SpaceViews
A publication of the Boston chapter of the NSS

Heading for the Lunar Surface

by Andrew J. LePage
January 17, 2000

Introduction

While Soviet efforts dominated lunar exploration during 1959, the newly formed National Aeronautics and Space Administration (NASA) was busy formulating plans to meet the formidable Soviet challenge. As the Pioneer lunar probes NASA inherited from the military racked up one failure after another, NASA officials turned to one of their newly acquired laboratories to get back on track.

In December of 1958, NASA was given control of the Jet Propulsion Laboratory operated under contract by the California Institute of Technology. Run by William H. Pickering, JPL already had valuable experience in space exploration. JPL engineers had worked with the Army Ballistic Missile Agency (ABMA) to build the first Explorer satellites as well as the Pioneer 3 and 4 lunar probes (see **Explorer: America's First Satellite** in the February 1998 issue and **Operation Mona: America's First Moon Program** in the April 1998 issue of *SpaceViews*). Eager to carve out a challenging niche in the space exploration business for themselves, JPL managers wanted the assignment of lunar and planetary exploration.

After an intense lobbying effort, JPL got its wish: In late December of 1959, JPL was directed to make plans to launch five lunar missions in 1961 and 1962. Throughout 1959, JPL and the ABMA were already studying potential follow-on lunar missions that would make use of the three-stage Atlas-Vega launch vehicle specifically being designed for lunar and planetary missions. Because the Vega upper stage largely duplicated the capabilities of the new Agena B already being developed by the USAF, JPL's home-grown Atlas-Vega was cancelled by NASA headquarters on December 11, 1959. As a result of this cost savings measure, JPL's lunar missions would have to be adapted to use the new launch vehicle.

Development of the Agena upper stage began in 1956 under a USAF contract with the Lockheed Missiles and Space Company. This stage was specifically designed for use with a modified Thor or Atlas to launch the military's various new surveillance satellites like Corona (see **Spy in the Sky** in the March 1, 1999 issue of *SpaceViews*). The Agena B was a greatly modified version of the original Agena A already in use. It was over 2.5 meters (8 feet) longer to accommodate a larger propellant supply and replaced the A model's Bell Aerospace Hustler 8048 engine with a slightly more powerful 8081. One new useful feature included in the Agena B was an in-orbit restart capability.

For lunar and planetary missions, this capability promised much more launch window flexibility, more accurate escape trajectories, and greater lifting capability over the direct ascent trajectories employed by earlier lunar probes.

Ranger is Born

By the end of January in 1960 (40 years ago this month), JPL's new lunar project, called Ranger, had taken form. The goal of this five-flight program was to hard-land an instrumented capsule on the surface of the Moon. The program would use two spacecraft designs designated Block I and Block II. The first two flights, using the Block I design, were meant to be engineering flights which would test the interface between the probe and launch vehicle as well as determine if a three-axis stabilized spacecraft could be controlled. Three-axis stabilized spacecraft provide a more stable platform for certain instruments, such as cameras, than do spin-stabilized probes like the earlier Pioneer probes. Typically, one axis is pointed towards the Sun to provide illumination for the spacecraft's power producing solar panels. With the Ranger probes, the other celestial reference used was Earth itself.

At Ranger's base was a 195-kilogram (430-pound) hexagon shaped magnesium frame bus 1.52 meters (5 feet) across that contained the spacecraft's central computer and sequencer, a backup battery, a pair of radio transmitters, and the attitude control system. Extending from the sides of the bus were a pair of solar panels which provided 155 to 210 watts of power for the spacecraft. Also extending from the base was a hinged dish-shaped high-gain communications antenna 1.22 meters (4 feet) across, which would be pointed at Earth with the aid of a light sensor. The spacecraft maintained its attitude with the use of ten nitrogen gas jets supplied by 1.1 kilograms (2.4 pounds) of compressed nitrogen held in three tanks.

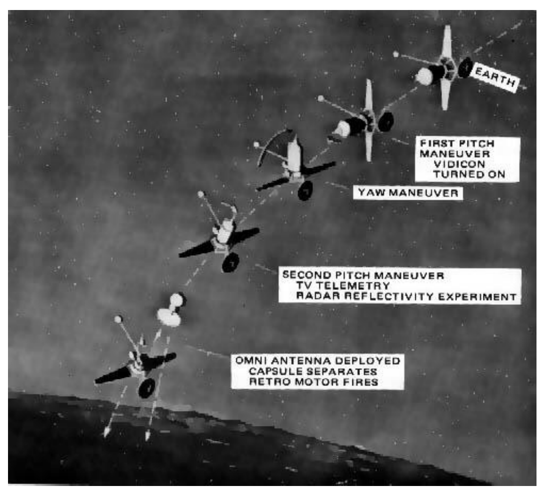
The Ranger Block I spacecraft that would not only test the Ranger design but be the prototype of future American interplanetary probes for the next quarter century. (NASA)

On top of the bus was an open aluminum truss structure topped with a low-gain antenna to aid in communications with Earth when the probe's high-gain antenna could not be used. When deployed in space, the Block I spacecraft was about four meters (13 feet) tall and 5.2 meters (17 feet) across its extended solar panels. A total of ten scientific instruments would be carried to study solar and cosmic radiation, cosmic dust, magnetic and electric fields, and perform various engineering tests. These experiments were mounted at various points on the bus and open truss structure. Some of these devices carried independent battery power supplies.

The original plan was to place Block I Ranger into an extended Earth orbit with an apogee of one million kilometers (620,000 miles). Such an orbit would allow a realistic test of the spacecraft design well away from the influences of either the Earth or Moon. The suite of scientific instruments would also supply much new information on the little explored cis-lunar environment as a side benefit.

The Block II spacecraft would actually attempt the lunar landing mission starting in early 1962. The basic bus was similar to the one used on the Block I probe, but the open truss structure above it was replaced with a new payload: A 150-kilogram (330-pound) package consisting of a small hard lander with a 22.6-kilonewton (5,080-pound) thrust retrorocket. The Ford Aeronutronic-built hard lander was a 64-centimeter (25-inch) diameter sphere weighing 43 kilograms (94 pounds). The exterior was composed of balsa wood to help absorb the force of impact.

Inside was a smaller 31-centimeter (one-foot), 25-kilogram (56-pound) sphere that was free to rotate on a cushion of Freon inside the balsa shell. The primary instrument carried was a seismometer sensitive enough to detect the impact of a 2.3-kilogram (five-pound) meteorite on the opposite side of the Moon. The delicate components of the seismometer were protected from the impact forces by a cushion of heptane. Also included in the capsule was a fifty-milliwatt transmitter, six silver-cadmium batteries, a temperature sensitive voltage oscillator, and a 1.7 kilograms (3.7 pounds) capsule of water for thermal control. The lander was designed to survive an impact of 67 meters per second (150 mph).



This diagram shows the approach profile of the Ranger Block II lunar impact mission. (NASA)

The 332-kilogram (730-pound), 3.1-meter (10.25-foot) tall Block II Ranger had additional modifications from its predecessor. The most important of these included the use of a 16-kilogram (36-pound) hydrazine-fueled course correction engine, providing 220 newtons (50 pounds) of thrust to fine tune its aim as it approached the Moon. This engine could be fired for a maximum of 68 seconds, giving a total velocity change of 44 meters per second (100 mph). Since any torques imparted during this engine's operation could not be compensated with the small attitude control jets, this engine was fitted with steering vanes at the exit nozzle.

The Block II Ranger also carried an entirely new set of instruments including a radar altimeter to provide ranging information as well as data on the lunar surface's radar characteristics, a gamma ray spectrometer mounted on a 1.8-meter (six-foot) boom to determine surface composition, and a television camera built by RCA with a JPL designed 102-millimeter (40-inch) focal length lens. The camera was expected to return over 150 images each containing two hundred scan lines during the last moments leading to lunar impact. Starting at an altitude of 3,900 kilometers (2,400 miles), the camera would continue transmitting down to 24 kilometers (15 miles) where objects as small as three meters (ten feet) across could be resolved.

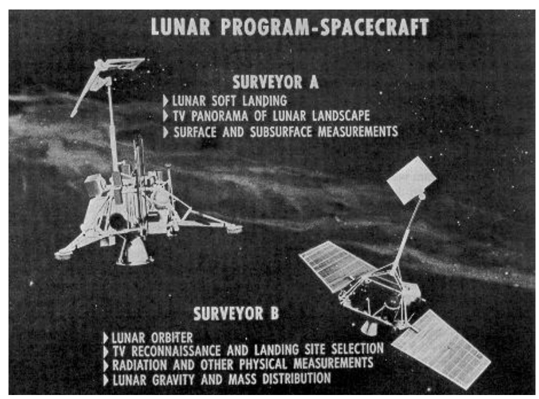
In order to minimize the chances of Earth organisms reaching the Moon, the entire spacecraft was sterilized first by baking components for 24 hours at 125 C (257 F), then cleaning all the parts with alcohol before they were assembled. Finally, the spacecraft was saturated in its Agena B nose faring with ethylene oxide gas for 24 hours before launch. The problems added by this procedure would prove to be an unnecessary complication for Ranger.

More Missions

Before the ink on the Ranger authorization was even dry, NASA had plans for even more ambitious lunar missions. In May of 1960, JPL's Surveyor project was authorized. As originally envisaged, Surveyor would consist of a single basic spacecraft which could be outfitted for two different missions. Surveyor A would be designed to soft land on the lunar surface. It would weigh about 1,100 kilograms (2,500 pounds) when launched and carry as much as 157 kilograms (345 pounds) of instrumentation. These instruments would include four television cameras: One would be used for approach photography and another would be used to monitor a semi-automated drill designed to penetrate up to 1.5 meters (five feet) below the lunar surface. Various instruments would then be used to analyze samples from this hole. Other instruments would include a seismometer and magnetometer, along with sensors to measure lunar gravity, radiation, atmosphere, and surface mechanical properties.

The lander would make use of a simple triangular frame upon which the various instruments and thermally controlled electronic compartments would be mounted. It would stand 3.5 meters (11 feet) from its three landing legs to the top of its mast mounted solar panel and high-gain antenna. After gentle landing at a speed of three meters per second (six MPH) with the use of a solid retrorocket and liquid-fueled, variable thrust engines, it would weigh about 340 kilograms (750 pounds). The mission would last for a minimum of 30 days and hopefully as long as 90 days. The first flight was expected in 1963.

The second variant considered was Surveyor B. This spacecraft would use the same basic structure as the lander but instead would be placed into a one hundred-kilometer (60-mile) high lunar orbit to perform television reconnaissance of the Moon's surface as well as perform other measurements of the lunar environment for a period of six months. On January 19, 1961, Hughes Aircraft received the contract to build Surveyor.



Originally the Surveyor program included not only a lander but also an orbiter to map the lunar surface. (NASA)

The launch vehicle for this new lunar spacecraft was to be the Atlas-Centaur then under development by NASA. The Centaur was to make use of liquid hydrogen and liquid oxygen as propellants; the first rocket built to do so. This combination provided about 30 to 40% more thrust pound for pound than most propellants then in use. Centaur development started officially on August 28, 1958, when the USAF received authorization from ARPA to develop a high-energy upper stage for use with the USAF's Atlas D and the ABMA's Juno V (later to become NASA's Saturn I - see **Juno V: The Prehistory of a Super Booster** in the September 1998 issue of

SpaceViews). By October of that year, Convair had received the contract to develop and build Centaur.

Because of the political climate of the time, program responsibility was transferred to NASA's new Marshall Space Flight Center (the former home of von Braun's ABMA group) in July of 1959 with the USAF relegated to an advisory role. The development of a hydrogen fueled rocket proved to be very difficult. One technical problem followed another delaying the launch of the first test article. Finally, on May 8, 1961, the first Atlas-Centaur was launched for a 15-minute suborbital test flight. After 44 seconds, Centaur's insulation panels started ripping off the ascending launch vehicle. Structural failure ensued and the hydrogen fueled Centaur exploded 54.7 seconds into the flight. The failure was studied and the stage was redesigned.

More redesign work added additional weight to the highly innovative Centaur and its expected performance dropped. As time wore on, it became clear thatCentaur would not be available as soon as engineers and space planners would like nor would it have the originally expected payload capability. But time would prove that this was only the beginning of JPL's headaches. Development problems with the innovative Ranger and its Atlas-Agena B would eventually lead to a string of failures that would almost doomed JPL's role as the nation's leader in lunar and planetary missions.

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Author

Drew LePage is a physicist and freelance writer specializing in astronomy and the history of spaceflight. He can be reached at lepage@visidyne.com