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The Cart before the Horse: Mariner Spacecraft and Launch Vehicles

By August 1960 when Clarence R. Gates and his colleagues at Jet Propulsion Laboratory began studying plans for an interplanetary spacecraft called Mariner B, NASA's lunar and planetary program was taking the basic form it would have for a decade. Mariner B, designed to explore Mars and Venus and the space between, competed for both financial and manpower resources with several other space science projects. Lunar spacecraft—Pioneer, Ranger, Surveyor, and Prospector—were the main attraction, while Mariner and Voyager with their planetary objectives took second billing.*[1] Lunar and planetary missions were arranged sequentially so that planners and scientists could progress from simple to complex tasks. Designers and engineers would likewise work on increasingly sophisticated spacecraft around a common chassis, or "bus," that could take successively more complex experiment packages into space. To meet these goals, NASA planned for the structured growth and development of several basic kinds of spacecraft. But spacecraft were only half the story.[2]

Reliable launch vehicles were essential to space exploration, and their lack had bedeviled the American space endeavor from the beginning. Reliability and payload capacity of the boosters (both proposed and in existence) defined the dimensions and possible use of each kind of spacecraft. While this relationship between launch vehicle and spacecraft was apparent in any space project, it had an especially negative effect on Mariner B.

EVOLUTION OF UNMANNED SPACE EXPLORATION TO 1960

Pioneer and Troublesome Launch Vehicles

Lunar exploration project Pioneer, America's bid in the early space competition, was approved in March 1958 under the initial direction of the Advanced Research Projects Agency, which assigned hardware develop-

*Lunar projects were given names related to terrestrial exploration activities; interplanetary projects were given nautical-sounding names that conveyed the impression of travel over great distances to remote lands.

ment to both the Air Force and the Army. But the two services each had a distinct approach to Pioneer, and the differences plagued the project from the start. On their first try, the Air Force team produced an unplanned pyrotechnic display when a Thor-Able launch vehicle exploded 77 seconds after liftoff from Cape Canaveral on 17 August 1958. *Pioneer 1*, launched on 11 October that year, was another disappointment; an early shutdown of the second stage prevented its attaining a velocity sufficient to escape Earth's gravity. After a 115 000-kilometer trip toward the moon and 43 hours in space, the probe burned up when it reentered Earth's atmosphere. The next month, *Pioneer 2*'s third stage failed to ignite; this spacecraft was also incinerated as it fell back to Earth. Meanwhile, the Army Ballistic Missile Agency and the Jet Propulsion Laboratory were working on a Pioneer lunar probe to be launched by a combination vehicle called Juno II, a Jupiter intermediate range ballistic missile with upper stages developed by JPL. A 6 December 1958 attempt to launch this four-stage rocket to the moon failed when the Jupiter first stage cut off prematurely. *Pioneer 3* reentered after a 38-hour flight.

Pioneer 4, the last of the series initiated by the Advanced Research Projects Agency, rose on its Juno II launch vehicle on 3 March 1959 and traveled without incident to the moon and beyond into an orbit around the sun, but without passing close enough to the moon for the lunar-scanning instruments to function. The U.S. attempt to beat the Soviet Union to the moon had already failed: *Luna 1*, launched 2 January, had flown by its target on 4 January. *Luna 2* next became the first spacecraft to land on another body in the solar system, crashing into the moon on 13 September 1959. *Luna 3*, launched 4 October, returned the first photographs of the moon's far side.

The U.S. effort continued to be less than successful. A sixth Pioneer lunar probe, a NASA-monitored Air Force launch, was destroyed when the payload shroud broke away 45 seconds after launch in November 1959. In 1960, two more NASA Pioneers failed, and the project died.* America's next entry was Ranger, NASA's first full-scale lunar project.[3]

Ranger: Atlas-Vega versus Atlas-Agena

The Ranger spacecraft—designed to strike the moon's surface after transmitting television pictures and gamma ray spectrometry data during descent—was one of the payloads planned for the Atlas-Vega launch vehicle. Atlas, an Air Force intercontinental ballistic missile developed by General Dynamics-Astronautics, had been selected by Abe Silverstein's Office of Space Flight Development for early manned orbital missions and deep space probes, and the decision had been based on several sound premises. If Atlas could be so adapted and if Thor and other intermediate-

*In 1965, NASA revived Project Pioneer with a new objective: to complement interplanetary data acquired by Mariner probes.

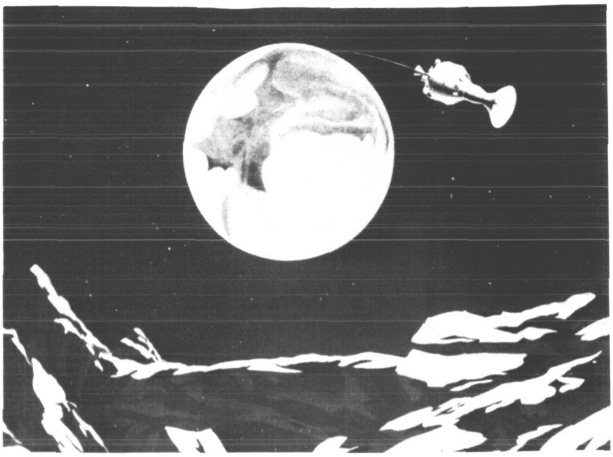
range ballistic missiles could be used for lightweight Earth satellites, then most of the funds NASA had earmarked for launch-vehicle development could be used for the development of a family of much larger liquid-propellant rockets for manned lunar missions. The space agency could purchase Atlas missiles from the Air Force and provide upper stages tailor-made for any particular mission, whether science in deep space or manned Mercury missions near Earth.

As defined in December 1958, three basic elements composed Atlas-Vega: (1) the Atlas missile, with its so-called stage and a half; (2) a modified Vanguard engine for the second stage; and (3) Vega, a new third stage under development at JPL. Vanguard was produced by General Electric. JPL's Vega would provide the extra thrust to reach the velocities necessary for planetary flights. According to the estimates, the combination would be able to place 2250 kilograms in a 480-kilometer Earth orbit or send approximately 360 kilograms to the moon. The first Atlas-Vega flight was optimistically scheduled for the fall of 1960.

On 17 December 1958 in Washington, representatives from NASA, the Advanced Research Projects Agency, the Army, and the Air Force considered launch vehicle development and agreed that a series of versatile, increasingly powerful launchers was a desirable goal. However, NASA wanted its first new launch vehicle to be Atlas-Vega, while the Air Force favored the smaller Atlas-Agena. Since neither vehicle could meet the requirements of both organizations, NASA and the Air Force agreed to pursue their separate courses. Both approved Atlas-Centaur, a higher-energy rocket under development for future use, but only the space agency projected a need for the much larger Saturn.

Vega was the first element in NASA's proposal for "A National Space Vehicle Program," a document sent to President Eisenhower on 27 January 1959 specifying four principal launch vehicles—Atlas-Vega, Atlas-Centaur, Saturn I, and Nova (subsequently replaced by Saturn V). NASA began its hardware development program by contracting with General Dynamics, General Electric, and JPL for the production of eight Vega launch vehicles, being considered for Ranger flights to the moon and for a 1960 Mars mission. To send a spacecraft to Mars "with sufficient guidance capability and sufficient instrumentation to transmit information to the Earth, we need at least a thousand pounds [450 kilograms] of payload," Milton W. Rosen, chief of the NASA Rocket Vehicle Development Program, reminded senators during April 1959 hearings on the agency's 1960 budget. Vega was the first launcher in the NASA stable that had "such payload carrying capacity."[4]

Atlas-Vega, however, was not destined to fly to either the moon or the planets; a competitor blocked the way. The Air Force had been concealing a significant fact—Lockheed Missiles & Space Company had been developing a much more powerful version of Agena, the B model.[5] The uprated Atlas-Agena B was unveiled in May 1959, almost instantly killing Atlas-



An artist's concept of the Vega Mars probe as seen from the Martian moon Deimos was presented to the Senate Aeronautical and Space Science Committee on 7 April 1959.

Vega. NASA began investigating the similarities between the two that spring, and in July the Civilian-Military Liaison Committee, established earlier to work out problems of mutual concern to NASA and the Department of Defense, ordered a review of the two systems. The committee's and NASA's findings agreed: one of the projects should be canceled. Since NASA was in no position to force the Air Force to terminate the somewhat more flexible Agena B, the agency conceded. On 7 December, Glennan telephoned JPL Director Pickering. All work on Vega would stop immediately.[6]

Glennan and his staff at NASA Headquarters were discomfited by Vega's cancellation. The duplicative project had not only cost them $17 million labeled for launch vehicle research, its cancellation had returned them to dependence on new Air Force rockets. JPL's unhappiness over losing Vega was compounded by dismay over NASA's new 10-year plan, which was clearly geared toward lunar rather than planetary activities.[7] Richard E. Horner, NASA associate administrator, wrote Pickering in December 1959 about the management's post-Vega thinking, discussing the recent transfer of the Army Ballistic Missile Agency in Huntsville, Alabama, to NASA (a transfer sought by NASA since October 1958) and Vega's cancellation. Although the cancellation was certainly "disturbing" and would "necessitate a major reorientation of the Laboratory work program," Horner believed that it would allow the entire NASA community to advance toward the agency's long-term objectives. Each NASA center working directly in space experimentation had been assigned "a major functional area of responsibility." The facility at Huntsville under the direction of Wernher von Braun was responsible for the development of launch vehicles and associated equipment. That organization would also control all launch-related activities to the point of orbital injection or some similar point in the trajectory of a probe. The Goddard Space Flight Center in Maryland would oversee the development and operation of Earth satellites and sounding-rocket payloads. Development and operation of spacecraft for lunar and interplanetary exploration was JPL's task. "It is pertinent to note here that the Administrator has decided that our efforts for the present . . . should be concentrated on lunar exploration as opposed to exploration of the planets," Horner added in his letter to Pasadena.[8]

Along with these clearly defined field assignments, major changes were taking place at NASA Headquarters. The former Office of Space Flight Development was divided into two directorates—the Office of Launch Vehicle Programs and the Office of Space Flight Programs.* Abe Silverstein would direct spaceflight, with JPL and Goddard reporting directly to him. Staff responsibility for launch vehicles would be directed by former Advanced Research Projects Agency specialist Maj. Gen. Don R. Ostrander, to whom the von Braun team would be accountable. These assignments were designed to establish clearer lines of responsibility for both administrative and functional purposes. (See charts in appendix G.)[9]

Within this new framework JPL, in carrying out its task of planning and executing lunar and planetary projects, would be in charge of mission planning, spacecraft development, experiments, mission operations, analysis of scientific data returned from space, and the publication of mission results. Since these activities could not possibly be carried out by JPL alone, headquarters "expected that a part of the developments will be contracted with industry and the Laboratory will assume the responsibility of monitoring such contracts," Horner noted. Pickering continued to resist such a role when he met with Silverstein a month later, but contracting for hardware development was agency policy. NASA would also exercise control over its field centers through annual program guidance documents written at headquarters. The Pasadena laboratory's independence was being curtailed as the men in Washington began to pull together a more centralized management system, but the relationship between headquarters and JPL was still not clearly defined.[10]

In December, going one step further in asserting headquarters' leadership, Silverstein outlined for JPL the space agency's plans for lunar and planetary missions for the next three years. Earlier that month the NASA Lunar Science Group, chaired by Robert Jastrow, had met to discuss proposals for lunar exploration. Harold Urey, Thomas Gold, Harrison Brown, and other scientists had agreed that a hard lunar landing, which by its crashing impact could help determine the nature of the moon's surface structure, would be an important first step. High-resolution pictures of the moon before impact would also be most important. Basing plans on the advice of the lunar group and the change in launch vehicles, Silverstein

*The distinction between programs and projects was first made clear by G. F. Schilling, Office of Space Science, late in 1959. *Programs* signified a related and continued series of undertakings geared toward understanding a broad scientific or technical topic; programs (e.g., examining the solar system) did not necessarily have foreseeable ends. *Projects* were the building blocks for programs and as such had limited objectives, limited duration (e.g., Project Mariner, Project Viking). While the space science personnel at NASA tended to maintain this distinction over the years, the concept was not as clearly observed in manned spaceflight, where the Apollo project grew so large it became a program.

advised Pickering that seven flights were planned through 1962. The first five would be launched by Atlas-Agena B for "lunar reconnaissance" in 1961-1962; two other spacecraft would be sent by Atlas-Centaur to Mars and Venus in 1962.[11] As part of an integrated lunar exploration program, the lunar spacecraft, Ranger, should also be capable of depositing an instrument package on the moon.

In late December, Homer Newell, Newell Sanders, Joseph A. Crocker, and Morton J. Stroller traveled to California to discuss how the projected flights fitted into the agency's long-range plans. Crocker explained that development should begin on four different spacecraft (designations in brackets indicate projects that emerged from this planning):

a. A spacecraft for use with the Agena on lunar work [Ranger],

b. a spacecraft for use with Centaur for planetary and lunar orbit, with perhaps a modification for soft landings [combination of Surveyor and Lunar Orbiter and Mariner B],

c. a spacecraft for use with Saturn on planetary work [Voyager] with some modifications, perhaps for instrumented landings of lunar rover vehicles [Prospector], and finally,

d. a spacecraft for use with the Saturn for unmanned circumlunar missions and return leading to perhaps some modifications for manned circumlunar missions and return.

Rather than be developed independently, the spacecraft would evolve, with more advanced spacecraft growing out of generation-to-generation experience.[12]

Pickering was still not fully reconciled to the moon-first priority laid down by Washington, believing that the limited opportunities for flights to the planets made it absolutely imperative that work begin immediately on planetary spacecraft. Newell and his colleagues relieved the director's anxieties somewhat by assuring him that there would be planetary flights "every time the near planets, Mars and Venus, were in optimum position." The JPL group was reminded, however, that the planetary program would be relying on the yet-to-be-developed Centaur launch vehicle for some time, until the more advanced Saturn family was ready.[13]

Surveyor, Mariner, and the Centaur

As headquarters directed, JPL personnel set about defining a lunar impact mission, but Atlas-Centaur-boosted spacecraft of the future were also an active concern. NASA hoped Surveyor, the first of these advanced craft, would allow a "tremendous stride forward in lunar exploration," since it would land softly on the moon, carrying a number of experiments,*

*The term *experiment*, as NASA uses it, refers to any exercise whose purpose is to gather scientific or engineering data (and also to the equipment used to perform an experiment). Few scientists would apply the term to some NASA experiments, e.g., photography of Earth from orbit.

including a surface sampler and an atmosphere analyzer. These instruments would provide scientists and designers information they needed to plan more sophisticated unmanned and manned landing missions. Mariner, the second spacecraft family to be powered by Atlas-Centaur, would be directed toward Venus and Mars. Two kinds of Mariner spacecraft were planned: an A model that would simply fly by those planets and a B model that could release a landing capsule toward Mars or Venus as the main bus flew by. A 1962 Mariner was expected to be launched toward Venus to measure the planet's surface temperature distribution, examine the atmosphere, and determine the extent of the magnetic field as it flew by.

Still later in the 1960s, two multipurpose spacecraft, Prospector and Voyager, atop mighty Saturn launch vehicles were to extend the scope of unmanned lunar and planetary exploration even further. Prospector was being designed to roam about the lunar surface as directed from Earth and examine the moon with a sophisticated array of instruments. Subsequent lunar rovers were to be used as logistic vehicles to marshal supplies for manned missions to the moon, or possibly as an early means of returning experiment samples. Voyager, too, was being designed with growth in mind. From the first missions in 1964 to either Venus or Mars with slightly larger landed payloads than the Mariner B capsule, Voyager was to grow larger and larger until a mechanized rover was sent to Mars or Venus. Prospector and Voyager represented the very distant future, but by the summer of 1960 JPL and NASA Headquarters were beginning to give serious attention to Surveyor and Mariner.[14] Both of these craft were scheduled for launch by Atlas-Centaur—the number two vehicle in NASA's plans—but development problems with the Centaur stage would seriously affect the timetable.

CENTAUR: TROUBLESOME LAUNCH VEHICLE

One of the earliest plans for a U.S. probe to Mars was based on the Atlas-Centaur launch vehicle. In 1956, Krafft Ehricke of General Dynamics began to study high-energy second stages that might be used with the Atlas missile. In examining oxygen-hydrogen rocket stages, he had three objectives in mind—using the unexcelled thrust of Atlas, providing an upper stage with a maximum energy output for its weight, and developing a launch vehicle that could be used for several different kinds of mission. Three specific "important mission classes" were considered for this new vehicle:

> High-altitude satellites in the 8-hour, 12-hour and 24-hour orbits for the purpose of global surveillance, early warning, and global communication.
>
> Launchings of instrumented space probes to the lunar surface and into the inner solar system, primarily to Venus and Mars. . . .
>
> Establishment of a small manned orbital laboratory for a crew of three to inaugurate systematic preparations for deep space missions of manned spaceships.[15]

For several reasons, Ehricke and his associates settled on 13 500 kilograms for the weight of their proposed high-energy stage. This was close to the upper limit that the existing Atlas could boost, and a stage of this approximate weight would have about the same diameter as Atlas and a reasonable length. By October 1957, studies for the prototype Centaur were complete, and Ehricke took his ideas to the Advanced Research Projects Agency. The agency was intrigued and encouraged Ehricke's team to draw up a plan for a launch vehicle stage that used two Pratt & Whitney pump-fed engines rather than pressure-fed engines. On the basis of these discussions, General Dynamics submitted a proposal for a Mars probe in August 1958.

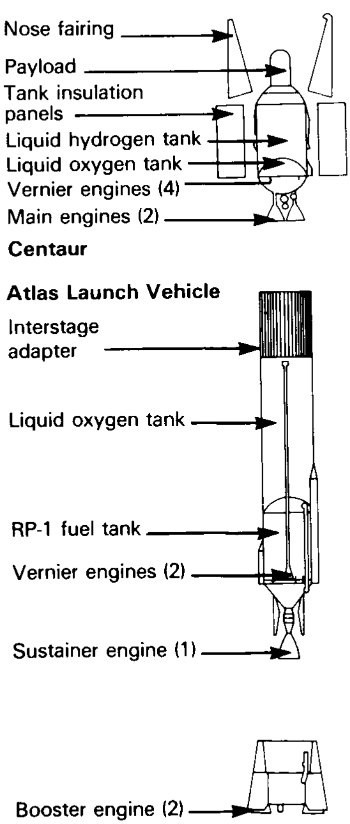
Ehricke noted that this particular suggestion for a flight to the Red Planet had been made because his team was "quite mission conscious and [wanted] to emphasize the importance of gaining an early capability to send probes to Venus and Mars in view of the infrequent intervals at which these missions [could] be flown." Some years are more favorable for planetary flights than others, and during advantageous years a rocket of given power can carry a much larger payload. Propitious opportunities for travel to Mars and Venus occur about every two years and generally last for about a month (appendix A). Unless the launch vehicle is unusually powerful, the geometry dictates a two-year delay once a launch window is missed. Separation between Mars and Earth at the time of closest approach varies from 55 million to 102 million kilometers over a cycle about 16 years long. (The most favorable opposition between 1970 and 1975 was in 1971, when the two planets were only 55.8 million kilometers apart.) Ehricke in 1958 looked toward a 1964 launch, to take a spacecraft past Mars in June 1965.

On 28 August 1958, the Advanced Research Projects Agency requested the Air Force Research and Development Command to oversee a contract with General Dynamics for the development of an upper stage for Atlas, to be propelled by oxygen and hydrogen. That stage, which was to weigh about 13 500 kilograms and have a diameter of about 3 meters, was to be powered by two engines capable of 67 000 newtons (15 000 pounds) of thrust each. Even though the effort required a major advance in the state of the art, an oxygen-hydrogen-powered stage appeared feasible. The resultant launch vehicle was intended to be a "space truck," bridging the gap between the less powerful Atlas-Agena and the much larger boosters of the future. Although a specific mission for the stage had not been defined, the first test flight was scheduled for January 1961, only 26 months after the contract with General Dynamics was signed.

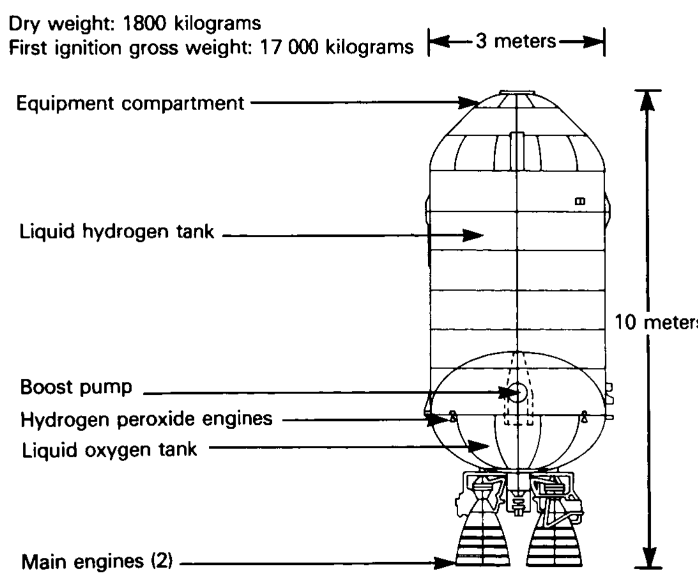
Given the short development time, limited budget, and injunction against impinging on the military Atlas program, the government was expecting a great deal from General Dynamics, which was responsible for vehicle development and overall project integration, and Pratt & Whitney, which had a contract for building the oxygen-hydrogen engines. After considerable negotiation, NASA, the Advanced Research Projects Agency, and the Air Force agreed in the summer of 1959 to a compromise system of management. The Air Force named Lt. Col. John D. Seaberg Centaur project director and assigned him to the Ballistic Missile Division's offices at the Los Angeles Air Force Station. Seaberg had a strong background in the missile field and intimate knowledge of the relatively new technology surrounding liquid hydrogen, having worked on the Air Force's highly secret Suntan Project, which had sought to tame liquid hydrogen for use as an aircraft fuel. Seaberg reported directly to Milton Rosen, project director at NASA Headquarters. This arrangement became official on 1 July 1959, when responsibility for Centaur was shifted to the space agency.[16]

During the winter of 1959–1960, NASA established a Centaur Project Technical Team of specialists from the field centers, to undertake a thorough study of the project and recommend ways in which it might be best conducted.[17] Centaur had grown in importance to NASA since the cancellation of Vega and was rapidly becoming more than an austere research and development experiment. It was a probable answer to launching specific payloads. Centaur, with its much greater thrust and coast-restart capability, promised a major technological improvement over existing vehicles.[18]

In early 1960, NASA Headquarters and JPL conducted a series of studies to determine the most suitable launch vehicle for early Venus and Mars flyby missions. On 8 July 1960, a team from JPL gave Administrator



Outlined at left are the major components of the proposed Atlas-Centaur two-stage launch vehicle for planetary probe missions. Below, the Centaur upper stage is nearly 10 meters tall and about 3 meters in diameter. General Dynamics/Astronautics, A Primer of the National Aeronautics and Space Administration's Centaur *(San Diego, 1964).*



Glennan a six-part briefing on the subject. Lab spokesman Robert J. Parks noted that the late 1960 Mars and early 1961 Venus launch windows would have to be ignored as NASA was "in no position to take advantage of them," but before 1970 there remained "exactly five opportunities to fire at Venus and four to fire at Mars." To make the best use of those, the proper order for developing spacecraft appeared to be "first planetary flybys, then planetary orbiters, and then the orbiter-landers, in which a part of the orbiting vehicle is detached and caused to enter the atmosphere and land on the planet relaying its information to the earth via the orbiter." Since Atlas-Centaur could not boost planetary orbiters (retrorockets would add considerably to the weight), JPL's 10-year flight schedule (see chart) called for using Centaur for flyby missions through 1964. In 1965, Saturn was to be used for planetary orbital experiments, leading to larger lander missions in 1967.[19]

The early flybys were important, since they would supply information about atmospheric and topographical conditions—data that would affect future landing craft. From the lab's point of view, the 1964 Venus and Mars opportunities were the big ones, and at least "three spacecraft developmental firings [were] required prior to . . . 1964." Repeating an increasingly familiar refrain, Parks told Glennan that after the first five Ranger launches, the planetary program would constitute "the major program activity of the Laboratory."[20]

Sending a spacecraft to either Venus or Mars depended on the availability of both Atlas-Centaur and sufficient funds. Atlas-Centaur was a big question mark, but nearly everyone was hopeful. Parks pointed out, however, that "FY61 fund limitations preclude developing and fabricating in time for a 1962 launching" a spacecraft meeting all the relatively severe requirements for a mission to Mars. Instead, JPL proposed a more modest spacecraft based on Ranger for a 1962 flight to Venus.

Although the small Ranger-class spacecraft would not be a true prototype of the 1964 Mariner, it would still provide an excellent early test. Assuming the availability of Atlas-Centaur in 1962, an 885-kilogram payload could be sent to Venus; 585 kilograms could be flown to Mars. Ranger weighed only 225 kilograms. Given the uncertain financial and launch vehicle situation, the JPL team favored sending the smaller craft to Venus in 1962, leaving the larger full-scale Mariner for the 1964 opportunity.[21]

Believing that Centaur would be ready on time, the Office of Space Flight Development disregarded JPL's advice. Headquarters planners in July 1960 proposed to launch a spacecraft designated Mariner A to Venus with Atlas-Centaur in 1962 after one test flight. Following a 1963 trial, a larger Mariner B, possibly with an instrumented lander, would be ready for Mars and Venus missions in 1964. JPL's austere 1962 super-Ranger was held in abeyance. Administrator Glennan approved the Mariner projects on 15 July 1960, just six days after he had approved three lunar Apollo feasibility studies.[22]

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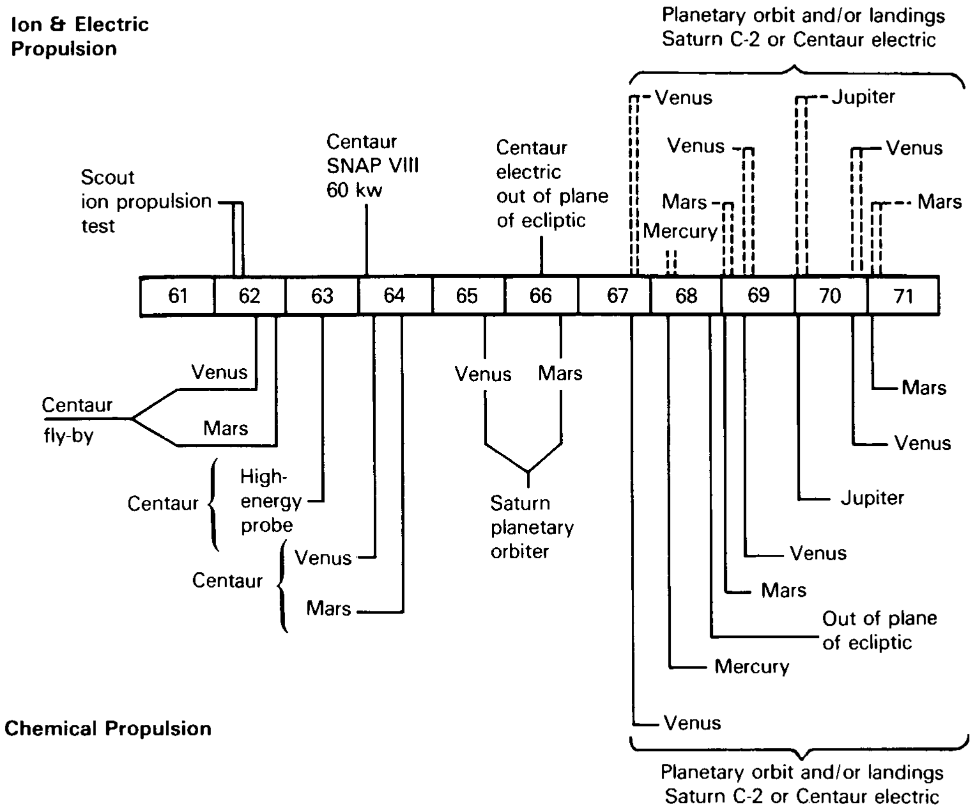
PROPOSED PLANETARY EXPLORATION SCHEDULE



A proposed 10-year programming chart was shown to NASA Administrator Glennan at the 8 July 1960 planetary program briefing. The proposals for launch vehicle upper stages above the timeline would use nonconventional—ion and electric—propulsion. (SNAP stands for "system for nuclear auxiliary power"; SNAP VIII would produce 60 kilowatts of electrical power.) Proposals for upper stages shown below the timeline would use conventional—chemical—propulsion.

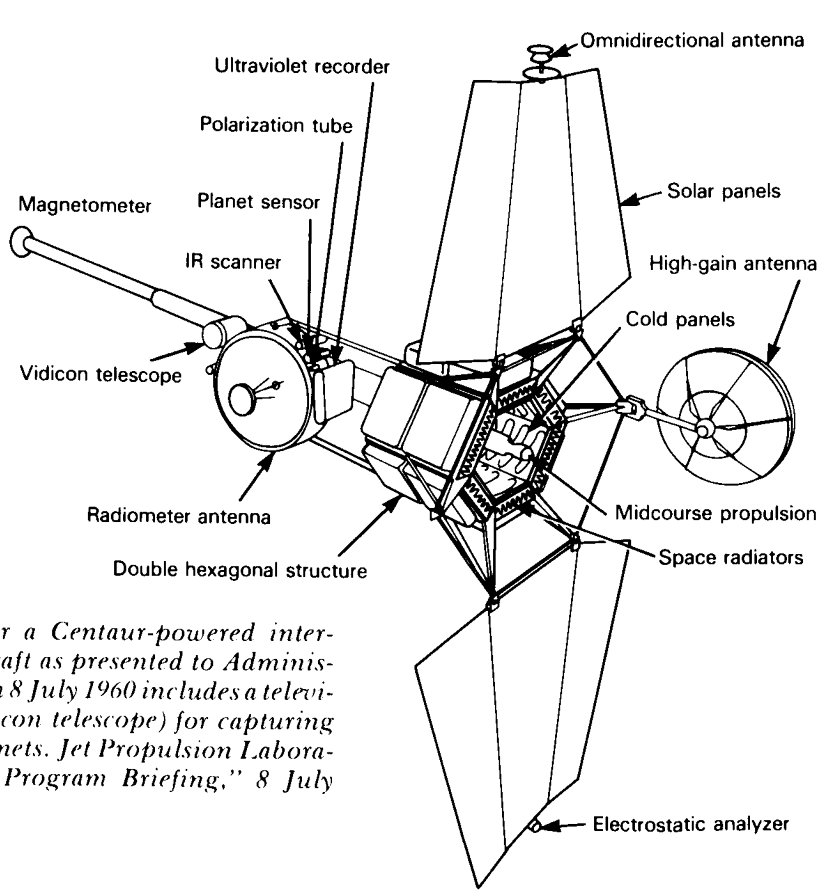
Planetary Mission Proposals

In August 1960, the Planetary Program Office at JPL began studying Mariner B, examining the feasibility of building a spacecraft capable of a variety of missions. Such a versatile craft using basic components with scientific instruments packed in modules promised lower production costs. A confidential "Mariner B Study Report" prepared in April 1961 concluded "that the Mariner B mission should involve a split capsule, in which the main body of the spacecraft passes by the planet and a small, passive capsule separates from the spacecraft and impacts the planet." Mariner B was expected to be used to investigate Mars and Venus.

In reviewing possible missions, Clarence Gates of JPL's Systems Division noted in JPL's study report that planners usually judged proposed spacecraft-borne experiments by three criteria:

> (a) The experiment should be conservative and should be based to the maximum extent possible on previous experience, technology, and components; (b) the experiment should, in its own right, be significant in the contributions that it makes to technology and scientific knowledge; and (c) the experiment should be daring and imaginative, should take a substantial stride forward, and should bridge the gap between our present state of knowledge and the more distant future.[23]

Gates went on to point out that it was "rare for these considerations not to lead in diverse directions." In 1961, Mariner A typified a conservative approach with a high chance of success. That craft was fully attitude-stabilized, using the sun and Earth as references. Power was to be supplied by sun-oriented solar panels, with backup batteries.While the propulsion system could be operated for a midcourse correction maneuver, Mariner A had neither an approach nor a terminal guidance system; thus, it could not be expected to rendezvous reliably with specific celestial coordinates near the target planet. Mariner B, the next step, would be more advanced technologically, contributing to the design and development of the still more ambitious Voyager.



JPL proposal for a Centaur-powered interplanetary spacecraft as presented to Administrator Glennan on 8 July 1960 includes a television camera (vidicon telescope) for capturing images of the planets. Jet Propulsion Laboratory, "Planning Program Briefing," 8 July 1960.

Plans for Voyager called for a 1080-kilogram spacecraft with a several-hundred-kilogram capsule capable of surviving atmospheric entry and descent to the planetary surface. Among the technological accomplishments required before Voyager could fly in 1967 were: "(a) approach guidance which will place the spacecraft in desired relation with respect to the planet; (b) techniques for aerodynamic entry into a planetary atmosphere; and (c) propulsion systems for the addition of the relatively large velocity increments required by the planetary orbiters."[24] But between Mariner A and Voyager lay the largely undefined Mariner B.

Gates and his associates looked at four basic missions to determine the best way to bridge that technological gap. First was a proposal for a Mars flyby and return mission. While passing by the planet, the spacecraft would collect photographs and other scientific information and then return to Earth where a reentry package would be recovered, complete with developed photographs. The Instrumentation Laboratory at the Massachusetts Institute of Technology had studied such a planetary mission for the Air Force in 1958-1959,[25] and the Air Force had successfully recovered a 38-kilogram data capsule from the Earth-orbiting *Discoverer 13* on 10 August 1960, proving the recovery concept feasible. To the JPL planners, however, such a mission was "unattractive"; the quality and quantity of data that could be transmitted electronically to Earth from Mars was "entirely adequate."

A second mission under consideration was a flyby with more instrumentation than on Mariner A. Since this project seemed repetitive, something had to be done to improve its appeal. An approach guidance system would enable the craft to pass closer to Mars but would also increase the demands placed on the communications and power capabilities, which in turn would add unwanted weight. All additions to the weight of the basic craft would subtract from the scientific payload, but tradeoffs between different elements of the spacecraft became the norm.

A planetary orbiter was the third suggestion, but it would require a major new element, a retromaneuver package. Once a spacecraft reaches that point in its flight where the gravity of the target planet begins to attract it, a retrorocket must be fired to slow its speed so that it can go into orbit. Even if this equipment were available in time, its weight would probably increase the total beyond the predicted capability of Atlas-Centaur. Guidance technology necessary for such an orbital mission was another uncertainty.

A lander mission, the fourth consideration, would also require advanced propulsion and guidance technology that would not be ready by the early 1960s. Two other problems with a lander mission were protecting scientific instruments during entry into the Martian atmosphere and developing a communications link to operate from the Martian surface.

After studying the four missions, Gates and his colleagues made three suggestions:

> One might (a) place the main body of the spacecraft in orbit around the planet and subsequently direct a small capsule to enter the atmosphere

> and land upon the surface; (b) the main body of the spacecraft might be directed to go by the planet and place a small capsule in orbit about the planet; or (c) the main body of the spacecraft might be directed to fly by the planet and send a small capsule to enter the atmosphere of the planet and land upon its surface.

Of these, the JPL planners considered the flyby with capsule the most promising. An orbiter-lander capsule mission was too ambitious technically, and a flyby with orbiting capsule would produce no data beyond that obtained from a flyby. The split capsule concept was the most attractive proposal, and it became the basis for the first missions that would employ Mariner B spacecraft.[26]

While the staff at JPL had been studying Mariner B proposals, Wernher von Braun's Army missile group based at Huntsville, Alabama, had become part of NASA. Designated the George C. Marshall Space Flight Center effective 1 July 1960, the new center was to oversee the development of NASA's large launch vehicles. Colonel Seaberg subsequently reported directly to Hans Hueter, director of the Light and Medium Vehicle Office, as Centaur was also shifted from Air Force management to Marshall control.

In midsummer 1960, there was considerable confidence within NASA that Centaur could be made to work, and the Centaur Project Technical Team requested the purchase of four more Centaur stages beyond the six already on order. Later that year, however, Atlas-Centaur began giving the NASA team problems.[27] During the first test of Centaur's dual engines at Pratt & Whitney's Sycamore Canyon facility near San Diego in November, a procedural error by test personnel led to the ignition of only one engine. Unignited propellant from the second exploded, damaging both engines.[28] Only after two more explosions in January 1961 was the cause of the faulty ignition understood and the problem corrected.[29]

The explosions delayed the scheduled June test flight of Centaur until December, and all NASA and Department of Defense projects tied to Atlas-Centaur were also affected. The predicted payload capacity of the first Centaur was lowered as well. On 17 January, Edgar M. Cortright, assistant director for lunar and planetary programs, in response to the new limitations, recommended that "Surveyor and Mariner B missions . . . be reshaped to fit the expected Centaur performance but in such a way as to have growth capability." While the design of the two spacecraft was being scaled down to meet Centaur's reduced lift capacity, NASA Headquarters and JPL, during the winter months of 1961, began to worry about the 1962 Mariner A mission to Venus. The revised Centaur launch schedule seemed to rule out such a flight (table 5). Alternative missions would have to be devised for 1962, but NASA still hoped to use Mariner A for Venus flights in 1964 and 1965, reserving Mariner B for Mars investigations.[30]

Meanwhile, NASA and Space Technology Laboratories examined Able M, an Able upper stage that could be used with Atlas. Originally developed for lunar missions, Able was considered briefly in 1961 as a backup for a Mariner A flight.

By the second week of August, it was generally recognized that Centaur would not be ready in time for a 1962 launch to Venus.[31] Consequently, Oran W. Nicks of headquarters and Daniel Schneiderman of JPL got together to discuss their mutual problem. Nicks was fully informed on the status of Centaur, and Schneiderman had a detailed knowledge of Ranger. Together they became convinced that JPL's earlier proposal for an austere spacecraft built on the Ranger chassis deserved another look. "As the result of the optimism generated by Schneiderman during the discussion," Nicks approved JPL's study of an Atlas-Agena for such a mission.[32]

Table 5
Centaur Launch Schedule as Modified in January 1961

Vehicle	Date	Mission	Orbit	Payload (kg)
1	Dec. 1961	Vehicle test	—	—
2	June 1962	Vehicle test	—	—
3	Oct. 1962	Vehicle test	—	—
4	Dec. 1962	Vehicle test	24-hr, 30°	45
5	Feb. 1963	Vehicle test	24-hr, 30°	113
6	Apr. 1963	Vehicle test	24-hr, 30°	113
7	June 1963	Vehicle test	Escape	Surveyor, 340
8	Aug. 1963	Vehicle test	24-hr, 30°	Advent, 299
9	Sept. 1963	Spacecraft	Escape	Mariner, 544
10	Oct. 1963	Vehicle test	24-hr, 30°	Advent, 299
11	Nov. 1963	Spacecraft	Escape	Surveyor, 340+
12	Dec. 1963	Vehicle test	24-hr, 30°	Advent, 299
13	Feb. 1964	Mariner	Venus	544
14	Feb. 1964	Mariner	Venus	544
15	Mar. 1964	Advent	24-hr equatorial	227
16	Apr. 1964	Surveyor	Lunar landing	952
17	May 1964	Advent	24-hr equatorial	227
18	June 1964	Surveyor	Lunar landing	952
19	July 1964	Advent	24-hr equatorial	227
20	Aug. 1964	Surveyor	Lunar landing	952
21	Sept. 1964	Advent	24-hr equatorial	227
22	Oct. 1964	Mariner	Mars	635 (?)
23	Nov. 1964	Mariner	Mars	635 (?)
24	Dec. 1964	Surveyor	Lunar orbit	726

As revised 17 Jan. 1961, the Atlas-Centaur launch vehicle would have six test flights before a Surveyor lunar landing was attempted in June 1963. That mission would have been followed by a DoD Advent communications satellite launch and then a Mariner planetary flight. Planned as further tests of Centaur, these missions would have carried scientific payloads.

SOURCE: Edgar M. Cortright to Thomas F. Dixon, "Recommendations on the Centaur Program," 17 Jan. 1961.

In its political desire to beat the Soviet Union to a planetary shot, the United States wanted to launch probes to the planets in 1962 if at all possible and chose Venus as the most likely target, since flights to Earth's closest neighbor would require less powerful rockets. On 28 August 1961, JPL proposed a 1962 Venus mission based on an Atlas-Agena launch vehicle, using a hybrid spacecraft that combined features of JPL's lunar Ranger and Mariner A. This proposed spacecraft, called Mariner R, could carry about 11 kilograms of instruments. The 1962 project would not have a significant influence on the schedule for lunar Rangers, but a reallocation of launch vehicles would be required.[33]

A Successful Flyby Mission

On 30 August 1961, the NASA Office of Space Flight Development took three actions: it approved Mariner R, canceled Mariner A, and directed JPL to prepare Mariner B for a Centaur flight in 1964 to either Mars or Venus. In less than 11 months, the lab personnel designed, developed, procured, and modified components for, fabricated, tested, and launched two Ranger-derived Mariner R spacecraft. Trajectory calculations, launch operations, mission design, and ground support facilities also had to be readied on a crash schedule as launches were set for 22 July and 27 August 1962. The first spacecraft was destroyed by the range safety officer less than five minutes after launch when the Atlas stage became erratic. Quick measures corrected the launch vehicle checkout procedures and the computer's guidance program, allowing the second attempt to proceed as planned. On schedule at 2:53 a.m., Mariner R-2 rose from its pad at Cape Canaveral. For a few moments, new guidance troubles with Atlas intimated yet another failure, but the ground crew overcame the malfunction in time for the separation of the Agena stage. *Mariner 2* was off on a long and successful journey to Venus.[34]

Success was sorely needed. The first three Ranger missions had been outright failures, and *Ranger 4* had crashed uncontrolled onto the far side of the moon on 26 April 1962, returning no useful data. *Mariner 2*'s successful journey blunted the mounting criticism of the unmanned lunar and planetary program and took some of the bite out of the NASA-JPL investigation of Ranger shortcomings. At a 14 December *Mariner 2* press conference in Washington, the NASA administrator declared the flyby "an outstanding first in space for this country and for the free world. . . ." Despite the space-race jargon, he was correct: *Mariner 2* was "the most significant and perhaps the most spectacular of our scientific efforts to date."[35]

Telemetered signals transmitted a large quantity of scientific and engineering data from the Mariner spacecraft for 130 days. During that time, the probe reported on the interplanetary environment, supplied data on Venus as it flew past on 14 December, and relayed additional information on outer space until radio contact was lost on 3 January. During its lifetime, *Mariner 2* provided intelligence almost continuously on magnetic fields, cosmic dust, charged particles, and solar plasma. In addition, the infrared radiometers scanned the surface of Venus for 42 minutes when the spacecraft flew by at a distance of 35 000 kilometers, finding average temperatures to be about 415°C. The extremely high temperatures and an obscuring atmosphere did not make Venus a likely locale for extraterrestrial life, and exobiologists began to consider the Red Planet a more desirable target for their search.[36]

While *Mariner 2* was readied for its flight to Venus, the Centaur team continued to have difficulties that led to additional schedule slips. On 9 April 1962, NASA Headquarters once again revised Mariner plans. The B mission with its soft-landing capsule was postponed until the 1964 Mars launch opportunity, and the 1964 Venus mission became another Mariner R flight.[37]

Scientific Organization and Payloads for Mars

Mariner B required the development of two kinds of experiments—those that would be carried on the flyby bus and those that would be landed on the planet's surface—but NASA had no general procedure for selecting scientific experiments for its missions. In April 1960, the Space Sciences Steering Committee was formed to bring together all the key people within the agency who had an interest in the space sciences. Reporting directly to Abe Silverstein, the committee, chaired by Homer Newell, recommended which projects should be undertaken and established working relations with outside scientists by forming a series of subcommittees. Headed by NASA personnel, these subcommittees had members and consultants from the scientific establishment, especially those associated with the Space Science Board of the National Academy of Sciences. By February 1961, there were seven discipline subcommittees—aeronomy, astronomy, bioscience, ionospheric physics, lunar science, particles and fields, and planetary and interplanetary science.[38]

Once the Space Sciences Steering Committee was in operation, Newell had some control over the advice that was given the agency about the kinds of missions it should fly. Thus, early in March 1961 he wrote Hugh Odishaw of the Space Science Board asking for suggestions for Mariner B experiments. Newell told Odishaw that present plans called for a planetary flyby and a planetary entry capsule. The main craft would come within 11 000–16 000 kilometers of Mars. If the mission was flown without the landing capsule, the probe could carry about 80 kilograms of scientific instruments. If an entry package was flown, instruments weighing about 23 kilograms could be landed, but it was uncertain how much weight the flyby half could support. Newell asked the Space Science Board to review "this problem and suggest a list of appropriate experiments."[39]

Odishaw responded with a report from several committees on 31 March. While the short notice prohibited an exhaustive reply, Odishaw noted that Mars missions had two desirable objectives—the study of the planet itself and the study of the interplanetary medium. Board scientists gave priority to "photographing the planet, determining atmospheric composition and conducting simple investigations of surface properties." And spacecraft experiments at the flyby distances should include study of the Martian magnetic field, radiation, aurora, airglow, and the like. After five days of briefings and discussions at JPL, the Space Science Board's Planetary Atmospheres Study Group developed a specific list of experiments for a lander mission:

Spacecraft flyby

Radiation package

Cosmic dust package

Photographic equipment (1-km resolution)

Magnetometer

Infrared spectrometer

Ultraviolet spectrometer

Capsule

Television

Temperature and pressure-measuring equipment operative during descent

Radar altimeter

Mass spectrometer

Gas chromatograph

Odishaw added that it was "gratifying to note that the experiments planned by JPL for the Mariner B mission followed closely those recommended in the first interim report of the board's Committee on the Chemistry of Space and Exploration of the Moon and Planets, which was provided to NASA on February 1, 1959." The Space Science Board scientists, less enthusiastic about a probe that would study only the space between Earth and Mars, did recommend experiments for such a mission, but they clearly believed priority should be given the capsule-lander project.[40]

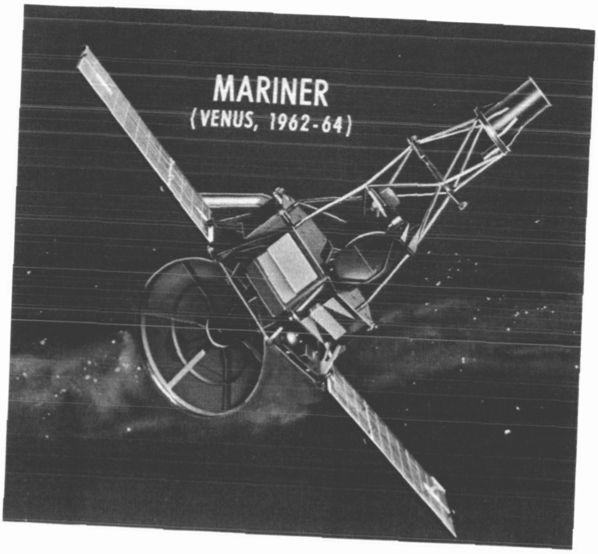
The summer of 1961 passed quickly, with planetary and unmanned space exploration taking a backseat to the accelerated manned lunar project Apollo. Yuri Gagarin's 12 April 1961 orbital mission galvanized American determination as the Soviet Union once again took the lead in space. On 26 May 1961, President Kennedy urged a joint session of Congress to commit the nation to landing and returning a manned expedition to the moon by the end of the 1960s.[41] Despite a sympathetic understanding of the plight of the space science community, Administrator James E. Webb, Glennan's successor, ordered the space agency's priorities to reflect the new national interest in reaching the moon. This change led to a reorganization of the agency.[42]

In 1961, "momentous decisions on both program and administrative matters [were] made in quick succession" at NASA, two of which left a lasting mark on the agency, as one historian put it. "One was the decision to strengthen NASA's general management by greatly strengthening the staff of the Associate Administrator, the other was the decision to reorganize NASA as a whole." The changes were effective 1 November 1961.[43]

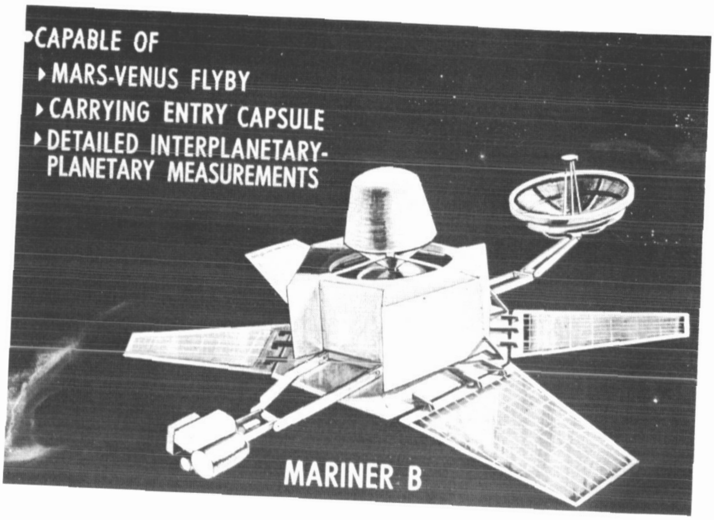
Establishing an independent Office of Space Sciences under Homer Newell's direction was the key change for the unmanned planetary program (see chart in appendix G). Edgar Cortright became Newell's deputy, while Oran Nicks was named director of lunar and planetary sciences. Nick's organization included Charles P. Sonett, chief of lunar and planetary sciences, and N. William Cunningham, Fred Kochendorfer, and Benjamin Milwitsky, chiefs of Ranger, Mariner, and Surveyor offices. Orr E. Reynolds became director of the Bioscience Program Office, with Freeman H. Quimby serving as his chief of exobiology programs. Colonel D.H. Heaton began directing the Launch Vehicle and Propulsion Programs Office, with Commander W. Schubert and D. L. Forsythe as chiefs of the Centaur and Agena launch vehicle offices. This team would guide the lunar and planetary program until the next reorganization two years later.

During October and November 1961, Ford's Aeronutronic Division began work on a preliminary design for a Mariner B landing capsule as NASA personnel began examining tentative experiments for the spacecraft and capsule. From 64 original proposals, 8 experiments were chosen for the flyby bus and 10 for the capsule.[44] Changes in this payload were quick in coming, however. On 19 February 1962, Sonett informed Nicks that a cutback in Centaur payload weight, due to Defense Department changes associated with its Advent satellite, forced his staff to review again the list of proposed Mariner B experiments. Investigators had already been warned by Newell that their proposed scientific payloads would be subject to limitations placed on the overall payload by engineering constraints. "It now appears that we will have to exercise our options to hold off some of these people," Sonett wrote. "We intend to fund them, wherever possible, for backup research so as not to put them out of the program entirely."[45]

On 4 May 1962, Newell wrote the investigators whose experiments were being dropped. Power, telemetry, and weight considerations had become "critical due to factors connected with booster capability and spacecraft design. . . . In view of these conditions, the successful entry of the capsule into the Mars atmosphere hinges upon the restriction to very light, simple instrumentation and direct transmission to Earth rather than by use of a capsule-bus telemetry system." Most unfortunately, the limitations on capsule performance would apparently confine the landed experiments "to



Artist conceptions of Mariner spacecraft were shown on slides in early 1962 Office of Space Sciences briefings on progress of the planetary program. Fabrication of Mariner R was scheduled for early 1962 completion and design of Mariner B for mid-1962, with completed prototype in mid-1963. Voyager design and development was to begin in mid-1962.



those intended to investigate the question of life and atmospheric composition." Nevertheless, NASA intended to develop a basic capsule design that would be flexible enough to permit investigators to fly more sophisticated experiments on subsequent missions to Mars.[46]

The uncertainty surrounding Centaur, both as to schedule and lift capacity, threw plans for Mariner B into a tailspin. The 1963 Mariner B test flight and 1964 Venus mission were canceled, and a 1964 test of the Mars version was added:*[47]

P[robe]-37	Mariner R [*Mariner 1*]	1962 Venus Mission
P-38	Mariner R [*Mariner 2*]	1962 Venus Mission

*Because of some congressional confusion over the use of such terminology as Ranger A, Surveyor B, Mariner R, and the like, Nicks suggested that all published NASA documents use a clearer system—Ranger Lander, Mariner Mars (year), Surveyor Orbiter, etc. This nomenclature was adopted in materials intended for external use, but internally NASA continued to use the briefer alphabetical designations.

P-40	Mariner R	1964 Venus Mission
P-41	Mariner R	1964 Venus Mission
P-39	Mariner B	1st quarter 1964 test flight
P-70	Mariner B	1964 Mars Mission
P-71	Mariner B	1964 Mars Mission
P-72	Mariner B	2nd quarter 1965 test flight
P-73	Mariner B	1965 Venus Mission
P-74	Mariner B	1965 Venus Mission

Continued problems with Centaur forced additional adjustments to the proposed Mariner timetable.[48] After 10 postponements of the first Atlas-Centaur launch, NASA tried again on 8 May 1962. Fifty-six seconds after liftoff, the vehicle exploded, and a week later the House Committee on Science and Astronautics began hearings to examine this troubled launch vehicle program. By late summer, the Office of Space Sciences—Nicks, Cortright, and Newell—had decided not to rely on Centaur for a 1964 Mariner B flight to Mars. Instead, they planned to use Atlas-Centaur in 1965 to send a B-class spacecraft to Venus, if the launch vehicle was ready then. The 1964 Mars B mission would be replaced by an Atlas-Agena-launched, lightweight spacecraft called Mariner C.[49]

During the fall of 1962, NASA personnel tackled various launch vehicle problems and studied their impact on the lunar and planetary probe program. On 7 September, 28 representatives from NASA Headquarters, Goddard Space Flight Center, and JPL met in Washington to take a new look at the relative merits of the proposed missions for the exploration of Mars during 1964. As they reviewed Mariners A, B, and R—their schedules, plans, and difficulties —Oran Nicks pointed to the problems with Centaur that had necessitated their using a spacecraft lighter than Mariner B. William G. Stroud, chief of the Aeronomy and Meteorology Division at Goddard, outlined his center's proposal for a planetary mission with a 210-kilogram spacecraft launched by an Atlas-Agena-Able. Stroud had in mind a hard lander equipped to measure the temperature, pressure, and composition of the Martian atmosphere and to detect life. Goddard's plan called for two launches in 1964 and three in 1965. In his turn, Robert Parks, now JPL's planetary program director, reviewed the lab's 1964 Mars proposal to send a 338-kilogram spacecraft launched by an Atlas-Agena on a flyby photographic mission. Similar in concept to the Venus Mariner R mission, the Mars flight would carry a television camera and an infrared spectrometer designed to detect organic molecules of the type produced by vegetation.

In the long sessions that followed these opening presentations, the specialists reviewed a number of important issues. Some of the major technical questions concerning the Goddard plan included: 1. Was it feasible to sterilize the capsule so that it would not contaminate the Martian environment? 2. Was the single 64-meter antenna to be built at Goldstone, California, sufficient for communications with a capsule on Mars? 3. Could existing command and guidance systems provide the necessary accuracy needed to land a capsule? 4. Would a single biological experiment provide meaningful results? The JPL proposal also was scrutinized: 1. Was existing tape recorder technology adequate for storing and relaying television picture signals to Earth? 2. Could the infrared detector and its related filters be protected against long exposure to space environment? In studying these questions, it became obvious that the detection of life, whether by a landed detector or television pictures taken as the spacecraft flew past the planet, was a predominant theme of both proposals.[50]

Parks wrote to Nicks 13 days after their Washington meeting, "One point about which we all seem to be sincerely convinced is the . . . importance of the biology of Mars." This conviction had been reinforced from many scientific quarters, including the 1962 Iowa Summer Study Group sponsored by the Space Science Board of the National Academy of Sciences. This body enthusiastically supported the search for extraterrestrial life. Parks noted:

> Although the chances (1) that life does exist on Mars and (2) that importing earth life forms would distort or contaminate the study of Mars life (if it does exist) are both admittedly not great, it does appear quite important that we not take undue chances in this regard. The cost of not taking this chance is small. The only thing to be lost is a possible delay in obtaining the information relative to the basic physical information about the solar system that can be obtained only, or most quickly, by landings on Mars. The answers to a great many of these basic physics questions can be learned by measurements in interplanetary space, by flyby and landing measurements of Venus, and flyby measurements of Mars.[51]

Once having made clear his preference for an early flyby to Mars rather than a lander, Parks, like others concerned over the Russian challenge, suggested that NASA's Mars strategy would probably be influenced by the competition from the USSR. He wondered if the Soviet Union was likely to send a spacecraft to Mars that would contaminate the surface even though the USSR had indicated that it also had plans for sterilization. If it did land a spacecraft, was it likely to "scoop us in obtaining Mars biology data?" Though Parks believed that the Soviet Union might well risk contaminating Mars, he did not believe that would justify NASA's taking such a chance as well.* The state of the Soviet "scientific instruments and long range communications is behind ours and gives us a definite advantage in making these difficult and delicate measurements." Even if the United States did not land an instrumented package on Mars until much later, Parks determined that the U.S. could demonstrate its space exploration capabilities through flybys until a safe and sufficiently large lander could be developed.

*The Soviet Union launched its first spacecraft to Mars on 1 November 1962, but after traveling about 106 million kilometers the transmitters aboard *Mars 1* fell silent.

Some specific requirements had to be met before NASA attempted landing on Mars. In Park's view, total capsule sterilization was the first problem for designers at JPL. A second concern was for "well thought-out and well-tested biological instruments (the present state of development of biological sensing instruments for a planet is . . . considerably behind the requirement)." NASA would have to develop and thoroughly test an entry and landing capsule capable of carrying a number of biological and atmospheric experiments, in addition to the indispensable communications equipment. An approach and guidance control system was a fourth consideration. Also desirable was a communications link that used a flyby craft as a relay. Parks clearly favored flyby spacecraft on the first mission, to help find safe, biologically interesting landing sites for later missions. Many technical difficulties had to be resolved before landers could be sent to Mars and Venus. The people at Goddard, he contended, either did not understand the problem or were allowing enthusiasm to overshadow logic.[52] The JPL-Goddard dispute would continue for months, reflecting both a difference in approach to planetary exploration and a JPL concern over the Goddard staff's intrusion into what had been an exclusive preserve of the California laboratory. The continued problems with Centaur ultimately answered the flyby versus lander question.

Centaur was a genuine troublemaker for the Office of Space Sciences, since its two major projects, Surveyor and Mariner, were structured around it. The Centaur crisis came to a head at a mid-September 1962 meeting at the Marshall Space Flight Center. From the very beginning, Wernher von Braun and Marshall's top management had not favored Centaur and had accepted the project only reluctantly. Saturn was their primary mission. "Only a few crumbs which have fallen from the banquet table of thought and effort at MSFC have been given to Agena and Centaur," wrote the Agena program chief.[53] But beyond the problem of time and inadequate resources was von Braun's basic disagreement with the design approach of Centaur. Assigning Marshall the Centaur job had indeed been a serious error.

In September 1962, von Braun told Newell that the best lunar payload he could expect with the existing Centaur design was 810 kilograms. Projected Surveyor weights ranged from 1125 to 1260 kilograms, and similar weight problems would exist for Mariner B.[54] Von Braun wanted to cancel Centaur and use Saturn for Surveyor and Mariner and so recommended to the Senior Council of the Office of Space Sciences in August 1962. Brian O. Sparks, JPL deputy director, presented a similar recommendation to Newell on 13 September: "The performance schedule and funding problems associated with the Centaur program have finally reached the point where it appears that the Centaur vehicle will not be able to meet the requirements of the unmanned lunar and planetary programs of this country."[55] After reviewing all Centaur's technical faults, the team at JPL noted that the formally approved Centaur program "is totally intolerable, as it precludes any sensible Surveyor Project, completely obviates any timely contribution by Surveyor to the Apollo program and forces Mariner to continue indefinitely on Atlas-Agena with the attendant lack of confidence to achieve even minimal objectives."

This trend toward minimum goals should be reversed, JPL urged. "Rather than progressive reductions in spacecraft weight allowance during the development stage, a clear margin for weight increase is needed." Additional payload capacity could lead to enhanced spacecraft reliability through the use of redundant systems (a lesson learned from Ranger) and further hardware improvements, impossible with a smaller capacity launch vehicle. Greater reliability might also reduce the total number of launches required to achieve particular goals. Looking at all possible launch vehicle combinations, JPL specialists concluded that the Saturn C-1 combined with the Agena had several obvious advantages:

> (a) The C-1 development program appears to be on a sound basis and reasonably predictable. [The first Saturn C-1 test flight took place on 27 October 1961 (SA-1) and the second (SA-2) on 25 April 1962.]
> (b) Substantial performance margins above our minimum requirements can be confidently expected.
> (c) Substantial use of all stages is already programmed for other purposes.
> (d) No new stage development is required.
> (e) The resulting over-all funding requirements can be expected to be essentially the same as those now expected for the Centaur-based program.[56]

JPL planners anticipated that a Saturn-Agena could boost an 810-kilogram Mariner B, a significant increase over the 225-350 kilograms proposed for Mariner C. That meant "many of the current physical and weight constraints on these spacecraft [could] be relaxed, redundancy . . . added in key areas, and realistic mission flexibility . . . incorporated" into planetary space probes. Marshall could apparently ready the first planetary Saturn-Agena for a 1965 launch of Mariner B to Venus; a Mariner B mission to Mars on Saturn-Agena might also be feasible for 1966.[57]

NASA management in Washington—especially Homer Newell—reacted negatively to the suggestion that Centaur be replaced with Saturn-Agena. Instead, Newell concluded that Centaur needed a new home. At the end of September, the project was transferred to the Lewis Research Center in Cleveland, which had been under the direction of Abe Silverstein since November 1961.[58] "Although the Centaur development has been fraught with difficulties, many of them were of a management nature," Newell suggested. He admitted that the arguments advanced in favor of Saturn were attractive at face value, but "the development status of the Saturn was presented with somewhat disproportionate optimism, compared to the Centaur." Newell also believed that JPL critics were being overly optimistic since they were counting on the successful adaptation of an untested Saturn second stage and Agena stage "to provide an operationally suitable vehicle on a competitive time scale with Centaur." Nor was NASA's director of space sciences convinced that Saturn would be as economical as it had been portrayed. Newell and his associates were not ready to abandon Atlas-Centaur for a new steed.[59]

A Review of Planetary Spacecraft for the 1960s

Although Centaur's future looked brighter at Lewis where Silverstein's enthusiasm was catching, the changes came too late for Mariner B, which was in jeopardy by the end of 1962. The longer Centaur was delayed the less likely it became that Mariner B would fly, especially since the next-generation spacecraft, Voyager, was being more precisely defined with each passing day. In December 1962, JPL informed headquarters that Mariner B-Centaur could not be launched in 1965 and proposed launching the mission in 1966 with Saturn-Agena. Oran Nicks wanted to continue the spacecraft's development with Atlas-Centaur, but he, too, noted that this would likely lead to technology that would not be used until the Voyager program. Perhaps, he suggested, a variation of the Mariner B capsule might be flown on the Voyager mission to Venus planned for 1967.[60]

More and more signs pointed to Mariner B's decline and Voyager's ascendancy. Independent Mariner B and Voyager programs would cost too much and, if Mariner B were flown, Voyager would surely be delayed, something no one at NASA wanted to see. In late December 1962, when Homer Newell asked Harry J. Goett, director of Goddard, for a plan for developing Mariner B's capsule, he requested that his specialists also consider possible Voyager applications for the hardware.[61]

At the outset of 1963, the proposed planetary science program consisted of three kinds of spacecraft. The first was Mariner C, the pared-down craft without a lander, which would be launched by Atlas-Agena, fly by Mars, and make a series of measurements, relaying them along with television images back to Earth. Uncertainty plagued Mariner B, the second spacecraft. It had been restructured and reoriented to take advantage of the 1966 Mars launch opportunity and, with a landing capsule, was to be launched by either Atlas-Centaur or Saturn-Agena. Third was the more ambitious Voyager, which was to send combination orbiter and lander spacecraft to Venus and Mars. The most likely time for Voyager's first flight was the 1967 Venus launch window. But the planetary program was to take some twists and turns that would alter the original plans. Mariner C, the 1964 Mars mission, would take on a vitality and distinct direction of its own. Mariner B would become a long-term project, transformed into a mission called Mariner Mars 66, inextricably entwined in the evolution of Voyager. Above all else, 1963 was to be the year in which Voyager, at least on paper, got off the ground.[62]

NASA learned some valuable lessons from Mariner B. First, it had been too ambitious for its time, representing too large a technological jump. The 1962 Venus flight and the revised 1964 mission to Mars made more sense, for they built upon the lunar experiences of Ranger. Second, launch vehicles would continue to make advanced planning a chancy business at best, and launch scheduling would become nearly impossible. Atlas-Centaur would fly successfully only near the end of 1963. Then six more flights would be made before Centaur was considered operational and ready for the 30 May 1966 launch of Surveyor to the moon. No one within NASA had anticipated such delays when planetary flights with Centaur were first proposed in the early 1960s.[63]

Not all the Mariner B experiences had negative overtones, however. Mariner B gave the space agency and prospective experimenters an opportunity to define the investigations that could and should be performed on Mars, and variations of several of the experiments proposed in October 1961 would fly on later Mariners and ultimately on the Viking missions. Mariner B also forced the early study of such basic questions as spacecraft sterilization and aerodynamic entry into planetary atmospheres. Looking toward a 1964 landing mission, NASA seriously examined these topics much earlier than it might have otherwise, which was fortunate, because both entry and sterilization were extremely complex. Finally, Mariner B sparked theoretical and practical design work on devices for the detection of extraterrestrial life by scientists and engineers who were excited and challenged by the prospective search for life on Mars.