The Air Force Ballistic Missile Division and the Pioneer Lunar Probes of 1958

The Pioneer lunar launches were significant because they took some of the earliest steps in the conquest and management of space. Although the Air Force had been working on the development of a reconnaissance satellite called Weapon System 117L since 1955, that program had yet to launch any hardware. The Pioneer missions were the Air Force's first operational ventures into space. They involved

- the first space launches of any kind attempted by the Air Force;
- the first deep space or lunar probes attempted by anyone as well as the world's first practical attempts, though unsuccessful, to place payloads in the vicinity of the moon;
- the world's first attempts to gather data about a celestial body other than earth by means of spacecraft as well as the world's first attempts to photograph a celestial body other than earth from a spacecraft;
- the first scientific measurements of the interplanetary environment, including the first observations from space of the earth's magnetic field, the first measurements of the density of micro-meteorites in outer space, and the first measurements of the dimensions of the earth's radiation belt;
- the first space mission (Pioneer 0) carried out under the direction of the newly formed Advanced Research Projects Agency (ARPA);
- the first missions (Pioneer 1 and Pioneer 2) carried out under the direction of the even newer National Aeronautics and Space Administration (NASA);
- one of the first programs to be transferred from the Department of Defense to NASA;
- the first use of the Thor missile as a space booster and the first step in the development of the Delta launch vehicle derived from it;
- the first activation and use of a space telemetry, tracking, and control network under Air Force control as well as the first significant two-way communications with spacecraft from ground stations;
- the first experience with space operations, and therefore a crucial learning experience, for many future leaders within DoD, NASA, and private industry.

Even before the Soviet Union launched Sputnik 1 on 4 October 1957, but especially after it launched Sputnik 2 a month later, space proponents within the Department of Defense were looking hard for any available upper stages to use on their available missiles, both to improve the range of intermediate-range missiles and to turn them into satellite launchers. The second stage of the Naval Research Laboratory's Vanguard launch vehicle, intended for placing the first U.S. satellite into orbit during the International Geophysical Year, was one of the few such available upper stages. In January 1958, AFBMD's technical advisory contractor, Space Technology Laboratories (STL), proposed using a modification of this second stage, which it called the Able, to extend the range and velocity of the Thor IRBM so that advanced ablative reentry vehicles for the Atlas ICBM could be tested in a more realistic environment. STL published a program plan for the reentry tests, named "Project Able" on 28 February 1958, and AFBMD carried out three launches using the Thor Able to test experimental reentry vehicles on 23 April, 9 July, and 23 July 1958. Even in ballistic launches, however, experiments related to space were creeping into the agenda, for each of these tests carried a mouse in a compartment within the reentry vehicle to gather data on biological responses to rocket flight and reentry.

At the same time, it was apparent that adding a third stage to the Thor Able would allow it to propel a small payload to a velocity great enough to escape earth's gravitation and reach the moon. Proposals for using the Thor Able in this way had begun to surface as early as the idea of using the launcher to test reentry vehicles. In 1956, the RAND Corporation had published a series of reports recommending lunar launches using missiles already under development, although it recommended using the Atlas with the Vanguard second stage. On 6 December 1957, the Air Force Scientific Advisory Board urged the Air Force to counter the volley of Sputniks with "a vigorous space program with an immediate goal of landings on the moon." AFBMD responded in part early in January 1958 by recommending to the Air Staff's deputy chief of staff for development, Lieutenant General Donald L. Putt, that the Thor Able be used for early space launches because Thor vehicles could be made available sooner than Atlas vehicles.

Later in January 1958, STL published two influential reports that ensured a role for the Thor Able in lunar probes. The first was "Lunar Missions with Thor Vanguard Stages," which described a mission using a three-stage Thor Able to launch a payload consisting of a television system and impact flash powder to achieve a "hard impact" on the moon in 1958. The second proposal, known as Project Baker, described a similar "hard impact lunar flight experiment" using surplus hardware from Project Able. AFBMD brought this proposal to Air Force headquarters, and Secretary of the Air Force James H. Douglas recommended it to Secretary of Defense Neil H. McElroy on 14 February 1958, noting that "the U.S. could make a major international psychological gain by beating the Russians to the moon." STL's program managers briefed their Project Baker proposal to the Purcell Panel of the President's Scientific Advisory Committee on 5 March 1958, learning that the Committee, charged with developing a national space program, had decided to recommend a lunar probe only if its contact with the moon promised to be "of real significance, and preferably of a type that the public can admire."

At this point, an important organizational change within the Department of Defense brought plans for lunar probes involving all three services to fruition, while, ironically, transferring broad direction and oversight to a new agency. On 7 February 1958, Secretary of Defense McElroy activated the Advanced Research Projects Agency (ARPA), which had been proposed for legislation by President Eisenhower the previous November. As part of the President's near-term reaction to Sputnik, ARPA was supposed to provide unified and centralized direction to the more promising yet riskier research and development projects within the Department of Defense. Under its first director, Roy W. Johnson, ARPA proceeded to ingest emerging space programs from every military agency and redirect them toward common goals. The new agency's first directives, issued in late March 1958, were for the lunar probes. ARPA wisely gave the first lunar missions five opportunities to reach their objective.

The Army had developed its own plans for space launches, including lunar launches, based on the Jupiter IRBM developed by the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal, Alabama. Late in 1957, the ABMA advocated lunar probes using a concept proposed by the Jet Propulsion Laboratory of the California Institute of Technology. The first directive that ARPA issued (ARPA Order 1-58, dated 27 March 1958) went to the Army Ballistic Missile Agency, instructing it to launch one or two lunar probes in late 1958 to early 1959. ARPA's second directive (ARPA Order 2-58, also dated 27 March 1958) went to the Air Force Ballistic Missile Division, instructing it to launch three lunar probes using the Thor Able configuration proposed by STL. These were to be launched "as soon as possible consistent with the requirement that a minimal amount of useful data concerning the moon be obtained." The third directive (ARPA Order 3-58, also dated 27 March 1958) went to the Naval Ordnance Test Station (NOTS) at China Lake, California, instructing it to develop a “mechanical ground scanning system” to be carried on the lunar probes. This device was actually a rudimentary television camera which NOTS had already brought to a fairly advanced state of readiness for rocket flights. On the same date as the first ARPA orders, Secretary of Defense McElroy released the first public announcement of the lunar probes which had now come under ARPA’s direction. Aside from describing the three directed efforts, the major characteristic of the announcement was an attempt to reduce public expectations of success. Roy Johnson said that DOD could not predict when lunar probes might be successful. Herbert F. York, ARPA’s chief scientist, predicted rather gloomily (but accurately) that it would take many launches to reach the vicinity of the moon.

AFBMD gave STL complete control over the design and assembly of both the payload and the launch vehicle. STL obtained most of the components on the open market or from government agencies. The payload consisted of a roughly doughnut-shaped fiberglass shell containing telemetry and experiments to measure the earth’s and moon’s magnetic fields, the intensity of radiation fields in space, and the number and intensity of micrometeorites. It also contained an imaging scanner to return a picture of the moon at closer range. For the third launch, STL replaced the scanner provided by NOTS with an imaging scanner that STL itself had developed. It was supposed to produce a television image of the moon by building up the image in 128 segments per line, with the television lens looking through an aperture in the side of the spacecraft to create one line of dark and light contrasts for each 128 revolutions of the spacecraft. A small solid rocket motor occupied the hole in the center of the doughnut, with its nozzle pointed in the direction of launch. The function of this retrorocket was to fire when the spacecraft reached the vicinity of the moon and reduce its velocity enough to allow the moon’s gravity to pull it into a lunar orbit. The spacecraft was fabricated and integrated in the buildings at STL’s R&D Facility, now Area A of Los Angeles AFB.

STL also established an assembly and checkout facility for the second stage in the Ramo-Wooldridge hangar at Los Angeles International Airport, and it assembled and tested upper stages there for both the three reentry launches and the three lunar probes. For the lunar probes, STL added two additional stages to the Aerojet second stage that had been tested in the reentry launches. The third stage consisted of a solid rocket motor developed by Allegheny Ballistics Laboratory as an advanced third stage for the Vanguard vehicle, but never flown. The fourth stage consisted of eight small solid rockets mounted in a ring around the base of the spacecraft. The ring was jettisoned after imparting the final increment of velocity.

When the Purcell Panel decided to recommend a lunar probe to the President’s Scientific Advisory Committee, it added another condition to those of significance and admirability. The panel also stipulated that the probes “not contaminate the moon either radiologically or biologically.” Although ARPA’s direction to AFBMD did not specifically say that the probes were to avoid impact with the moon, ARPA director Roy W. Johnson understood the concerns of the IGY scientists very clearly. In August 1958, just before the first lunar launch, the U.S. IGY Committee drew Johnson’s attention to the recommendations of international scientists against contaminating the moon. Johnson replied that, although accidental impact was possible, “there is no intent to achieve an impact on the moon with any of the presently planned lunar vehicles and efforts will be made to avoid such impact.” To guard against accidental contamination, STL proceeded to sterilize the payload’s components with ultraviolet light.

We should note, therefore, that an important change had taken place in mission planning: the lunar probes no longer were intended to strike the moon. Although STL's proposals had called for "lunar impact," and although Major General Schriever, commander of AFBMD, was under the impression shortly after ARPA issued its first directive that lunar impact was still the objective, the newer plans instead called for the probes to enter an orbit around the moon or to pass by it. The change had come at the insistence of the scientific community, which was concerned about the risk of contaminating the moon chemically or biologically. Infecting the first extraterrestrial body it encountered would not have been an acceptable outcome for one of America's major contributions to the International Geophysical Year.

To track and control the lunar probes, both the Air Force team of AFBMD and STL and the Army team of ABMA and JPL built on existing systems as much as possible. The existing systems consisted primarily of the Naval Research Laboratory's tracking and telemetry system called Minitrack, built to support the Vanguard program for the International Geophysical Year, and the Jet Propulsion Laboratory's system called Microlock, built to support ABMA's Explorer program. However, Vanguard and Explorer were satellite systems; the tracking and control system for the lunar probes had to focus on a more distant trajectory, with one end about 400 thousand miles away. The distinction was important because—aside from pointing the antennas for data acquisition—the remote position and velocity of the fourth stage and the spacecraft had to be known with some precision in order to fire the fourth stage rockets and the retrorocket by radio command. New ground stations had to be activated with the correct viewing angles for events that had to be tracked and controlled. With that in mind, AFBMD and STL constructed the primary new ground station for the Air Force lunar launches at South Point, the isolated, southernmost point on the Island of Hawaii. The equipment they installed there included a steerable, sixty-foot-diameter parabolic antenna on a concrete base, four helical array antennas, and a five-kilowatt doppler-command transmitter and antenna. Additional helical antennas and equipment were set up near the launch site (the Air Force Missile Test Center at Cape Canaveral, Florida) and at a commercial site near Singapore. Finally, AFBMD worked through diplomatic channels to obtain an agreement with the University of Manchester in the United Kingdom to use the univerity's giant 250-foot-diameter parabolic radio telescope at Jodrell Bank to obtain tracking and telemetry data at previously unattempted distances. STL added an instrumentation trailer and personnel to the control room at Jodrell Bank.

ABMA and JPL made an important addition to the existing resources for tracking and control. In April 1958, they began construction of an 86-foot-diameter parabolic dish antenna at Goldstone, California, in the Mojave Desert. The complex was completed in November 1958, too late for the third and last Air Force lunar launch on 8 November 1958, but just in time for ABMA's Pioneer 3 launch on 6 December 1958. The Goldstone antenna not only successfully supported the Army's Pioneer 3 and Pioneer 4 launches but, after NASA's acquisition of JPL and other Army space resources on 3 December 1958, proved to be the first in an eventual global network of NASA antennas for interplanetary missions known as the Deep Space Network.

All three Air Force lunar launches took place at the Thor launch site, Launch Complex 17A at Cape Canaveral. The first launch, using Thor 127, was on 17 August 1958. Unfortunately, the first stage engine exploded 77 seconds after liftoff, and the flight returned no useful data. The mission subsequently acquired the rather derisive designation Pioneer 0. The second launch, that of Pioneer 1 using Thor 130, occurred on 11 October 1958. It reached an altitude of 71,700 miles, completed fourth stage burn, and returned much useful scientific information from the payload, especially about the extent of the Van Allen Radiation Belts. However, its trajectory and velocity were slightly off, and it did not achieve escape velocity. After telemetry showed that the lunar mission had failed, the launch team attempted to insert the spacecraft into an earth orbit by firing the retrorocket, but its batteries were too cold to ignite the rocket, and it reentered 43 hours after liftoff. The third launch, that of Pioneer 2 using Thor 129, took place on 8 November 1958. All went well until the third stage motor failed to ignite and the remaining stages reentered after 42 minutes of flight. Although none of the three missions reached the vicinity of the moon, Pioneer 1 was nevertheless the world's first successful space probe. Overall direction of the Pioneer program officially passed from ARPA to NASA on 1 October 1958, but the newly installed NASA officials made it clear that they did not intend to change any existing plans for the missions.

The Army Ballistic Missile Agency (ABMA) used its own Juno II launch vehicles, also launched from Cape Canaveral, for the following two lunar missions. The payloads for both were designed and built by the Jet Propulsion Laboratory and were much lighter than STL's spacecraft. Each probe carried two radiation monitors. The first ABMA probe (Pioneer 3) carried a photoelectric sensor to test whether it could activate an imaging scanner camera during a lunar fly-by, and the second ABMA probe (Pioneer 4) carried both the sensor and the scanner. Pioneer 3 lifted off on 6 December 1958. Like Pioneer 1, it failed to reach escape velocity but did reach an altitude of almost 70,000 miles. The payload returned additional scientific information about the distribution of the Van Allen Radiation Belts. The Pioneer 4 mission, launched from Cape Canaveral on 3 March 1959, was much more successful as a lunar probe. It was the first U.S. mission to escape from the earth's gravitational field, passing the moon at a distance of about 37,000 miles and gathering radiation data as it went into permanent orbit around the sun. Unfortunately, an error in trajectory caused by the second stage did not bring it close enough to the moon for the photoelectric sensor to activate the imaging scanner.

By then the Soviet Union had already performed the first successful lunar fly-by. Its Luna 1 spacecraft had passed within 3,977 miles of the moon on 3 January 1959 before becoming the world's first spacecraft to enter solar orbit. The Soviets soon achieved the first lunar impact as well with Luna 2 on 14 September 1959. On 7 October 1959, Luna 3 successfully achieved the early Pioneer missions' ultimate goal of photographing the far side of the moon. Although the Pioneer missions had put America in the race for the moon, the national space program had a lot of catching up to do.

As we noted at the beginning of this essay, the lunar launches of 1958 involved a number of significant firsts. Surely another of the program's most interesting features is the fact that it was a prototype of cooperation, though not always harmony, among several military and civil space programs. The nine U.S. space launches before Pioneer 0, all within the Vanguard and Explorer programs, had been carried out with a fair degree of autonomy by the Navy and Army. The same cannot be said of the early Pioneer missions. They spanned several divisions between agencies, both new and old. Circumstances forced AFBMD, ABMA, NOTS, ARPA, NASA, and others to work together on the first lunar program. Even its relationship with the scientific enterprise of the International Geophysical Year affected AFBMD's mission planning.

It would be an exaggeration to say that the Air Force and NASA, in particular, learned to cooperate because of Pioneer. Nevertheless, the Pioneer lunar program was a precedent for later relations between the Air Force and NASA in the Mercury and Gemini programs. Circumstances compelled AFBMD to accept overall direction for its first space missions, first from ARPA and then, by a process of transition, from NASA. When called upon later to develop and execute major portions of the Mercury and Gemini programs under NASA's overall direction, it had already had the experience of doing so for Pioneer in a fairly benign relationship.

The Pioneer lunar missions of 1958 were not without technical accomplishments, even though they did not fulfill the hopes of participants. However, at least for the Air Force, their broader significance lay in creating precedents and beginnings. The program was important primarily because of the groundwork it laid for later military and civilian space programs. Being first was not easy.