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SPACE WEEK

50 Years Ago

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AS-506 lifts off from Launch Pad 39A at the Kennedy Space Center July 16, 1969. This sixth flight of the Saturn V launch vehicle, developed under the direction of the Marshall Space Flight Center, delivered astronauts Neil Armstrong, Edwin Buzz Aldrin, and Michael Collins to lunar orbit. Better known as Apollo 11, the mission marked the first manned lunar landing. Image courtesy of NASA

THE PATH TO THE MOON

The Apollo 11 Moon landing influenced a whole generation of young people to follow careers in science and engineering. Can we hope, after 50 years, that we are returning to the same path?

At *Design News*, we live and breathe engineering. So when we saw a chance to honor the accomplishments that resulted in landing on the Moon 50 years ago, we had no doubt we needed to cover the 50th anniversary. Our coverage has been extensive and detailed—we know you would expect nothing less. For me, however, it has been more personal—more than just another assignment. »»»

Astronaut Edwin E. Aldrin Jr., lunar module pilot of the first lunar landing mission, poses for a photograph beside the deployed United States flag during an Apollo 11 extravehicular activity (EVA) on the lunar surface. The Lunar Module (LM) is on the left, and the footprints of the astronauts are clearly visible in the soil of the moon. Astronaut Neil A. Armstrong, commander, took this picture with a 70mm Hasselblad lunar surface camera. While astronauts Armstrong and Aldrin descended in the LM, the "Eagle", to explore the Sea of Tranquility region of the moon, astronaut Michael Collins, command module pilot, remained with the Command and Service Modules (CSM) "Columbia" in lunar orbit. Image courtesy of NASA

I had been sitting on the beach since well before dawn, swatting mosquitoes, checking and rechecking my 35-mm camera with its long lenses and trying to contain my youthful nervous energy. I was 12 years old—ready to enter sixth grade in the fall, but standing now among nearly a million people who had come to watch Apollo 11 begin their historic mission to the Moon. The sun finally rose behind us revealing a crystal-clear day. Even at a distance 12 miles to Launch Pad 39A, I could see the brilliant white pencil-thin shape of the Saturn V rocket that would propel three human beings beyond the Earth to set foot on the lunar surface.

I heard the final countdown through the tinny speakers of thousands of transistor radios. To this day I can remember the exact words. “Twelve…eleven…ten…nine…ignition sequence start…six…five…four…three…two…one…zero…all engines running. Liftoff! We have a liftoff…32 minutes past the hour, liftoff of Apollo 11.” I saw a bright flash, and then a brilliant orange light at the base of the launch pad. There was silence at first, then a cheer from the crowd before a boom and roar louder than our thousands of assembled voices. There was an odd crackling sound as the rocket rose into the sky, leaving behind a long white contrail.

Moments after the rocket launch, control of the Apollo 11 mission was turned over to Houston. There, in a room filled with rows of consoles sat the engineers—each wearing a white, short-sleeved, polyester shirt and a clip-on tie. The average age of the engineers at NASA for the Apollo missions was 27—young enough that, to a 12-year-old space nerd, they represented my future. I was convinced, in fact I was certain, that in a very short few years I would be one of those NASA engineers, sending rockets into the heavens to explore the planets.

Armstrong and Aldrin did walk on the Moon just four days later and were followed by five more Apollo missions. I did go to engineering school, but when I graduated 10 years after that first Moon landing, my country was no longer particularly interested in exploring the cosmos. The Space Shuttle worked in low-Earth orbit—important work, yes, but not exactly traveling to the planets.

Fifty years have passed since that moment in history on the beach in Florida when I watched Apollo 11 lift-off. It wasn’t the first Saturn V launch that I witnessed in person, nor would it be the last, but it was the one that made all the difference. It set me on a path toward a career in science, engineering, technology, and mathematics—what we would call STEM today. Apollo 11 reached a kind of greatness that mankind, led by legions of slide-rule carrying engineers, had never before achieved and have never attained since.

If reaching for the stars is something we have done in the past, we are possibly on the brink of doing so again. Perhaps, somewhere, there is a 12-year-old whose future is just waiting to be shaped by something even more audacious than going to the Moon. Maybe, by remembering that moment 50 years ago, as we have done here, we can claim a small role in building that future.

Something important began with Armstrong’s “one small step.” Although we have stumbled, faltered, and even occasionally failed, the bravery and sacrifice of those who have come before us demand that we continue to follow down the path that they started. ■

July 16, 1969

THE LAUNCH OF APOLLO 11

One of the most remarkable voyages in human history began 50 years ago on this date.

By Kevin Clemens

Image courtesy of NASA

The Apollo 11 Saturn V lifts off with astronauts Neil A. Armstrong, Michael Collins and Edwin E. Aldrin Jr. at 9:32 a.m. EDT July 16, 1969, from Kennedy's Launch Complex 39A. Image courtesy of NASA

It began at 9:32 am Eastern time on July 16, 1969.

The mighty Saturn V rocket launched the Apollo 11 spacecraft from Pad 39A at the Kennedy Space Center in Florida. On board were Mission Commander Neil Armstrong, Command Module pilot Michael Collins, and Lunar Module pilot Edwin "Buzz" Aldrin. Apollo 11 would be the third time that astronauts would leave Earth's orbit—Apollo 8 had orbited the moon in December of 1968, and in May Apollo 10 had served as a dress rehearsal, orbiting the moon and testing the systems and lunar lander without actually touching down on the lunar surface. Now, all was ready for humans to set foot on the moon.

Two hours, 44 minutes into the flight, after one-and-a-half Earth orbits, the S-IVB third stage of the Saturn V reignited for a second burn of five minutes, 48 seconds. The thrust served to place Apollo 11 into a translunar orbit. Then, the command and service module, or CSM, named "Columbia" separated from the third stage. Columbia rotated around to face the spacecraft-lunar module adapter, or SLA, which contained the lunar module, or LM, named "Eagle". Columbia and Eagle docked for the first time and the lunar module was extracted from the SLA. The S-IVB stage separated and another firing of its rocket injected it into heliocentric orbit four hours, 40 minutes into the flight. ■

July 17, 1969

APOLLO 11'S SECOND DAY IN SPACE

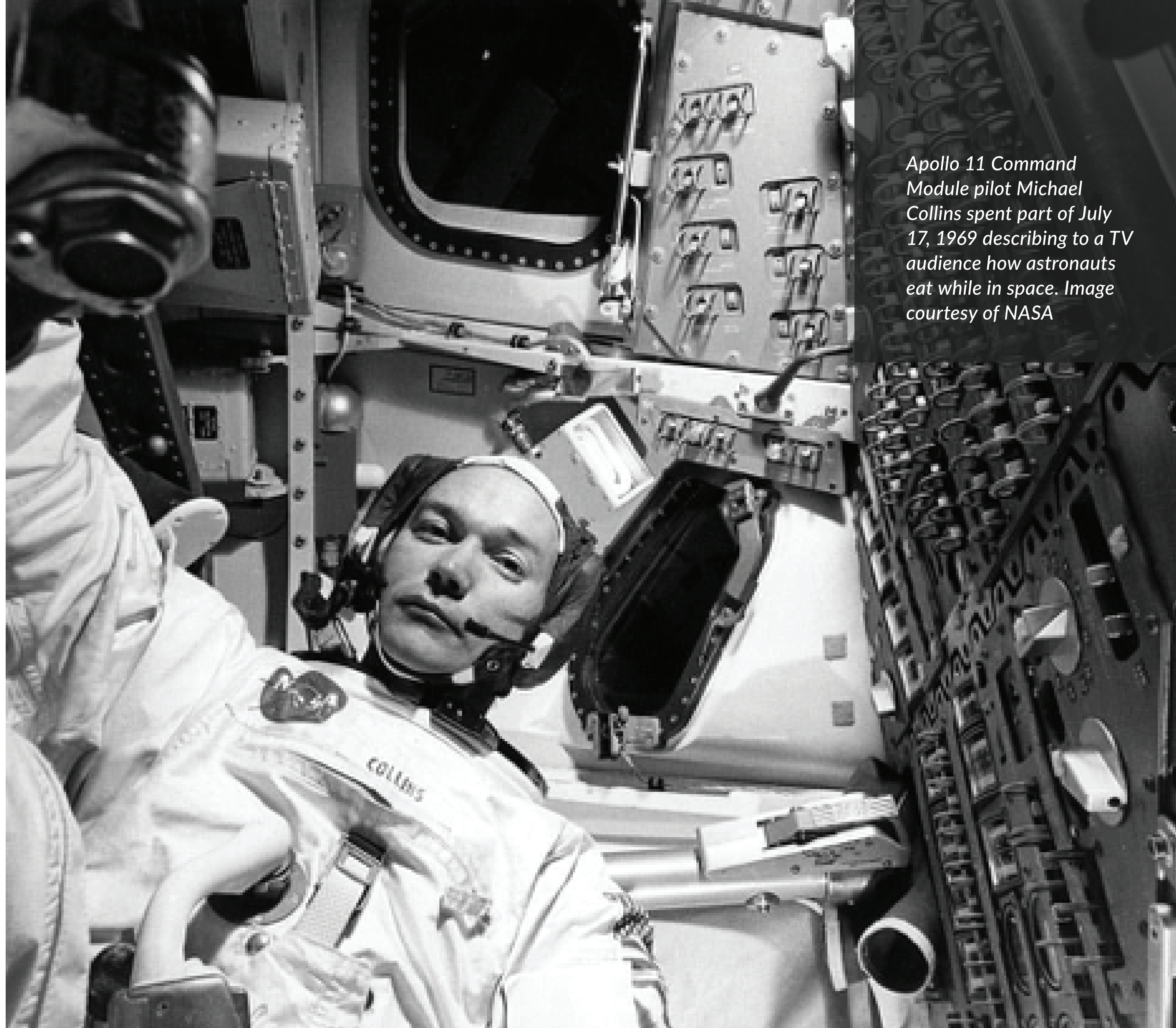
The second day of the Apollo 11 mission saw the spacecraft on course for the moon.

By Kevin Clemens

Image courtesy of NASA

After a successful launch from Cape Kennedy on July 16th, the Apollo 11 astronauts were tasked on July 17 at 12:17 pm with a three-second burn of the Service Module Propulsion System (SPS). This was one of four scheduled midcourse corrections programmed for the flight. Later that afternoon the Apollo 11 astronauts did a color television broadcast from the spacecraft, showing viewers back home what the Earth looked like from 147,300 miles away. Their broadcast lasted 36 minutes and Command Module pilot Michael Collins described the food that the astronauts ate in the zero-gravity environment of the Apollo 11 spacecraft.

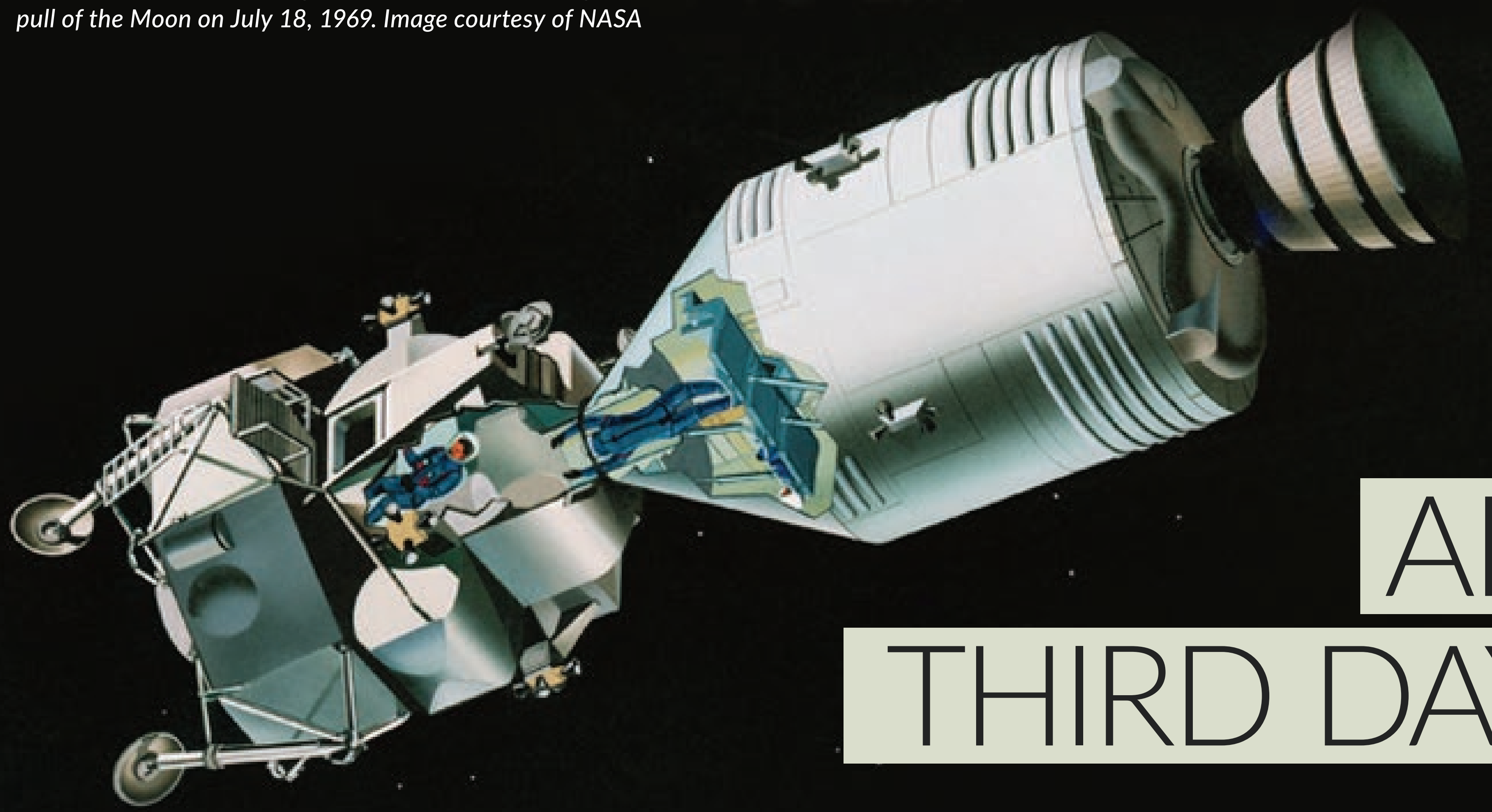
The launch from the Cape had been so successful that the last two midcourse corrections were not needed on Apollo 11's journey to the moon. ■



Apollo 11 Command Module pilot Michael Collins spent part of July 17, 1969 describing to a TV audience how astronauts eat while in space. Image courtesy of NASA

July 18, 1969

The Command Module, Service Module, and Lunar Module of Apollo 11 passed from the gravity of the Earth to the gravitational pull of the Moon on July 18, 1969. Image courtesy of NASA



APOLLO 11'S THIRD DAY IN SPACE

On the third day of the Apollo 11 mission, it was time to check out the lunar module.

By Kevin Clemens

Image courtesy of NASA

Apollo 11 consisted of three separate modules: the command module (CM) where the crew of three spent most of the journey, a service module that contained fuel cells, oxygen tanks and rocket engines that would take them to the moon and back, and the lunar module (LM) that would carry Armstrong and Aldrin to the surface of the moon.

On July 18, at a distance of 201,000 miles from the Earth and a mere 55,200 miles from the moon, the astronauts started another television transmission while opening the hatch to the lunar module named Eagle. Armstrong moved through the 30-inch hatch into Eagle, followed by Aldrin and the pair checked over the lander to make sure that nothing had gone amiss during the liftoff and journey across space to the moon.

Later that evening, the Apollo 11 spacecraft passed from the gravity of the Earth into the gravitational field of the Moon. Traveling at just over 2,000 miles-per-hour, they would soon enter orbit around the moon, in preparation for a landing, just two days away, on July 20. ■

Image courtesy of NASA

Image courtesy of NASA

July 19, 1969

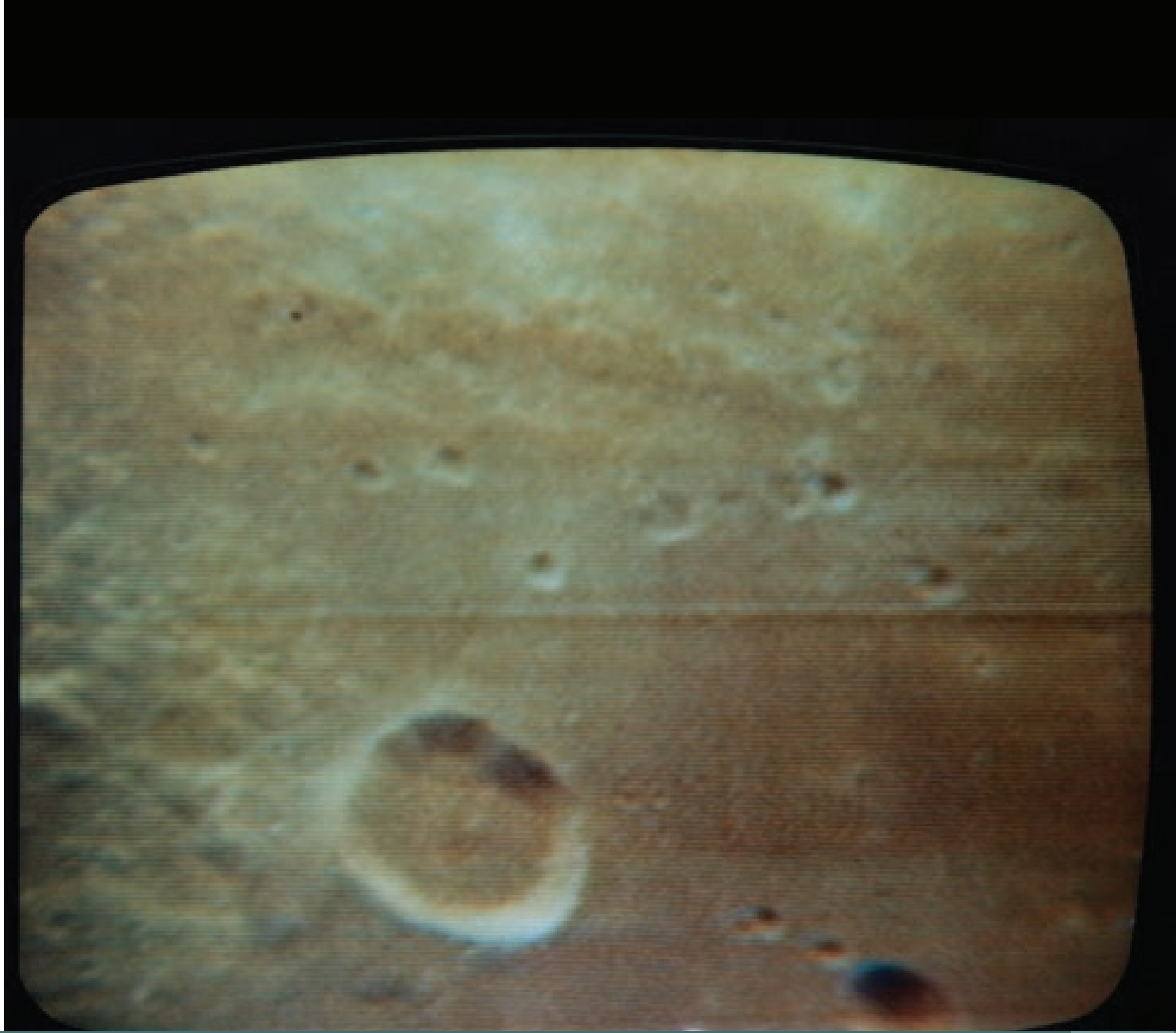
APOLLO 11 REACHES THE MOON

On the fourth day of the Apollo 11 mission, the spacecraft entered orbit around the moon.

By Kevin Clemens

On the fourth day of the Apollo 11 mission, the crew needed to fire the engine of the Service Module to put the spacecraft into orbit around the moon. This lunar orbital insertion maneuver was required to take place on the far-side of the moon, out of contact with Mission Control. The 357.5 second burn of the rocket motor went perfectly, placing Apollo 11 into an elliptical lunar orbit of 69 by 190 miles. Later, a second burn of the Service Module rocket for 17 seconds changed that orbit to 62 by 70.5 miles.

The crew also did another live TV broadcast from their two docked spacecraft from lunar orbit. With the moon so close, attention was focused on the next day when the Lunar Module Eagle would separate from the Command Module Columbia and land on the Moon's surface. ■



A close-up view of the Sea of Fertility on the lunar surface from the window of Columbia during the fourth live television transmission made from the Apollo 11 spacecraft during its second orbit of the moon on July 19, 1969. Image courtesy of NASA

ONE GIANT LEAP FOR MANKIND

Astronaut Neil Armstrong becomes the first human to set foot onto the Moon.

By Kevin Clemens

With Eagle landed on the lunar surface, the flight plan called for the astronauts to begin their explorations after a four-hour rest period. The rest was quickly abandoned as Armstrong and Aldrin began their preparations. Even so, it was almost four hours after the landing that Armstrong emerged from the Eagle and deployed a black and white TV camera from the side of the LM in order to beam images of his first steps back to Earth. »»»

Neil Armstrong poses for his official Apollo 11 portrait. Image courtesy of NASA

Armstrong descended a ladder at 11:56 p.m. on July 20, 1969, and uttered the words, “That’s one small step for man, one giant leap for mankind.” About 20 minutes later, Aldrin followed him. The camera was then positioned on a tripod about 30 feet from the LM. Half an hour later, President Nixon spoke with the astronauts by telephone link from the White House.

During the EVA, in which they both traveled up to 300 feet from the Eagle, using a sort of hopping gate to move about on the low gravity lunar surface, Aldrin deployed the Early Apollo Scientific Experiments Package (EASEP) experiments. Armstrong and Aldrin both gathered the all-important lunar surface samples. After spending one hour, 33 minutes on the surface, Aldrin re-entered the LM, followed 41 minutes later by Armstrong. The astronauts had been outside the LM for more than two-and-a-half hours.

Armstrong and Aldrin would spend 21 hours, 36 minutes on the moon’s surface. That included a rest period with seven hours of sleep. The next phase of the mission, firing the LM ascent stage so that Eagle could return to a rendezvous with Columbia would be one of the most dangerous parts of the mission. If it failed to ignite, the two astronauts would be stranded forever on the surface of the Moon, with no hope for rescue. ■

Neil Armstrong took this image of fellow astronaut Buzz Aldrin as he stepped off the LM ladder and onto the lunar surface. Image courtesy of NASA

“That’s one small step for man, one giant leap for mankind.”

THE EAGLE HAS LANDED!

For the first time, a manned spacecraft from planet Earth landed on the Moon.

By Kevin Clemens

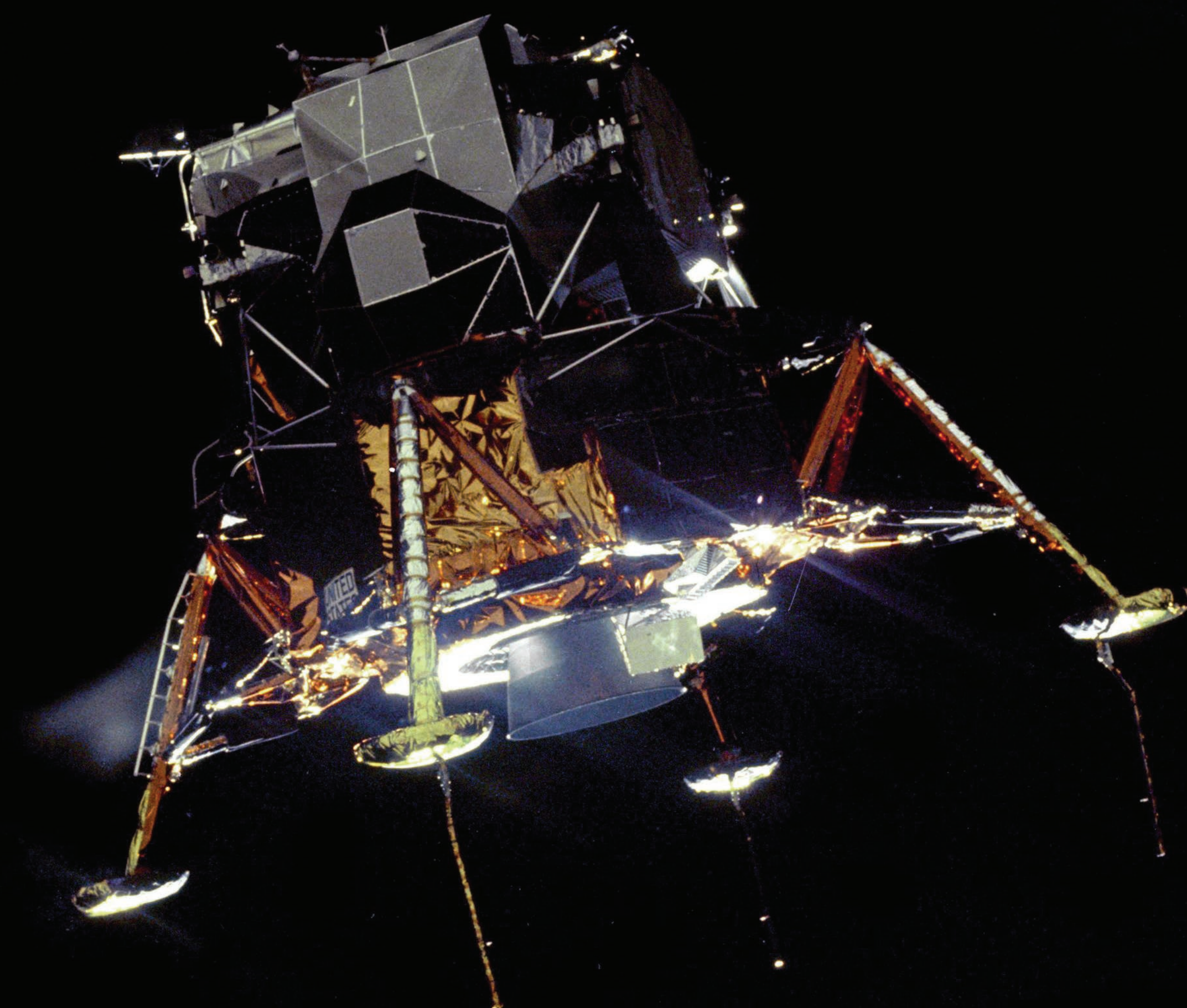


Image courtesy of NASA

It was time. On July 20, Armstrong and Aldrin entered the Lunar Module (LM), making their final checks before undocking Eagle and separating from Columbia. On board the Command Module, astronaut Michael Collins made a visual check of Eagle and gave the go ahead for a landing.

While the LM was behind the moon on its 13th orbit, its descent engine fired for 30 seconds to begin its descent orbit insertion. On a trajectory that was virtually identical to that flown during the landing dress rehearsal by Apollo 10, Eagle's new orbit was 9 by 67 miles. After Columbia and Eagle had reappeared from behind the moon, and when the LM was about 300 miles from its landing target, the descent engine fired for 756.3 seconds. Eight minutes, the LM was at about 26,000 feet above the surface and about five miles from the landing site.

The descent engine continued to provide braking thrust as the LM neared the lunar surface. As Eagle neared the surface, Armstrong took manual control. The powered descent ran 40 seconds longer than preflight planning due to Armstrong's deft maneuvering of the LM to avoid a crater during the final phase of landing. The Eagle finally set down in the Sea of Tranquility at Site 2 about four miles downrange from the predicted touchdown point and almost one-and-a-half minutes earlier than scheduled. ■

"Tranquility Base here, the Eagle has landed!"

RETURN TO EARTH AND SPLASHDOWN

July 22-24, 1969

Re-entry from space has never been easy, but Apollo 11 successfully returned from the Moon and ended its historic journey on July 24, 1969.

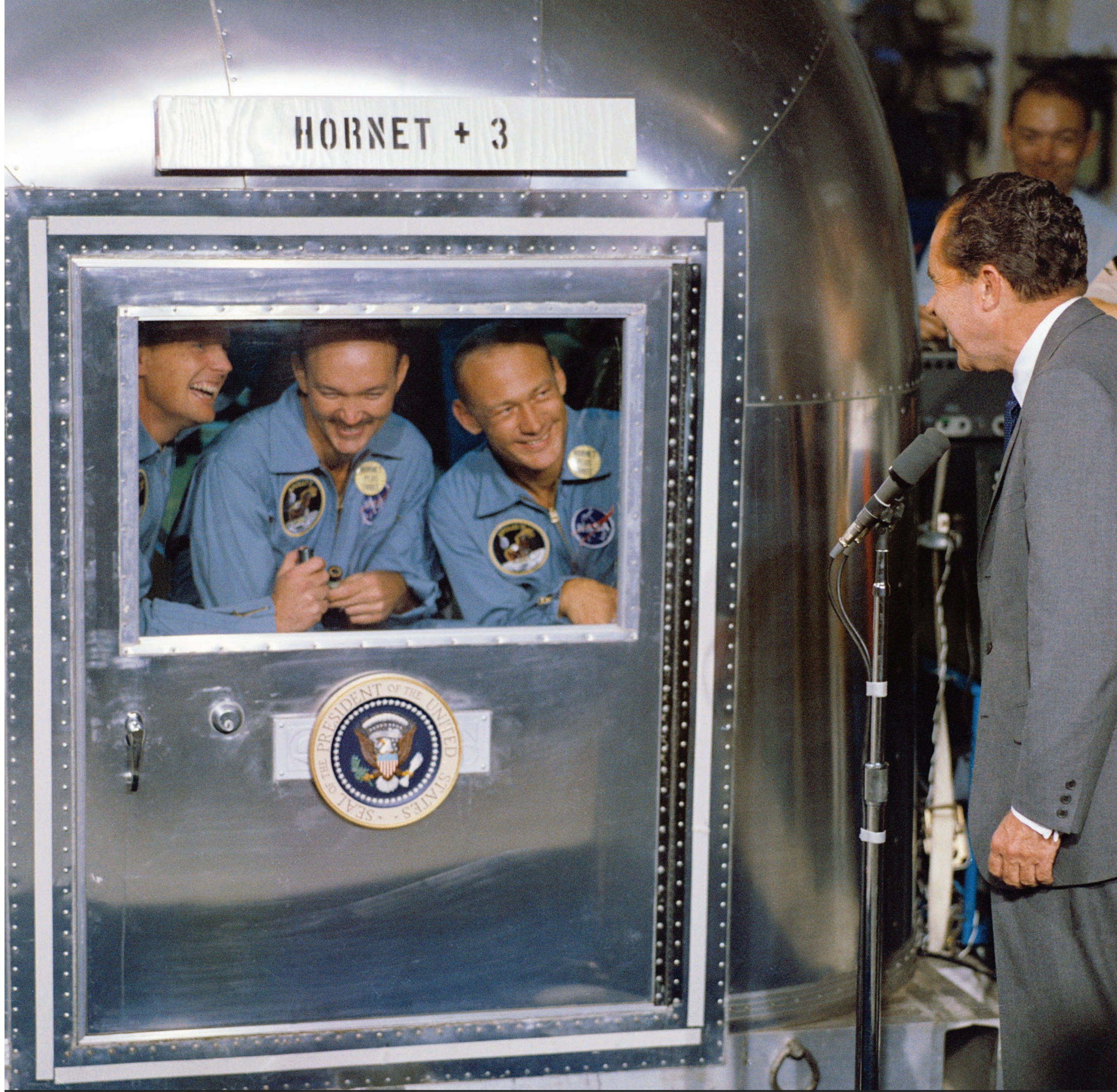
By Kevin Clemens

Apollo 11's three parachutes bring it safely home to a splashdown in the Pacific Ocean. Image courtesy of NASA

Returning from the Moon took two days for Apollo 11, during which time two more television transmissions were made by the astronauts.

Re-entry procedures were initiated on July 24, 44 hours after leaving lunar orbit. The Command Module (CM) separated from the Service Module (SM) and was rotated around to a heat-shield-forward position. Because of bad weather in the original Pacific Ocean target area, the landing point was changed by about 250 miles. The CM Columbia entered the Earth's atmosphere at 12:35 pm, protected from the intense heat, caused by friction with the air, by the spacecraft's heat shield.

As Apollo 11 entered the denser part of the atmosphere, three parachutes were deployed and Columbia splashed down 13 miles away from the USS Hornet recovery ship. Apollo 11's total flight time to the Moon and back had been 195 hours, 18 minutes, and 35 seconds. After the spacecraft hatch was opened by the recovery crew, the astronauts donned isolation suits to ensure that they wouldn't spread any possible lunar microbes. President Richard Nixon was on-board the Hornet to congratulate and welcome the astronauts home. These three men had just returned from one of humankind's most remarkable, challenging, and historic journeys. ■



President Richard Nixon welcomes home the Apollo 11 astronauts (from left, Neil Armstrong, Michael Collins, and Buzz Aldrin.) The astronauts were quarantined after their mission to ensure they did not bring back any contamination from the moon. Image courtesy of NASA

BEYOND THE RIGHT STUFF

WHY THE FIRST MAN ON THE MOON HAD TO BE AN ENGINEER

This photograph of Neil Armstrong, Apollo 11 commander, was taken inside the Lunar Module (LM) while the LM rested on the lunar surface. Image courtesy of NASA

Much like the astronauts who preceded him, Neil Armstrong was as much an engineer as a test pilot.

By Charles Murray

The first man to set foot on the moon was an engineer, and for good reason.

Neil A. Armstrong had all the skills and knowledge that the National Aeronautics and Space Administration (NASA) needed to do the job. He was a test pilot who had flown rockets and he was an engineer who understood the complicated systems necessary to land a lunar module in the vacuum and low-gravity atmosphere of the moon. »»»

The first man on the moon considered himself equal measures test pilot and engineer. Image courtesy of NASA

"It's the combination of those things that made him very proud," James R. Hansen, author of the best-selling biography, First Man: The Life of Neil A. Armstrong, told Design News. "His identity as a test pilot and astronaut was never separate from his identity as an engineer. He felt they were part and parcel of the same thing."

Nor was Armstrong alone. All his predecessors in the Mercury, Gemini, and Apollo programs were technical to the core. And even among those, Armstrong stood out. "He was an engineer-plus," Hansen said. "The other astronauts had the engineering backgrounds. But they didn't have the depth or richness of experience as a functioning, working, professional engineer that Neal had."

Beyond Pop Culture

Popular culture seldom recognizes it that way, however. The 1979 book, The Right Stuff, celebrated the early astronauts for their work as test pilots, barely alluding to their engineering backgrounds. And that image was permanently etched into American history for decades afterward.

In describing the so-called "right stuff" qualities, author Tom Wolfe wrote that the idea "seemed to be that a man should have the ability to go up in a hurtling piece of machinery and put his hide on the line and then have the moxie, the reflexes, the experience, the coolness, to pull it back in the last yawning moment – and then go up again the next day, and the next day and every next day, even if the series should prove infinite – and ultimately, in its best expression, do so in a cause that means something to thousands, to a people, a nation, to humanity, to God."

But the book – a masterwork by most accounts – was only half-right in its depiction of the right-stuff qualities, historians say. "The book suggests that (Chuck) Yeager was the one with the right stuff, but that's not really true," Hansen said. "Yeager was a great stick-and-rudder guy, but the real ones with the right stuff were the guys like Armstrong and the others who were engineer-pilots. Yes, they were great pilots, but they also had an understanding of the systems and technology that was highly professional."

Indeed, a quick look at the backgrounds of the early astronauts bears out Hansen's assertion. The original "Mercury Seven" astronauts, colorfully depicted in Wolfe's book, all earned degrees in engineering, or had degrees from the US military academies, which were essentially engineering degrees, even if not identified as such.

The study of thermodynamics and circuit theory was neither as romantic nor as poetic as the commonly-held right-stuff imagery, but it was nevertheless critical to who the astronauts really were, historians say. "Gus Grissom once said, 'I fell in love with the steam tables,'" noted George Leopold, author of *Calculated Risk: The Supersonic Life and Times of Gus Grissom*. "Guys like him and (Wally) Schirra and John Young were doing all doing the guts of the aircraft — the wiring, the voltages, the nuts and bolts."

Moreover, the astronauts were earning engineering degrees in an era when most Americans hadn't finished high school. In First Man, Hansen points out that during the 1940s, less than one in four Americans completed high school, and only about one in 20 went on to college.

Still, the need for education kept growing as the astronaut program evolved. The second wave of nine astronauts, including Armstrong, were deliberately selected for their greater technical acumen. Most had earned degrees in aerospace or aeronautical engineering from such schools as Cal Tech, Princeton, Georgia Tech, Michigan, and Purdue. Later, astronauts Buzz Aldrin and Ed Mitchell even brought PhDs from Massachusetts Institute of Technology.

The Mercury Seven astronauts, famously depicted in the book, The Right Stuff, all had engineering backgrounds. From left to right: Gordon Cooper; Wally Schirra; Alan Shepard; Gus Grissom; John Glenn; Deke Slayton; and Scott Carpenter. Image courtesy of NASA

"When they selected the second group, they were looking for engineering know-how related to matters such as how to rendezvous and how to dock with another spacecraft," Leopold said. "The astronauts were chosen to be able to help with that. They were tops in their fields, world class."

The Engineering Effort

Indeed, the chosen astronauts had to be a part of an extraordinarily broad engineering effort. Even on matters outside their areas of expertise, they still needed to be able to communicate in the language of engineers. They needed to have familiarity with material science, thermodynamics and fluid mechanics, as well as matters involving voltages, currents, and power draws.

Engineering played such a huge role that the astronauts couldn't afford to simply be stick-and-rudder pilots, historians say. At one point, there were more than 400,000 engineers and technicians contributing, not only at NASA, but at contractor sites around the country. Many worked more than 16 hours a day in pursuit of President John F. Kennedy's dream to put a man on the moon by decade's end. And the astronauts had to be an integral part of that culture, working countless hours, while sometimes walking outside to stare at the moon for inspiration.

"If they started a test at the Cape on a spacecraft, they didn't leave until the test was completed," Leopold told us. "Sometimes the test lasted a week. They would just keep going and sleep in the hangar, and take turns working until the test was finished."

Armstrong was perfect for such a culture, historians said. He pitched in on the design of a crane-and-cable assembly to help simulate lunar landings, and was notorious for bringing engineering teams to the brink of exhaustion. "The engineers said they would play cards and drink coffee because they never knew when Armstrong would quit," Leopold said. "Sometimes, he would go all night."

At times, the intensity also brought engineers to the breaking point. When three astronauts – Grissom, Ed White, and Roger Chaffee – died in a tragic fire in 1967, the pressure on the engineering community grew. There were reports of marriages breaking up, and even suicides.

"One engineer said, 'We came back like gladiators,'" Leopold recalled. "They were focused and they were going to fix it."

A White Socks Engineer

It was in the midst of that high-pressure cooker environment that the astronauts played a key role. They served as part of a team that was required to invent new technologies and combine systems that had never been combined before. They had to figure out how to integrate electrical, electronic, and mechanical systems, and make them work – all with a man aboard. Moreover, they had to do it flawlessly.

Armstrong's biographer said the "first man" was in his element amid such efforts. He had previously served, not only as a rocket pilot on the X-15, but as an engineering research test pilot at Edwards Air Force base. His blend of engineering experience and test piloting was perfect for the mission. "The research test pilot is really an engineer in the cockpit," Hansen told us. "It's about looking for data and learning about the man-machine interface in the medium he's flying in."

Armstrong's background -- he held a BS from Purdue and an MS in aeronautical engineering from USC -- enabled him to play a key role in conceptualizing a vehicle that could simulate flight in a low-gravity lunar environment. The resulting vehicle later became the lunar landing research vehicle, and finally evolved into a trainer that Armstrong used incessantly. "None of the other astronauts could have done anything like that," Hansen said, referring to his conceptualization.

Given such engineering contributions, Armstrong in later years grew frustrated with the pop culture image of astronauts as old-fashioned, scarf-out-the-window, flyers. It was particularly frustrating, Hansen said, because Armstrong felt he was equal measures engineer and test pilot. "When he left NASA in 1971, he had all kinds of opportunities to run for political office or to be a corporate executive," Hansen said. "And what did he decide to do? He chose to go to the University of Cincinnati to teach aerospace engineering."

Another of his goals was to write an engineering textbook, Hansen added. Although he could have authored a book to top The New York Times list, it wasn't his desire. "That tells us a lot," Hansen said. "He never wanted to get too far out of his lane."

Speaking at a press gathering many years later, Armstrong summed up his affinity for engineering. "I am, and ever will be, a white socks, pocket protector, nerdy engineer," he said.

It was vintage Armstrong. "That's how he saw himself," Hansen recalled. "And that's who he really was." ■

Neil Armstrong offered experience as an engineering research test pilot and as a rocket pilot on the X-15. Biographer James Hansen referred to Armstrong as "an engineer in the cockpit." (Image source: Wikipedia)

Image courtesy of NASA

THE BATTERIES

THAT POWERED THE LUNAR MODULE

Landing on the moon took a huge amount of engineering skill, not the least of which went into developing the batteries that would provide electricity on the lunar surface.

By Kevin Clemens

When President Kennedy proposed, on September 12, 1962, that the US land a man on the Moon before the end of the decade, he set in motion a huge scientific and engineering enterprise. Eventually more than 400,000 engineers and technicians would contribute to the effort—not only at NASA, but at companies that served as contractors around the country. »»»

The design and development of the Lunar Module (LM) was the responsibility of Long Island, New York aviation pioneer Grumman. The role of the LM was to transport two astronauts from lunar orbit, support them while on the Moon, and then to return them and their Moon rock samples to a rendezvous with the Command Module (CM).

Two Stages

Right from the start, it was decided that the LM would have two stages, each with its own rocket engine and power systems. The descent stage rochet was highly controllable and could be throttled to allow the LM to hover just before landing. The ascent stage rocket engine was much simpler—once it ignited it held a single level of thrust until it was shut down. This was done to make the ascent stage as reliable as humanly possible—if the ascent stage engine did not fire there would be no rescue and the two astronauts would die on the surface of the Moon.

Size and weight became the critical factors in the LM design. Every ounce of the spacecraft had to be launched from the Earth by the Saturn V rocket, and the original design, which had weighed 22,000 pounds, eventually ballooned to nearly 34,000 pounds by the time it flew with Apollo 11. For the Grumman team of 7,000 employees, led by Thomas J. Kelly, the LM Chief Engineer, reducing weight in a spacecraft that was not much larger inside than a phone booth was a major challenge.

Electrical Power

Initially, the plan was to provide electrical power for the LM through a hydrogen fuel cell. In February 1965, after months of study, NASA approved a switch from fuel cells to batteries. Thomas Kelly in his 2001 book, “Moon Lander: How We Developed the Apollo Lunar Module,” NASA had become increasingly concerned about the growing complexity of the fuel cell system in the LM. The Command Module would continue to use fuel cells for electrical power because of its longer mission duration. But the LM only needed its electrical power for a couple of days and the simpler battery system was attractive.

The battery supplier for the LM was Eagle Picher. The company had already been supplying batteries to the military for a long time and with the space program all the way back to the first satellite launched by the US, the Explorer I. In addition, the company was already supplying more than 40 batteries for the Saturn V rocket.

Chosen For Reliability

The chemistry for the batteries was chosen for its reliability and familiarity. “All of these were silver oxide-zinc batteries,” Jack Brill explained to Design News. Brill was the project engineer for the Apollo program for Eagle Picher. “I actually started work in 1962- about the time everything kicked off,” said Brill. “I was a young guy, just out of college. I graduated with a mechanical engineering degree and started work in 1962. When I first started I did a lot of mechanical design work. The Vietnam War was kicking off really strong at that time, and I started working on critical batteries for the military. I was the project engineer on the Apollo battery. I was the mechanical design and manufacturing engineer for the Lunar Module batteries,” Brill told us.

“The whole goal was lightweight. There was a lot of design to take the weight out. We broke a lot of ground there—in fact we started using titanium cases. The main thing was to get the weight out. We went from stainless, to magnesium, to titanium. They would take a small number of recharges— 25 times or so—but they were never intended for that,” Brill said.

There were four batteries in the descent stage of the LM and two more to power the ascent stage. The batteries had alternating plates of silver and zinc, separated by paper insulation and surrounded by a liquid potassium hydroxide electrolyte.

An Entire Career

The success of the Apollo 11 Moon landing led to more work for the Eagle Picher space battery designers. “I spent almost my whole life there. I was there when the space industry started. I built different batteries for different experiments on the Moon. We built batteries for the lunar rover,” said Brill. “I retired after 52 years, in 2014. I stayed longer than I meant to! I finished as the Director of Engineering, but all the way through I was involved in space,” he added.

What does it mean to Jack Brill, looking back 50 years to his involvement with the first Moon landing? “At the time we were just so busy doing the job and our goal was to never make mistakes,” Brill told us. “It’s nerve-wracking when something you do might kill somebody. When I look back, there was a lot of achievement that I was part of—I came along at the right time and I saw a lot of wonderful things. I saw a lot of launches…” ■

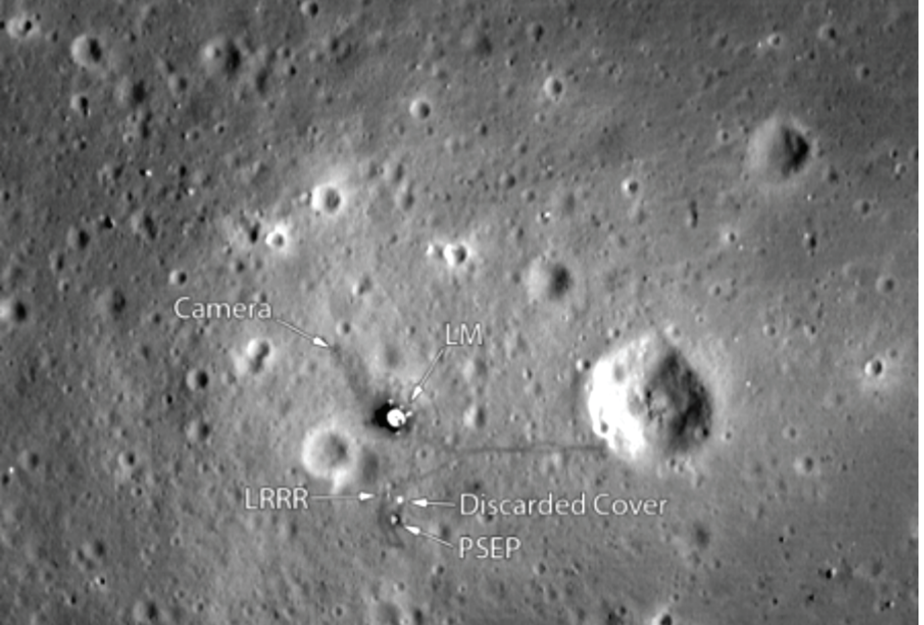
THAT SMALL STEP

IS STILL THERE AFTER 50 YEARS

For the past 10 years, NASA's Lunar Reconnaissance Orbiter has continued to send back detailed photos of the lunar surface—including the sites of the Apollo Moon landings.

By Kevin Clemens

Image courtesy of NASA



Apollo 11 landing site captured from 24 km (15 miles) above the surface by NASA's Lunar Reconnaissance Orbiter(LRO). Tracks of the astronauts can be seen between the LM and various other discarded pieces of equipment. (Image source: NASA Goddard/Arizona State University)

The remnants of the footsteps are still there. Fifty years after Neil Armstrong and Buzz Aldrin walked on the surface of the moon, the evidence of humankind's first venture off our small blue planet is still visible. The astronauts had spent over 21 hours on the lunar surface after their Lunar Module (LM) had landed there on July 20, 1969. They had explored for more than 2-1/2 hours the surface outside of their spacecraft. Then they blasted off using the ascent stage of the LM, and leaving behind the descent stage on the surface.

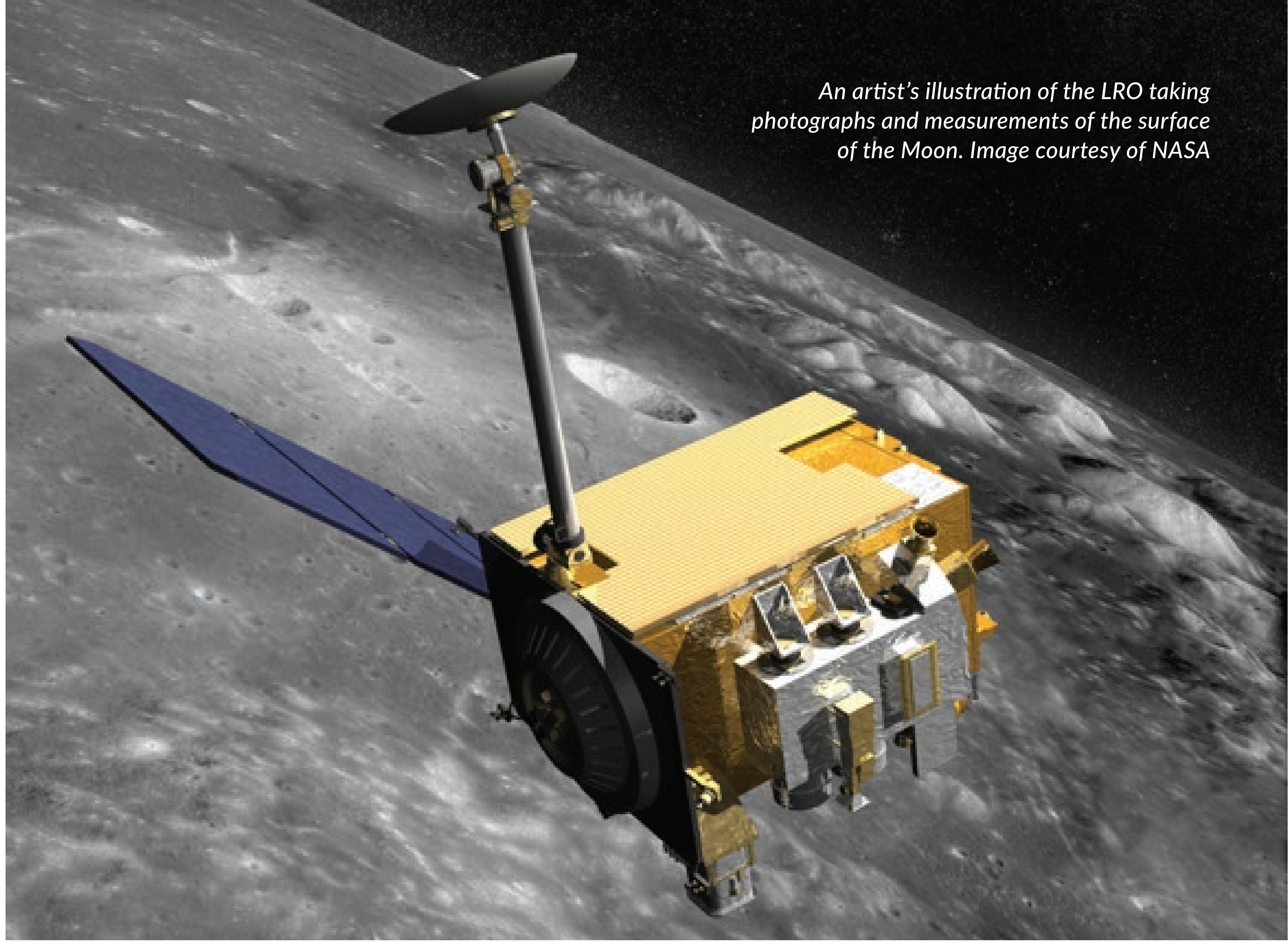
In November of 2009, NASA released images of the Apollo 11 lunar landing site in the Sea of Tranquility. The images, taken by the Lunar Reconnaissance Orbiter (LRO) from just 15 miles above the Moon's surface, shows the discarded descent stage of the LM, as well as tracks created by the astronauts as they moved about in the dust on the surface.

One of the astronaut's trails leads to the Passive Seismic Experiment Package (PSEP), which was set up to provide the first lunar seismic data. It continued to return data for three weeks after the astronauts left. Also visible in the LRO photo is the Laser Ranging RetroReflector (LRRR), which allows precise laser measurements between the Earth and Moon to be made. It is still operating to this day and the discarded cover of the LRRR can be spotted nearby, where it was dropped by one of the astronauts.

Another trail follows an unplanned excursion near the end of the time spent on the surface. Armstrong ran over to get a look inside Little West crater, about 50 meters (164 feet) from the LM. This was the farthest either astronaut ventured from the landing site. Armstrong and Aldrin's tracks during their time on the lunar surface cover less area than a city block.

The LRO was launched on June 18, 2009 and entered lunar orbit on June 23, 2009. LRO's mission is to help identify sites close to potential resources with high scientific value, favorable terrain, and the environment necessary for safe future robotic and human lunar missions. The LRO has also photographed all of the Apollo lunar landing sites, as well as the locations where various the jettisoned Lunar Modules have impacted the lunar surface, after having returned the astronauts safely to the orbiting Command Module.

According to NASA, the instruments on board the LRO spacecraft return a range of global data, including day-night temperature maps, a global geodetic grid, high resolution color imaging and the moon's UV albedo. There has been particular emphasis on the polar regions of the moon where continuous access to solar illumination may be possible, and the potential for frozen water in the permanently shadowed regions at the poles may exist. LRO data sets have been deposited in the Planetary Data System (PDS), a publicly accessible repository of planetary science information.


An artist's illustration of the LRO taking photographs and measurements of the surface of the Moon. Image courtesy of NASA

Because the Moon lacks any atmosphere that would cause erosion, short of a major meteor strike at the landing location, the only degradation of the tracks of footprints and equipment remaining on the moon comes from the impact of micro-meteors. It theory this means that the artifacts from the Apollo 11 Moon landing could remain undisturbed for centuries—or at least long enough to become a prime tourist attraction for the inhabitants for a future Moon base. ■