymas, Mex.
Zanzibar	White Sands, N. Mex.
Indian Ocean Ship	Corpus Christi, Tex.
Pacific Ocean Ship**	Eglin, Fla.

*Part of the Cape Canaveral station complex.
**Stationed in the Atlantic Ocean for three-orbit orbit missions.

The Mercury network is being modified and augmented to meet the increased requirements of future manned space flights.

WHAT IS PROJECT GEMINI?

The next major step after Mercury in the United States manned space flight program is Project Gemini. This project's goals are:

(1) To determine man's performance and behavior during prolonged orbital flights of as much as 2 weeks, including his ability as a pilot and controller of his craft;

(2) To develop and perfect techniques for orbital rendezvous and docking, the bringing together and coupling of craft in orbit.

(3) To carry out scientific investigations of space that require participation and supervision of men aboard a spacecraft.

(4) To demonstrate controlled entry into the atmosphere and landing at a selected site.

The Department of Defense is participating with NASA in Project Gemini. The Secretary of Defense and the NASA Administrator have agreed on joint arrangements for the planning of experiments, the conduct of flight tests, and the analysis and dissemination of results.

THE TWO-MAN GEMINI SPACECRAFT

externally resembles the Mercury spacecraft. It is 1½ feet wider than Mercury at the base and lengthened proportionately. It provides about 50 percent more cabin space than Mercury and weighs about 7,000 pounds. Two men will pilot the Gemini spacecraft.

In contrast to Mercury, many Gemini components will be outside the crew compartments and arranged in easily removable units, thereby facilitating check-out and maintenance.

Included in Gemini equipment are docking apparatus for coupling with another vehicle in space; a life support system for maintaining pressure, temperature, and atmospheric composition of the crew cabin; instruments to collect, transmit, and record data on conditions of the spacecraft and astronauts; guidance and controls systems operating in conjunction with a computer to aid in navigation, rendezvous with another craft, entering earth's atmosphere, and landing; radar to aid in rendezvous operations; and a landing and recovery system including a small parachute to stabilize the craft, the paraglider mechanism, landing gear, and recovery aids such as tracking beacons, flashing lights, and two-way voice radios.

HAS EJECTION SEATS

Unlike the Mercury spacecraft, Gemini will have no escape tower. Instead, each astronaut will have an ejection seat (similar to that used in a fighter aircraft) for escape during launch or for emergencies in the recovery phase.

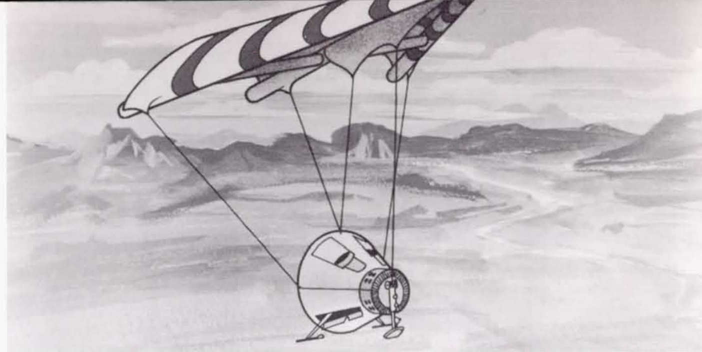
Roll-out couches and hinged doors will facilitate pilot entry into and exit from the craft. Two windshields, one for each astronaut, supplant the single porthole of Mercury.

ADAPTER SECTION TO BE ATTACHED

Gemini's resemblance to Mercury is partially obscured by the two-piece adapter section which is attached to the heat shield at Gemini's base. The adapter section is $7\frac{1}{2}$ feet in diameter at the top, $7\frac{1}{2}$ feet long, and 10 feet in diameter at its base. It weighs about 2,200 pounds. It is made up of the *equipment* and *retrograde modules*. As an aid in distinguishing the Gemini parts, the crew section has been designated the *reentry module*.

The equipment module contains fuel, fuel cells (see below), oxygen for breathing, and a propulsion system for orbital attitude control (orientation) and maneuvers. The retrograde module, sandwiched between the equipment and reentry modules, contains the braking rockets that decelerate Gemini and enable it to descend from orbit. It also contains a propulsion system to aid in orienting and maneuvering the spacecraft.

The astronauts jettison the equipment module during preparation for return to earth. They discard the retrograde module just before entry into the atmosphere.



Flared parawing gives Gemini sufficient lift for pilots to control the craft's landing area.

FUEL CELLS SUPPLY ELECTRICITY

Gemini will be the first spacecraft to utilize fuel cells for electrical power. Its two fuel cells will create electricity through a chemical reaction of hydrogen and oxygen. A byproduct of this reaction is a pint of drinking water per kilowatt hour.

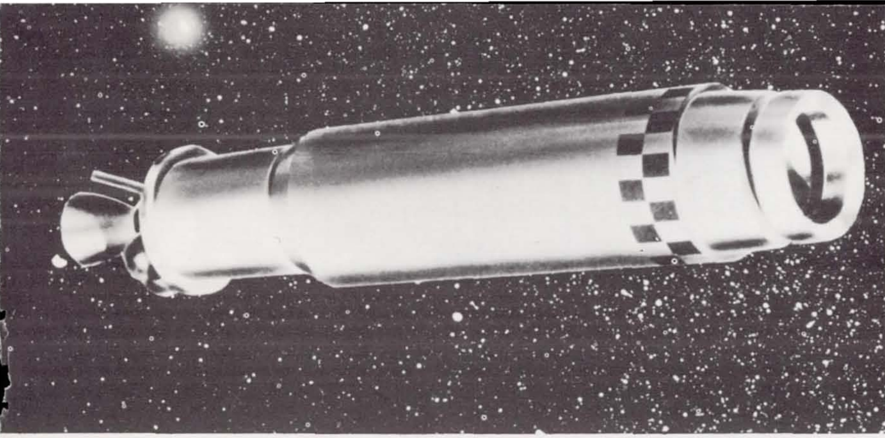
The fuel cells are located in the equipment module which is jettisoned when the spacecraft is readied for atmosphere entry. An array of silver zinc batteries located in the reentry module provides power after the equipment module is discarded.

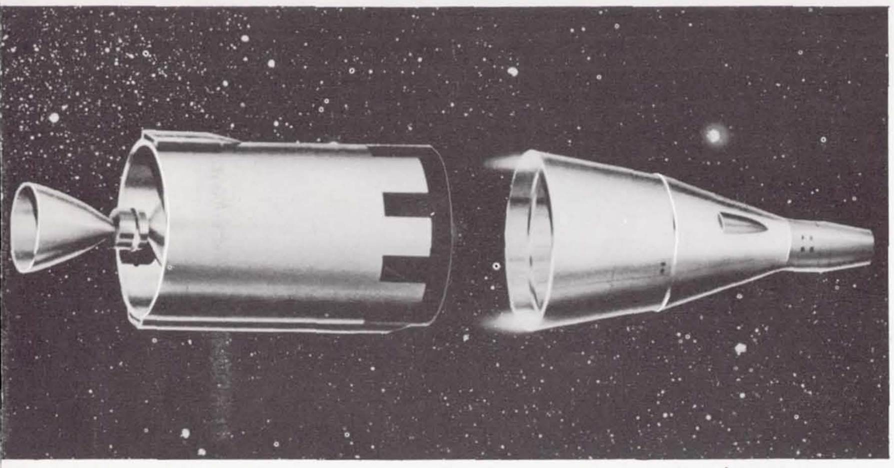
TO LAND LIKE AN AIRPLANE

Early Gemini flights will employ parachutes for landing. Eventually, the parachutes will be replaced by a 45-foot wide wedge-shaped paraglider, based on a concept developed by Francis Rogallo of NASA's Langley Research Center.

The paraglider will be part of the equipment of the reentry module, the only part of Gemini designed to return to earth. The device, deployed at about 40,000 feet, will enable the astronauts to maneuver the module to any desired landing point within a 20-mile radius. Moreover, the paraglider will permit the module to land like an airplane with the pilots sitting upright and looking forward.

When the paraglider is deployed, a spoon-shaped nose ski will automatically extend from the module. The crew will then lower two outrigger skids. The spacecraft will be designed to land with a forward speed of about 45 miles per hour,





Left, above: ***Agena in circular orbit after launch by Atlas.***

Left, below: ***Gemini separates from second stage of Titan II and goes into elliptical orbit.***

TO LAUNCH THE GEMINI SPACECRAFT

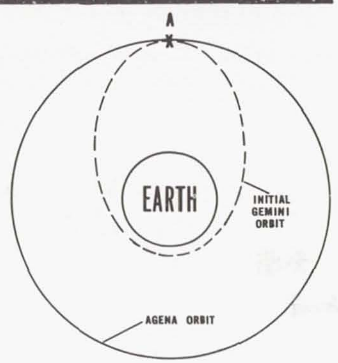
For launching the Gemini spacecraft, NASA has chosen the Titan II booster, a U.S. Air Force vehicle. Titan II utilizes a type of liquid propellant which can be stored indefinitely in the fuel tanks. Thus, unlike other liquid-fuel boosters whose propellants must be held at cryogenic (intensely cold) temperatures, Titan II can be fueled in advance of a launch countdown and need not be drained of propellants if a launch is postponed. Flight tests of Titan II started March 16, 1962, and are continuing.

Titan II has a 430,000 pound thrust first stage and 100,000 pound thrust second stage. It is 90 feet high and 10 feet in diameter at the base. The Atlas employed to launch Mercury generates 367,000 pounds of thrust.

HOW WILL THE GEMINI ORBITAL RENDEZVOUS EXPERIMENT BE CARRIED OUT?

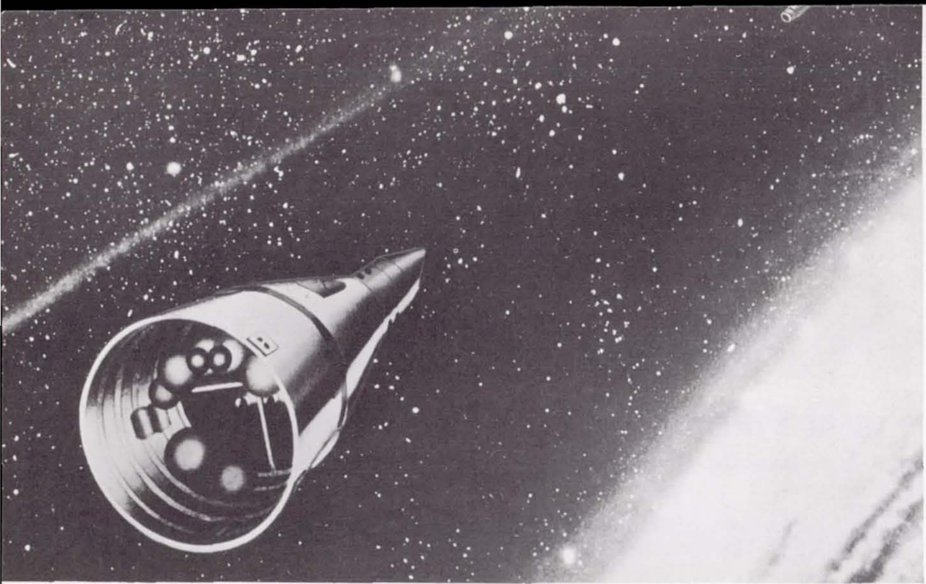
PHASE 1—LAUNCH AND INSERTION INTO ORBIT

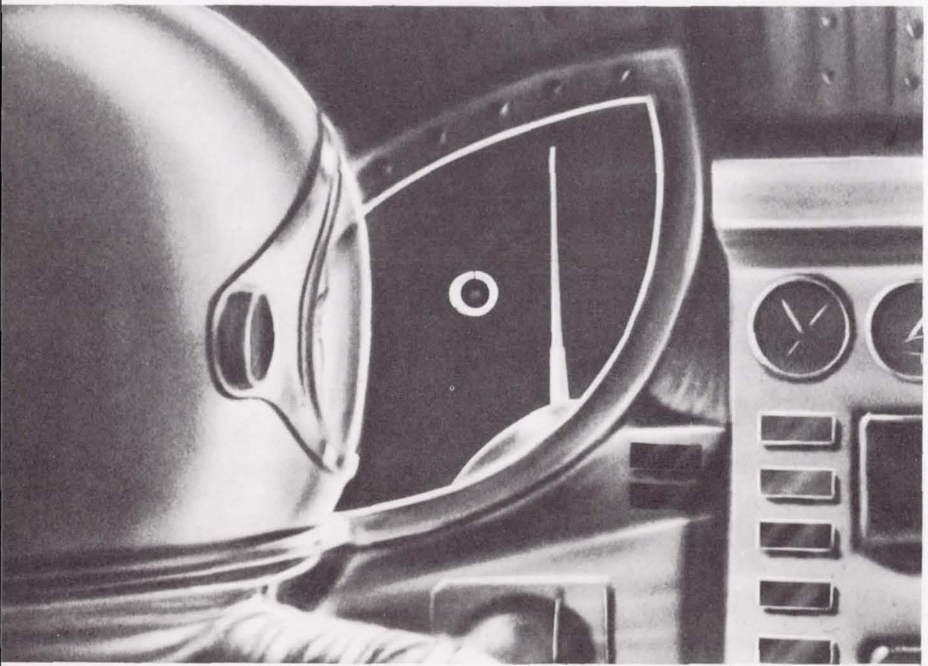
In the Gemini orbital rendezvous mission, an Atlas will first launch an Agena rocket, modified to link up with the Gemini spacecraft, into a near-circular orbit. Ground stations will track Agena and determine the best time to launch Gemini. Later, a Titan II will propel Gemini into an elongated orbit with an altitude generally lower than that of Agena but with apogee (highest altitude) at the same altitude of the Agena orbit.

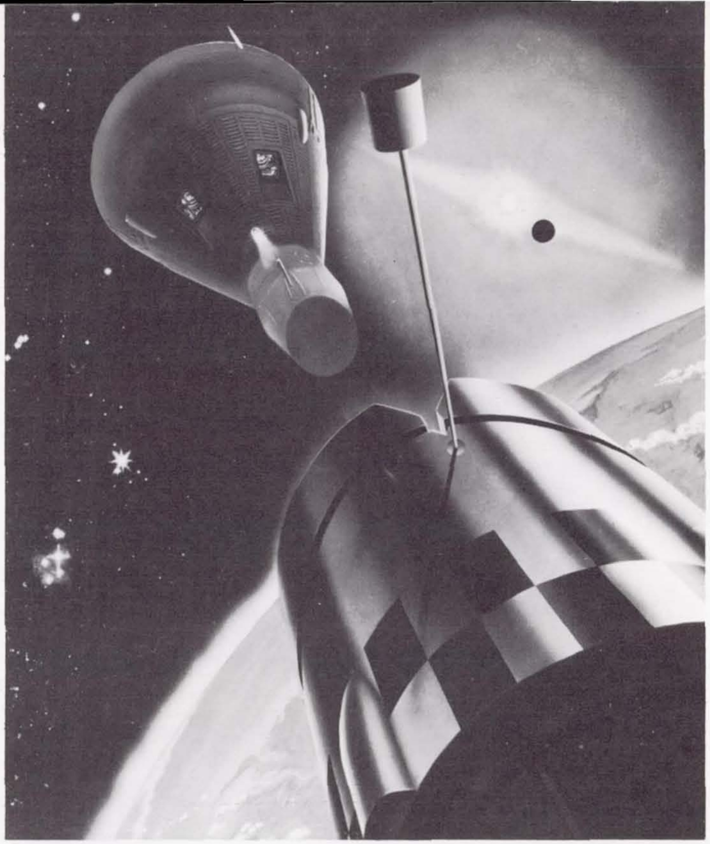


Intentionally disproportionate sketch highlights the shorter path of the initial Gemini orbit which enables the spacecraft to overtake the rocket. A Gemini engine will be fired at about the point A, placing Gemini into an orbit almost identical to that of Agena.

692-386 O - 63 - 3







Left, above: ***Maneuvering rockets firing, the Gemini spacecraft begins to close in on the Agena.***

Left, below: ***Gemini astronaut observes Agena through windshield as he guides his craft toward the rocket vehicle.***

Above: ***Gemini spacecraft closes in on Agena.***

Because its altitude is lower, Gemini will be able to circle the earth more quickly than Agena and gradually overtake the rocket. When the two are most favorably located relative to each other, a Gemini rocket will be fired to increase Gemini's speed and to thrust the spacecraft into a circular orbit almost identical with that of Agena.

PHASE 2—CLOSING

As soon as Gemini's radar acquires Agena, the so-called closing phase of rendezvous begins. Radar information is fed into Gemini's computer which tells the pilots which rockets to fire and when and how long they must operate them to keep the craft stabilized and gain on their target. When the two craft are about 20 miles apart, the astronauts are expected to sight Agena and supplement radar information with visual observation. A high-intensity flashing light on Agena will help the astronauts keep their target in sight. By the end of the closing phase, Gemini and Agena will be 10 to 100 feet apart and traveling in the same orbit.

PHASE 3—DOCKING

The final phase of rendezvous is docking, the link-up of the two vehicles. In this phase, much of the sensing, computing, and decision requirements are within the capability of man. Using visual observation, the astronauts will carefully maneuver Gemini into contact with Agena. They are aided by an aiming bar on the Gemini spacecraft and a notch in the rocket's receiving cone.

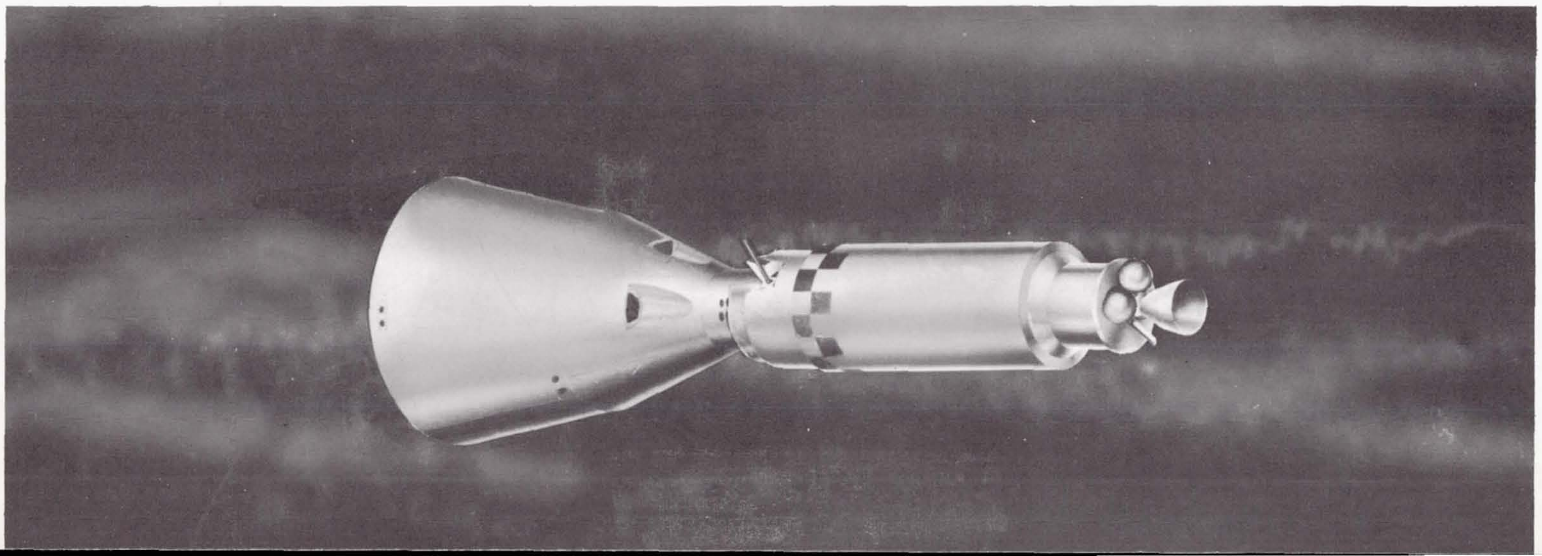
As they near their target, the astronauts must reduce the relative velocities between the two craft to less than 1½ miles per hour, although both are whirling around the earth at about 18,000 miles per hour. Moreover, they must align the conical nose of their craft with the docking socket of the Agena.

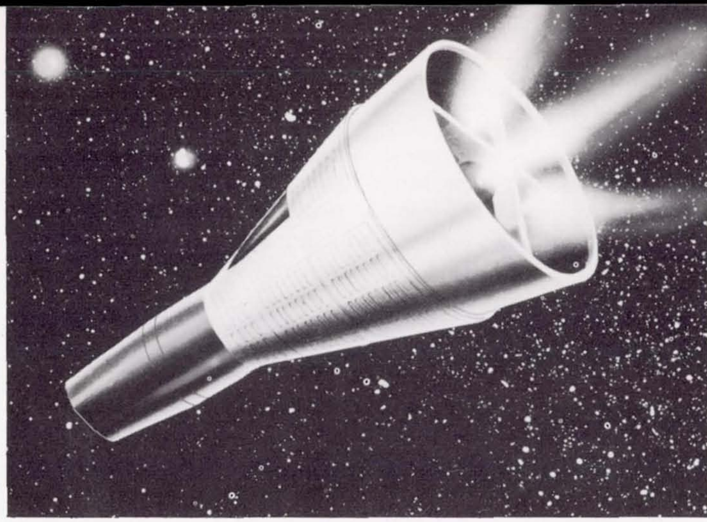
They will accomplish this by using the attitude controls to pitch Gemini (move its nose up or down), yaw the craft (turn its nose to the right or left), or roll it around the long axis, as conditions demand.

Docking will be accomplished when the cone-shaped nose of Gemini is gently nudged into the matching slot of the Agena. Coupling of the craft will be automatic, and the astronauts will be able to operate the joined vehicles as a single unit, adding the Agena's propulsion system to that of the Gemini spacecraft.

At the conclusion of their mission, the astronauts will detach Agena and jettison the equipment module. Then, they will turn the spacecraft around, fire the retrorockets to slow down and descend to earth, and discard the retrograde module. After reentry they will deploy a small parachute called a drogue to stabilize the spacecraft. At about 40,000 feet, they will unfurl the paraglider and pilot their spacecraft to an airplane-style landing at a selected ground location.

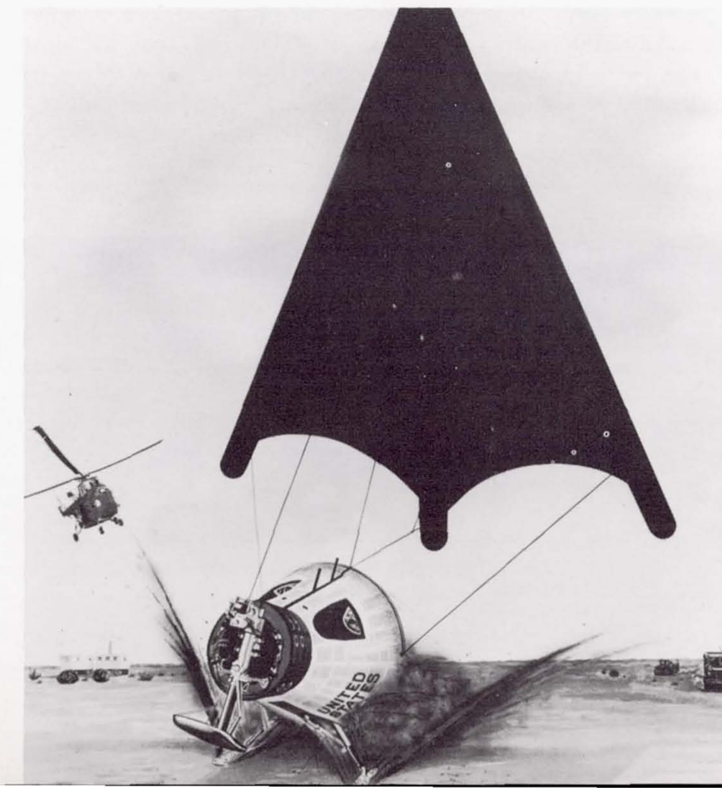
Gemini and Agena assembled.





Above: ***After separation from Agena and jettison of equipment section, Gemini retrorockets are fired to decrease speed for descent to earth.***

Below: ***Mission's end. Recovery aircraft and vehicles race to pick up pilots and spacecraft.***



WHAT IS THE SIGNIFICANCE OF ORBITAL RENDEZVOUS?

Before man can truly call himself the master of space, he must master orbital rendezvous. This technique may ultimately make it possible to assemble the huge space stations and the massive interplanetary craft required for manned expeditions to Venus, Mars, and perhaps as far as Pluto on the outer rim of the solar system, much sooner than if direct flight were necessary. Rendezvous may also enable astronauts of the future to refuel, repair, and resupply spacecraft, rescue other astronauts from disabled craft, and ferry crews between the earth and space stations or between space platforms and planets.

Moreover, mastery of orbital rendezvous is needed to fulfill the United States timetable for landing men on the moon and returning them safely to earth. By means of rendezvous in lunar orbits, the Saturn V, which is under development, can meet the launch power requirements of the lunar mission. On the other hand, a direct earth-moon flight and a similarly direct return would require a launch vehicle about 50 percent larger and generating some 60 percent more thrust than Saturn V.

The first rendezvous of craft in space will represent a significant accomplishment in positioning and timing. To be practicable, however, rendezvous must be reduced to the routine and commonplace instead of the demanding and unique—and become a thoroughly reliable operation.

GEMINI CREW MAY STEP OUT INTO SPACE

During advanced stages of the Gemini program, its pressure-suited crew may open the hatches and emerge from the spacecraft while in orbit. Moreover, they may push themselves from the craft, and appear to float in space as they speed around the earth at about 18,000 miles per hour. For this operation, they will be tethered to the craft to insure their return. Gemini will store sufficient oxygen to re-fill its cabin when the astronauts return.

This experiment will help pave the way for future operations in which man can make repairs, assemble orbiting stations, and perform other functions in space.

WHAT IS PROJECT APOLLO?

Project Apollo is the biggest and most complex project of the United States manned space flight program. Its goal, to land Americans on the moon and return them safely to earth, is expected to be accomplished in three steps:

(1) Earth-orbital flights of up to 2 weeks duration during which crews will gain experience in handling the basic spacecraft and conduct scientific observations requiring man's direct participation.

(2) Earth-orbital flights during which crews will gain experience in handling the basic spacecraft, and in deployment and docking with the 2-man lunar excursion module.

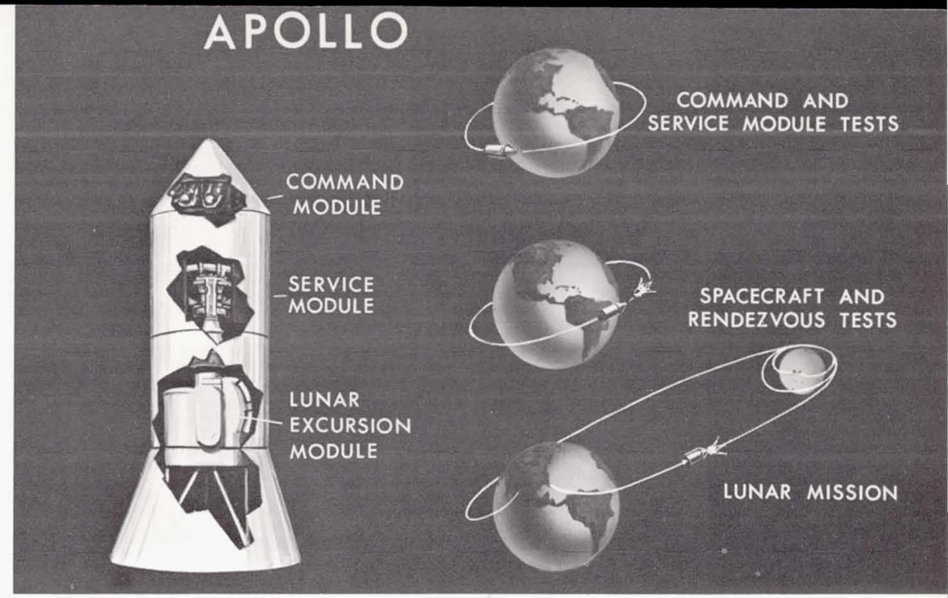
(3) Landing of an expedition to explore the moon and return to earth.

THE THREE-MAN APOLLO SPACECRAFT

will be composed of three sections or modules:

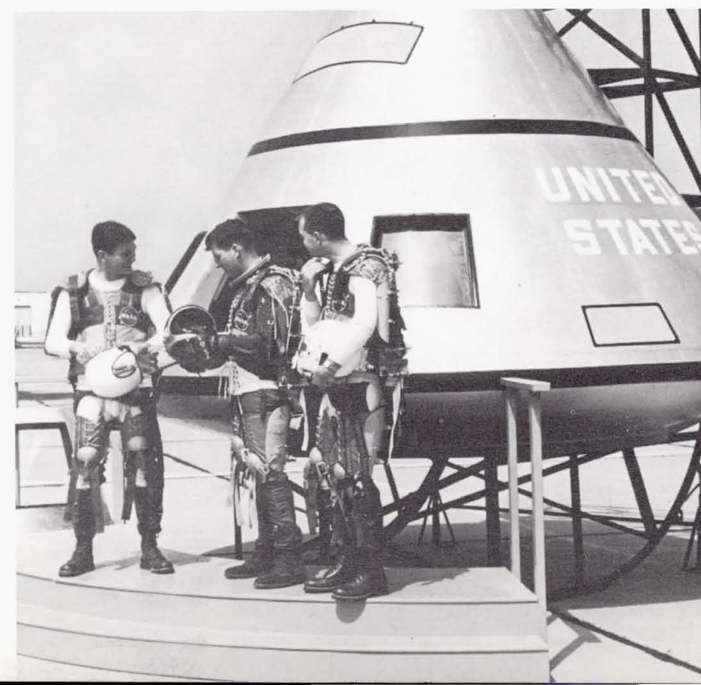
(1) COMMAND MODULE

The command module may be likened to the passenger and crew compartment of an airliner. It will be designed so that three men can work, eat, and sleep in it without wearing pressure suits. In addition to life support equipment, it will contain windows, periscopes, controls, and instrument panels to enable the astronauts to pilot their craft. It may have an airlock to permit a pressure-suited crewman to exit into space. Of the three modules, only the command module will return to earth. Thus, it must be built to withstand the tremendous deceleration forces and intense heating caused by entry into earth's atmosphere.



Above: *Left—artist's conception of Apollo spacecraft at launch from earth. Cutaways show some of interior. Right—The three steps of the Apollo project are shown in sequence from top to bottom.*

Below: *Exterior view of preliminary mock-up of Apollo command module.*



The module will have some maneuverability in the earth's atmosphere, and the pilots will be able to guide their craft toward a predetermined landing area. The command module will weigh about 5 tons, stand 12 feet tall, and have a base diameter of about 13 feet.

(2) SERVICE MODULE

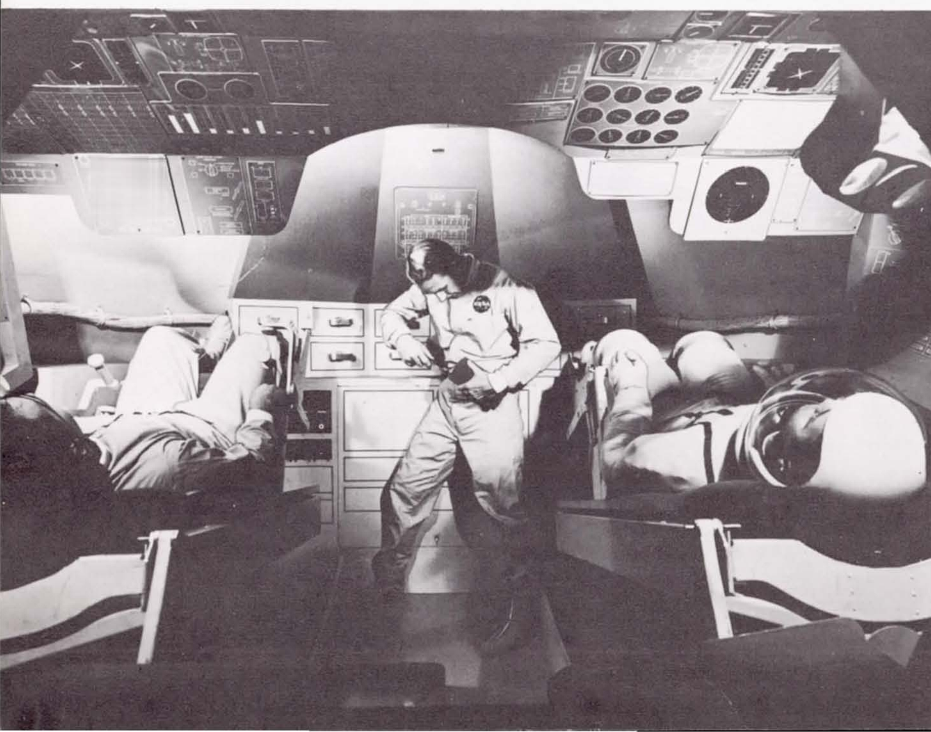
The service module will contain fuel and rockets so that the pilots can propel their craft into and out of lunar orbit and change their course in space. This segment will weigh about 25 tons, and measure 23 feet high and be about 13 feet in diameter. It will be jettisoned just before entry into earth's atmosphere.

(3) LUNAR EXCURSION MODULE

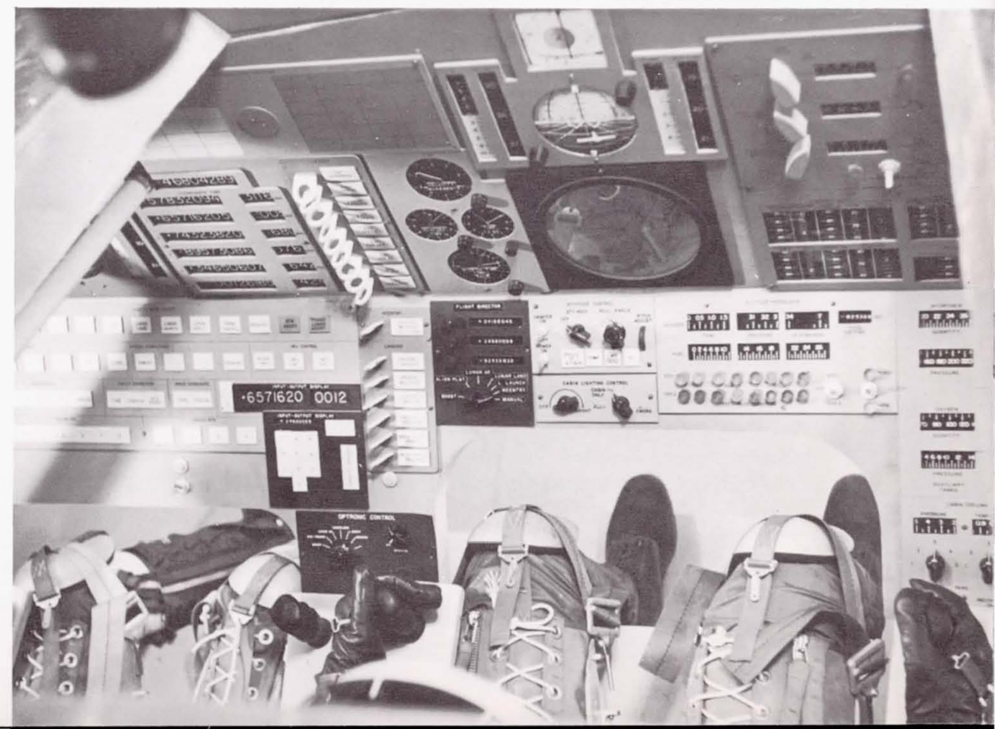
The lunar excursion module—informally called the "Bug"—will be designed to carry two men from lunar orbit to the moon's surface, to be launched back into lunar orbit, and to rendezvous with the parent craft (Apollo command and surface modules). After the crew transfers to the command module, the parent craft jettisons the excursion module.

When fully fueled and assembled, the Bug will weigh some 12 tons, be about 15 feet high, and have a nominal diameter of 10 feet. Braking rockets will enable the module to hover, while the astronauts survey their landing area, and to land gently on the moon. Before landing, the excursion module will extend five spider-like legs which will support it on the lunar surface.

The legs and landing rocket will support the excursion module in launch from the moon and will be left on the moon. When the module leaves the moon's surface, it will have a mass of about 4 tons.

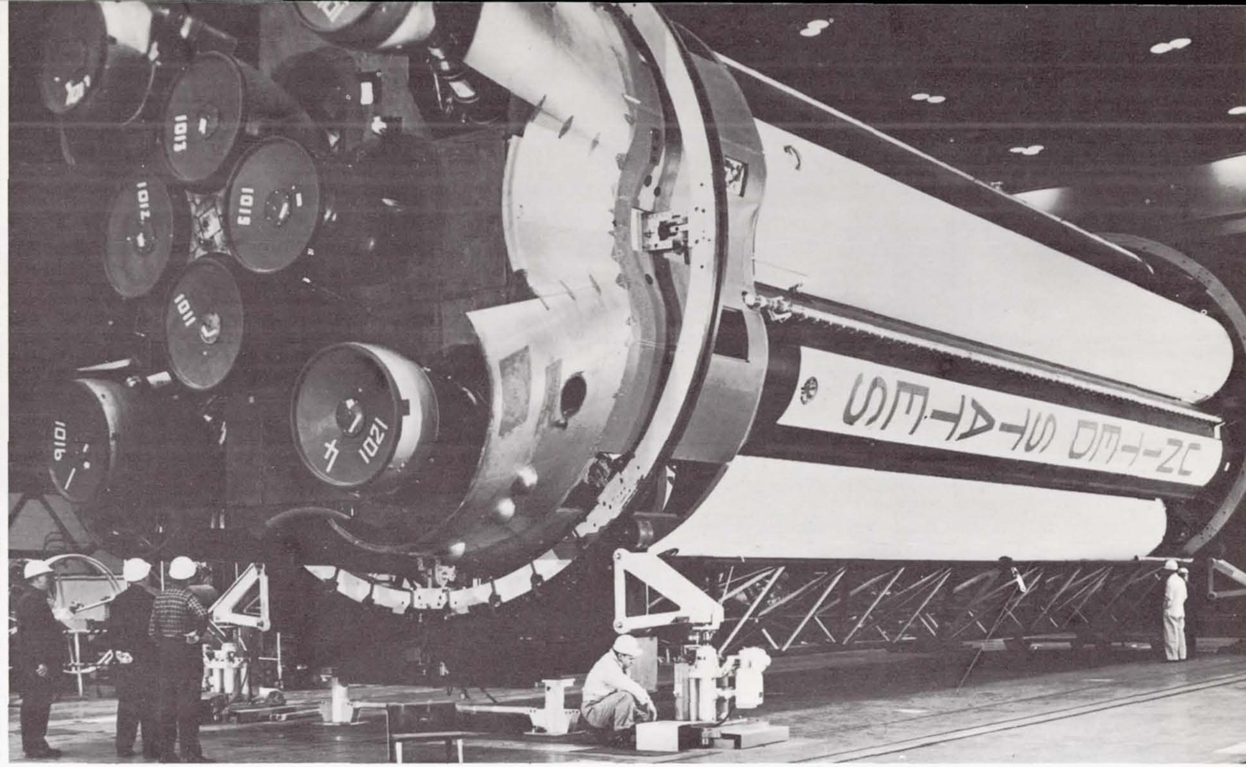


Interior of Apollo command module mock-up. Astronauts will be able to live and work here without space suits.



Pilots' instrument panel, Apollo command module mock-up.

Model of lunar excursion module.



Massive first stage of Saturn I.

TO LAUNCH APOLLO SPACECRAFT

The successful test flights of the 1.5-million-pound-thrust first stage of Saturn I, which is four times more powerful than the Atlas booster, represent major forward steps in Project Apollo. Saturn I has been assigned the role of launching Apollo on earth-orbital missions. Its first stage, a cluster of eight engines, is the Free World's most powerful existing booster.

The second stage will consist of a cluster of six engines producing a total thrust of 90,000 pounds. This powerplant is fueled by liquid-hydrogen and liquid oxygen, a propellant mixture that is far more efficient than the refined kerosene and liquid oxygen used by most liquid-propellant rockets. When operational, Saturn I will be able to orbit a spacecraft weighing about 11 tons.

For docking and maneuvering missions, a Saturn IB launch vehicle will be employed. The Saturn IB, using a more powerful second stage than the Saturn I, will be able to orbit a spacecraft weighing 16 tons.

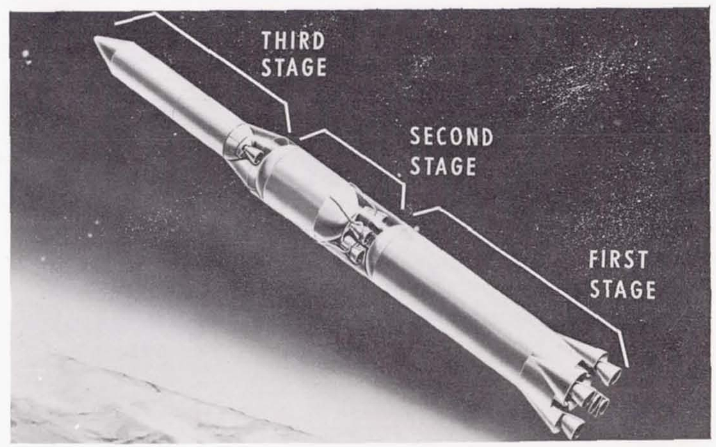
For Apollo lunar missions, NASA is developing the Saturn V, which will generate 7.5 million pounds of thrust at liftoff. The first stage is to be a cluster of five engines, each generating 1.5 million pounds of thrust. These engines are being ground tested. Upper stage powerplants will consist of 200,000-pound-thrust liquid-oxygen liquid-hydrogen engines—five in the second stage, and one in the third. The Saturn V is designed to launch a 45-ton spacecraft to the moon or place a 110-ton spacecraft in earth orbit. (Formerly, Saturn I was called Saturn C–1; Saturn IB, Saturn C–1B; and Saturn V, Saturn C–5 or Advanced Saturn.)

For boosting very heavy payloads into earth orbit, and beyond, NASA is studying a vehicle of awesome power called Nova. Nova will possess at least two to three times the weight-lifting force of the Saturn V.

APOLLO STEP ONE—EARTH ORBITAL MISSIONS

In the first phase of the Apollo project, the command and service modules will be launched into earth orbit by the Saturn I. At launch, the command module will be atop the vehicle, with a rocket-propelled escape tower resembling that on the Mercury spacecraft. The service module will be just below the command module.

The astronauts will remain in space for as long as 2 weeks before return to earth. During this time, they will acquire experience in operating their craft and will conduct assigned



Left: ***Saturn I roars from pad in thunderous start of successful flight test of first stage.***

Above: ***Artist's sketch of Saturn V, assigned to launch Apollo spacecraft on lunar missions.***

scientific experiments and observations requiring man's direct participation and supervision.

APOLLO STEP TWO—RENDEZVOUS REHEARSALS

When the greater power of the Saturn IB launch vehicle becomes available, all three modules of the Apollo spacecraft can be launched into earth orbit. At launch, the Bug is below the service module. In orbit, it will be possible to move the command and service modules around and dock them nose to nose with the Bug. Airlocks can be opened and two of the three astronauts can climb into the Bug.

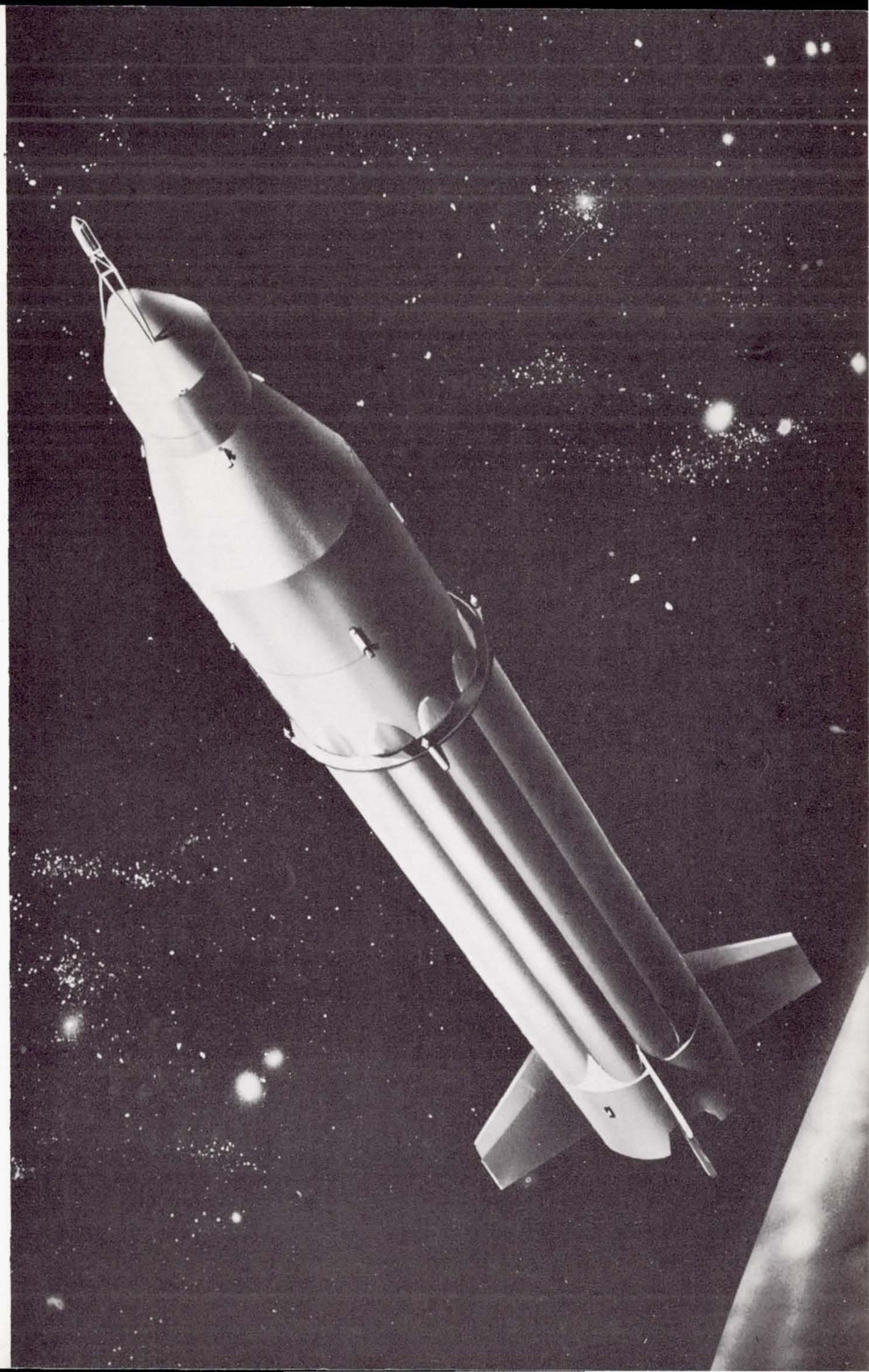
They will detach the Bug and practice flying it away from the mother craft and then returning the two together. These rehearsals, conducted close to the earth, will enable the astronauts to familiarize themselves with the equipment and learn the skills that they will need to carry out such operations in the vicinity of the moon. When the maneuvers have been completed, the astronauts will return to the command module, discard the Bug in orbit, and use the service module rocket to change their flight path to one that will bring them safely back to the earth.

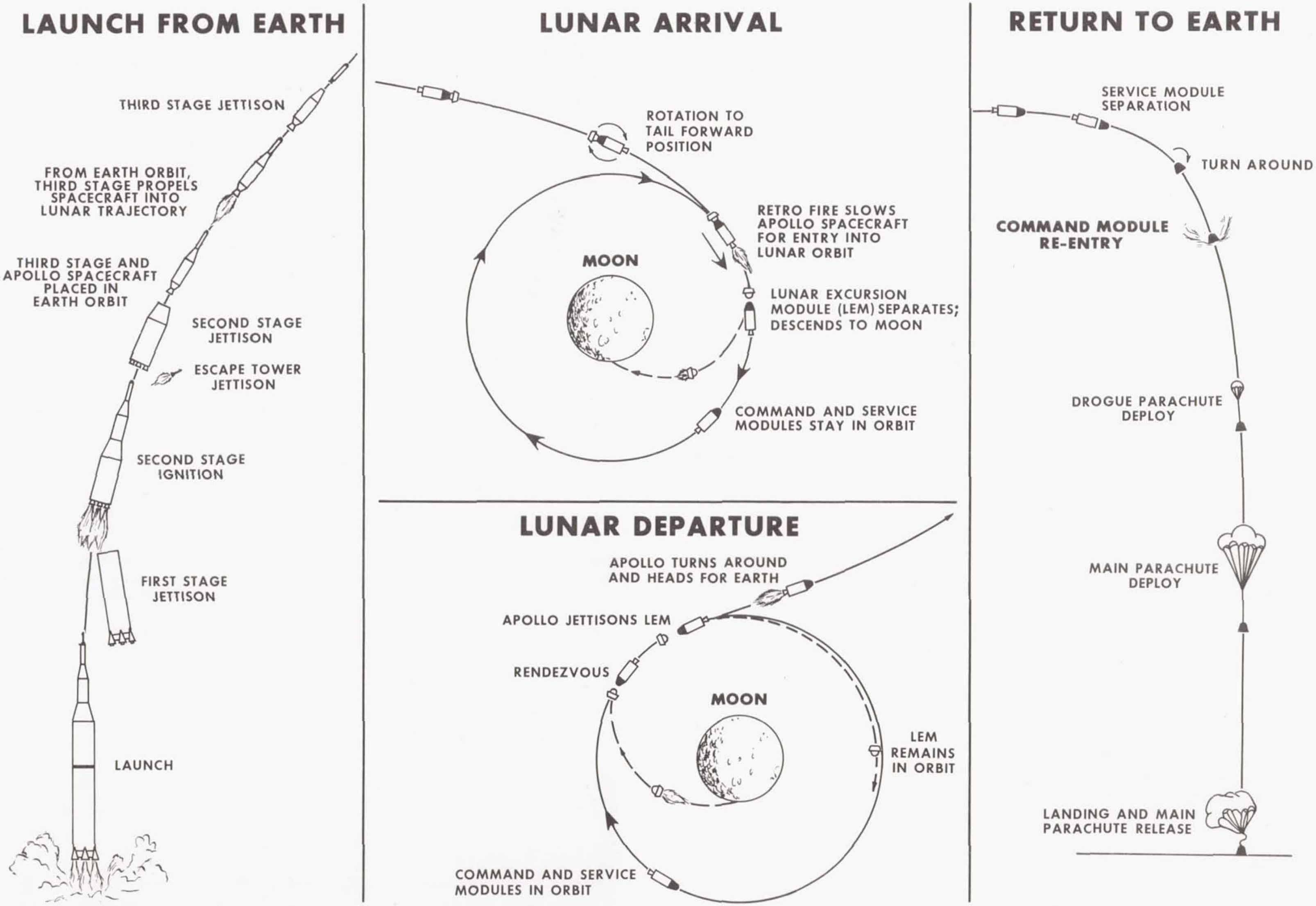
APOLLO STEP THREE—EXPLORING THE MOON

The mission to the moon will become possible when the enormous power of the Saturn V launch vehicle becomes available. To appreciate the great increase in launch power that is planned by NASA, it is best to compare the newer launch vehicles with the Atlas, which is now used for launching the Mercury spacecraft.

The Mercury spacecraft weighs about 3,000 pounds. The Saturn I to be used in the first phase of Project Apollo will have

Right: ***Saturn launches Apollo (artist's conception).***





Sequence of major events in Apollo lunar landing mission.

the power to lift the equivalent weight of almost seven Mercury spacecraft into low earth orbit. The Saturn IB, to be used in the second phase, will have the power to lift the equivalent of almost 11 Mercury spacecraft into the same low orbit.

For the landing on the moon, more than 10 times the lifting power of the Saturn I is required. The three-stage Saturn V will be able to boost into earth orbit the equivalent weight of 80 Mercury spacecraft.

Together with the three modules of the Apollo spacecraft, the Saturn V will stand about 360 feet tall (more than the length of a football field), and will weigh about 6 million pounds at launch.

On a lunar landing mission—which may be preceded by one or more flights into deep space and possibly culminate in a flight into lunar orbit and return to earth—the first two stages of the Saturn V and part of the fuel of the third stage are burned to place the spacecraft and third stage into an earth orbit. At the proper position and time for achieving a lunar trajectory, the third stage will be fired to accelerate the assembly to a speed of about 25,000 miles per hour in the direction of the moon.

Following burn-out of the Saturn V third stage, the Apollo crew will disconnect the command and service modules (parent craft) and link the command module nose to nose with the lunar excursion module.

During the flight to the moon, the Apollo astronauts must be ever alert to the threats of dangerous solar flares and other space hazards. In the uncharted blackness of space, they will have to pilot their ship to the moon by taking bearings on stars and other astronomical bodies. They will be aided by navigation and guidance equipment, including a computer, star-seeking devices, and electronic apparatus.

Periodically, they will check their own physical and mental conditions and the condition of every piece of operating equipment on board their craft, and make scientific observations. They will report frequently to earth.

When they reach the moon's vicinity, the astronauts will rotate Apollo to a tail-forward position and fire a rocket in the service module to swerve into an approximately 100-mile altitude lunar orbit. As Apollo coasts around the moon, two crewmen will transfer from the command module to the lunar excursion module. The third man will remain in the command module.

The two crewmen will separate their excursion module from the parent craft and fire braking rockets to descend. At low altitude, they will fire their vehicle's tail rockets so that the craft hovers, permitting a final scrutiny of their landing area. At this point, the pilots can rocket their ship back to the parent craft without landing, should they so decide. To land, they will extend their craft's landing gear, five spiderlike legs, and vary the motor's thrust for gentle touchdown.

The astronauts will spend a day or more on the moon, collecting surface samples, taking photographs, examining the lunar surface and moonscape, and performing other scientific experiments. They will radio their reports back to earth, which will be clearly visible to them.

On future missions, the astronauts may lengthen their expedition on the moon. Toward this end, NASA is studying a carrier which could be launched in advance of Apollo toward the projected landing area. The carrier would contain spare oxygen, food, water, fuel, and perhaps additional scientific instruments.

Upon completing their work, the astronauts will take off and rendezvous in lunar orbit with the parent craft. After astronaut transfer to the command module, the excursion module will be jettisoned. A 22,000-pounds thrust rocket in the service module will then be fired boosting Apollo from lunar orbit toward earth.

A critical part of this mission is entry into earth's atmosphere. At the return speed of 25,000 miles per hour, Apollo must follow an extremely precise flight path called an entry corridor to avoid burning up or bouncing back into space.

The astronauts will use the service module for propulsion and maneuver until they are in the entry corridor. Then, they will jettison the service module.

The command module will be subjected to extreme stresses and searing heat as the atmosphere slows its headlong flight. At about 60,000 feet, a small parachute called a drogue will open and stabilize the craft. At about 10,000 feet above earth, the large main parachutes will deploy to lower the command module gently to a predetermined land area. Recovery forces will race to pick up the astronauts and their spacecraft.

WHY ARE INITIAL MANNED LUNAR LANDINGS TO BE ACCOMPLISHED VIA LUNAR ORBIT RENDEZVOUS?

Selection of the lunar orbit rendezvous method for accomplishing initial manned landings on the moon followed a year-long study by some 700 outstanding scientists, engineers, and researchers. The study indicated that lunar orbit rendezvous offers the quickest, most reliable, and most economical way of landing the first American expedition on the moon.

The principal advantage stems from the fact that only a part of, rather than the whole, Apollo spacecraft will land on the moon. Consequently, propulsion (and weight) requirements for braking the lunar landing and for takeoff from the moon are greatly reduced. The net result is that the Apollo spacecraft launched from earth need weigh no more than 90,000 pounds instead of approximately 150,000 pounds.

A single Saturn V will be able to launch as much as a 90,000-pound Apollo to the moon. On the other hand, two Saturn V's and the employment of earth orbital rendezvous would be needed to launch a 150,000-pound Apollo. As an alternative, a direct launch of the 150,000-pound spacecraft would require a vehicle with almost twice the capability of the Saturn V. Such a launch vehicle could not be made operational as soon as the Saturn V.

Among additional advantages of lunar orbit rendezvous over other methods is that the lunar ferry will be tailored specifically for its job. Thus, it should perform the function of landing and takeoff from the moon more efficiently than a multi-task vehicle.

UNMANNED SPACECRAFT—TRAILBLAZERS FOR APOLLO

Unmanned instrumented spacecraft will precede man to the moon. Such craft can provide vital information about the unfamiliar environment; help determine favorable landing areas; and proof-test many of the systems to be used for manned journeys.

A series of Ranger spacecraft will take close-up pictures of the moon's surface. Some of the pictures are expected to distinguish lunar features as small as eight inches across. In addition, Ranger will gather data on gamma radiation in the lunar environment.

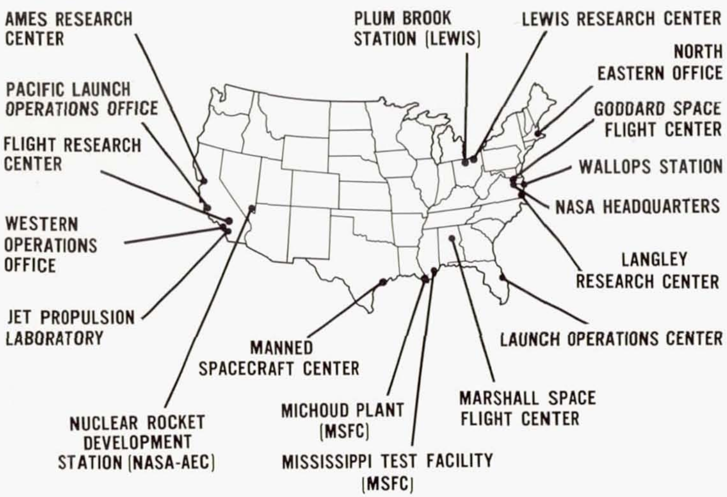
Two kinds of Surveyor spacecraft are being built to make preliminary selection of and verify the suitability of sites for manned lunar landings. The craft will also provide information on radiation and meteoroids that is essential to design of protective shielding for Apollo spacecraft and astronaut space suits.

In determining sites for manned landings, one kind of Surveyor craft will go into lunar orbit. It will send pictures of the moon that will be used as a basis for preliminary selection of sites. Another kind will soft-land on the moon and check the surface of the proposed site for strength and stability. Moreover, it will telecast pictures of the terrain in the vicinity of the site.

A series of satellites called Orbiting Solar Observatories are pointing instruments at the heart of the sun. Some of their information may contribute to development of reliable methods for predicting solar flares, which can subject astronauts to lethal intensities of radiation. A reliable forecasting system would make possible scheduling of moon journeys during relatively safe solar periods.

Other satellites and probes will monitor the space near earth and between the earth and the moon to gather additional data essential to successful accomplishment of the Nation's manned lunar landing program.

NASA INSTALLATIONS



WHO IS CONDUCTING PROJECTS MERCURY, GEMINI, AND APOLLO?

Projects Mercury, Gemini, and Apollo are directed by the National Aeronautics and Space Administration. This Government agency has statutory responsibility for the peaceful exploration and utilization of space for the benefit of all mankind. The work is conducted in plants and laboratories of NASA, other Government agencies, industry, and education.

The United States team of pilots and pilot-trainees for these space flight projects is made up of the original seven Mercury astronauts, selected in April 1959, and a pool of nine astronaut trainees, named in September 1962.

For the most part, physical, psychological, educational and experience criteria for the selections of Mercury astronauts and astronaut trainees were similar. The newer standards, however, reduced the age limit from 40 to 35 because of the long range nature of the manned space flight program. They also opened the way for civilian volunteers. Among requirements were a degree in engineering, biological science, or physical science, and experience as a jet test pilot.

Like the Mercury astronauts, the trainees will be put through a rigorous program. Academically, the program includes but is not limited to science, engineering, aerodynamics, and celestial navigation. Among training activities are spacecraft operation, practice in simulators for controlling craft in space, including orbital rendezvous, approach to and landing on the moon, and experience in operating while weightless and under high gravity forces of acceleration and deceleration.

Together with the Mercury astronauts, the astronaut trainees will form the United States team for advanced space exploits of the future.

Left: *The original seven Mercury astronauts: Front row, left to right—Walter M. Schirra, Jr., Donald K. Slayton, John H. Glenn, Jr., and M. Scott Carpenter. Back row, left to right—Alan B. Shepard, Jr., Virgil I. Grissom, and L. Gordon Cooper, Jr.*

Right: *Nine additional astronaut trainees selected September 1962. Front row, left to right: Charles Conrad, Jr.; Frank Borman; Neil Armstrong; John W. Young. Back row, left to right: Elliott M. See, Jr.; James A. McDivitt; James A. Lovell, Jr.; Edward H. White II; Thomas P. Stafford.*


ES M.DIVITT

SPACE,
THE "NEW OCEAN"

PRESIDENT KENNEDY has described space as "a new ocean" on which the United States must sail, "and be in a position second to none."

The President and the Congress have established a fast-paced, hard-driving program to develop our capabilities in space to meet every national requirement. One objective is to gain the scientific knowledge and develop the technology which will enable American astronauts to explore the moon within this decade.

The resources of Government, industry and education have been mobilized to achieve our goals in space. Rapid progress is being made in the development of advanced launch vehicles and spacecraft, in the establishment of essential facilities, and in organizing the scientific and technological support required in this great pioneering endeavor.

Formidable problems must be overcome. These include the development of more powerful rockets; of shielding against the dangerous radiation of space; of life-support systems that virtually duplicate the environment of the earth for extended periods of time; of materials, systems and power sources which will withstand and function in the hostile environment of space.

More must also be learned about the performance of men in space. We must investigate the effects of extended periods of

U.S. GOVERNMENT PRINTING OFFICE : 1963 O—692-386

James E. Webb, NASA Administrator.

weightlessness. We must learn how well man can navigate in the vast reaches of space. We must determine what psychological factors may affect our astronauts, exposed to isolation and confinement over long periods of time.

Why, you may ask, is it so vital that we conquer space? Here are some of the reasons:

We must learn about space because knowledge begets progress and new and better ways of life for all mankind. Just as past investments in scientific research and technological development are largely responsible for the comfort and convenience of life today, so will our space dollars contribute to the improvement of our lives tomorrow.

Scientific and technological prowess is achieving increasing recognition throughout the world as a social, economic and political force. Our position as leader of the Free World requires that we continue to demonstrate our leadership in this field, in space, as well as on the earth.

Our national defense requires that the United States make certain that the exploitation of space will be peaceful and open to all nations, and that none will ever be tempted to use it as an avenue of aggression against us.

We must dispel any doubt that a people who govern themselves can measure up to the challenges of the modern world. Thus, the lasting impression on mankind of our space program may well be that our nation has demonstrated the determination and the capability to meet the challenges of space, and carry out the exacting and massive effort which is required.

As President Kennedy said in 1961:

"In a very real sense, it will not be one man going to the moon—it will be an entire Nation. For all of us must work to put him there."

JAMES E. WEBB, NASA ADMINISTRATOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

In the summer of 1958, Congress passed an act creating the National Aeronautics and Space Administration. The act declared "that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of mankind." On October 1, 1958 this new agency was established.

Congress provided that aeronautical and space activities sponsored by the United States shall be directed by this civilian agency, "except for activities peculiar to or primarily associated with the development of weapons, military operations, or the defense of the United States." The act further states: "The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

"The expansion of human knowledge of phenomena in the atmosphere and space;

"The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;

"The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;

"The establishment of long range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;

"The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;

"The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control non-military and space activities, of information as to discoveries which have value or significane to that agency;

"Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof; and

"The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment."

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 25 cents