Air and Space this Week

Item of the Week

NASA'S PROJECT RANGER

Originally appeared March 20, 2023

KEY WORDS: Ranger JPL ARPA Pickering Newell Jastrow Urey Swamp Castle

Intermediate steps were required to fulfill JFK's pledge to "land a man on the Moon and return him to the safety of the Earth" before "the decade is out." For the manned spaceflight part of the equation, NASA created the Mercury, Gemini, and Apollo projects. But to acquire the information necessary to plan the actual Moon landings, we had to learn a LOT more about the Moon and the lunar surface environment. NASA used a three-part approach here, too, creating the Ranger, Lunar Orbiter, and Surveyor projects. This week's Item is about the first named, Ranger, a series of nine spacecraft, on the occasion of the 58th anniversary of the launch of Ranger 9*.*

INTRODUCTION

NASA planners envisioned a progressively-more sophisticated set of lunar exploration spacecraft to provide the information, technology, and capabilities necessary to plan for the Apollo landings. The easiest, hence first, method of finding out more about the Moon was to send an instrumented spacecraft to crash into it, acquiring data all the way to impact. This was the Project Ranger. Next of in level of sophistication was the five-mission Lunar Orbiter project, which provided a lot of remote sensing images of the lunar surface with detailed looks at prospective landing sites. Finally, a series of robotic landers were sent to the Moon to provide detailed information on the nature and landing potential for the lunar surface; the seven-spacecraft Surveyor Project.

When I reviewed the Project Ranger in preparation for writing this Item, I couldn't help but think of the Swamp Castle sketch in *Monty Python and the Holy Grail*. [The King said I'd have to be daft to build a castle in the swamp. But I did anyway. It fell down and sank into the swamp. I built another. It fell down and sank into the swamp. I built another. It burned down, fell over, and sank in the swamp. I built another. It stayed up and is the strongest castle in the kingdom.]

Space exploration, by definition, is a "cutting-edge" endeavor, and cannot be accomplished without a lot of trial-and-error efforts, and a series of (hopefully minor) setbacks. Doing the near-impossible, on schedule and (usually) under budget is NASA's way, but as it was with the exploration of Mars, the Moon is Hard.

PROJECT RANGER: BEFORE THE BEGINNING

A group of Caltech students back in the 1930s indulged their aeronautical research interests by creating a rocket research club, building their own rockets. The faculty tolerated such activities, but regarded them as a hobby, not a program. But the military was interested in the value of rocketry, and gave Caltech Guggenheim Aeronautical Laboratory a contract to conduct rocket R&D. Caltech built an Army establishment operated under contract by Caltech, located at the foot of the San Gabriel Mountains in Pasadena, and there developed rockets for use as jet-assists for heavy military aircraft. The outfit's success, and that of the Nazis in rocket warfare, led to further contracts, and in 1944, the lab was reorganized and named the Jet Propulsion Laboratory. They were tasked with the development of tactical ballistic missiles and other rocketry projects.

JPL rocket development continued into the 1950s, and they expanded into the use of radio and other telemetry/guidance systems, working with Wernher von Braun and the Army's Redstone Arsenal in Huntsville, Alabama. In spite of it being Army, JPL was a very academic environment, attracting brilliant but not necessarily military types, like Richard Feynman, Al Hibbs, and William Pickering.

America, and its leaders, were shocked when the USSR launched *Sputnik 1*, and terrified when they launched *Sputnik 2* (which was large enough to be a nuke). America had lost a lot of face, especially when our first satellite launch efforts ended in public failure.

What to do?

William Pickering had come to JPL in 1929 from New Zealand. He was an electrical engineer, and worked initially on the study of cosmic rays using instrumented balloons. During WWII, he taught electronics for military students. The director of the Radiation Laboratory at MIT was at JPL helping design and develop missile telemetry and instrumentation, and would soon become Caltech's next president. He soon picked Pickering to be the Director of JPL, in 1954.

Pickering was in position to suggest a response to Sputnik. Why not hit the Moon?

The rocket technology necessary to hit the Moon was either at hand or would be soon. The early Explorer satellites, under development and available soon, were spin-stabilized and could be used quickly as a prototype for the spacecraft needed. Caltech put forward Pickering's plan as "Project Red Socks" in late 1957, three weeks after *Sputnik 1*.

The Army went "meh" at first. But the newly-created Advanced Research Projects Agency (ARPA) was of a different opinion. Their director was eager to surpass the Rooskies. And aiming at the Moon seemed a great way to do it.

Ike agreed, and on **March 27**, 1958, the Secretary of Defense announced that ARPA's Space program would focus on the exploration and collection of data from the vicinity of the Moon. The program was part of America's contribution to the International Geophysical Year (for more on the IGY, see here). ARPA's "Pioneer Program" comprised five flights, three for the newly-created Air Force and two for the Army. The former would use the Thor missile, with a liquid-fueled Vanguard upper stage; the latter the Jupiter-C booster and a solid-fuel upper stage built by JPL.

ARPA's Pioneer Program was not the only American Space effort. *Explorer 1* (in which JPL had a large part of the effort) had been launched on January 31, 1958. It didn't carry much in the way of scientific instrumentation, but what it did carry revealed the presence the "Van Allen Radiation Belt" after the researcher who built the detector. Additional information about the Belt region came from the follow-up missions of *Explorers 3* and *4*. ARPA had to ramp up its capabilities for exploring cislunar and lunar Space.

Meanwhile, the Pioneer Program had some difficulties. The first Air Force Thor launch, on August 27, 1958, went awry and was destroyed by the Range Safety Officer. The problem was a pump failure in the booster. The Air Force tried again on October 11. They did a little better; the booster worked OK but there was a premature shut-down of the second stage engine. The third stage did not have enough oomph to get the *Pioneer 1* satellite to LEO. The third attempt came on November 8. This time the booster and second stage worked well but the third stage failed to ignite. Shades of Swamp Castle – they should have tried a fourth time!

While all the Air Force activity was going on, JPL was working on instrumentation that would help explore the Belt and the lunar environment. The *Explorers* had shown that conventional film would be too badly damaged to be used in the region of the Belts, so JPL canceled their camera design a radiation-proof camera, recording, and transmission system. It would fly on the next Pioneer mission.

The Air Force had its shot (as did the Navy with Vanguard). Both failed. It was the Army's turn.

On December 6, 1958, *Pioneer 3* was launched on a trajectory that should have taken it past the Moon into interplanetary Space. The booster failed partially, but it still sent the probe over 100,000 km from the Earth. Van Allen's radiation detector returned useful data about the Belt region, revealing that there were actually two almost-separate zones of trapped charged particles. The detector was so successful that it was selected to fly again on the Army's final Moon-region mission.

Pioneer 4 was launched on March 3, 1959. This time the entire rocket worked as planned, giving *Pioneer 4* escape velocity. The Van Allen instrument showed that there was little radiation above the Belts and that the Belts comprised charged particles from the Sun trapped by the Earth's magnetic field.

The primary mission of ARPA's Pioneer Program was to get to the vicinity of the Moon before the Russians did. Alas, the USSR's *Luna 1* spacecraft beat them to the general area of the Moon a few weeks before *Pioneer 4*.

ARPA's chance was over, and the mission of Space exploration was subsumed soon thereafter by the creation of the civilian National Aeronautics and Space Administration. JPL would remain a Caltech operation, under contract to NASA. Redstone's Space-related work would become NASA's Marshall Space Flight Center, at which Wernher von Braun and his Paperclip guys would build the rockets that would eventually take us to the Moon.

The success of the Explorer program, and the move of the Space program to a civilian Agency, began to attract a number of soon-to-be-famous scientists and engineers. The head of NASA's

Office of Space Flight Development was Abe Silverstein, and his deputy was Homer Newell. At the time, NASA was torn between “sky science,” upper atmosphere and near-Earth study; and planetary scientists, who were interested in exploring the Moon and eventually the planets. Newell was in the former group, and established a team to address “sky” science, but he also created a companion “theoretical division” to study cosmology, astronomy, and planetary science, and named Robert Jastrow to head it (even though he was a “sky” guy, too).

Jatrow was a good choice, in large part because he knew enough to seek good advice. He went to Nobel Laureate Harold Urey, who explained the importance of the study of the Moon most eloquently. Jastrow was an immediate convert, and brought Urey to NASA HQ to meet with Newell. That meeting, in December, 1958, was the birth of the NASA lunar exploration program.

NASA did not have a lunar program at the time, only the remnants from the earlier military programs. Jastrow and Urey convinced Newell the NASA should begin a systematic lunar exploration program. In response, Newell formed an *ad hoc* Working Group on Lunar Exploration, to be chaired by Jastrow and to include Urey and a number of other senior scientists, such as Frank Press (author of my Geology 101 textbook!) and Harrison Brown. They would be the go-betweens serving NASA and the broader academic community.

The had the brain power and the will. They had the instruments necessary for exploration under development. All they needed was rocketry.

The Air Force’s Atlas missile had become the American’s primary ICBM. GE had developed an upper stage for it, named Vega. They’d be ready soon, too. [Long-time readers of A+StW may recall my story about the Structural Dynamics Lab at NASA Ames where problems concerning the Atlas missile were solved.]

A lot of evolution was underway at NASA HQ in 1959 and 1960. The prior use of words like “project” and “program” had not been strictly defined. But now a “program” became a related series of undertakings to accomplish a broad (set of) goal(s), and “project” became a subset of a program, designed to accomplish one or more of the program’s goals, but to have a fixed start and ending. On April 30, 1959, NASA issued its first five-year plan for the exploration of deep Space. No specific projects were identified, but the report outlined a program of progressively more sophisticated projects, together with science and engineering goals. They also began paying attention to interplanetary launch windows…

The NASA *ad hoc* Working Group was entirely focused on the Moon, but the JPL guys had a broader perspective; the wanted to explore the Solar System and beyond. They, too, had developed a plan and schedule for sending missions to the Moon, Mars, and Venus.

The previous success of *Luna 1*, and their following successes later in the year, especially *Luna 3*’s imaging of the far side, made NASA prioritize the Moon. The Air Force had upgraded the Agena upper stage so that it could be re-started in flight, and the Vega rocket faded away.

On December 21, 1959, Abe Silverstein assigned seven new flights to JPL in place of the cancelled Atlas-Vega rockets. At least the first five would use the Atlas-Agena missile combination. Silverstein called for the completion of the seven flights within 36 months.

The mandated effort would require a lot of technological development, including: the new launch vehicle, a spacecraft with attitude control, appropriate scientific experiments and instruments, an adequate communications/guidance system, AND the management structure to accomplish the necessary tasks. There was a lot of managerial maneuvering and engineering work conducted during the period of 1960 to 1961. If you want to get into the details, the best resource is NASA SP-4210 (see Reference section on the website).

This was at the height of the Cold War. NASA was taking on a high-risk, short-time-fuse responsibility, to “seize the initiative from the Russians” and to demonstrate to the World the value of the “American Way.” Recall that this was before JFK’s mandate.

Another problem was the geopolitical situation. The Bay of Pigs invasion was in April, 1961, and the Cuban Missile Crisis was in October, 1962. The launch detection technology on both sides of the Cold War was primitive, and there was considerable concern that a launch to the Moon or planets might get mis-interpreted as an ICBM attack, which would allow scant time for analysis and response…

By August, 1961, Project Ranger was ready to go. To Swamp Castle.

RANGER 1

The Ranger spacecraft were designed in three “blocks” or phases, in increasing sophistication, to meet the specific mission requirements. Uniformity of spacecraft design was desirable, as it decreased development and production costs significantly, but mission requirements and available technology allowed three different versions.

Block 1 was the simplest design, more useful to test rocketry and support systems than to produce scientific results. The first two Ranger missions would use Block 1 design. Block 2 Ranger spacecraft would carry a TV camera, a radiation detector, and a seismometer in a separate armored capsule that had a rocket motor that would slow the capsule to a survivable speed. *Rangers 3*, *4*, and *5* would be Block 2 designs.

Block 3 Ranger spacecraft would carry a better TV camera that could reveal progressively smaller surface details all the way to impact. They didn’t have a (crash) landing capsule.

Ranger 1 was launched on August 21, 1961. Its booster worked correctly and it entered an LEO parking orbit, awaiting a re-start of its Agena engine to take it to a higher orbit, simulating/testing it doing so to take a later Ranger to the Moon. The Agena failed to re-start. *Ranger 1* separated from the Agena as planned, tumbled, and fell into the swamp. No scientific data were returned.

RANGER 2

The second and last Ranger Block 1 spacecraft, *Ranger 2*, was launched November 18, 1961. It was virtually identical to *Ranger 1*. It, too, made its LEO parking orbit without difficulty. However, a gyro problem prevented even an attempt at restarting the Agena's engine. The *Ranger 2* spacecraft separated from the Agena, tumbled, and fell into the swamp the next day.

RANGER 3

In spite of the problems with the Agena, *Ranger 3* was readied to go to the Moon. It was launched on January 28, 1962. From the NSSDC *Ranger 3* webpage: "The mission was designed to boosted (*sic.*) towards the Moon by an Atlas/Agena, undergo one mid-course correction, and impact the lunar surface. At the appropriate altitude the capsule was to separate and the retrorockets ignite to cushion the landing. A malfunction in the booster guidance system resulted in excessive spacecraft speed. Reversed command signals caused the spacecraft to pitch in the wrong direction and the TM antenna to lose earth acquisition, and mid-course correction was not possible. Finally, a spurious signal during the terminal maneuver prevented transmission of useful TV pictures. *Ranger 3* missed the Moon by approximately 36,800 km on 28 January." At least *Ranger 3* didn't fall into an Earthly swamp; it is lost somewhere in interplanetary Space in a heliocentric orbit instead.

RANGER 4

Ranger 4 was launched on April 23, 1962. It was essentially the same as *Ranger 3*. The spacecraft never deployed its solar panels and it never oriented itself with respect to the Sun and Earth (necessary for normal communications). Its instruments operated for about 10 hours before the on-board batteries were exhausted to the point they would not work. A low-power omni-directional signal from the spacecraft allowed it to be tracked. It certainly wasn't the strongest castle in these parts" and "fell into the swamp" on April 26 when it impacted on the Moon's far side.

RANGER 5

Ranger 5 was launched on October 18, 1962 (dangerously because it was the height of the Cuban Missile Crisis). It made LEO and its trans-lunar injection burn OK, but soon after it was on its way to the Moon is suffered a power failure, and we lost contact after its batteries were exhausted. *Ranger 5* missed the Moon by 725 km, and like *Ranger 3*, *Ranger 5* is lost in the swamp of interplanetary Space.

RANGER 6

NASA had high hopes for *Ranger 6*, the first of the Block 3 spacecraft, with improved cameras, communications, and other systems. It was launched on February 2, 1964. The trip to LEO was without problem, and the Agena refire worked perfectly to put *Ranger 6* on a lunar trajectory. The planned mid-course correction went well, and the spacecraft impacted the Sea of

Tranquility dead on target. But the imaging system failed completely. Another castle had fallen into the swamp. But the next "castle" was *Ranger 7*, and it and its followers would become the "strongest castles in these parts!" And there were no curtains.

RANGER 7

I remember the televised news about the subsequent Ranger missions. They were basically a countdown in reverse, with no real-time imaging for the public. But they certainly fired at least one young person's imagination!

Ranger 7 was launched on July 28, 1964. The launch, injection to lunar trajectory, and mid-course correction worked as planned. It impacted the Moon between Mare Nubium and Oceanus Procellarum on July 31, its Block 3 multi-camera system producing 4,308 photographs during the last 17 minutes of its life. The mission was a total success. Finally!

The area where *Ranger 7* impacted was officially renamed Mare Cognitum, or the "Known Sea" because *Ranger 7* gave us a close-up view. The crater formed by its impact was identified years later in images acquired by the *Lunar Reconnaissance Orbiter*.

RANGER 8

Ranger 8 was launched on February 2, 1965. It was essentially identical to the other Block 3 Rangers, and its launch to LEO parking orbit was uneventful. However, during the burn of the Agena stage to send it to the Moon, the camera system suffered a bad power underflow, in spite of a normal separation from the Agena and deployment of its solar panels. The power situation resolved itself and no further problems were developed. Mission controllers did not point the cameras at the impact site during the final approach, but rather aimed off to the side to get a broader sweep of the Moon's surface from relatively close range (likely due to a desire to have info to support the first landing attempt). There was less and less tranquility at Mare Tranquillitatis; *Ranger 8* hit not too far from the *Ranger 6* impact site.

RANGER 9

The successes of *Rangers 7* and *8* showed the Block 3 version of Rangers to be the "strongest castle," and allowed mission planners to do a little more lunar science at the expense of planning for landing missions. *Ranger 9* was targeted for Crater Alphonsus, a large (and beautiful) crater near the center of the Moon's near side. A Russian astronomer had claimed that he had observed an active lunar volcanic eruption inside the crater. [He may actually have been right – there are craters within Alphonsus that are surrounded by dark material. Normally, impact ejecta, especially for "fresh" craters, has a lot of glass and is brighter than the surrounding terrain. Basaltic ash can be pretty dark….] In any case, the *Ranger* 9 spacecraft was launched successfully on **March 21**, 1965, **fifty-eight years ago this week**, and journeyed to its planned demise without significant problems. It returned 5,814 photographs before it hit Alphonsus on March 24. Its impact site was also imaged by the *Lunar Reconnaissance Orbiter*.

CONCLUSION

Project Ranger admittedly got off to a swampy start, but rallied for its final three missions to accomplish all of the Project Ranger science and engineering objectives. Check out the lunar exploration timeline (see References) to get a better understanding of how the Ranger missions fit into the other activities that were going on at the same time with NASA and assorted elements of world history. NASA had again done the nearly impossible, on time, on budget, as only NASA can!

REFERENCES

BOOKS

NASA SP-4210, *Lunar Impact: A History of Project Ranger*, available on-line at: https://history.nasa.gov/SP-4210/pages/Cover.htm

Newell, Homer E., 2010, *Beyond the Atmosphere: Early Years of Space Science*, Dover Books on Astronomy series, ISBN-13: 978-0486474649

Wilhelms, Don E., 1993, *To a Rocky Moon: A Geologist's History of Lunar Exploration*, available on-line at: https://www.lpi.usra.edu/publications/books/rockyMoon [Chapter 5 is particularly germane!]

OTHER SOURCES

National Space Science Data Center's Ranger page (with links to each individual Ranger missions): https://nssdc.gsfc.nasa.gov/planetary/lunar/ranger.html

NSSDC Image Catalog for the Moon: https://nssdc.gsfc.nasa.gov/imgcat/html/group_page/EM.html

NASA Moon Exploration page (with links to all lunar missions): https://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

NASA Lunar Exploration Timeline: https://nssdc.gsfc.nasa.gov/planetary/lunar/lunartimeline.html

Lunar and Planetary Institute Ranger page: https://www.lpi.usra.edu/lunar/missions/ranger

LRO Ranger 7 impact site image: http://lroc.sese.asu.edu/posts/52

The *Ranger 8* impact site was imaged by *Lunar Orbiter 2*: https://history.nasa.gov/SP-168/p94a.htm

The *Ranger 9* impact site was imaged by *LRO*: https://www.lroc.asu.edu/featured_sites/lroc_features/Ranger%209/feature_highlights

FYI: *LRO* also imaged subsequent impact sites: https://www.lroc.asu.edu/featured_sites

Last Edited on 19 March 2023