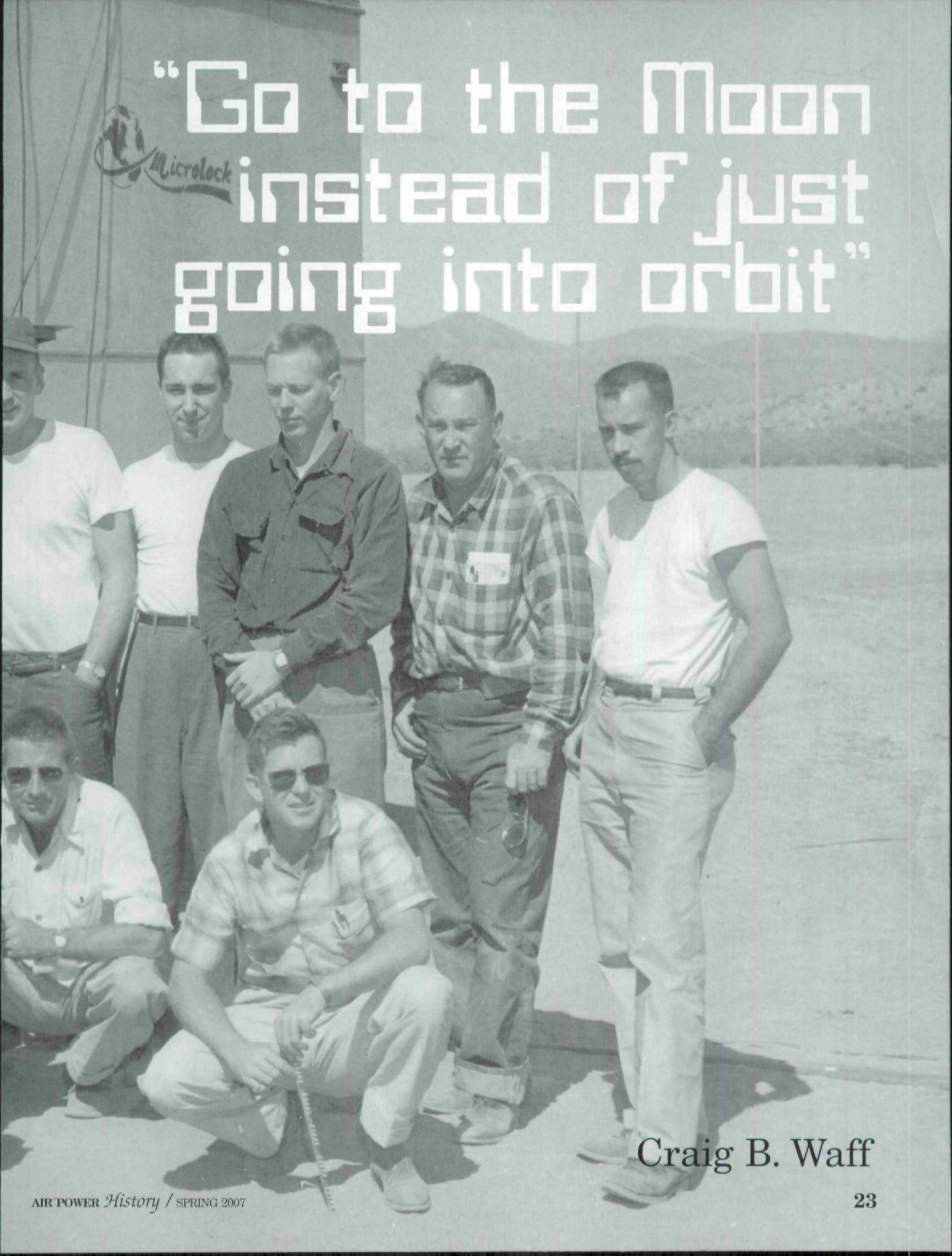
"Go to the Moon instead of just going into orbit"



Craig B. Waff

(Overleaf) Ground crew of a Microlock receiver station. *(Photo courtesy of the author.)*

The U.S. government's first publicly stated commitment to launch spacecraft that would escape from the Earth's gravity and scientifically explore interplanetary space and the other bodies in the solar system was made on March 27, 1958, nearly six months after the Soviet Union had launched *Sputnik 1,* the world's first Earth-orbiting satellite. On that day, Secretary of Defense Neil McElroy announced that his department's newly formed Advanced Research Project Agency (ARPA) would proceed with several programs for launching a number of small unmanned spacecraft. The programs that he authorized, with the prior approval of President Dwight D. Eisenhower, included not only scientific Earth-orbiting satellites, but also "efforts to determine our capability of exploring space in the vicinity of the moon, to obtain useful data concerning the moon, and provide a close look at the moon."[1] These authorized lunar-probe attempts, which would shortly receive the *Pioneer* name designation and be mostly launched (1958-1959) under the auspices of the new civilian space agency, the National Aeronautics and Space Administration (NASA), established later in 1958, initiated a long series of space-probe missions that NASA has conducted in the subsequent nearly half century.

BUCHHEIM VIEWED SPACE FLIGHTS AS THE GUIDED-MISSILE EQUIVALENT OF AROUND-THE-WORLD B–52 BOMBER FLIGHTS

McElroy's announcement strongly suggested that the primary purpose of the Pioneer probes was scientific. The authorization of the probes under military, rather than civilian, auspices, however, leads one to speculate whether the Eisenhower Administration had other unstated reasons for giving the go-ahead to rather challenging space missions at a time when American rockets and missiles were still suffering numerous launch failures. Somewhat surprisingly, the motivations for the Pioneer lunar-probe authorizations have hitherto not been historically investigated. One reason why historians may have failed to investigate in detail the origins of the program was its distinct lack of success in scientific investigation of the Moon—only one of the probe attempts successfully escaped the Earth's gravity, and it passed nowhere near the moon. A more probable reason was the unavailability of numerous relevant documents concerning the program for many years because of Cold War security classification policies. Many relevant documents, however, had been declassified by the late 1980s, when I began researching the origins of NASA's Deep Space Network (DSN) communication system, which in turn required a study of the space program that was responsible for the construction and installation of the DSN's first ground-based antenna.

Pre-Sputnik Space-Probe Proposals

The political benefit that could be gained from the first successful deep-space probe was perceived over a year prior to the launch of *Sputnik 1* by engineers and analysts of the RAND Corporation, a consultant organization based in Santa Monica, California. Since 1946 it had carried out broad-based studies relating to national security and missile technology, primarily for the United States Air Force. In the spring and summer of 1956 a RAND team led by Robert W. Buchheim issued a series of reports that proposed combining an Atlas intercontinental ballistic missile (ICBM) with a Vanguard second stage, or alternatively a Titan ICBM with an Aerobee rocket, to provide a means for depositing on the lunar surface a package of scientific and radio equipment capable of transmitting data to an Earth station.[2] The team also advocated interplanetary flights to the vicinity of Venus and Mars, the two planets nearest the Earth.

Although a shortage of funds in the spring of 1957 forced the Air Force to suspend RAND's continued consideration of the interplanetary missions, Buchheim on May 2 presented to the service a proposed lunar-probe program that he argued would not only advance scientific knowledge but also serve as a technological show of force in the face of evidence of a Soviet high-level space-flight program. With regard to the latter purpose, Buchheim viewed space flights as the guided-missile equivalent of around-the-world B–52 bomber flights or atomic-submarine cruises under the polar ice cap.[3]

Because the Atlas and the Titan were still undergoing development and testing in 1957, neither missile would be capable of launching probes to the Moon and the planets for several years at least. This situation, however, did not discourage the manufacturers of these missiles, perhaps in response to RAND's suggested program, from submitting proposals for deep-space missions to the Air Force. The Martin Company claimed that its Titan could be combined with upper stages to achieve reconnaissance flights around the Moon. Similarly, the Convair Astronautics Division of General Dynamics proposed that its Atlas ICBM, together with upper stages, be used to (1) put payloads well in excess of 1,000 lb in orbit around the Moon, the planet Venus, and the planet Mars; (2) land a payload of less than 1,000 lb on the Moon; and (3) put a still smaller payload between the planet Mercury and the Sun.[4]

The RAND, Martin, and Convair proposals did not receive any endorsement from senior Air Force officials. Quite the contrary, the service on July 29,

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1957, issued a directive discouraging public mention of the terms *space, space technology,* and *space vehicles,* because some news stories describing Air Force research and development as efforts in "space flight" had caused unhappiness at Air Force headquarters, within the top echelons of the Department of the Defense, and in Congress. This directive, which reflected the general pre-Sputnik political mood, went on to order that "No statements can be made which might in any way cause the national media to describe valid Air Force projects as efforts to fly to the moon." This directive may have been largely prompted by a speech that General Bernard A. Schriever, head of the Air Force's ballistic-missile program, gave in San Diego in February 1957 in which he predicted not only that "about 90 percent of the developments in the ballistic-missile program can be applied to advancing in space, satellites and other vehicles," but also that "In the long haul our safety as a nation may depend upon our achieving 'space superiority.' Several decades from now the important battles may not be sea battles or air battles, but space battles, and we should be spending a certain fraction of our national resources to insure that we do not lag in obtaining space superiority." On the day after the speech, he received a wire from the Secretary of Defense's office instructing him to "not use the word 'space' in any of your speeches in the future." At this time the Eisenhower Administration was seeking to establish, via the orbiting of a civilian, scientific Vanguard satellite, a "Freedom of Space" principle that would allow it later to orbit reconnaissance satellites that would fly over the territory of a foreign country, such as the Soviet Union. It was thus alarmed at Schriever's public advocacy of space as a potential future battleground[5]

The political mood changed after the successful Soviet orbiting of the *Sputnik 1* satellite on October 4, 1957. Although the Eisenhower Administration tried in its public statements to downplay the significance of this event, many commentators, inside and outside of the government viewed it as shattering a public perception of United States technological superiority and requiring an appropriate American response.[6] Most of these commentators considered the launch of American Earth-orbiting satellites to be the top priority, and aerospace companies and individuals in fact submitted hundreds of satellite proposals to the Defense Department in the months immediately following the *Sputnik* launch. Several organizations, however, argued for a response that would clearly go beyond what the Soviet Union had accomplished—sending a probe to the Moon.

THE UNITED STATES SHOULD HAVE OTHER SPACE PROGRAMS UNDER DEVELOPMENT, THE STAFF ARGUED, IN CASE VANGUARD FAILED

The Jet Propulsion Laboratory and Project Red Socks

One of the first institutions to advocate a lunar mission in the period immediately after the orbiting of *Sputnik 1* was the Jet Propulsion Laboratory (JPL), in Pasadena, California, managed by the California Institute of Technology (Caltech). JPL began as an off-campus facility used by several Caltech graduate students in the late 1930s to conduct early rocket propulsion experiments. As an Army Ordnance facility in the 1940s and 1950s, it developed a jet-assisted takeoff (JATO) engine for airplanes during World War II and the Corporal and Sergeant surface-to-surface tactical nuclear missiles during the early Cold War years. In 1955, JPL, in conjunction with Wernher von Braun's Guided Missile Development Division at the Army's Redstone Arsenal in Huntsville, Alabama, had vied unsuccessfully for the assignment of launching the first United States satellite during the International Geophysical Year (IGY) (July 1957-December 1958).[7]

In the introduction to a proposal entitled "Project Red Socks," formally printed on October 21, 1957, JPL staff members observed that the *Sputnik 1* launch had had "a tremendous impact on people everywhere" and had a "significance … both technical and political." [8] They argued that United States must regain stature "in the eyes of the world" and could best do so by undertaking a program that was "significantly different, different in kind and preferably technologically more advanced" than the Soviet satellite.[9] One possibility was to launch into orbit a satellite significantly heavier than *Sputnik 1.* As the staff members were well aware, however, current United States rocket capability was insufficiently powerful for such a task.

On the other hand, they pointed out, available rockets could send a relatively small probe to the Moon, and JPL had "some fairly sophisticated instrumentation and communication" capability that could facilitate a successful lunar mission. Believing that the launching of the *Sputnik 1* satellite implied that the Soviet Union already had the rocket capability to conduct flights to the Moon carrying scientific instruments, the JPL staff argued that the United States must demonstrate as soon as possible a similar capability.[10] In the words of JPL director William H. Pickering, they advocated that the country "go to the moon instead of just going into orbit." [11] Adding to the JPL staff's desire to undertake a lunar mission was its perception that the United States program for placing a 20-pound Vanguard satellite in orbit during the IGY period had a low probability of succeeding. The United States should have other space programs under development, the staff argued, in case Vanguard failed.

The "only means available" by which the United States could achieve a "Moon rocket" before the Soviet Union, according to the JPL staff, was the use of a lengthened Jupiter intermediate range ballistic missile (IRBM) as the booster, or first stage, plus a configuration of upper stages that employed solid-propellant rocket motors that the laboratory had developed for the Army's Sergeant rocket. The second, third, and fourth stages would use, respectively, eleven, three, and one of these motors. JPL and Redstone Arsenal had proposed such a configuration in late 1955 for the purpose of orbiting six 15- or 20-pound satellites during the IGY.

Although this "Project Orbiter" proposal lost out to the Navy's Vanguard for the assignment of

Eberhardt Rechtin, chief of JPL's Electronics Research Section. *(Photo courtesy of the author.)*

launching the first United States satellite, a variant configuration (lacking the fourth stage) was subsequently used (September 20, 1956, and May 15 and August 8, 1957) in conjunction with the Jupiter C (actually a lengthened Redstone missile with an uprated engine) for the re-entry testing of missile nose cones. The Red Socks proposal noted that two of the three tests in this series had been "completely successful," and that "the soundness of the re-entry test vehicle (RTV) program is no longer speculative; it is a matter of history."

A SUCCESSFUL PHOTOGRAPH OF THE FAR SIDE OF THE MOON WOULD BE PERCEIVED BY THE GENERAL PUBLIC AS A DRAMATIC DEMONSTRATION OF AMERICAN SPACE CAPABILITY

Because the Arsenal (subsequently renamed the Army Ballistic Missile Agency, or ABMA) and JPL had already purchased hardware for several more launch vehicles, JPL officials asked for authority "to conduct a program immediately for the purpose of making nine flights to the moon." The program would begin by using the Jupiter/RTV-upper-stage-cluster combination (subsequently called Juno II) to send a 15-lb payload around the Moon in June 1958, a flight that "would provide valuable guidance and instrumentation information, as well as define an early capability." In the second phase of the program, which would start in January 1959, the Jupiter would be mated with a scaled-up RTV configuration that would enable a 120-lb payload to be sent to the Moon. This new configuration (subsequently called Juno III) would make use of the Grand Central Rocket Company "Meteor" engine that had been developed for the third stage of the Vanguard rocket .[12]

The remaining portion of the "Red Socks" proposal, drafted by Eberhardt Rechtin (chief of JPL's Electronics Research Section since 1954), was devoted to the electronics capability of the proposed lunar probes and to the specific payload that might be delivered. He ruled out the use of extremely sophisticated electronics on the first few flights because of limitations on weight (between 20 and 100 lb) and type of electrical power source (conventional batteries) and "considerations of time schedule, missile environment, and reliability." Rechtin instead recommended the inclusion of one or more photocells and a radio beacon. He calculated that 30 lb of mercury batteries would permit the transmission of around 1 million bits of information from the vicinity of the Moon. This figure was "equivalent to four times the detail of one frame of a standard television picture," according to a footnote in the proposal.

As for the specific experiments that should be conducted on the proposed flights to the Moon, Rechtin suggested that the first 15-pound-payload mission carry a single photocell with a fairly wide field of view and a modified Microlock transmitter radiating 2 watts of power and operating continuously in the vicinity of the Moon. (Microlock was the communication system that JPL had developed for Project Orbiter and would subsequently use in the early Explorer satellites.) Such a radio beacon could telemeter information on temperature, pressure, and light intensity measured by the photocell as it observed the Moon through a port in the side of the spacecraft. As the spacecraft rotated, the Moon could be coarsely scanned, enabling a measurement of the distance of nearest approach to the Moon.

For the later flights carrying the 120-lb payload, Rechtin suggested a logical extension of this experiment utilizing six photocells, each with a 1-milliradian-by-1-milliradian field of view. He calculated that if the spacecraft rotated at 3 revolutions per minute and flew by the Moon at a distance between 2,000 and 10,000 mi, this apparatus could obtain in one hour a two- or three-tone black-and-white picture of the far side of the Moon with a resolution of between 2 and 10 mi. The optical data for such a picture would be stored on magnetic tape and then played back at 1/30th of the original speed and relayed to Earth by a 3-watt Microlock transmitter during a period when the receiving station could see the spacecraft. Rechtin characterized his proposed experiments as meeting "the necessary qualifications of being simple, rugged, and valuable." [13]

Left unsaid, but certainly in the minds of JPL officials, was the expectation that a successful photograph of the far side of the Moon would be perceived by the general public as a dramatic demonstration of American space capability. Perhaps in order to give government officials an exaggerated idea of just how dramatic a close-up picture of the Moon might be, the JPL staff included in its proposal an artist's drawing of a spacecraft passing over a lunar surface area featuring large, distinctive craters, with the Earth looming behind the Moon. In other words, the spacecraft was viewing

Secretary of Defense Neil McElroy.

the hitherto unseen far side of this body, an achievement that would likely regain stature for the United States.

In his typewritten draft of the electronics section of the Red Socks proposal, Rechtin initially recommended a 50-ft-diameter paraboloid dish antenna on the ground for communicating with the probes while they were in the vicinity of the Moon.[14] He crossed out this recommendation, however, and instead in the margins (and in the printed version of the proposal) advocated 4 x 4 arrays of the single Microlock helical antennas that JPL used to track the September 1956 firing of the Jupiter/RTV rocket. Rechtin most likely made this alteration upon more careful consideration of the urgency of the program that JPL was recommending. JPL engineers would need considerable time to set up a large paraboloid antenna, and in any case only a long-term flight program could justify its higher cost.

INTENSE INTER-SERVICE RIVALRY BETWEEN THE ARMY AND AIR FORCE... APPARENTLY PLAYED A MAJOR ROLE IN DELAYING ANY IMMEDIATE ACTION ON JPL'S PROPOSAL

In late October 1958 Pickering and Caltech President Lee A. DuBridge took the Red Socks proposal to Lt. Gen. James Gavin, chief of Army Research and Development, who enthusiastically supported it. At a meeting shortly thereafter with Defense Secretary Neil McElroy, however, the reception to the proposal was more cautious. Intense interservice rivalry between the Army and Air Force at this time, particularly regarding the development and deployment of IRBMs, apparently played a major role in delaying any immediate action on JPL's proposal. Pickering later recalled that McElroy asked Deputy Defense Secretary Donald A. Quarles, to stay in the office to hear JPL's presentation. Afterwards, Quarles, a former Secretary of the Air Force, commented that while the proposal was "interesting," he felt that "the Air Force ought to be allowed to study it and make a comparable counterproposal rather than just accepting this out of the blue as an Army proposal." When McElroy agreed with Quarles, Pickering, well aware of "the feelings between the Air Force and Army at that time," assessed that the Pentagon would take no immediate action on the Red Socks proposal.[15]

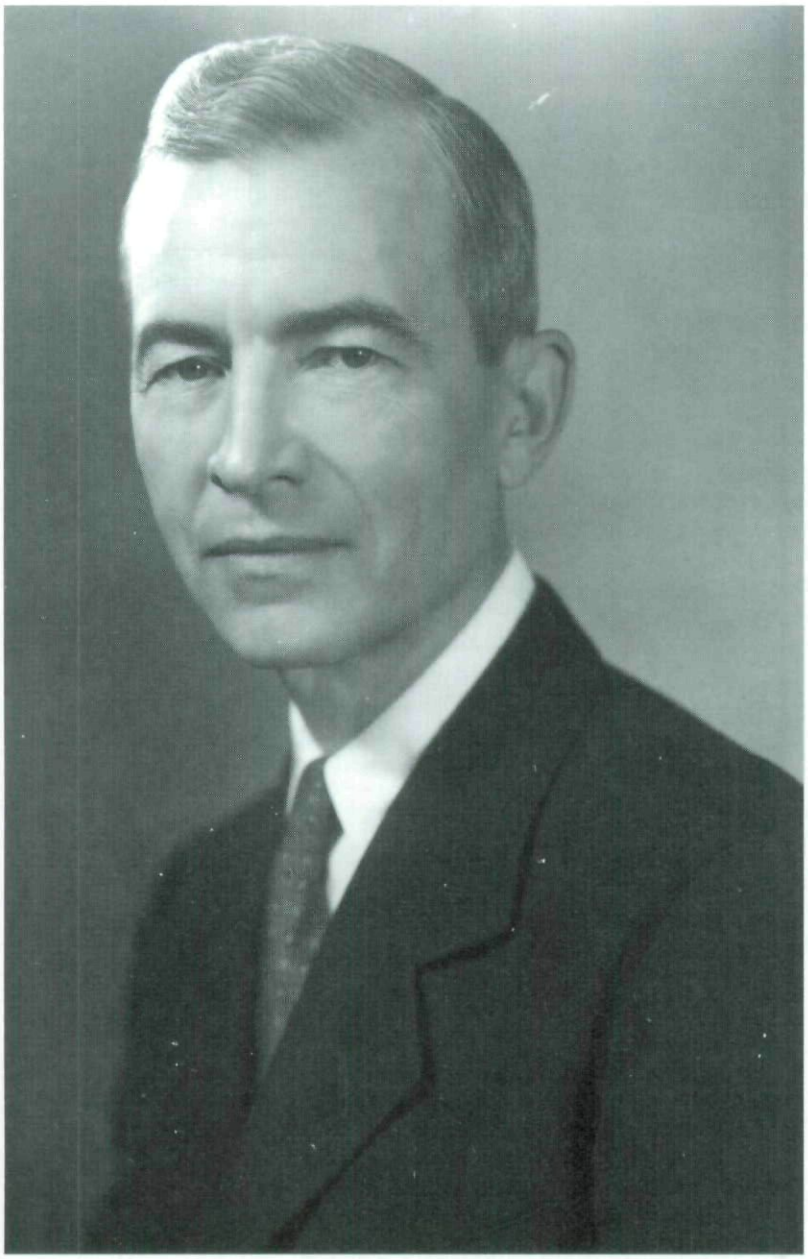
Pickering was apparently suspicious, however, that the Air Force, with Quarles' encouragement, would also make a lunar-probe proposal, using a missile of its own as the launch vehicle. He, therefore, assigned several JPL engineers to continue to study the Moon flight concept over the next few months.[16] This study was undertaken while much of JPL's staff was heavily involved in the preparation of an Earth-orbiting satellite authorized by President Eisenhower in early November as a backup to the Vanguard program.

Pickering's suspicions were not groundless. Several individuals in the Air Force and working for its principal contractors were prepared to dispute the JPL assertion that the Jupiter/RTV-upper-stages combination was the only launch vehicle capable of propelling a payload to the vicinity of the Moon. And like Pickering and his JPL colleagues, they perceived political urgency in undertaking a lunar-probe program.

Space Technology Laboratories and Project Baker

In order to get a new assessment of the relative military air-power strengths of the United States and the Soviet Union, President Eisenhower ordered a series of top secret meetings of high-level scientific, industry, and United States Air Force technical personnel that were held in Baltimore in late October 1957. At these meetings, presided over by nuclear physicist Edward Teller, the Air Force invited the country's leading aircraft and missile manufacturing companies to submit unmanned lunar-probe proposals. The invitation may have been prompted by knowledge of JPL's Red Socks proposal and by speculation that Soviet Union might announce a lunar probe on November 7, 1957, the 40th anniversary of the Bolshevik revolution.[17]

The invitation was not ignored. Over the next few months the companies submitted as many as 300 proposals for lunar probes and other space projects with "some based on a crash program for meeting urgent requirements and others looking far into the future."[18] Among those making immediate lunar-probe launch-vehicle suggestions were Douglas Aircraft Company (Thor plus Vanguard second and third stages), North American Aviation (XSM-64 [Navaho] plus upper stages), and Lockheed (Atlas plus upper stages). On October 30,



Deputy Secretary of Defense Donald A. Quarles.

a "Short Term Space Flight Program" subcommittee of the Teller group recommended the Douglas-made Thor—the Air Force's rival to the Army's Jupiter for deployment as an IRBM in Europe—as the booster during the immediate future for satellites and lunar probes.[19]

STL OFFICIALS ANTICIPATED BOTH SCIENTIFIC AND POLITICAL BENEFITS FROM AN EARLY LUNAR FLIGHT

Perhaps based on this recommendation, the Air Force began focusing its attention in mid-November 1957 on a Thor-Vanguard combination for launching lunar probes. On November 20, in a briefing to officials of the Los Angeles-based Air Force Ballistic Missile Division (BMD) (a part of the Air Research and Development Command) and the Ramo-Wooldridge Corporation (which served during the 1950s as technical adviser and systems engineer to BMD regarding ballistic missile development), Douglas recommended for lunar missions use of a Thor IRBM as a booster, a cluster of third-stage Vanguard engines as a second stage, and a single third-stage Vanguard engine as a third stage.[20]

On December 12, Ramo-Wooldridge engineer Paul Dergarabedian, in an internal company memo, described the combination of a Thor with Vanguard second and third stages as "a promising lunar impact configuration." [21] Such a configuration was seen as a logical development from a re-entry test vehicle—Thor booster and Vanguard second stage—that Major General Bernard A. Schriever, commander of the BMD, had authorized two weeks earlier. The development of this re-entry test vehicle, known as Project Able (later, Able 0), would be undertaken by the division and Ramo-Wooldridge, with launches scheduled in April, May, and June 1958.

Dergarabedian's proposed three-stage configuration became the basis for a formal proposal, entitled "Project Baker," that Space Technology Laboratories (STL), a newly formed Los Angeles-based subsidiary of Ramo-Wooldridge, sent to BMD on January 27, 1958.[22] STL staff members asserted, as JPL staff had for the Jupiter, that the Thor was the "only large high performance booster that could be made available for a lunar flight experiment during the next one to two years." [23] In a cover letter, Louis G. Dunn, STL's executive vice president and general manager and Pickering's predecessor as director of JPL, reported his company's estimation that a hard impact on the Moon could be achieved by October-November 1958 if STL was authorized to proceed immediately with a program of three lunar probe attempts.[24]

Like their counterparts at JPL, STL officials anticipated both scientific and political benefits from an early lunar flight. By "carrying a moderate payload of scientific instruments with telemetering means for transmission of signals of conditions to be found on the moon," an early lunar probe could provide the information needed to develop rocket vehicles carrying several thousand pounds of payload that the STL staff was certain would be in operation within a few years. The staff suggested, however, that "the prestige of sending the first rocket to the moon, with clear proof that it reached its objective," might be of "even greater national importance" than any scientific or technical benefits.[25]

STL engineers calculated that a minimum payload of 60 lb was possible if a Thor booster with a standard thrust of 150,000 lb and a Vanguard third stage with a standard propellant were used. They suggested, however, that it might be feasible to improve the Thor's thrust to 175,000 lb and to substitute an improved propellant in the third stage; if so, a maximum payload of 100 lb would be possible. The relatively small weight, in either case, made the selection of a suitable payload, the STL staff observed, "a difficult problem." Among the fundamental requirements, they argued, were a tracking beacon (for determining whether the rocket was performing as expected and telemetering certain basic data) and a magnetometer (for measuring the moon's magnetic field), weighing respectively an estimated 20 lb. and 3 lb. In addition, if an accelerometer cut-off system in the third stage was not required, the 10 lb designated for it could be used instead to make measurements of meteorite impacts

and lunar-atmosphere characteristics and spectra.

The STL staff suggested that the remaining payload capability—27 lb in the minimum payload and 67 lb in the maximum payload—could be allocated to fulfill the other, nonscientific objective of the mission, i.e., provide some means of clearly indicating, especially to the general public, that the probe had impacted on the Moon. One way of providing evidence of this result would be to trigger a high-intensity flash system at the time of impact. The staff, recalling that the American rocket pioneer Robert H. Goddard had estimated that "as little as 10 lbs. of flash powder would produce sufficient light on the dark part of the moon to be visible from the earth," thus allocated the remaining 27 lb in the minimum payload to a flash system.

A heavier but more dramatic means of indicating that the probe was approaching the Moon, they suggested, would be the use of a television camera taking a series of pictures of both the Earth and the Moon as the probe followed a trajectory from the former to the latter. Beyond its public-relations value, the television camera could provide some scientific benefits. The STL staff pointed out that "pictures of the earth from space which could show cloud patterns over half the globe should give extremely valuable data to meteorologists," while pictures of the Moon taken during the last few hours before impact would probably be significant, depending on their quality and lighting conditions, in sharpening the images of various lunar features. STL engineers estimated that a television system with a 10-watt transmitter power would probably weigh about 50 lb, making it feasible only if the maximum payload capability was obtainable, and if the flash system was reduced by 10 lb in weight.[26]

JPL WAS CERTAINLY AWARE THAT IT WAS NOT THE ONLY ORGANIZATION SHOOTING FOR THE MOON

To receive the television picture and other data on the ground, STL engineers suggested using a 60-ft-diameter antenna. They cautioned, however, that an antenna of this size could obtain only a moderate-quality picture unless transmission was slowed down from one picture per second to one picture per ten seconds. Alternatively, increasing the diameter of the antenna to 200 ft would result in "greatly improved picture quality." Clearly aware that the Project Baker lunar proposal could not alone justify the cost of a new antenna of this size, the STL engineers suggested that its construction, or use of an existing large antenna, "might be undertaken in cooperation with radio astronomy and long range communication projects." [27]

BMD greeted the "Project Baker" proposal with immediate enthusiasm. Only two days after STL's submission, Col. Charles H. Terhune, Jr., deputy commander of weapons systems (and later a deputy director at JPL under Pickering), proposed to his superiors that after the first three Thor boosters available in 1958 for "extra curricular work" were used in the Project Able re-entry tests, the next three, due to be delivered in August, September, and October of 1958, be employed in a "Hit the Moon" program.[28]

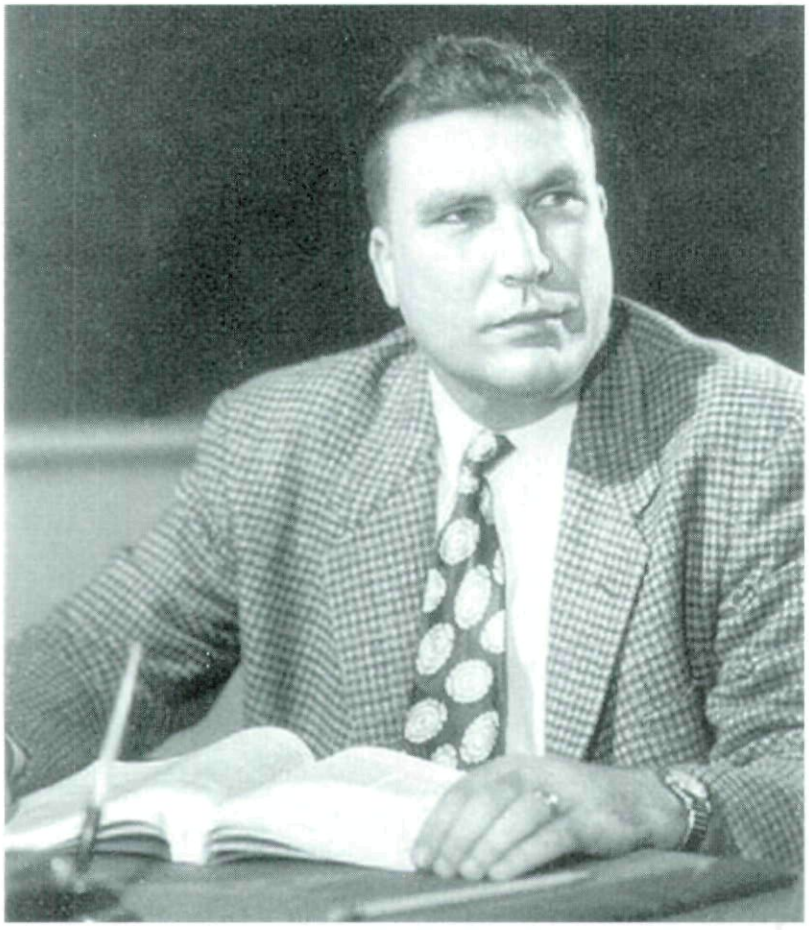
Terhune's desire to schedule the lunar-probe attempts as soon as possible may have been prompted in part by a suspicion that his division's rivals in the Army were busy making similar plans. The very next day (January 30, 1958), in fact, JPL and ABMA engineers discussed the subject at a meeting held in the JPL office at the Air Force Missile Test Center at Cape Canaveral, Florida, where they were waiting out a weather-caused delay in the Army's first attempt to launch a satellite. (A Jupiter C/RTV combination, known as Juno 1, would the following night successfully launch *Explorer 1,* the nation's first Earth-orbiting satellite.) During the meeting the engineers allocated the second Juno II launch in November 1958 and the first Juno III launch in February 1959 for JPL lunar probes.[29]

JPL was certainly aware that it was not the only organization shooting for the Moon. On February 4, Jack Froehlich, the Explorer project manager at JPL, sent a telex to Ernst Stuhlinger, head of the Space Sciences Laboratory at ABMA, informing him of the possibility that the first lunar probe could be ready in time for the first Juno II launch slated for October 1958. In addition to citing several technical reasons for advancing the launch date of the first lunar probe, Froehlich observed that the "Competition seems to be aiming for the very same goal." [30] Both engineers had read an *Aviation Week* article published two weeks earlier that had reported on BMD plans to send a payload to the Moon "probably within the next few months" using a Thor/Vanguard launch vehicle.[31]

Thus at the end of January 1958 both JPL and STL were actively competing for an assignment to launch probes to the vicinity of the Moon. The two organizations saw merit in having the probes obtain scientific data, but both perceived that the proposed missions could also serve as political responses to the Soviet Union's launching of *Sputnik 1* in October and a much heavier *Sputnik 2* on November 3. Both had also considered potential communication systems for receiving dramatic pictures of the lunar surface that would fulfill this nonscientific goal. The assemblage of the launch vehicles, the construction of the probes, and the setting up of the communication systems could not be undertaken, of course, until approval was received from the highest levels of the United States government.

PSAC and the Desire for Something that the Public Can Admire

Authority to launch lunar probes would come only slowly and reluctantly from the Eisenhower Administration. Early on, the Administration publicly took the stance that it would not rush to approve projects of little intrinsic merit that it perceived as hysterical responses to the Sputnik satellites, and proposals to hit the Moon were among such projects. Although Deputy Secretary of Defense Quarles had privately encouraged competing lunar-probe proposals from the Army and the Air Force, he testified on November 27, 1957, before the Preparedness Investigating Subcommittee of



Herbert F. York, director of the Livermore Laboratory. *(Photo courtesy of the author.)*

the Senate Armed Services Committee, that [32]

I find in the existence of the first satellites no cause for national alarm. In this respect I am disagreeing with many people who have been saying "Let's beat them [the Soviet Union]"; "Let's put up a bigger satellite"; "Let's hit the moon with a rocket" .... We must not be talked into "hitting the moon with a rocket" just to be first, unless by so doing we stand to gain something of real scientific or military significance.

EISENHOWER ..."WOULD RATHER HAVE A GOOD REDSTONE [IRBM] THAN BE ABLE TO HIT THE MOON, FOR WE DON'T HAVE ANY ENEMIES ON THE MOON!"

Eisenhower himself in early February 1958 told Republican Party legislative leaders that he "would rather have a good Redstone [IRBM] than be able to hit the moon, for we don't have any enemies on the moon!" He declared that he would not be drawn into a "pathetic race" with the Soviet Union, and he characterized a lunar probe as "useless." [33]

Despite this public negative attitude of Eisenhower and his Administration concerning lunar-probes, proposals for them came under renewed study by high government advisors and officials as a result of actions that the President took shortly after the launching of *Sputnik 2*. On November 7, four days after this event, President Eisenhower went on nationwide television to announce that he was appointing James R. Killian, Jr., then president of the Massachusetts Institute of Technology, as head of the newly created Office of the Special Assistant to the President for Science and Technology.

Two weeks later, in accordance with a recommendation by Killian, Eisenhower transformed the Office of Defense Mobilization's Scientific Advisory Committee, set up in 1951 by President Harry S. Truman, into the President's Scientific Advisory Committee (PSAC) and expanded its membership to make it more representative of the entire scientific community. Its chairman, Columbia University physics professor and Nobel Prize winner I.I. Rabi, stepped aside to allow Killian to succeed him.

After the first attempt to launch a Vanguard satellite ended in spectacular failure on December 6 (the explosion of the first stage of its launch vehicle within seconds of liftoff was recorded on live national television), PSAC members, among other activities, soon began debating "the components and the organization which a well-conceived American space program must possess." [34] On February 4, 1958, President Eisenhower formally ordered a special study to recommend the outlines of a space program and an organization to manage it. Killian assigned the study to a Space Studies Panel comprised of Harvard University physicist and Nobel Prize winner Edward M. Purcell (chairman), Herbert F. York (director of the Livermore Laboratory), Lt. Gen. James H. Doolittle, USAF (Ret.) (vice president of Shell Oil Company and chairman of the National Advisory Committee for Aeronautics), and Edwin H. Land (president of the Polaroid Corporation), all PSAC members.[35]

Earlier, on the same day in late October 1957 that Pickering and DuBridge had presented JPL's Red Socks proposal to McElroy and Quarles, they had also briefed the old Science Advisory Committee but received only a lukewarm reception. Pickering recalled the committee members as being "not sure that this was more of a stunt, as it were, and ... not really that enthusiastic about it from a scientific point of view, and even though Sputnik had happened already I don't think they really had quite the appreciation from a political point of view of the value of doing something like this." [36]

PSAC's Space Studies Panel had a more expansive view of the value of space technology. In a document entitled *Introduction to Outer Space* that President Eisenhower issued publicly on March 26, 1958, Purcell and York identified four factors that "give importance, urgency, and inevitability to the advancement of space technology." In addition to scientific observation and experiment, there was also the human urge to explore, defense needs, and national prestige. Regarding the last factor, they argued that "To be strong and bold in technology will enhance the prestige of the United States among the peoples of the world and create added confidence in our technological, industrial, and military strength." [37]

York, in particular, actively encouraged the lunar probes proposed by JPL and STL and visualized them, if successful, as both producing scientific data and enhancing national prestige. York had a long-standing strong interest in space travel (as presented in science fiction) and in the astronomy of the

solar system, and he thus approached the work of the Space Studies Panel with "special enthusiasm" and a delight that he was now "being asked to plan the real thing." He perceived lunar probes as among those projects that could "both be useful in themselves [obtaining scientific data] and outclass the Russians in their public relations impact." [38]

This potential dual value of lunar probes prompted the Space Studies Panel to summon representatives of JPL, STL, the Army Signal Corps' Research and Development Laboratory (Fort Monmouth, N.J.), and the Naval Ordnance Test Station (NOTS) (Inyokern, Calif.) to a meeting at the Executive Office Building next to the White House on February 17. In addition to Purcell and York, PSAC members Hugh L. Dryden (director of the National Advisory Committee for Aeronautics), Alan T. Waterman (director of the National Science Foundation), and Emanuel R. Piore (chief scientist of the International Business Machines (IBM) Corporation), along with S. Paul Johnson (director of the Institute for Aeronautical Sciences) of the PSAC staff, attended the meeting.

THE FIRST ATTEMPT TO LAUNCH A VANGUARD SATELLITE ENDED IN SPECTACULAR FAILURE

At the beginning of the meeting York, subbing for a late arriving Purcell, made it clear that the goal of restoring national prestige was the major factor driving PSAC's interest in gaining approval for an immediate program of lunar probes. He informed the visitors that PSAC had decided that the United States should "attempt a lunar mission with the objectives of: a. Making contact of some type with the moon as soon as possible, but with the limitation, b. That the contact be of a type that has significance such that the public can admire it." York further stated that the panel had concluded, given the second objective, that "some kind of visual reconnaissance" was the most significant experiment that a lunar vehicle could carry. York and Dryden, and to a lesser extent Waterman and Purcell, all emphasized "the very great significance of bringing back some pictorial information, particularly of the other side of the moon." [39] What was probably in the minds of the panel members may have been revealed in the *Introduction to Outer Space* document: "Photographs of the back or hidden side of the moon may prove quite unexciting, or they may reveal some spectacular new feature now unguessed." [40]

With the goal of potentially dramatic photographs in mind, PSAC invited camera developers from the Signal Corps and NOTS (William Stroud[41] and Howard Wilcox, respectively) to present at the February 17 meeting a state of progress of their devices to representatives of JPL and STL, the leading proponents of lunar probes and launch vehicles. York expressed his hope that the conference would "induce some interactions that would result in an earlier accomplishment of lunar experiments of significance." [42]

The "interactions" were in fact quite animated. Clarence (Johnny) Gates (manager of JPL's Guidance Systems Analysis section), recalled that the meeting was "quite competitive" and had a "somewhat charged atmosphere": "We said we could do this and the guys from STL disagreed. And the guys from STL said they could do something, and we disagreed. There was a challenge present in the meeting as to 'Were we speaking the truth, were we credible?'." [43] Another participant, A.F. Donovan (head of STL's Astrovehicles Laboratory), reported to Dunn examples of this competitiveness:[44]

Mr. Stroud started to complain to the Committee that they expected to have equipment available for reconnaissance, but there were no vehicles. I countered that we could have vehicles needing equipment within three months. When I asked him what he could deliver in three months, he had no equipment. This degenerated to his opinion that our vehicles would not work, and my opinion that our vehicles had more chance of working than his equipment. When we got into this phase it became somewhat clearer that Mr. Stroud had been brainwashed by the Army. Dr. Wilcox of NOTS kept arguing that either he could produce equipment, or that Mr. Stroud's equipment could be adapted for our use within the three months period, given suitable priority and authorization. Dr. Gates of JPL expressed extreme skepticism of our ability to establish a satellite orbit [i.e., an orbit around the Moon].

Donovan also reported to Dunn that he was "personally ... very skeptical that the JPL system can come anywhere near the Moon." [45]

Gates and his colleague Walter K. Victor, an electrical engineer working under Rechtin, informed the panel that JPL was already developing two types of reconnaissance systems for its Juno III-launched lunar probe. They, therefore, gained little from the meeting other than detailed information about STL's plans.

On the other hand, during the interval between submission of the "Project Baker" proposal and this meeting, the STL staff had changed the goal of its proposed lunar mission from a surface impact to orbiting a 30-lb satellite around the Moon. Such a spacecraft, because of its repeated passes over the lunar surface, would be particularly well suited for obtaining a picture of the far side of the Moon. At the meeting, therefore, Donovan expressed interest in the television scanning systems presented by Stroud and Wilcox, which he assessed were "considerably further along than I had believed any systems were for possible application to the Baker mission." [46]

Despite his interest in the Signal Corps and NOTS camera systems, Donovan informed the panel of STL's plans to include in its first few flights only a simple telemetering transmitter to communicate "minimum data, perhaps measurements of the moon's magnetic field" and its hope "to obtain other significant data by observing the trajectory of the satellite." He emphasized that company engineers in the initial missions were "making every attempt to keep it [the payload] as simple as possible to maximize the probability of success, and were reluctant to introduce television scanning systems or equivalent devices of a low probability of success." [47]

The Purcell committee members, however,

were adamant about attempting to get visual data, and hinted rather broadly that they felt lunar missions that did not attempt to fulfill this objective would have great difficulty receiving PSAC's endorsement. The point was emphasized by Killian, who came into the middle of the meeting for about 10 or 15 minutes. Gates recalled vividly many years later Killian's declaration that PSAC wanted "something flashy, showy, and cheap." The PSAC chairman made it clear that he perceived the lunar-probe project as "all froth, no substance, a stunt" and "just fluff," and that he wanted "something that they could flash in front of the public, something that would have no future, no substantial continuity, no real value." [48]

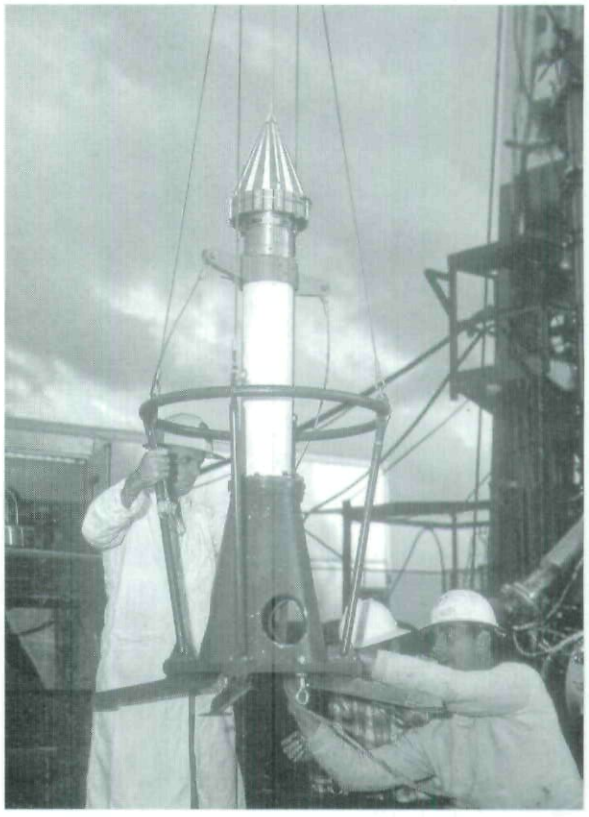
PSAC WANTED "SOMETHING FLASHY, SHOWY, AND CHEAP."

Based on these strong views expressed by the subcommittee members and Killian, Donovan recommended to Dunn that STL should immediately expand its "studies of significant measurements that can be made by simple telemetering in order to try to define significant experiments that can be done without television to minimize opposition to an early launching." He cautioned, however, that "It is imperative that we carefully review the possibilities of the Signal Corps and NOTS television units for application to Project Baker. To fail to do so on a positive and constructive basis would result in an enormous amount of ill will and potential opposition from the Killian Committee." Donovan warned that "We can expect a continuing and increasing pressure from the Killian Committee to get significant data and, if possible, visual data from our lunar experiments. They will insist that we use all possible resources for this purpose." [49]

The Space Studies Panel considered alternatives to a camera. Purcell reported on studies that he had done indicating that a minimum of 200 lb was necessary to place a permanent marker on the Moon, apparently too heavy a payload for the initial lunar-probe attempts. In addition, Donovan reported that the panel expressed "little enthusiasm for a momentary flash at impact." Furthermore, opposition recently expressed by biologists to contamination of the Moon by radioactive or germ-carrying material excluded the possibility of "landing an atomic bomb on the moon." [50] (In 1956 William W. Kellogg in one of the RAND reports had suggested exploding an atomic bomb on the Moon in order to create a visible flash and seismic motion.[51])

THE USSR CAN MAKE A LUNAR SHOT AT ANY TIME NOW, AND WILL PROBABLY DO SO BEFORE THE US CAN

One day after the meeting with the STL and JPL representatives and the television scanning system designers, York sent to Killian the Space Studies Panel's tentative recommendations concerning "the first phase" (1958-1959) of the United States space program. Among the recommendations were approval and implementation of lunar-probe attempts by both the ABMA/JPL and BMD/STL teams. The panel members recommended that the attempts be given the highest priority because they believed that "the USSR can make a lunar shot at any time now, and will probably do so before the US can, and that the US must do all it can to mitigate the Sputnik-like reaction which would follow the USSR achievement." [52] York



would soon have an opportunity to implement this recommendation.

ARPA and the Desire to Beat the Russians

Already, on February 12, President Eisenhower had signed a Congressional act authorizing the creation, within the Department of Defense, of an Advanced Research Projects Agency (ARPA) that would manage new weapon programs during the early stages of research and exploratory development. This act was passed in response to a desire by Eisenhower and McElroy to have "any new missile or related program hereafter originated ..., whenever practicable, be put under a single manager and administered without regard to the separate services." In addition, the new agency was authorized, for no longer than a year after the act took effect, "to engage in such advanced space projects as may be designated by the President." [53] ARPA would eventually transfer these projects to any new space agency proposed by Eisenhower and authorized by Congress.

Anticipating the legislative approval of the new agency, Secretary of Defense McElroy on February 7 named Roy E. Johnson, an executive at General Electric, as the first director of ARPA. Johnson in turn selected Rear Admiral John E. Clark, the director of the Navy's Guided Missiles Research Division, as his Deputy Director on March 5. Thirteen days later Johnson announced the appointment of York as chief scientist of the new agency. In his autobiographical account, however, York noted that he had already been effectively at work at ARPA for several weeks, and thus he was already on board when ARPA officials pri-

(Left) In this photograph, the lunar and planetary exploration satellite, Pioneer III, is being prepared for installation to Juno II (AM-11) launch vehicle.

(Right) Director of the U.S. Army Ballistic Missile Agency's (ABMA) Development Operations Division, Dr. Wernher von Braun, and Director of Missile Firing Division, Dr. Kurt Debus, are shown with unidentified individuals, discussing two components that would make up the Pioneer IV Lunar Probe. The mercury batteries (left) and the conical shroud. *(NASA photos.)*

ARPA'S DECISION TO ENDORSE AN IMMEDIATE PROGRAM OF LUNAR PROBES WAS BASED ON A DESIRE TO "BEAT THE RUSSIANS."

vately informed BMD (and presumably ABMA as well) on March 16 that the agency had approved the proposed lunar-probe attempts.[54] One of the first things York did as chief scientist, a history of ARPA notes, was to "hang a large picture of the moon on his wall next to an empty picture frame which, he felt, was 'soon' to receive the first picture of the backside of the moon." [55] Both Clark and York would later recall that ARPA's decision to endorse an immediate program of lunar probes was based on a desire to "beat the Russians." Johnson in particular, according to York, was "eager to surpass the Soviet Union in any way possible." [56]

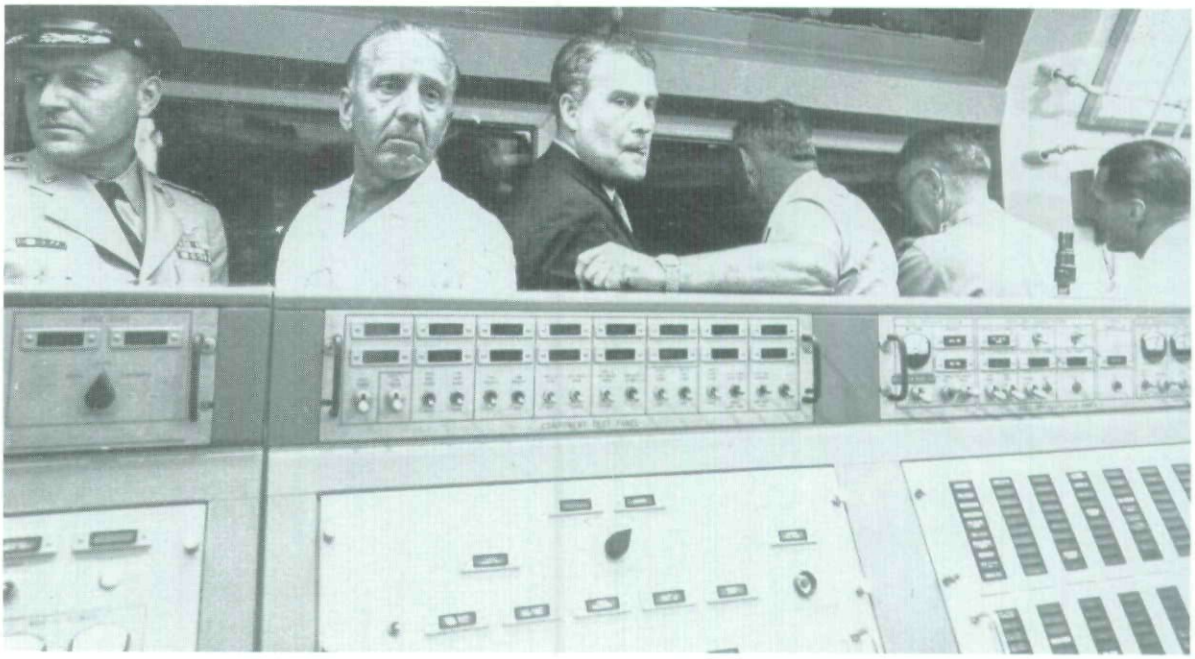
President Eisenhower's March 24 decision to approve the JPL and STL proposals for early lunar-probe attempts was apparently reluctantly made for the same reason. As late as March 18, during a meeting with Republican leaders, he argued against the United States getting involved in a race to the Moon with the Soviet Union and explained that a successful lunar probe could be achieved only after "a long series of painstaking steps." Nevertheless, he ultimately approved the probes, "fearful of another blow to national prestige," according to historian Robert A. Devine.[57]

The presidential approval led to McElroy's issuance on March 27 of ARPA's first three orders, all concerning lunar probes. Specifically, he gave ABMA authority to undertake one, and possibly two, 15-lb lunar probe attempts with Juno II vehicles in or about November and December 1958, and BMD authority to make three 30-lb lunar-probe attempts with Thor-Vanguard vehicles "as soon as possible." In addition, NOTS was ordered to develop a camera system for the Air Force probes.[58] Not surprisingly, the Army and Air Force organizations called upon JPL and STL to perform major tasks in their respective lunar-probe programs.

Mission Operations

The activities that JPL and STL undertook in connection with the approved Pioneer lunar-probe attempts are beyond the scope of this article, but a brief summary of these missions follows. The Air Force made its first attempt on August 17, 1958. The probe's Thor-Able launch vehicle lifted off successfully from the launch pad at Cape Canaveral, but at 73.6 sec into the flight a turbopump bearing failed and the liquid-oxygen (LOX) pump stopped in the Thor booster. A violent vehicle motion ensued, causing a rupture of either the main LOX tank or the main LOX duct and a subsequent explosion that destroyed the vehicle. The malfunction occurred when the vehicle had reached an altitude of 56,000 ft and a downrange distance of 27,000 ft. The probe it carried is sometimes called *Pioneer 0*.[59]

The Pioneer lunar-probe program was transferred to the newly formed National Aeronautics and Space Administration on October 1, 1958. The subsequent launches in the program were thus made under the auspices of NASA, although Air Force and Army personnel continued to participate in the launch activities at the Cape. The second probe, christened *Pioneer 1* and launched on October 10, went much further but traveled nowhere near the Moon. The first two rocket stages performed excellently, but when the third stage burned out, the payload had an inertial velocity about 500 ft/sec lower than the desired 35,206 ft/sec. Although all the vernier rockets were fired in an attempt to provide the needed additional velocity increment, the



This photograph shows Dr. von Braun, third from the left, in the blockhouse at the Florida launch facilities on March 3, 1959. He and others gathered for the launch of the Pioneer IV satellite. Behind Dr. von Braun is Kurt Debus, who managed the Florida launch facilities. To the right of Dr. von Braun is Army General John B. Medaris. Next to him is General John Barclay. At this time, Dr. von Braun and his associates were members of the Army Ballistic Missile Agency in Huntsville, Alabama. *(NASA photo.)*

impulse was insufficient. The payload thus failed to achieve escape velocity, reaching a maximum altitude of 71,700 mi.[60] The third probe, *Pioneer 2,* was launched on November 8, 1958. The first two stages again performed well, but the third stage failed to ignite, resulting in a maximum altitude of 963 mi for the upper stages and payload.[61]

PIONEER 4, WAS THE ONLY ONE OF THE FIVE ARPA-AUTHORIZED ATTEMPTS TO REACH ESCAPE VELOCITY

The later launches of the two Army lunar-probe attempts enabled them to be used to explore further a phenomenon whose discovery, by the *Explorer 1* and *3* Earth-orbiting satellites, was the most important scientific achievement of the early Space Age—radiation trapped in a belt surrounding the Earth at certain altitudes The first attempt (*Pioneer 3*) was made on December 6. Because of a premature cutoff of the booster and angular dispersion in the upper stages, the probe met a fate similar to that of *Pioneer 1,* reaching a maximum altitude of 63,500 mi. Ground-based antenna stations set up by JPL at Cape Canaveral, Mayagüez (Puerto Rico), and Goldstone (in California's Mojave Desert) all performed well, and the unplanned reentry of the payload enabled transmission of scientific data from two traverses of the desired altitudes for the cosmic-ray experiment.[62]

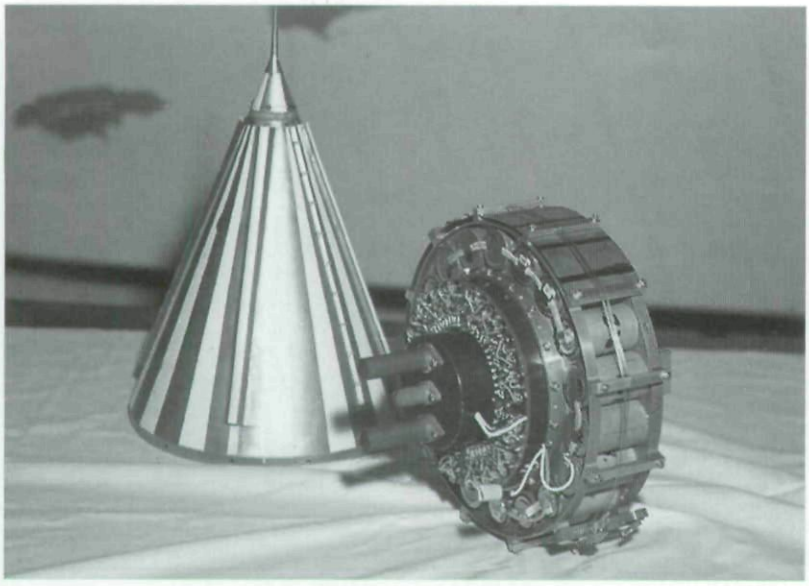
The second Army lunar probe, *Pioneer 4,* was the only one of the five ARPA-authorized attempts to reach escape velocity. After earlier attempts to launch on February 28 and March 1, 1959, were canceled due to weather and technical problems, the Juno II vehicle lifted off on March 3. During its ascent, the probe, like its predecessor, transmitted data on the Earth's radiation belts to the Mayagüez and Goldstone stations. The probe passed too far away (37,000 mi) from the Moon, however, to activate the camera system; thus no photograph was obtained. The probe transmitted signals for about 82 hours until its batteries became exhausted. When Goldstone received the last probe signal (on March 6 during the station's fourth period of successful signal acquisition and tracking), the probe was at a distance of 407,000 mi, setting a communications-distance record for the time.[63]

Pioneer 4's success in escaping the Earth's gravity, however, came too late in the more general space competition between the United States and the Soviet Union. The latter had already, on January 2, 1959, successfully launched *Luna 1,* which passed by the moon at the much closer distance of 5,985 km two days later.

Conclusion

As this study has shown, the potential scientific and political benefits that might be reaped from successful lunar probes had already been seriously discussed in the United States for nearly two years prior to the Soviet Union's orbiting of *Sputnik 1.* The shock of that event, and the desire to conduct a space mission that would be perceived as outdoing the Soviet accomplishment, was certainly a major motivation for two military-related engineering organizations, the Army's Jet Propulsion Laboratory and the Air Force contractor Space Technology Laboratories, to propose immediately the launching of probes launched toward the Moon. The same considerations also led two newly-formed government organizations, the President's Science Advisory Committee and the Department of Defense's Advanced Research Projects Agency, to recommend authorization of the probe attempts to President Eisenhower. Eisenhower, despite desiring to avoid getting the United States involved in a "space race" with the Soviet Union, appears to have eventually reluctantly approved the lunar-probe attempts in an effort to avoid a potential second "space shock" that might occur if the Soviets accomplished a successful lunar mission first.

Despite the Cold War motivations underlying the proposal, endorsement, and authorization of the Pioneer lunar-probe attempts and the failure of any of them to come anywhere near the Moon



Assemblies of Pioneer III, lunar and planetary exploration satellite and the payload for AM-11 (Juno II). Pioneer III was launched on December 6, 1959. *(NASA photo.)*

before a Soviet probe did so, one can nonetheless argue that they laid several foundations for the solar-system exploration program that NASA would carry out in succeeding years. Space Technology Laboratories (later renamed TRW) would subsequently construct several solar, interplanetary, and Jupiter probes (all under the Pioneer name), and the Jet Propulsion Laboratory would become NASA's principal field center for managing, and in some cases constructing, lunar and planetary probes. Also, the ground-based antenna that JPL personnel erected at Goldstone (in California's Mojave Desert) would become the cornerstone for the Deep Space Network, the worldwide system of antennas (at Goldstone, as well as in Australia, Spain, and formerly in South Africa) that have tracked, communicated with, and commanded NASA's solar-system space probes since the early 1960s. ■

NOTES

1. "Secretary McElroy Announces New Space Programs," Department of Defense (hereafter: DOD) News Release No. 288-58, Mar. 27, 1958; Jack Raymond, "U.S. Plans Moon Rockets; Initial Outlay Is 8 Million," *The New York Times,* Mar. 28, 1958, pp. 2 & 8. For detailed contemporary accounts of the Pioneer lunar-probe missions, see the publications cited in reference notes 59-63 below. The most detailed historical account of the program (and the contemporary parallel Soviet effort) is T. A. Heppenheimer and Peter Gorin, "Match Race: The first contest for the moon was settled long before Neil Armstrong reached the lunar surface," *Air & Space Smithsonian*, 10, no. 6 (February/March 1986), 78-87. The Pioneer missions are also briefly discussed in Cargill Hall's book on Project Ranger (ref. 8). Neither of these publications, however, provide any detailed discussion of how and why the Pioneer lunar-probe attempts came to be authorized.

2. G.H. Clement, *The Moon Rocket* (RAND Report P-833, rev.), May 7, 1956 (paper presented at the "Earth Satellites as Research Vehicles" symposium, Philadelphia, Apr. 18, 1956); R.W. Buchheim, *General Report on the Lunar Instrument Carrier* (RAND Report RM-1720), May 28, 1956; H.A. Lang, *Lunar Instrument Carrier—Landing Factors* (RAND Report RM-1725), June 4, 1956; R.W. Buchheim, *Motion of a Small Body in Earth-Moon Space* (RAND Report RM-1726), June 4, 1956; H.A. Lieske, *Lunar Instrument Carrier—Ascent Flight Mechanics* (RAND Report RM-1727), June 4, 1956; W.E. Frye, *Lunar Instrument Carrier—Powered Flight Guidance* (RAND Report RM-1729), June 4, 1956; R.W. Buchheim, *Lunar Instrument Carrier—Attitude Stabilization* (RAND Report RM-1730), June 4, 1956; R.T. Gabler, *Lunar Instrument Carrier—Tracking and Communications* (RAND Report RM-1731), June 4, 1956; E.C. Heffern, *Lunar Instrument Carrier—Vehicle Design Considerations* (RAND Report RM-1732), June 4, 1956; R.W. Buchheim, *Artificial Satellites of the Moon* (RAND Report P-873), June 14, 1956 (published openly in Associazione Italiana Razzi (ed.), *Proceedings of the VII International Astronautical Congress, Rome, 17-22 September 1956* (Rome, 1956), pp. 587-643); W.W. Kellogg, *Observations of the Moon from the Moon's Surface* (RAND Report RM-1764), July 27, 1956; S.H. Dole, *Visual Detection of Objects on or near the Moon* (RAND Report RM-1900), May 27, 1957.

3. This summary of the RAND work is based on Alfred Rockefeller, Jr. (Air Force Ballistic Missile Division historian) to Gen. Terhune, "Able-Able 1 Chronology," Nov. 12, 1959, "Able-1 (Lunar Probe)" folder, Space Systems Division History Office (hereafter, SSDHO) files, Los Angeles Air Force Base (hereafter, LAAFB), and on Merton E. Davies and William R. Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology* (Santa Monica, Calif.: The RAND Corporation, 1988), pp. 71-73. Rockefeller cited a RAND report entitled *Space Flight and the Air Force* (dated May 2, 1957, and still carrying to this day a secret classification) as his source for Buchheim's presentation of the same date. Rockefeller did not specify the Air Force organization or officials to whom Buchheim made his presentation.

4. Evert Clark, "Indecision Blocks Prompt Moon Strike: Pentagon is swamped by proposals to send existing hardware to Moon; bottleneck is in high echelons," *Aviation Week,* 68, no. 6 (Feb. 10, 1958), 26-27.

5. "Space Flight Regained" (Washington Roundup), *Aviation Week,* 67, no. 15 (Oct. 14, 1957), 25. The response to Schriever's speech is discussed in Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1960* (Maxwell Air Force Base, Alabama: Air University Press, 1989), vol. 1, pp. 545 and 549, and on p. 15 of Schriever's essay "Military Space Activities: Recollections and Observation" in R. Cargill Hall and Jacob Neufeld 9eds.), *The U.S. Air Force in Space: 1945 to the Twenty-first Century: Proceedings, Air Force Historical Foundation Symposium, Andrews AFB, Maryland, September 21-22, 1995* (Washington, D.C.: USAF History and Museums Program, 1995).

6. On the reaction of the American public to the orbiting of *Sputnik 1,* see Donald N. Michael, "The Beginning of the Space Age and American Public Opinion," *The Public Opinion Quarterly,* 24, no. 4 (Winter 1960), 573-82; Lynne L. Daniels (compiler), *Statements of Prominent Americans on the Opening of the Space Age: A Chronology of Select Statements October 4, 1957 to November 13, 1958* (NASA Historical Note No. 21), July 15, 1963; Martha Wheeler George, *The Impact of Sputnik I: Case-Study of American Public Opinion At the Break of the Space Age October 4, 1957* (NASA Historical Note No. 22), July 15, 1963; Robert D. Lapidus, "Sputnik and its Repercussions: A Historical Catalyst," *Aerospace Historian,* 17, nos. 2 & 3 (Summer-Fall 1970), 88-93; and Walter A. McDougall, "Sputnik, the Space Race, and the Cold War," *Bulletin of the Atomic Scientists,* 41, no. 5 (May 1985), 20-25.

7. For further information on JPL, see Clayton R. Koppes, *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (New Haven and London: Yale University Press, 1982).
8. Jet Propulsion Laboratory (hereafter: JPL), *Project Red Socks,* October 21, 1957, p. 1, copy in History Collection (Doc. 2-581b), JPL Archives. The History Collection was generated by R. Cargill Hall in the late 1960s and early 1970s during the course of his research for his book *Lunar Impact: A History of Project Ranger* (NASA SP-4210; 1977).
9. Pickering interview by Hall, Aug. 20, 1968, p. 6 of transcript in History Collection (Doc. 2-753), JPL Archives.
10. Pickering to Lee A. DuBridge (President of Caltech), Oct. 25, 1957, History Collection (Doc. 2-581a), JPL Archives.
11. Pickering interview (ref. 9), p. 6.
12. JPL, *Project Red Socks,* pp. 1-3.
13. *Ibid.,* pp. 4-5.
14. E. Rechtin to J.E. Froehlich, "Material for requested letter on project New Moon," Oct. 18, 1957, "Juno Administrative" section, microfilm roll 33-1A, JPL Archives.
15. Pickering interview (ref. 9), p. 6.
16. See, for example, the following unpublished documents in the JPL Archives: J.I. Shafer, "Alternate Program to RED SOX," Nov. 2, 1957, "Juno Internal Correspondence 1/58-4/58" section, microfilm roll 211-2; J. Small & H. Bank to Distribution, "Red Socks Project," Nov. 19, 1957, "Deal & Red Sox" section, microfilm roll 211-2; [J.D. Burke], "Red Sox objectives and design study," undated, "Deal & Red Sox" section, microfilm roll 211-2; J. Small & J.D. Burke to A.R. Hibbs, "Aerodynamic coefficients for Red Sox," Dec. 6, 1957, "Deal & Red Sox" section, microfilm roll 211-2; J.D. Burke, "Research Vehicles Using the Jupiter Powerplant," Dec. 26, 1957, handwritten copy in "Deal & Red Sox" section, microfilm roll 211-2, and typed copy in "Juno Administrative" section, microfilm roll 33-1A.
17. "New Soviet Surprise?" (Washington Roundup), *Aviation Week,* 67, no. 17 (Oct. 28, 1957), 25; "U.S. Accelerates Moon Plans," *ibid.,* no. 18 (Nov. 4, 1957), 27.
18. Ansel E. Talbert, "Missile Tests Bring Moon Trip Closer," *New York Herald Tribune,* Jan. 30, 1958. A lower figure of approximately 250 proposals was cited in "USAF Plans Moon Strike Within Months: Payload to Moon to be tried with Thor, two stages of Vanguard; Redstone to explore nuclear blasts," *Aviation Week,* 68, no. 3 (Jan. 20, 1958), 26-27.
19. Rockefeller, "Atlas-Able 1 Chronology" (ref. 3), p. 1. This subcommittee was also known as the Barlow committee. Regarding the Army-Air Force competition for the IRBM assignment, see John B. Medaris with Arthur Gordon, *Countdown for Decision* (New York: G.P. Putnam's Sons, 1960) and Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York and London: Columbia University Press, 1969).
20. Rockefeller, "Atlas-Able 1 Chronology" (ref. 3), p. 2.
21. P. Dergarabedian to A.F. Donovan, "Other Multiple-Stage Combinations with a Thor Booster," Dec. 12, 1957, "Able-1 (Lunar Probe)" folder, SSDHO files, LAAFB; Rockefeller, "Atlas-Able 1 Chronology" (ref. 3), pp. 2-4.
22. For further information on Space Technology Laboratories and its relationship with the Ramo-Wooldridge Corporation (shortly to become TRW), see "Ramo-Wooldridge to Sever Ties With Space Technology Division," *Aviation Week,* 69, no. 8 (Aug. 25, 1958), 24; "USAF Traces Ramo-Wooldridge Growth," *ibid.,* no. 22 (Dec. 1, 1958), 77, 81, & 84-85; Irving Stone, "STL Broadens Missile, Space Roles," *ibid.,* 70, no. 20 (May 18, 1959), 54-55, 57, 59, 61, 65, & 67-69; Stone, "STL Probes Missile Defense Techniques," *ibid.,* no. 21 (May 25, 1959), 55-57, 59, 61, & 65; Stone, "STL Integrates Space Probe Payloads," *ibid.,* no. 22 (June 1, 1959), 55-56, 61, & 63-64.
23. STL, *Project Baker: Hard Impact Lunar Flight Experiment* (Exhibit 1 to Proposal 26-10), Jan. 27, 1958, p. 2, copy in SSDHO files, LAAFB.
24. Dunn to Col. C.H. Terhune, "Proposal 26-10, Project Baker," Jan. 27, 1958, attached to proposal (see preceding reference).
25. STL, *Project Baker,* p. 1.
26. *Ibid.,* pp. 7-8 & 10.
27. *Ibid.,* p. 27.
28. Terhune to Gen. Schriever and Gen. Ritland, "Use of 315 Boosters," Jan. 29, 1958, "Able-1 (Lunar Probe)" folder, SSDHO files, LAAFB.
29. A.R. Hibbs, "Minutes of Meeting, JPL and ABMA, January 30, 1958," Mar. 14, 1958, pp. 2-3, copies in "ABMA & AOMC" section, microfilm roll 33-1A, and "Juno Internal Correspondence 1/58-4/58" section, microfilm roll 211-2, both in JPL Archives.
30. Froehlich to Stuhlinger, Feb. 4, 1958, "Juno-TWX" section, microfilm roll 33-1A, JPL Archives.
31. "USAF Plans Moon Strike Within Months" (ref. 18), pp. 26-27.
32. House Committee on Armed Services, *Inquiry into Satellite and Missile Programs,* Hearings before the Preparedness Investigating Subcommittee, 85th Cong., 1st & 2nd Sess., pt. 1, Nov. 25-27, Dec. 13-14 & 16-17, 1957, and Jan. 10, 13, 15-17, 20-21, & 23, 1958, pp. 301-2.
33. Quoted in Stephen E. Ambrose, *Eisenhower. Volume Two: The President* (New York: Simon & Schuster, 1984), pp. 457-58.
34. Eugene M. Emme, "Presidents and Space," pp. 5-138, esp. p. 23, in Frederick C. Durant, III (ed.), *Between Sputnik and the Shuttle: New Perspectives on American Astronautics* (AAS History Series, vol. 3) (San Diego, Calif.: Univelt for the American Astronautical Society, 1981).
35. John D. Morris, "President Orders Killian to Study Space Programs," *The New York Times,* Feb. 5, 1958; James R. Killian, Jr., *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology* (Cambridge, Mass., and London: MIT Press, 1977), p. 122.
36. Pickering interview (ref. 9), p. 6.
37. The entire document is reprinted in Killian, *Sputnik, Scientists, and Eisenhower* (ref. 35), pp. 288-99. The quotation is from p. 289.
38. Herbert F. York, *Making Weapons, Talking Peace: A Physicist's Odyssey from Hiroshima to Geneva* (New York: Basic Books, 1987), pp. 112 and 146.
39. A.F. Donovan to Louis G. Dunn, "Meeting with Killian Subcommittee on Space with Reference to Project Baker" (Ramo-Wooldridge interoffice memorandum GM 58-0165-06470), Mar. 5, 1958, pp. 1-3 and 5, "Able-1 (Lunar Probe)" folder, SSDHO files, LAAFB. This memorandum cites no date for the meeting, but it is listed as occurring on February 17 in the Rockefeller chronology (ref. 3, p. 4).
40. Killian, *Sputnik, Scientists, and Eisenhower* (ref. 35), p. 295.
41. Stroud, chief of the Astro-Instrumentation Branch of the Astro-Electronics Division at the Signal Corps' Research and Development Laboratory (also known as the Watson Laboratories), would in 1959 join NASA's Goddard Space Flight Center, where he became chief of meteorology in the center's Satellite Applications Systems Division and project manager of NASA's *Tiros 1* meteorological satellite, which contained two television cameras and sent back information about the Earth's cloud cover (NASA press releases, [1959] and Apr. 4, 1960, Stroud biographical file, NASA HQ History Office). The television scanning system on which he was working in 1958 was slated to be used on an upcoming Vanguard satellite.
42. Donovan, "Meeting with Killian Subcommittee" (ref. 39), p. 3.

43. Gates oral history interview by author, Pasadena, Calif., Dec. 12, 1990.
44. Donovan, "Meeting with Killian Subcommittee" (ref. 39) p. 7.
45. *Ibid.*, p. 6.
46. *Ibid.*, p. 9.
47. *Ibid.*, p. 5.
48. Gates interview (ref. 43).
49. Donovan, "Meeting with Killian Subcommittee" (ref. 39) p. 9. JPL's Rechtin shared Donovan's reluctance to introduce visual reconnaissance systems took quickly on lunar probes. When the subsequent ARPA order authorizing Army lunar probes was amended to have the second attempt have the objective of "taking, developing and scanning a photograph of the moon," Rechtin characterized the camera system as "far more dramatic and hence desirable in a Cold War application," but warned that "the risk is correspondingly higher." Rechtin to Froehlich, Apr. 15, 1958, "Juno - TWX" section, microfilm roll 33-1A, JPL Archives.
50. Donovan, "Meeting with Killian Subcommittee" (ref. 39) p. 8.
51. Kellogg, *Observations of the Moon from the Moon's Surface* (ref. 2), pp. 9-13.
52. York to Killian, Feb. 18, 1958, "Space (4)" folder, box 15, "Records of the Office of the Special Assistant for Science and Technology" files, Dwight D. Eisenhower Library, Abilene, Kansas. I am grateful to Donald C. Elder III for bringing this memorandum to my attention, and to Thomas W. Branigar, archivist at the DDE Library, for providing me with a photocopy of the document.
53. The Eisenhower-McElroy desire, expressed by the President in a televised address on November 3, 1957, and the excerpt from the Congressional act are quoted in Alice C. Cole, et al. (eds.), *The Department of Defense: Documents on Establishment and Organization 1944-1978* (Washington, D.C.: Office of the Secretary of Defense Historical Office, 1978), p. 173.
54. "Career of ARPA Head At GE Detailed," *Aviation Week,* 68, no. 7 (Feb. 17, 1958), 28-29; "Top Appointments Announced for ARPA," DOD News Release No. 197-56, Mar. 5, 1958; "Dr Herbert York Named to Head New *IDA* Division and *ARPA* Science Post," DOD News Release No. 250-58, Mar. 18, 1958; Rockefeller, "Able-Able 1 Chronology" (ref. 3), p. 4; York, *Making Weapons, Talking Peace* (ref. 38), p. 141.
55. Richard J. Barber Associates, Inc., *The Advanced Research Projects Agency, 1958-1974,* December 1975, p. II-26. I am grateful to Dr. Herbert York for providing me with a copy of this unpublished history, which was prepared under Department of Defense Contract No. MDA 903-74-C-0096.
56. Cargill Hall interviews with Clark and York on Nov. 1 and Dec. 17, 1971, partial transcripts in History Collection (Documents 2-2233 and 2-2235), JPL Archives.
57. Eisenhower to McElroy, Mar. 24, 1958, History Collection (Doc. 2-2363), JPL Archives; Robert A. Devine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (New York and Oxford: Oxford University Press, 1993), pp. 108-10. Within the White House, Special Assistant for International Affairs Frederick Dearborn was an advocate of lunar probes in late 1957 and early 1958. He perceived them as one of several demonstrations of technological progress that could regain the psychological initiative for the United States in the cold war against the Soviet Union. Dearborn died in February 1958, however, and it is thus unclear what role he may have played in Eisenhower's ultimate approval of lunar-probe attempts. See Rip Bulkeley, *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space* (Bloomington and Indianapolis: Indiana University Press, 1991), pp. 174-75.
58. Johnson to Major General John Bruce Medaris (Commanding General, ABMA), "ARPA Order #1-58," Mar. 27, 1958, copies in History Collection (Documents 2-2226 and 2-2365a), JPL Archives, and "16.5 Pioneer" folder, NASA HQ History Office files; Johnson to Schriever, "ARPA Order # 2-58," Mar. 27, 1958, copies in "Able-1 (Lunar Probe)" folder, SSDHO, LAAFB, and History Collection (Documents 2-2222, 2-2230, and 2-2365a), JPL Archives; Johnson to Commander, Naval Ordnance Test Station, "ARPA Order #3-58," Mar. 27, 1958, "Able-1 (Lunar Probe)" folder, SSDHO, LAAFB.
59. For accounts of this mission, see Brig. Gen. O.J. Ritland (Vice Cmdr., BMD) to Schriever, Aug. 18, 1958, "Able-1 (Lunar Probe)" folder, SSDHO, LAAFB; Evert Clark, "First U.S. Lunar Probe Fails After Promising Launch," *Aviation Week,* 69, no. 8 (Aug. 25, 1958), 20-23; STL, *Able-1 Final Report* (ref. 2), pp. 74 & 82.
60. For accounts of the *Pioneer 1* mission, see Richard Witkin, "U.S. Rocket Rising 80,000 Miles, but Will not Circle the Moon; May Be in Orbit around the Earth," *The New York Times,* Oct. 12, 1958, p. 1; "Scientists Weigh Satellite Role For Lunar Rocket's Last Stage," *The New York Times,* Oct. 12, 1958; William Hines, "Rocket Slows, Due to Miss Moon; Soars 77,740 Miles But Assumes Path In Orbit to Earth; Pioneer's Deviation Attributed To Slight Defect in Firing," *The* [Washington, D.C.] *Sunday Star,* Oct. 12, 1958, pp. A-1 & A-3; "Hawaii Station 'Saw' Rocket Die; Radio Equipment Tracked Pioneer's Plunge Into Earth's Atmosphere," *The New York Times,* Oct. 15, 1958; Evert Clark, "Pioneer Indicates Restricted Radiation," *Aviation Week,* 69, no. 16 (Oct. 20, 1958), 30-33; A. R. Hibbs, "Pioneer Cosmic Ray Data," Oct. 20, 1958, copies in "ABMA & AOMC" section, microfilm roll 33-1A, and "Conferences Technical 1958" section, microfilm roll 614-102, JPL Archives; "Pioneer Failure Detailed," *Aviation Week,* 69, no. 17 (Oct. 27, 1958), 34; Schriever to Lt. Gen. S.E. Anderson (Cmdr., Air Research and Development Command), Nov. 4, 1958, ""Re-entry (Able-0)" folder, SSDHO files, LAAFB; Philip J. Klass, "Little Radiation Data Gained from Pioneer," *Aviation Week,* 69, no. 23 (Dec. 8, 1958), 33; STL, *Able-1 Final Report* (ref. 2), pp. 74-75 & 82-83.
61. STL, *Able-1 Final Report* (ref. 2), pp. 74-75 & 84. For an extensive compilation of press accounts of the *Pioneer 2* mission, see *Analysis of the Implementation and Media Coverage of the NASA Information Plan 3rd Space Probe November 8, 1958,* copy in SSDHO files, LAAFB.
62. For accounts of the *Pioneer 3* mission, see John W. Finney, "Army Vehicle Nearly Reaches Speed of Escape Gravity" and "Moon Rocket Dies Over Africa; Burns Out After 38-Hour Trip; Pioneer III Disintegrates in Earth's Atmosphere—Rose 63,000 Miles," *The New York Times,* Dec. 7 & 8, 1958; Evert Clark, "Radiation Belt Explored by Army's Pioneer III Probe," *Aviation Week,* 69, no. 24 (Dec. 15, 1958), 28-31; William Hines, "Man Gets Green Light For Travel Into Space; But Van Allen Stresses Caution In By-Passing Belt of Radiation," *The* [Washington, D.C.] *Evening Star,* Dec. 28, 1958; "Van Allen Defines Space Radiation Belts; Two distinct bands found by Pioneer III, Iowa scientist tells American Astronautical Society," *Aviation Week,* 70, no. 1 (Jan. 5, 1959), 19-20; JPL, *SPS 1* (ref. 41), Feb. 1, 1959, pp. 2-7 & 111-15; Allen E. Wolfe (ed.), *Juno Final Report, Volume II. Juno II: Space Probes* (ref. 41), pp. 52-62.
63. For accounts of the *Pioneer 4* mission, see William Hines, "U.S. Probe Labeled 'Completely Successful'," *The* [Washington, D.C.] *Evening Star,* Mar. 3, 1959, pp. A-1 & A-6; "Pioneer 300,000 Miles in Space; Discoverer Found Orbiting Earth," *The New York Times,* Mar. 5, 1959, pp. 1 & 10; John W. Finney, "Pioneer's Radio Fades in Space; But Its Signals Set Distance Record Before Dying," *The New York Times,* Mar. 7, 1959; "Pioneer Probe Passes Moon, Orbits Sun," *Aviation Week,* 70, no. 10 (Mar. 9, 1959), 321-22; Evert Clark, "Sun May Be Origin of Van Allen Radiation; U.S. lunar probe detects new intensity in belts; data indicates inner layer particles are protons,"

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