Saturn and the future

The coming family of Saturn space vehicles, including the new C-5, will bring scope and flexibility to our manned and unmanned missions near earth, to the moon, and beyond

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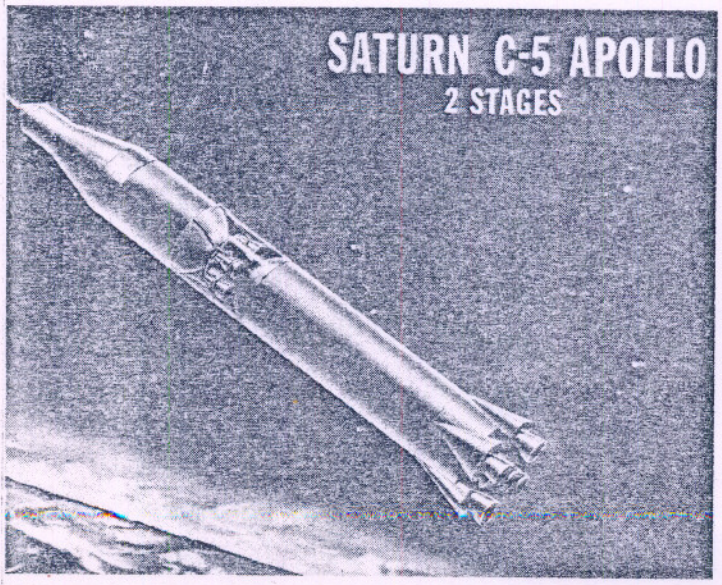
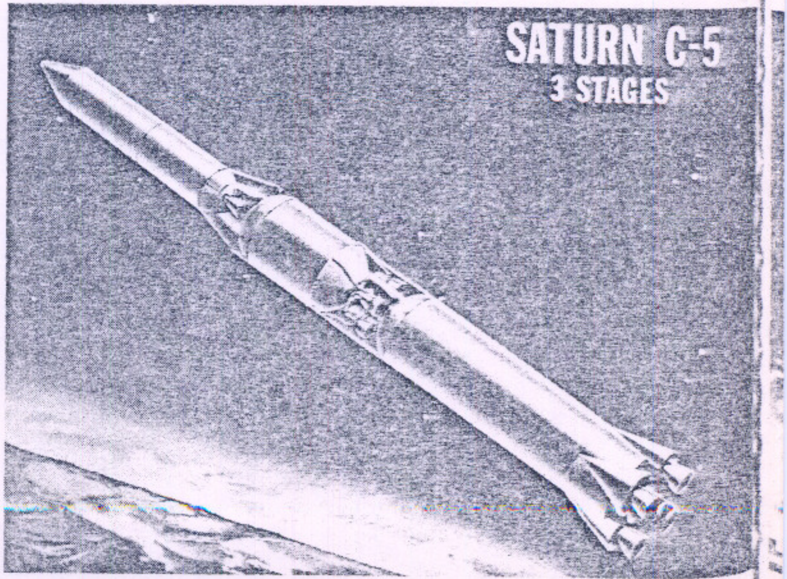
We are fortunate to be living in one of the most fascinating ages in the history of civilization. Whether we call it the atomic age or the space age is of little importance so long as we clearly recognize the significance of our moment in history.

Most of us understand the meaning of space exploration, but many still feel they must support either of two extreme positions. At one extreme there is the idealistic prognosticator with a dreamy vision of the beckoning and mysterious worlds of space, while at the other end we find the hardheaded debunker and defender of the *status quo* with his carping attitude of "Why go out there?" Between these two extremes, this country has meanwhile succeeded in developing a hard-driving national space exploration program for which, during the last calendar year, the American taxpayer has spent well over $2 billion. I have no doubt that this has been one of the wisest investments he has ever made.

It is not surprising that many people still fail to see why this investment in space is so necessary. People living in a plentiful society such as ours often have a tendency to resist change by clinging to what is old and familiar. Their position was put well in the story told by T. Keith Glennan, former NASA administrator, about Mark Twain listening to the complaints of an old riverboat pilot who was having trouble making the switch from sail to steam. The old man wanted no part of the newfangled steam contraptions. "Maybe so," replied Twain, "but when its steamboat time, you steam."

Achievements in the exploration of space are directly linked to over-all technological advancement, and in our age such advancement is indicative of the relative position of nations. We Americans have already felt the sting of being second in a race in which we should, and could, have been first. Any remaining doubts that we are really in



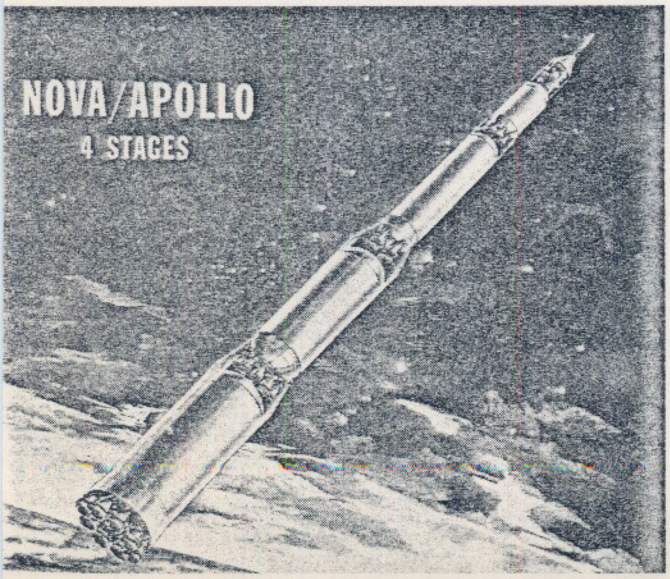


a space race with the Soviet Union were dispelled by President Kennedy's decision last spring to launch an ambitious program for manned lunar exploration. We have the capacity to be first to the moon, we must be first.

Unmanned artificial satellites are being launched with increasing frequency to perform a wide variety of services for mankind. Our Tiros meteorological satellites have proved their worth by permitting meteorologists to predict the weather more accurately and to detect disastrous storms. The military has developed warning and reconnaissance satellites to help us maintain our military posture. Earth-circling navigational and geodetic satellites are proving themselves daily. We are also designing such scientific satellites as orbiting solar observatories and the orbiting geophysical observatories. Perhaps of most immediate and practical interest is the communications satellite, which will help put the man in the street in closer touch with his fellow humans around the world.

Our whole civilization is built upon a structure of rapid communications. Horses replaced runners, trains replaced horses, and for fast mail delivery airplanes replaced trains. By 1866 the first transatlantic telegraph cable had been laid. Then, 61 years later, the first international radiotelephone circuit was put into operation. Another 29 years passed before the more reliable transatlantic submarine telephone cable was completed in 1956. Now we are on the verge of space satellite communications.

Plans for Relay (scientific), Rebound (scientific), Advent (military), and commercial communications satellites are based on the use of Thor and Atlas boosters. Much larger and more complexly instrumented communication satellites could be placed in 24-hr synchronous orbits by Saturn carriers as they become available in the next few years. Depending on the version of Saturn selected, multi-ton satellites could be orbited for both commercial and military communications. They would even make possible worldwide television coverage.



Our attention is by no means confined to terrestrial space; both the moon and the planets are in for an important share of our efforts. Early lunar exploration plans call for rough-landing of instrumented capsules on the moon. This series of missions, composed of nine flights in the Ranger project (including two already made) will be made possible by Atlas-Agena B vehicles. Later, seven Surveyor soft-lunar-landing flights will be undertaken with Atlas-Centaur carriers, the first in 1963.

Lunar and Planetary Programs Aided

Present plans for unmanned lunar-surface exploration tentatively include the use of Prospector craft, different versions of which could be designed to rove over the lunar surface and remotely transmit their data, to physically return sizable lunar samples to earth, and to provide logistic transportation in support of manned landings. Saturn carrier vehicles are required for the Prospector program.

Unmanned exploration of other planets within the solar system will be carried out under projects Mariner and Voyager. Mariner Mars and Venus probes will be launched first by Atlas-Agena B and later by Atlas-Centaur vehicles. Attempts will be made to direct two spacecraft to the vicinity of Venus between July and September 1962. These will be followed by the launching of an advanced Mariner on a Mars flyby trajectory in late 1964.

Larger and heavier Voyager probes would be placed in departure trajectories by Saturn vehicles. They would incorporate guidance and propulsion systems to enable them to enter orbits about Mars and Venus. Once in orbit, Voyagers could perform planetary atmosphere and surface observations, perhaps sending instrumented packages to the ground to gather additional data.

Besides moon, Venus, and Mars probes, more complex spacecraft to probe the inner and outer areas of the solar system will be launched as Saturn vehicles with higher payload capabilities become available. These probes will monitor solar activities at various distances from the sun; gather data on magnetic fields, particles, radiations, and other phenomena throughout the solar system; and study Mercury and the outer planets and their moons. Saturn vehicles will bring the solar system within the reach of man.

Orbital flight around earth will be our first step toward manned deep-space explorations. America's man-in-space effort is now being carried out under NASA's Project Mercury. By the time this issue of *Astronautics* appears, our first astronaut may have already orbited earth and have been successfully recovered.

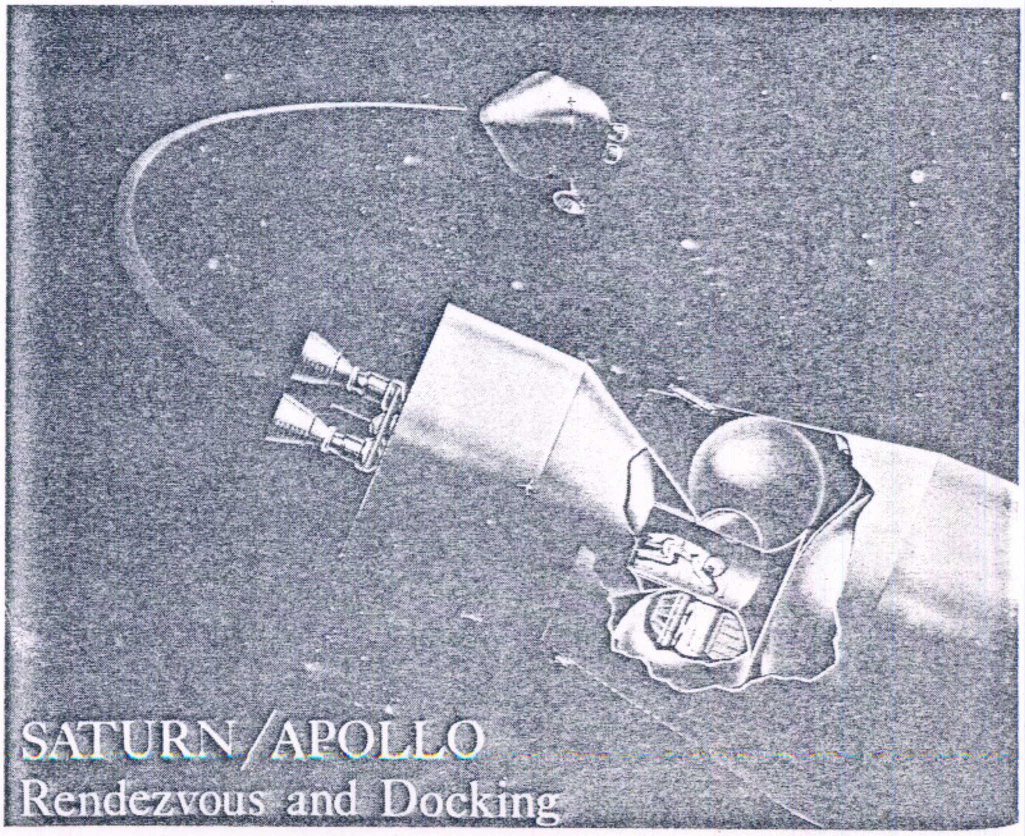
Project Mercury is only the beginning of a sustained program of manned space flight. Its successor, the Apollo manned spacecraft project, calls for the development of a highly flexible system that may serve as an earth-orbiting space laboratory, a circumlunar flight vehicle, and a lunar lander. The design of the Apollo system is based on the "building block" or modular concept.

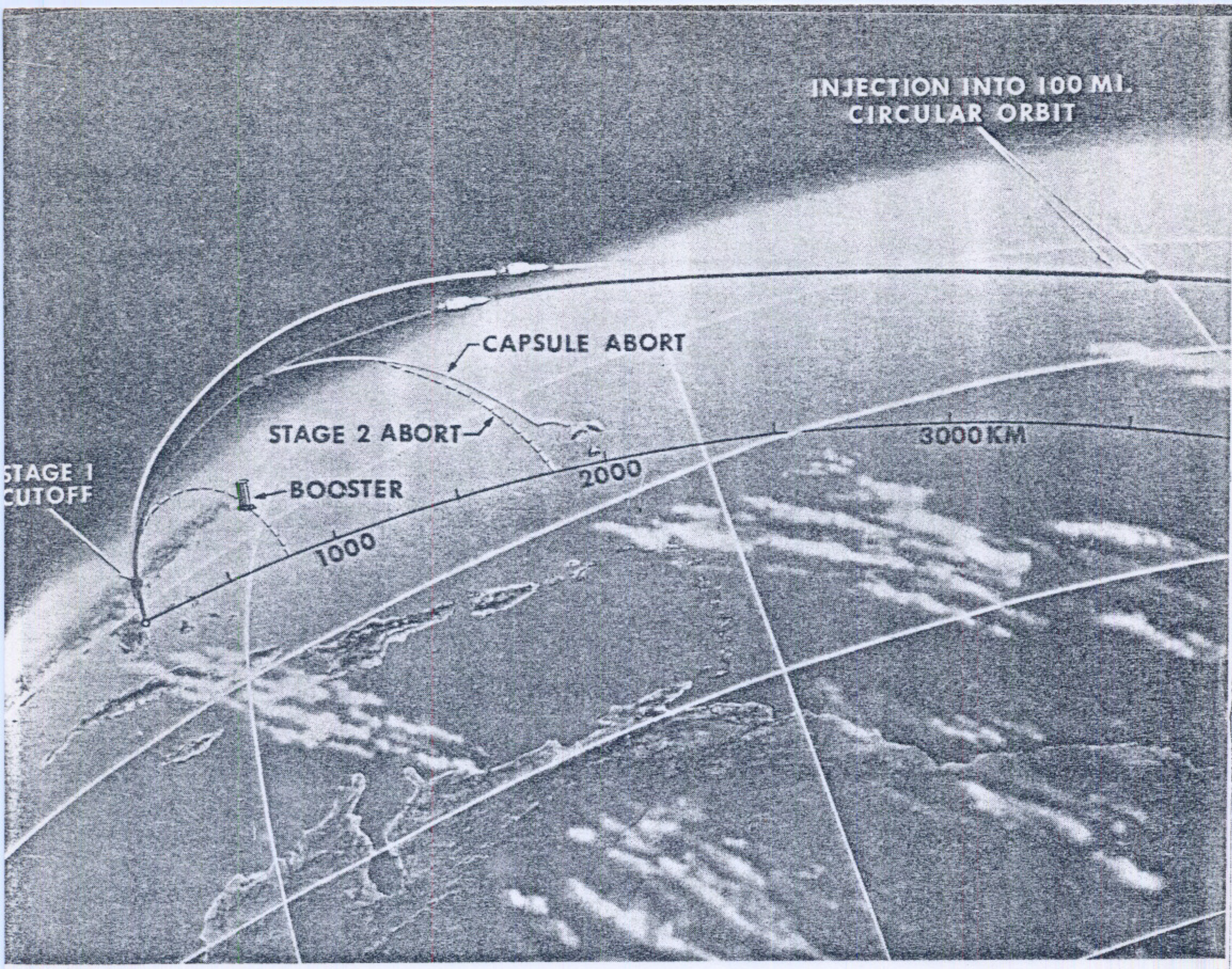
The key component of Apollo is the *command module,* a pressurized compartment for a three-man crew and equipment. Below this is the *service module* containing electrical power supplies, as well as propellants and a propulsion unit for orbital maneuvers and re-entry. For earth-orbit missions these two modules are all that are required; they are mated to the upper stage of the two-stage Saturn carrier vehicle by an adapter section. However, since Saturn has power to spare, a *space-laboratory module* may be inserted between the service module and the adapter, allowing scientific experiments to be conducted in orbit. Earth-orbiting Apollos are being developed within Phase A of the over-all Apollo program. Phase A Apollos will permit the crew to stay in orbit for approximately two weeks.

In Phase B, circumlunar and lunar orbital flights will be conducted. The Phase B Apollo will use the same command module as earth-orbital tests (without the space laboratory module), but it will have enlarged propulsive power in the service module. Phase C Apollo provides means for conducting lunar landings. The Apollo lander incorporates a separate *lunar-landing module,* which is attached to the service module. The latter will provide sufficient propulsive power for a lunar takeoff and return to earth, and it doubles as an emergency propulsion system in case the flight must be aborted before the lunar landing.

Apollo Command Module Returns

Of the huge stack of Saturn stages and Apollo modules piled on top of one another before departure from earth, only the Apollo command module will return to the surface of the earth. Regardless of the mission, the configuration of this module is not expected to vary greatly. It contains guidance, navigation, computing, communications, life support, and other equipment. Windows will give the Apollo crew direct vision of rendezvous, lunar landing, and other space operations.





Typical Saturn–Apollo Flight

All Saturn–Apollo spaceships will take off from the Atlantic Missile Range, Fla. Early Apollo earth-orbital spacecraft will be launched by Saturn C-1 carriers, an advanced version which can lift a little over 30,000 lb of payload into orbit. Manned lunar circumnavigation and manned lunar landings will utilize the giant Saturn C-5, the development of which has recently been authorized.

Saturn C-5 will be 396 in. in diam and about 350 ft long. Its takeoff weight will be slightly over 6-million lb, or 3000 tons. (This is equal to the weight of a light cruiser or, to remain in the frame of aerospace thinking, the takeoff weight of about 25 fully loaded Boeing 707's.) To lift this enormous weight off the ground, the Saturn C-5 first stage will be powered by five kerosene-oxygen F-1 engines, giving a total thrust of 7.5-million lb. The second stage will be powered by five J-2 liquid-oxygen–liquid-hydrogen engines, producing a total thrust of 1-million lb. For orbital missions, a two-stage version of the C-5 would normally be used, while for escape missions a third hydrogen-oxygen stage powered by a single J-2 may be added to increase the payload. Saturn C-5 will be able to place well over 200,000 lb (almost the equivalent of one Boeing 707) into a 300-mi. orbit and to project at least 85,000 lb into an earth-escape trajectory.

Even the huge new Saturn C-5 will not be powerful enough to provide us with a capability to carry our three-man Apollo crew in a direct flight from the surface of the earth to the surface of the moon and back. A still larger rocket, generally referred to as Nova, and almost twice as powerful as Saturn C-5, would be needed to do the job.

As long as we do not have a Nova, we will depend on two Saturn C-5 upper stages rendezvousing in a low orbit around the earth. The arithmetic behind this rendezvous business is very simple. We believe that for the return flight we need about 50,000 lb of departure weight on the surface of the moon to carry the three-man Apollo command module back to earth. (CONTINUED ON PAGE 112)

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To have this departure weight available on the moon, we must inject, during the moonbound part of the voyage, a total weight of about 150,000 lb into the earth-to-moon transfer trajectory. This requires a departure weight of about 400,000 lb from a 300-mi. earth orbit—which happens to be twice the useful orbital payload of a Saturn C-5. It is obvious that the C-5 offers us a possibility of performing the manned lunar landing with a single orbital rendezvous. Conversely, to provide the necessary push for a manned lunar landing in a direct flight from the earth's surface, Nova must have the equivalent of an orbital payload capability of 400,000 lb.

The orbital-rendezvous method, for all its obvious complications, has the attractive feature of offering a high degree of flexibility in operational modes and adaptability to the ever-changing weight and performance figures. Some possible operational modes are as follows:

(1) Orbital Boarding. The complete orbital-launch vehicle, fully fueled and loaded, is placed into orbit by a powerful carrier. A second, much smaller vehicle carries the crew into orbit where they board the launch vehicle. (This mode may be attractive for Nova-type lunar flights to avoid exposure of astronauts to the hazards of the earth-to-orbit portion of the flight with a still scantily tested Nova—at a time when smaller orbital carriers may have proved their reliability in numerous prior flights.)

(2) Orbital Connecting. The mechanical joining of the upper and the lower portions of the moon vehicle is accomplished in orbit. (The two portions have been carried into orbit with two consecutive C-5 flights.)

(3) Orbital Fueling. The orbital launch vehicle is carried by one C-5 into orbit as a complete unit but with not completely filled propellant tanks. Fuel (or liquid oxygen) is carried into orbit by a separate C-5 tanker and is transferred in orbit to the orbital launch vehicle.

(4) Orbital Assembly. The orbital launch vehicle is assembled in orbit from subsystems, such as propulsion units, structural components, propellants, and payload. (This scheme is a little more involved. It appears promising for future use of electrically propelled deep-space ships.)

Following the first tentative steps into space with Project Apollo, man will pull on his seven league boots and take giant strides across space to the nearer planets of the solar system. For Mars, and perhaps Venus, direct surface landings should be possible in this century if the state of the art of astronautics continues to advance rapidly. However, landings on frozen Jupiter, Saturn, Uranus, and Neptune may never be feasible, and man may be limited to landings on their moons. The problems of direct landings on these giant worlds are extremely complex and pose demands upon the design of manned spaceships that are far beyond our present capabilities. To illustrate the magnitude of the problem, we need only consider the difficulty of trying to decelerate a spacecraft in the tremendous gravitational field of Jupiter and then attempting to take off again through an amazingly thick, turbulent atmosphere.

A Crucial Measure

In view of such complexities, the public may question the need for space travel, especially *manned* space travel. Aside from rhetorical answers, we can say that it is a necessity because it is a part of man's destiny. Perhaps the best answer is the one given by Nobel laureate Joshua Lederberg at the First International Space Science Symposium of COSPAR, held in Nice, France, in January 1960: "The human species has a vital stake in the orderly, careful, and well-reasoned extension of the cosmic frontier; it will be a crucial measure of the maturity of our national consciences and their concern for posterity, how we react to the adventuresome and perplexing challenges of space flight." ♦♦