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THE 50TH ANNIVERSARY OF APOLLO 17

HUMANKIND'S LAST CREWED MISSION TO THE MOON—SO FAR

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➤ Astronaut Eugene A. Cernan, commander, makes a short checkout of the Lunar Roving Vehicle on 12 December 1972 during the early part of the first Apollo 17 extravehicular activity at the Taurus-Littrow landing site. (Photo credit: NASA)

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From the Chief Historian

FIFTY YEARS AGO this December, the crew of Apollo 17 completed humanity's last voyage to the Moon. Leaving the lunar surface for the final time on 14 December, Commander Gene Cernan spoke the now famous quote, "We leave as we came, and, God willing, we shall return, with peace and hope for all mankind." Cernan's words articulated both the stunning success of Project Apollo and the immense melancholy of those who were not ready to see the program conclude.

NASA's human spaceflight program has spent the intervening 50-year period from Apollo 17 working in low-Earth orbit and preparing to pick up where that program left off. The 135 launches of the Space Shuttle, the building of the International Space Station, and the many lessons learned living and working in the microgravity environment laid the groundwork for Artemis.

On 16 November of this year, NASA took the next major step in the program with the launch of Artemis I. Millions around the world watched live as the Space Launch System (SLS) rocket launched the Orion spacecraft on its scheduled 25-day mission that will see the uncrewed vehicle log over 1.4 million miles and travel farther (40,000



Apollo 17 astronaut Harrison H. Schmitt photographs the site where he has taken rock and soil samples near the rim of Camelot Crater at Station 5 in the Taurus-Littrow valley. (Photo credit: NASA)

miles beyond the far side of the Moon) than any human-rated spacecraft has ever traveled.

As of this writing, Orion is still making its initial flight around the Moon and returning stunning images rivaling the Apollo 8 "Earthrise." This historic milestone represents a truly monumental achievement. But this is only the first step.

As historians, we must always consider the deeper context and analytical frameworks. What do past programs, including Apollo, the Space Shuttle, and the International Space Station, tell us about what we can expect from this and the next steps? Will abandoning the Cold War approach of Apollo and embracing a more coalition-building approach that includes commercial and international partners make this

What do past programs, including Apollo, the Space Shuttle, and the International Space Station, tell us about what we can expect from this and the next steps?

From the Chief Historian (continued)



↑ On Day 13 of the Artemis I mission, Orion reached its maximum distance from Earth and captured this image of the spacecraft with Earth and the Moon. (Photo credit: NASA)

new round of lunar exploration more sustainable? Will success for Artemis coupled with potential new markets lead to a revolution in aerospace technology capable of reaching Mars?

As a social historian, I must also ask questions about potential ramifications back on Earth. What cultural impacts might a permanent presence on the Moon ultimately produce? Could becoming an interplanetary species produce a transcendent shift in us as a species? Will expansion beyond low-Earth orbit have positive or negative impacts on economic and social inequality?

Here, the example of Apollo is instructive. That program occurred against the backdrop (and, at times, at the forefront) of one of the most transformative periods in U.S. history. Running parallel with the social revolution of the 1960s, Apollo experienced many incredible triumphs as well as tremendous setbacks (cancellation of several final missions) and tragedies (Apollo 1).

Beyond delivering on President Kennedy's end-of-the-decade goal and extraordinary scientific discoveries, some of the greatest legacies of that program took place back on Earth. The federal investment in aerospace

infrastructure across the southern United States transformed the economics of much of the region. Critical investments in university engineering and science programs created foundations that continue to pay off with technological and scientific breakthroughs. Apollo 8 delivered an uplifting message at the end of a dreadful year (1968) and, with the capture of the "Earthrise" photo, stoked the flames of the environmental movement.

Beyond delivering on President Kennedy's end-of-the-decade goal and extraordinary scientific discoveries, some of the greatest legacies of that program took place back on Earth.

As we watch Artemis I and subsequent lunar missions, I am excited for the next round of amazing scientific discoveries and impressive engineering firsts. Hopefully the lessons of Apollo will prove a helpful framework for discovery both on the Moon and back home. If we are paying attention, I am sure they will. ■

Brian C. Odom
Chief Historian

The Pyroclastic Colors at Shorty Crater

Color-Correcting 50-Year-Old Photos Provides New Insight into Lunar Geology

» By Ronald A. Wells and Harrison H. Schmitt

A **POLLO 17 ASTRONAUT** Harrison H. Schmitt discovered startlingly bright orange, red, and yellow deposits in a trench he dug across the rim of Shorty Crater on the Moon in 1972. A 68-centimeter core of this deposit and its underlying material includes black, partially devitrified beads and shards. Post-mission examination disclosed that the deposit is composed of volatile-rich, pyroclastic ash. The very small volcanic glass beads and shards making up this soil, rich in titanium

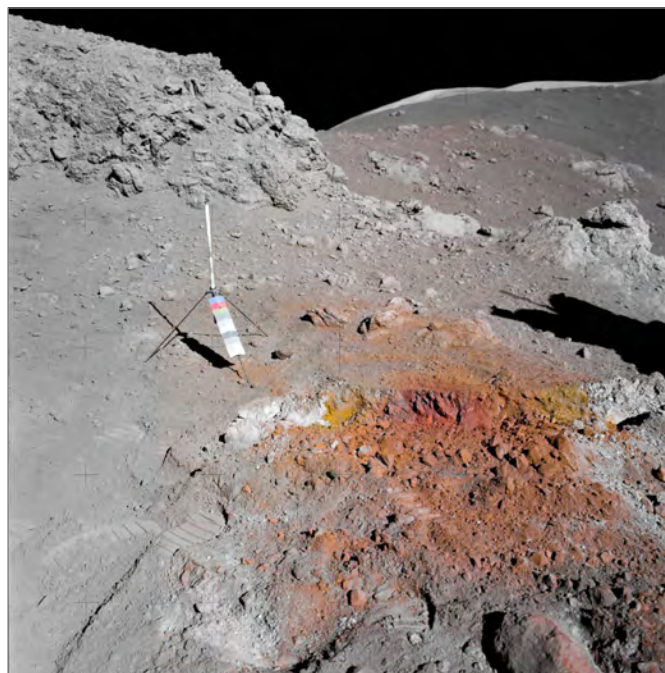
and low in silica, were products of fire fountains erupting from depths of roughly 500 kilometers during ancient lunar history. Inexplicably, photo prints from the prime Ektachrome SO-368 Hasselblad film made at the time, as well as later digital scans, depicted the trench as having a dull, pale brownish color (figure 1). Modern software techniques, however, allow restoration of the colors that Schmitt described *in situ*¹ and for many decades afterward (figure 2).

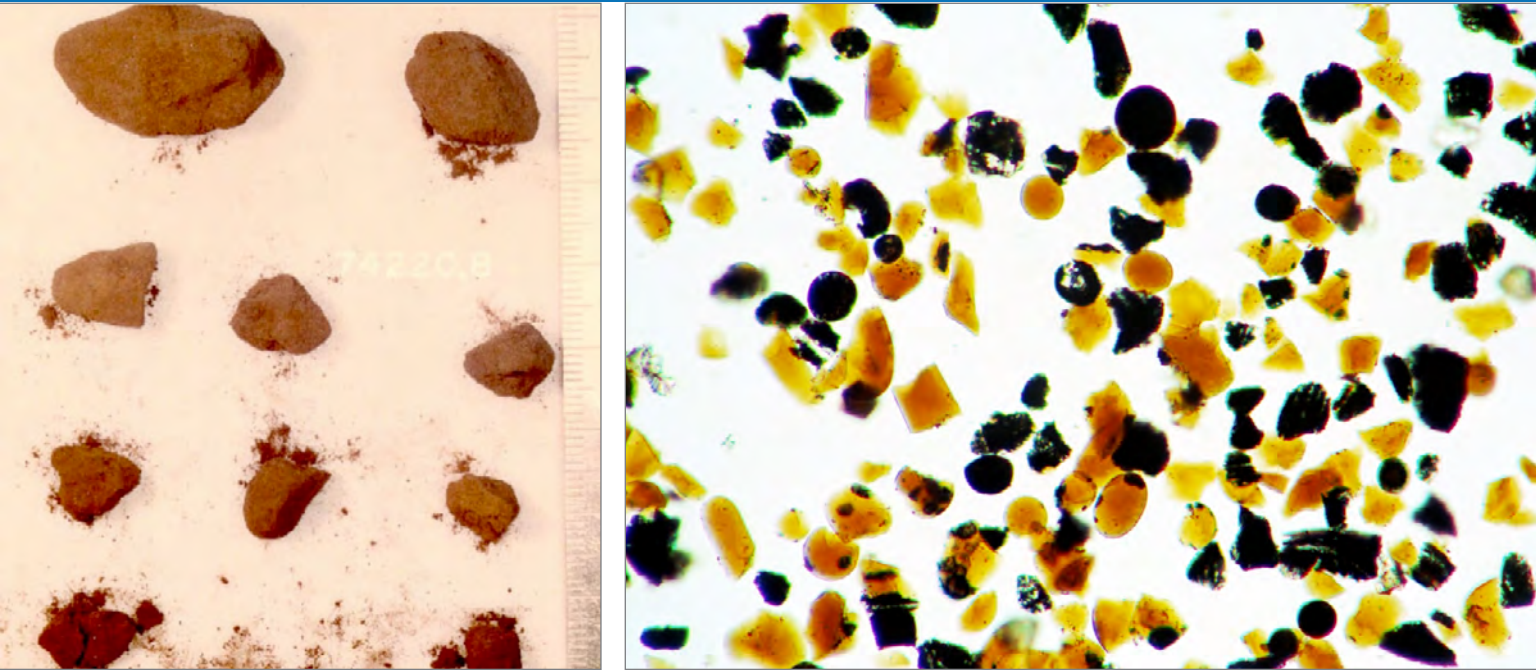
For nearly half a century, there has been a disconnect in the scientific community between what Schmitt actually saw on the Moon and described at the time and the documentary evidence. Schmitt recently worked with Wells in recapturing the original colors using photo-editing software.² Images were first contrast-balanced; then, by adjusting the red, orange, and yellow color channels, it was possible to match the colors Schmitt had observed. The color-corrected photo shown in figure 2 was approved by Schmitt after eight iterations or adjustments of the balancing process.

Figure 3 (left) shows a collection of red and brown soil clods (sample 74220,8) taken from the central, redder area of the trench seen in figure 2. The right portion of this figure is a transmission photomicrograph of orange, yellow, and black glass shards collected from a

↓ **Figure 1.** Original Johnson Space Center digital scan AS17-137-20990 of the trench dug by Harrison H. Schmitt at Shorty Crater. (Photo credit: NASA)

↓ **Figure 2.** Contrast-balanced and color-corrected version of figure 1 as described in text. (Photo credit: NASA/derivative photo; copyright © by Tranquillity Enterprises, s.p., 2018)





↑ **Figure 3. Left:** Red and brown soil clods (sample 74220,8) taken from the central red area of the trench shown in figure 2. (Photo credit: NASA image S75-34259) **Right:** A transmission photomicrograph of orange, yellow, and black glass beads and shards taken from a core drill tube. (Photo credit: NASA image S73-15171)

core drive tube that had been inserted through the orange soil behind the trench to the right of the gnomon. The red/orange/yellow color differences of the beads appear to be related to the iron/titanium ratios of the glass. The black color of some of the beads is a consequence of the partial devitrification of the colored glass that results in dark crystallites in clear glass. The clear glass has essentially all the titanium removed from it by crystallization of the mineral ilmenite (FeTiO_4). The latter effect can be seen in the photomicrograph. Several black beads in the center and upper mid-left of the photo appear to have irregular white patches. Those are actually clear glass with the white background showing through.

After Schmitt returned to the Command Module (CM), he took several photos from lunar orbit with the Hasselblad 250-millimeter camera over southwestern *Mare Serenitatis*.³ In addition, the CM pilot, Ron Evans,

took a Hasselblad photo with the 80-millimeter lens. The color-corrected versions all show distributions of orange-red-black ash deposits in and around numerous craters in *Mare Serenitatis*, extending the range of these volcanic products well beyond Shorty Crater in the Taurus-Littrow valley. These observations have profound implications for lunar geology and are described in more detail by R. A. Wells and H. H. Schmitt.⁴

Shorty Crater provided remarkable close-up views of the volcanic rim and ejecta debris seen in the Hasselblad orbital photos. But it was not until Schmitt had seen the color panorama of the entire crater that the full significance of its formation became apparent (figure 4 on the following page). The characteristics of these volcanic products provide an improved understanding of the geochemical and geophysical nature of the Moon's interior. The volatiles accompanying these eruptions of

The characteristics of these volcanic products provide an improved understanding of the geochemical and geophysical nature of the Moon's interior.

deep-seated magma, including water, suggest a much wider internal distribution for them than heretofore indicated. They also represent a potential ancient source of the water known to be present as ice at the lunar poles. Certainly, the widespread nature of these volatiles and deep-seated eruptions attest to a more colorful Moon and add constraints to the ongoing debate on the origin of the Moon itself. ■

The Pyroclastic Colors at Shorty Crater (continued)

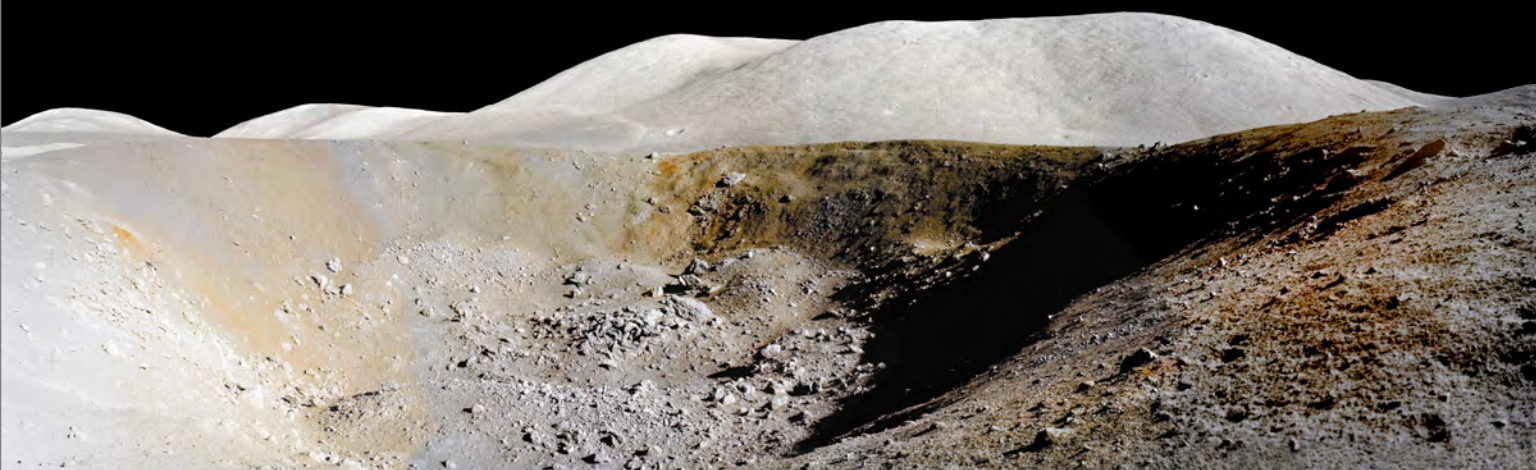


Figure 4. A contrast-balanced, color-corrected panorama of Shorty Crater assembled from the seven NASA photos taken by Eugene Cernan (left to right): AS17-137-21005, -00, -01, -02, -03, -04, and -24. The trench dug by Schmitt in figure 2 is off the photo on the rim at the middle left edge. The distance across the crater looking toward the mountains is ~110 meters. From left to right to the wall center, red debris streaks; orange ash slides; a thin, long, angled wedge-shaped black ash slide; and red and red-black splotches can be seen. Wall material on the right side of the crater is composed of brown and red-brown debris. (Photo credit: NASA/derivative photo; copyright © by Tranquillity Enterprises, s.p., 2018)

Acknowledgments

Elements of this article were presented at the Geological Society of America (GSA) 2019 Annual Conference in Phoenix, Arizona. See <https://gsa.confex.com/gsa/2019AM/webprogram/Paper332002.html> for more details.

Financial support was provided in part by NASA grant NNX09AM43G and a SURA travel grant to GSA2019 (Wells).

Ronald A. Wells is the editor-in-chief of Apollo 17 astronaut Harrison H. Schmitt's personal website, <https://www.americasuncommonsense.com>.

Endnotes

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- 2 Wells and Schmitt, "Color-Balancing"; Wells and Schmitt, "Multi-Colored Lunar Surface Features." op. cit.
- 3 H. H. Schmitt, "Lunar Mare Color Provinces as Observed on Apollo 17," *Geology* 2 (1974): 55–56; B. K. Lucchitta, figure 36, in *Apollo over the Moon: A View from Orbit*, ed. H. Masursky, G. W. Colton, and F. El-Baz (Washington, DC: NASA SP-362, 1978), p. 49; B. K. Lucchitta and H. H. Schmitt, "Orange Material in the Sulpicius Gallus Formation at the Southwestern Edge of Mare Serenitatis," 5th Lunar Science Conference Proceedings, Houston, TX, 18–22 March 1974, vol. 1 (New York: Pergamon Press, Inc., 1974), pp. 223–234.
- 4 R. A. Wells and Harrison H. Schmitt, "Colors Across the Moon," chap. 4 in R. A. Wells, *Apollo over the Moon in Perspective: 3D Anaglyphs and Other Views from Orbit*, vol. 2 (Burlington, ON, Canada: Apogee Books, 2021), pp. 171–202, <https://www.cgpublishing.com/Books/9781989044131.html>.

Hidden Engineering Support for the Apollo Missions

» By **Gary W. Johnson**, Senior Safety Engineer, J&P Technologies, Inc.

MANY OF US have seen photos, articles, and videos of the Mission Control Center (MCC) at the Manned Spacecraft Center (now known as Johnson Space Center) in Houston, Texas, where flight directors and flight controllers worked at consoles during the Apollo missions. Scenes from the MCC during the Apollo 11 lunar landing, the safe return of the crew of Apollo 13, and of course the Apollo 13 film starring Tom Hanks have circulated widely. Less well known were the group assembled in the Mission Evaluation Room (MER) in a building nearby, where I, along with other engineers and managers, supported the Apollo flight controllers during the missions.

NASA Manned Spacecraft Center's Mission Evaluation Room

Prior to the Apollo 7 crewed mission, Apollo engineers worked alongside their flight control counterparts in the MCC backroom, called the Staff Support Room (SSR), as they supported the uncrewed Apollo missions. During the Apollo 4 mission in August 1967, the first Saturn V launch, while I manned



↑ The MER's managers' table, with MER manager Donald D. Arabian seen talking on the phone. (Photo credit: NASA)

the Electrical Power System (EPS) console in the MCC SSR, manager Dr. Christopher C. Kraft came back and said that the SSR was too crowded and that engineering would have to provide support from outside the MCC.

The Apollo Program Office established the MER on the third floor of Building 45, next to Building 30, where the MCC was located. I remember the first mission support from the MER was Apollo 7, the first crewed Apollo mission.

Apollo 13

On the evening of 13 April 1970, when the explosion of Apollo 13's Service Module (SM) oxygen tank occurred, I was on duty in the MER, and I did not leave the MER until the following morning. At that point, the CSM



Read more about the history of the Mission Evaluation Room in JSC's Building 45.

Hidden Engineering Support for the Apollo Missions (continued)



↑ The MER as seen during Apollo 11. The left side of the table was for Command and Service Module (CSM) engineering support, while the right side was for Lunar Module (LM) support. The author, responsible for the NASA CSM electrical power system (EPS), is shown wearing the striped shirt and sitting near the back of the left-hand side of the table. On his right is North American Aviation Space Division's Harry Horii, manager for the CSM EPS. Across from him is NASA LM EPS subsystem manager Art Campos, looking at the TV monitor, and to his left is Grumman Bethpage manager for LM EPS Stan Feinberg. The TV monitor at the back would display LM EPS data when the LM was active and displayed CSM EPS data when the CSM was active. The data shown on the display replicated what was seen by the MCC Flight Controllers. The headsets allowed the engineers to listen to the flight crew and Flight Director. The black phones allowed them to call the MCC Flight Controller to request another data display or call home. The room had other tables with engineers covering other spacecraft systems and safety, reliability, and quality assurance. (Photo credit: NASA image S69-52725)

was completely unpowered, and the engineers supporting the active LM systems were experiencing a high level of activity.

Prior to the Apollo 13 launch, I was concerned about the possibility of needing to use the Command Module's (CM) battery charger to charge the Lunar Module (LM) batteries, so I worked with the Lunar Module Electrical Power Subsystem Manager, Arturo "Art" B. Campos, to develop a procedure using an on-board umbilical to electrically connect the battery charger output on a CM bus to the LM bus that the batteries were connected to.

This was documented in a memorandum with copies to my management and the Flight Operations Electrical, Environmental, and Consumables (EECOM) personnel.

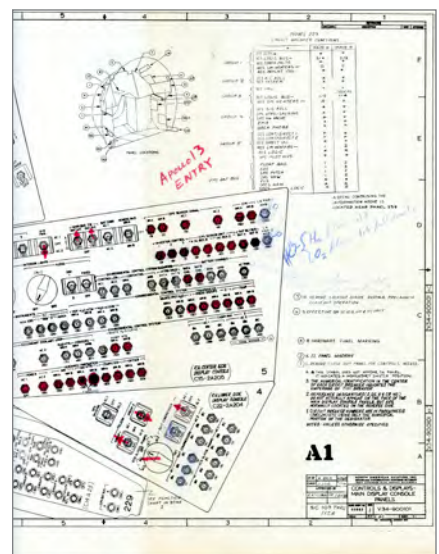
After the explosion of the SM oxygen tank, I went over to my office to get the memorandum documenting the procedure; then Art and I wrote a reverse procedure (MER SPAN CHIT) to

→ Marked-up CM display panel drawing with switch and circuit breaker positions marked in preparation for the Apollo 13 reentry. (Scanned part of V34-900101, Rev. AC, Controls and Displays—Main Display Console Panels.)

provide power to the unpowered CM from the LM. The CM entry batteries had been run down while powering the spacecraft as the crew prepared to go to the LM. By using the LM batteries to power the CM, the entry batteries were recharged for reentry.

Later, prior to reentry, I was also busy working on the CM power-up configuration before we jettisoned the LM. This consisted of marking up a CM display panel drawing with switch and circuit breaker positions. If a circuit breaker was to be closed, it was marked red, and if it was to be open, it

↓ Harry Horii (left) confers with the author (right) in the MER as they support the Apollo 13 mission. (Still from the [NASA documentary Apollo 13: Houston, We've Got a Problem](#))



Hidden Engineering Support for the Apollo Missions (continued)

was marked blue. Switch positions were shown by a red arrow in the direction to be positioned. This information was then provided to the Flight Control Team, which converted the information to a checklist to be read to the crew.

Apollo 15

I was also involved in the MER engineering support that allowed Apollo 15 to proceed for a lunar landing mission. During the mission, after trans-lunar injection (TLI) and just after transposition and docking, the Service Propulsion System (SPS) thrust light illuminated with no engine fire command present. This light indicated the presence of a short to ground in the SPS ignition circuitry. Ignition would have occurred if the engine had been armed. This condition was a “No Go” for Lunar Orbit Insertion (LOI). I noted that the short indication first occurred just after Earth orbit insertion, when the spacecraft was in zero gravity, and then occurred a second time as mentioned above after TLI. In reviewing the SPS circuitry, the only place where one could find something floating in a closed cavity was the delta-V thrust panel switch. Knowing that the switch contained a braided wire that could have a loose wire strand, and that if it shorted to case (ground) it would illuminate the SPS thrust light, I could explain what the crew was seeing. The MER Manager gave me permission to go to the MCC to explain this theory of what could be causing the thrust indication. I explained what I considered to be the cause of the indication to Kraft. Kraft said this sounded plausible, but we needed to perform a test to prove the short was just causing the light to illuminate and not issuing a fire command to the SPS. The crew procedure was modified for a test firing

of the SPS during a midcourse correction. The successful firing verified that the short was isolated to the system A delta-V thrust switch and allowed implementation of an alternate procedure to safely fire the SPS engine and successfully continue the mission.

Post-flight failure analysis showed that inside the delta-V thrust panel switch there indeed was a loose wire strand from the switch’s braided wire that was causing the short to ground.

Apollo 16 and 17

Prior to Apollo 17, the MER’s track record of solving mission problems led the Marshall Space Flight Center Director to contact MER Manager Don Arabian, asking for support from the MER engineers in finding the cause of several Lunar Rover Vehicle (LRV) instrumentation anomalies. During Apollo 15 and 16, multiple intermittent battery instrument anomalies occurred during the rover’s operation in the low-temperature environment of the Moon.

I was working as the Sequential Subsystem Manager, and my investigation of the grounding circuitry revealed that the small 22-gauge return wires to the meters and ampere-hour integrator were crimp-spliced with the large 12-gauge battery return wire (there were a total of five wires in the splice). An open circuit to ground and power return would explain the anomalies seen in flight.

The number of these return wires and the size difference exceeded the Manned Spacecraft Center spacecraft requirements on the splicing of different gauge wires in a single splice, as large differences can result in a loose

Read More of Gary Johnson's Experiences with NASA's Human Spaceflight Program:

-  Gary Johnson: Lessons Learned from 50+ Years in Human Spaceflight and Safety, 30 April 2018
-  Gary Johnson's Oral History Interviews

connection on some of the small-gauge wires. The investigation also revealed that the qualification LRV that was tested in a thermal vacuum chamber had solder connections, not the crimp splices as used on the LRVs.

The Apollo program did not want to impact the planned launch of Apollo 17, so they did not plan to make corrections to the LRV grounding to fix the problem. The grounding problem did not affect the LRV motor drive or mobility, only the electrical information displayed to the crew, and the MCC would keep track of battery ampere hours.

NASA engineering and contractor spacecraft design engineering supported the Apollo 17 mission in the MER as with the previous Apollo missions. After the Apollo 17 crew splashed down in the Pacific Ocean on 19 December 1972, the engineers in the MER removed their headsets as the Apollo program came to an end. The MER went on to support Skylab as well as test and orbital flights in subsequent programs until April 1988, when it was upgraded and moved to Building 30. ■

Acknowledgment

Thank you to SAIC’s Safety and Mission Assurance Senior Communications Analyst/Editor Joanna M. Opaskar.

Lunar Groundwork: Research and Technology in the Age of Apollo

» By **James Anderson**, Historian, Ames Research Center



↑ The Apollo 17 Command and Service Modules photographed from the Lunar Module during rendezvous and docking maneuvers in lunar orbit. Note the exposed Scientific Instrument Module Bay, where a lunar sounder, an infrared scanning spectrometer, and a far-ultraviolet spectrometer were housed along with a panoramic camera, mapping camera, and laser altimeter. (Photo credit: NASA)

WHEN THE S-IVB stage impacted the Moon following its separation from the Apollo 17 spacecraft on 10 December 1972, the resulting quake was detected by a network of passive seismometers on the Moon that had been stationed at the landing sites of Apollo missions 12, 14, 15, and 16. The less advanced Apollo 11 seismometer had returned data for about three weeks but was no longer able to detect impacts in December 1972. With the existing network of seismometers in place, Apollo 17 continued to advance the seismic study of the Moon, laying out a new array of geophones embedded around the Taurus-Littrow site and recording signals from eight explosive packages that Commander Gene Cernan and Dr. Harrison H. “Jack” Schmitt deployed and later detonated. Those seismic studies, however, were merely one facet of how this final Apollo mission built upon its predecessors and executed what was arguably the most ambitious itinerary for scientific exploration of the Apollo era.

Apollo 17 surpassed many of the benchmarks that prior missions had established. Cernan and Schmitt spent 75 hours on the Moon as Command Module Pilot Ronald Evans orbited

overhead. That was more than three times the duration of Apollo 11 and 4 hours more than the previous record holder, Apollo 16. They traversed more than 21 miles. That was 4 miles farther than the Apollo 15 and 16 missions, which also had a lunar rover, a defining feature of the extended-duration “J” missions. For comparison, Apollo 17’s 21 miles was 140 times the distance traversed during Apollo 11. Greater geographical coverage and more time on the surface enabled a greater opportunity to explore. Along the way, Apollo 17 collected the heaviest haul of lunar samples of any mission at just

Greater geographical coverage and more time on the surface enabled a greater opportunity to explore.

over 242 pounds of material, which included the deepest core samples drilled on any Apollo mission.

At least 10 new experiments debuted on Apollo 17, some of which were conducted aboard the Command and Service Module, while all the remaining experiments—whether aboard the CSM or on the lunar surface—followed up on many of the experiments that had been initiated earlier in the program. Some of the experiments even continued research into space biology that NASA had incorporated into crewed flights during Project Gemini, such as two in space biology, Biostack and Biocore, that investigated the effects of radiation. In fact, eight vertebrates traveled to the Moon on Apollo 17. Joining the three

Lunar Groundwork: Research and Technology in the Age of Apollo (continued)



Gene Cernan hammers a double core in the distance while seismic charge number 5 appears in the foreground (right) in this photo taken by Harrison Schmitt at Geology Station 9 during their third lunar extravehicular activity. (Photo credit: NASA)

astronauts, five pocket mice made the journey for Biocore, while Biostack, which had also flown earlier in the Apollo program, included specimens such as bacterial spores, plant seeds, and shrimp and insect eggs. Radiation in deep space remains one of the most significant threats to life during a prolonged trip and is currently the focus of experiments aboard the Orion capsule as well as on a dedicated space biology CubeSat, BioSentinel, that Artemis I recently deployed.

Not all the technology used on Apollo 17 was new, of course. Reliability and simplicity are crucial support factors that enable cutting-edge achievements. Throughout the Apollo landings, an array of geological tools was used. Aside from the development of the cordless drill, many of the tools were as mundane as hammers, rakes,

tongs, and scoops. One of the most frequently used tools was a simple dust brush. The potential for inflicting damage, combined with its pervasiveness, makes lunar dust an especially treacherous obstacle to many operations. Astronauts attempted to brush the dust off themselves before returning inside the Lunar Module, while outside the Lunar Module they frequently had to dust off equipment, from camera lenses to the rover's thermal surfaces and reflectors. The dust even imperiled the success of the mission at the beginning of the first traverse in the rover. In the right shin pocket of his suit, Gene Cernan's hammer inadvertently caught the right rear fender, knocking off the fender extension. The damage was potentially far greater than aesthetic. The turning of the rover's wheel soon kicked up enough lunar dust to become a nuisance that also



↑ Lunar surface extravehicular activity training at Kennedy Space Center, Florida. Scientist-astronaut Harrison Schmitt (foreground) simulates scooping up lunar sample material. Astronaut Eugene Cernan (background) holds a sample bag. (Photo credit: NASA)

The potential for inflicting damage, combined with its pervasiveness, makes lunar dust an especially treacherous obstacle to many operations.

Lunar Groundwork: Research and Technology in the Age of Apollo (continued)

threatened the thermal and mechanical functioning of the rover. Cernan spent a few minutes re-attaching the fender extension with “good old-fashioned American gray tape” as he described it while making the repair, but the fix fell off after about an hour. There are some issues that not even duct tape can solve.

On the ground in Houston, team members developed a plan for the second attempt at the fender fix in advance of the next two traverses. Duct tape received a mild redemption, returning once more to hold together an array of maps that would act as the fender. Instead of just duct tape, this time some clamps in the Lunar Module were repurposed to keep the replacement fender firmly in place. It held for the remainder of the mission. The issue is not unique to the Moon. Earlier this year, the accumulation of Martian dust on the solar panels of the InSight lander led to the gradual winding down of its extended mission, four years after landing and operating successfully on the Red Planet. In the trade space of potential engineering solutions for mitigating something like dust, sending a human with a brush to clean off some solar panels for a robotic mission on Mars or the Moon is comical. There is something about the fender fix on Apollo 17 that—while less critical than the carbon dioxide filter solution



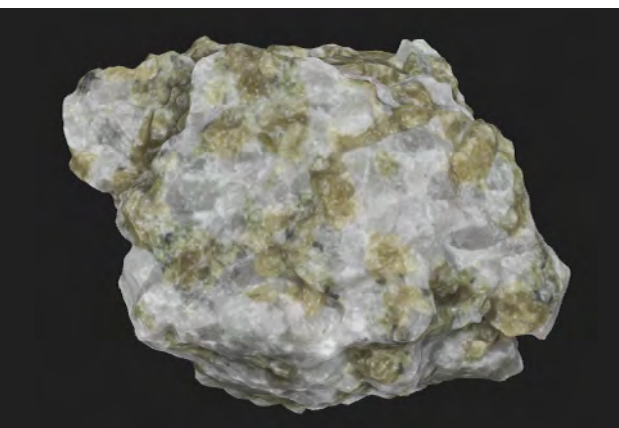
↑ **Left:** From left to right, John Young, Charlie Duke, Deke Slayton, Rocco Petrone, and Ron Blevins discuss the prototype for the rover replacement fender. Note the lunar maps, tape, and clamps that ultimately held the fender in place for the remainder of the traverses. (Photo credit: NASA) **Right:** A close-up view of the lunar rover with the final makeshift repair to the right rear fender. Schmitt is seated in the rover. (Photo credit: NASA)



on Apollo 13—is distinctly human. So, what might we take away from Apollo 17, beyond the mission highlights such as Schmitt becoming the first and, so far, only scientist to walk on the Moon?

The mission's success built upon a network. It was a network that first enabled Apollo to achieve its political and engineering feats, and, once Apollo 11's success was established, the network supported the expansion in

the engineering and scientific scope that occurred over the rest of the Apollo missions. Far more than simply a network of scientific instruments like the seismometers deployed during Apollo, the “lunar groundwork” of Apollo had also utilized existing space-based infrastructure, such as the solar-weather-monitoring network that the early Pioneer spacecraft composed. Apollo was never intended to create a self-sustaining Moon colony, but it was a series of integrated missions that built upon each previous mission rather than existing as repetitive one-offs that wound down as soon as the funding and the success of Apollo 11 subsided. In that context, even though subsequent Apollo missions had already been canceled and attention turned to the Space Shuttle, Apollo 17 was a culmination of what the program was able to achieve after the initial planting of flags and footprints. ■



← Lunar Sample 76535, collected at Station 6 of the Taurus-Littrow valley, is perhaps the most interesting rock that was returned from the Moon by the Apollo missions. Classified as a troctolite, it appears almost gemlike due to its atypical luster and color and has a unique crystalline structure. (Image credit: NASA)



Apollo 17 Crew Salutes Plum Brook Station

» By **Bob Arrighi**, Historian, Glenn Research Center

↑ The Engineering Building, seen here in the late 1960s, was the hub of Plum Brook management activities. The large cafeteria served as the primary staff assembly area. (Photo credit: NASA)

JUST BEFORE 1 P.M. on 16 February 1973, Apollo 17 astronauts Eugene Cernan, Ronald Evans, and Harrison Schmitt were whisked out of the cold and into the Engineering Building at NASA's Plum Brook Station¹ in Sandusky, Ohio. The crew, which had recently completed NASA's final Moon landing, were in the midst of the Agency's largest post-mission publicity tour to date. The men, the last humans to visit the Moon as part of Project Apollo, were feted at the Super Bowl, the White House, the U.S. Capitol, and dozens of other stops across the nation.

The visit to Lewis Research Center's (present-day Glenn Research Center) remote test facility at Plum Brook was different, however. On 26 December 1972—one week after the Apollo 17 crew returned to Earth—NASA Headquarters privately informed Lewis Center Director Bruce Lundin that it was terminating its nuclear propulsion

and power work in order to concentrate its decreasing financial resources on near-Earth space activities. The decision would result in the closure of Plum Brook Station and the separation of hundreds of employees.

In 1956, the Lewis Laboratory leased 500 acres at the massive, but inactive, Plum Brook Ordnance Works, located 60 miles west of the Cleveland campus, to construct a large test reactor to support its nuclear propulsion research. As construction progressed, the laboratory leased another 2,700 acres at the site to build a collection of smaller facilities to study high-energy cryogenic propellants. As this first wave of facilities began operation in the early 1960s, NASA formally acquired the entire 6,000-plus-acre property and began constructing larger facilities, including the nation's largest vacuum chamber and only facility for firing full-scale rocket stages in a simulated space environment.

Although some of the Plum Brook work had immediate applications for Centaur and the Saturn stages, much of the research was on nuclear propulsion systems, cryogenic fuel depots, and other advanced technologies for future extended missions to distant destinations such as Mars.

On Friday, 5 January 1973, Lundin made the trek to Sandusky to address the Plum Brook staff. Lundin's grim expression while taking the podium in the cafeteria dashed any hopes for post-holiday commendations. Instead, Lundin explained that as a result of post-Apollo reductions in federal funding, NASA was terminating programs with long lead times, including the nuclear work. As a result, the station would be closing imminently. The employees were tasked with wrapping up test programs and systematically mothballing the facilities while seeking new employment.

Apollo 17 Crew Salutes Plum Brook Station (continued)

It was into this environment that the Apollo 17 crew arrived several weeks later, on 16 February. It was a hectic day that also included stops at two local schools, a press conference, and

...the station would be closing imminently. The employees were tasked with wrapping up test programs and systematically mothballing the facilities while seeking new employment.

a visit to the Lewis campus. At Plum Brook, the three astronauts joined station manager Alan “Hap” Johnson at the head table in the cafeteria. Johnson noted the tight schedule and quickly turned the microphone over to the crew.

After a couple of droll comments to break the ice, Cernan addressed the situation. “Having never been here, it really is a privilege to be here because I’ve heard so much about what goes on. I know what’s happening here, and I wish I could bring you news from somewhere that someone’s changed their mind about closing Plum Brook or at least changing what they plan on doing with it. But I don’t have any of those words.”

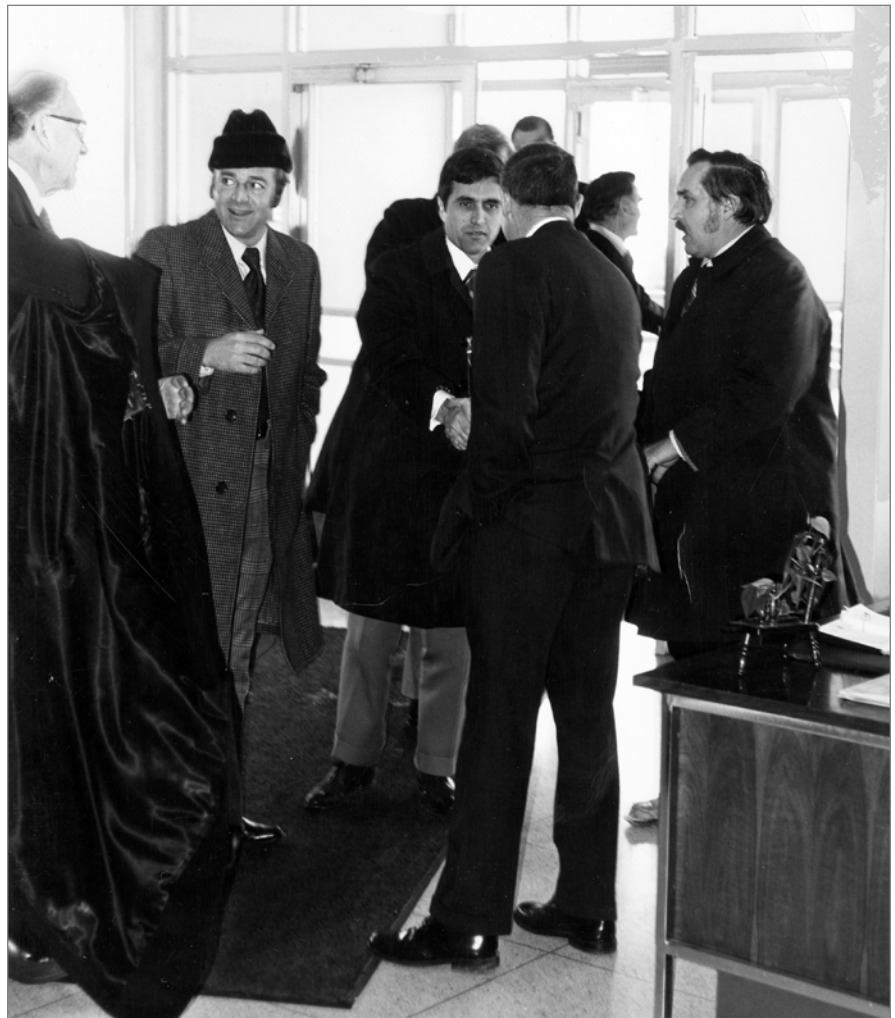
Instead, Cernan reminded them that Center management and local elected officials were working hard to ease the transition. He then switched gears, facetiously relating the difficulty in waking

Evans during the mission. Cernan then offered some general praise similar to that given to Agency employees across the country before returning his focus to those gathered in the room.

Although maybe in a few short months, many of you won’t be here in Plum Brook and many of you might not be here with NASA, but take with you a feeling of pride and a feeling of accomplishment for what you have contributed directly into the Apollo program, certainly

directly into the efforts of NASA and probably more important into the efforts and the prestige and a leadership of our entire nation. And wherever you go and whatever you do, I don’t think you’ll ever have to hold your head low to anybody for that. You can be proud. And if just by being here today I can give you a little bit of an identity, a little bit of feeling of belonging to those accomplishments, then certainly our visit here was

↓ Congressman Charles Moser (left) and Plum Brook Manager Alan Johnson (back to camera) welcome Ron Evans and Harrison Schmitt into the Engineering Building at Plum Brook Station. (Photo credit: NASA)



Apollo 17 Crew Salutes Plum Brook Station (continued)



↑ Plum Brook manager Alan “Hap” Johnson (left), Gene Cernan (center), and Ron Evans address the Plum Brook staff on 16 February 1973. (Photo credit: NASA)

more than worthwhile. For me it was very personally gratifying.

Cernan lightened things up again with more ribbing of Evans, who in turn related a couple of amusing aspects of the mission. Schmitt concluded the event by comparing the Agency’s upcoming near-Earth space activities to the settling of the American West, while stressing the need for further human exploration of the universe. At the end of the 30 minutes, the entourage filed out and headed to their next

stop, and the Plum Brook employees returned to their duties safely terminating station activities.

Neither the closure of Plum Brook Station nor the Agency’s focus on the Space Shuttle was permanent, however. NASA brought four major facilities at Plum Brook back online in the late 1980s and early 1990s whose subsequent tests have included large shroud separation systems, landing airbags for Mars Pathfinder, a radiator for a space station power system, the

Delta III cryogenic stage, and SpaceX’s Crew Dragon. Meanwhile, NASA has introduced several plans to return to the Moon in recent decades, most significantly with Artemis. In 2020, Plum Brook supported Artemis by testing the Orion spacecraft in simulated space conditions inside the Space Environments Complex. ■

Endnote

- 1 Plum Brook Station was renamed Neil A. Armstrong Test Facility in 2021.

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◀ Astronaut Ronald E. Evans holds up an autographed color photograph of the 7 December 1972 liftoff of Apollo 17, which he presented to the staff in appreciation for their contributions to human spaceflight. Looking on are astronauts Harrison H. Schmitt (center) and Eugene A. Cernan. (Photo credit: NASA/LaRC)

The Crew of Apollo 17 Visits NASA Langley

» By **Rob Wyman**, History and Archives Program Manager, Langley Research Center

A T THEIR OWN REQUEST, Apollo 17 astronauts Eugene A. Cernan, Ronald E. Evans, and Dr. Harrison H. Schmitt visited NASA's Langley Research Center in Hampton, Virginia, on 27 February 1973 to thank staff members for their contributions to human spaceflight.

"We stood on the shoulders of giants as we shot for the stars," said Cernan, pointing out that many of those giants were in the audience that had gathered in the hangar to listen to the astronauts talk about their voyage. "You here at Langley have a tremendous tradition. NASA really got its birthright here

and it is something we are all proud of," he added.

Evans spoke about his reaction on seeing Earth on his way to and back from the Moon. "It's my home—your home. We realized there is only one Earth and we must protect that Earth."

"We stood on the shoulders of giants as we shot for the stars."

Schmitt emphasized Langley's work on the Lunar Orbiter program, stating that it also played an important role in bringing science into the Apollo program. Not only did the orbiters successfully photograph 99 percent of the lunar surface—helping to identify locations for the lunar landing sites—but they also studied the Moon's gravity field, along with its radiation and micrometeoroid environment.

Schmitt also said there was "no question that Langley has to go into history as the ancestral home of manned spaceflight."

Langley made many other foundational contributions to the Apollo program. Several of the most significant facilities used to develop techniques for Lunar Orbit Rendezvous and to prepare the astronauts for Apollo missions were designed, built, and operated by Langley. These included the rendezvous and docking simulator and the lunar landing simulator, extravehicular activity techniques, and aerodynamics and structures research.

Following their remarks, the three astronauts presented then-Center Director Edgar Cortright with a replica of the plaque left on the Moon and an autographed color photograph of their 7 December 1972 liftoff from Kennedy Space Center in Florida. ■

Remote Sensing: A Breakthrough Technology for Archaeology

» By **Priscilla Foreman**, Summer and Fall 2022 NASA History Intern



↑ Deep in the Guatemalan jungle, Tom Sever and Ph.D. student Robert Griffin study a crumbled “stele,” a stone pyramid used by the Maya to record information or display ornately carved art. Sever and Griffin found the stele and other ruins hidden for more than 1,000 years during an expedition that relied on NASA remote sensing technologies to pinpoint sites of ancient settlements. (Photo credit: NASA/T. Sever)

IN THE SUMMER OF 1972, while Apollo 17 Commander Eugene A. “Gene” Cernan, Command Module Pilot Ronald E. Evans, and Lunar Module Pilot Harrison H. “Jack” Schmitt were in training for their upcoming lunar mission, the launch of another project NASA was working on would lay the foundation for expanding how we study Earth. Earth Resources Technology Satellite (ERTS)-1, later renamed Landsat 1, was launched on 23 July 1972 from Vandenberg Air Force Base in California. A collaboration between NASA and the United States Geological Survey (USGS), Landsat 1 became the oldest continuous Earth-observing satellite imaging program.

With this focus, Landsat 1 became a new tool transforming the study and practices of remote sensing. “Remote sensing” generally refers to obtaining information from the land surface through sensors mounted on aerial or satellite platforms. USGS Director Dr. V. E. McKelvey wrote, “The ERTS spacecraft represents the first step in merging space and remote-sensing technologies into a system for inventorying and managing the Earth’s resources.”¹ NASA scientists were not the only ones who saw the potential in using satellite Earth-observation technology, and

one man in particular saw how it could revolutionize his field of study: Dr. Thomas L. Sever.

The Pioneer

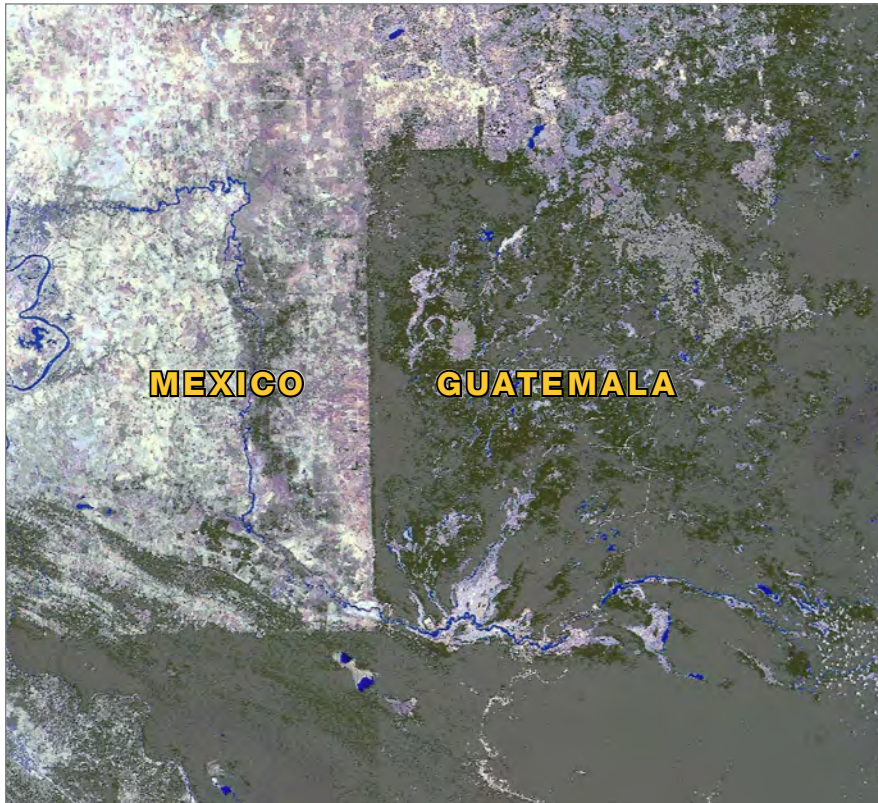
Tom Sever’s path to NASA was anything but conventional. He started off in seminary on track to become a priest but changed gears, deciding instead to earn a master’s degree and doctorate in archaeoastronomy and anthropology. After completing his doctorate, Sever worked for an environmental nonprofit as an archaeologist. While working on one project in Peru, Sever became frustrated and thought there must be a better way to do this. He began reading

“Traditional archaeology wasn’t going to work for me to answer the questions I had.”

and researching new technologies he could utilize. “Traditional archaeology wasn’t going to work for me to answer the questions I had,” Sever remembers.² After reading about imaging

work happening at National Space Technology Laboratories, now named Stennis Space Center, in 1981 Sever joined a Stennis team interpreting satellite images. On the side, Sever began mapping archaeological sites with the satellite imagery. Using the satellite imagery, he found what looked like ancient roadways in Chaco Canyon, New Mexico. Teams then verified the discovery on the ground: the paths were there and had been used by past civilizations. From this discovery, Tom Sever established himself as NASA’s only archaeologist and was energized by his findings. He began to organize conversations on the innovations that remote sensing could bring to the field of archaeology. Many archaeologists had their doubts about using this technology, but through more conversations with leading archaeologists, the great value of these applications became apparent. “They came away from the visit convinced that the new technologies to which they were introduced may represent the kind of scientific breakthrough for archaeology

Remote Sensing: A Breakthrough Technology for Archaeology (continued)



↑ The razor-sharp border between Mexico and Guatemala, as seen in this 1988 Landsat image, shows the impact of high rural population on the rainforest. Guatemala's sparsely populated Petén district stands in stark contrast to the stripped and tilled landscape of Mexico. This image prompted the leaders of Mexico and Guatemala to set aside long-standing tensions and focus on preserving the rainforest. (Image credit: NASA/Landsat)

in the second half of the 20th century that radiocarbon dating was in the first half of the century.”³ In March 1984, Tom Sever put on NASA’s first Conference on Remote Sensing in Archaeology, funded by NASA, the National Science Foundation, and the National Geographic Society. The conference was attended by 22 professional archaeologists and included numerous presentations on remote sensing technology and examples of its applications. The conference established collaboration between NASA and the archaeology community and led to NASA requesting proposals for

funding for several archaeology projects with remote sensing technologies.

Sever’s work went on to influence foreign government officials. In one such project, Sever used Landsat images to identify Maya sites near a proposed hydroelectric dam project. When identifying Maya sites near the Mexico-Guatemala border, images revealed that Mexico’s forests were decimated, while Guatemala still had rainforest cover. This discovery was crucial to the formation of the Guatemala Maya Biosphere Reserve, which was created in 1990 to help preserve the largest tropical rainforest in Central America.

Tom Sever’s contributions to remote sensing use in archaeology were substantial, and through his efforts, more archaeologists began to use these new technologies. While archaeologists were seen as the outliers in the scientific community in adopting remote sensing technology in the 1980s, there is less reluctance today.

Developments in Recent Decades

One of the most apparent improvements to remote sensing is new technologies improving our ability to see and view our planet through imagery; the Landsat program itself is now in its ninth iteration. Outside of improved remote sensing technology over the past 50 years, a key growth factor in remote sensing usage is improved accessibility. It is now easier than ever for anyone to use remote sensing technology. Sever remembers an episode in 1985: “The head of Harvard’s anthropology department told me my problem was that I was trying to bring math and science to a group of people that became archaeologists because it didn’t require math.”⁴ The anecdote illustrates how Sever faced difficulties convincing his primarily anthropology and archaeology colleagues to utilize new remote sensing technology.

At the heart of numerous remote sensing initiatives today is citizen science, where the public plays a substantial part in projects. One such project, GlobalXplorer, invites the public to analyze images of archaeological sites to identify disturbance and possible looting. NASA’s Applied Sciences Program makes satellite data available for the public to use to tackle various issues. While this more accessible approach to technology [\(continued on page 20\)](#) »

The Public's Understanding of the Problem of Space Debris

» By **Madelyn Pollack**, Summer and Fall 2022 NASA History Intern

ALTHOUGH THE GENERAL PUBLIC is familiar with terms such as “space junk” and “orbital debris” today, these words have been relevant since the launch of the first human-made satellite, the USSR’s Sputnik. When people stared up at the sky in late 1957, hoping to catch a glimpse of Sputnik, what they actually saw was its discarded rocket body—not the satellite itself. Since that time, the amount of defunct material in Earth’s orbit has multiplied at exponential rates. Space debris represents a risk to spacecraft, potentially damaging or destroying them through high-speed collisions or a sandblasting effect from the smallest objects. And although most debris burns up in the atmosphere, larger pieces can reach Earth’s surface intact, posing hazards to life on the planet.

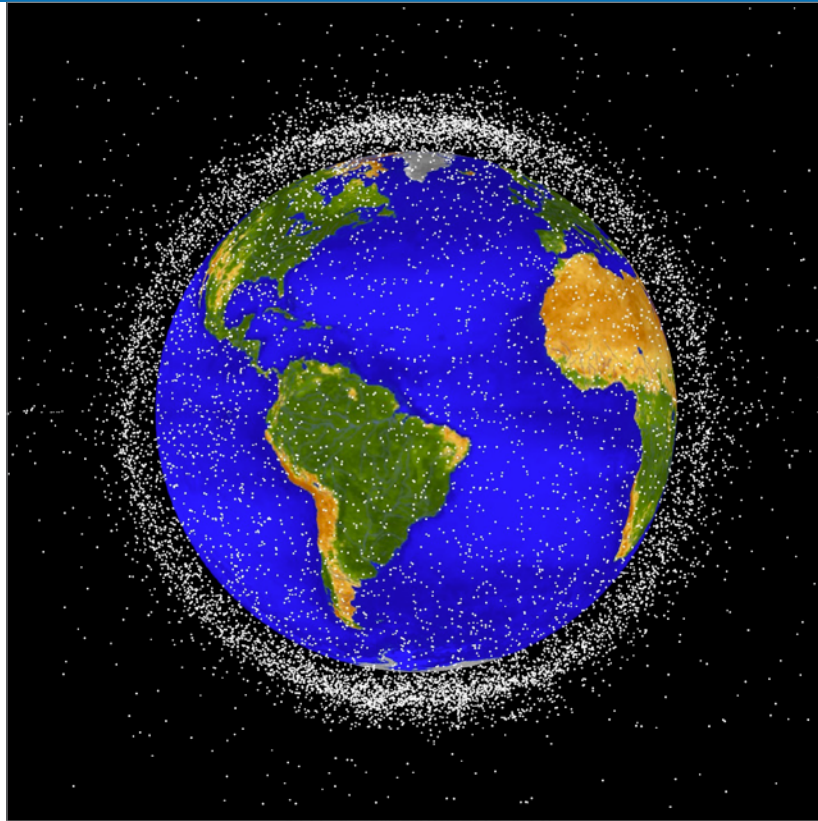
 Listen to Sputnik’s beeps.

Some historical events featuring space debris are more infamous than others. Unforgettably, Project West Ford, a Cold War communications project, intentionally launched millions of tiny

copper needles into orbit in 1961 and 1963.¹ The reentry of the Skylab and Mir space stations into Earth’s atmosphere and their crashes into Australia (1979) and the Pacific Ocean (2001), respectively, highlighted the dangers to all people on Earth as spacecraft deorbit. But more concerning to the future of spaceflight are in-orbit collisions, such as the 2009 event in which the defunct Russian Cosmos 2251 satellite smashed into the active U.S. Iridium satellite. It was the worst collision event to date, breaking both satellites into countless pieces that now orbit Earth at high speeds and present danger to active missions at similar altitudes. Debris can also be broken apart and increase in numbers when a country undergoes anti-satellite tests to blast their nonfunctioning spacecraft, like the November 2021 occurrence

orchestrated by Russia that forced astronauts on the International Space Station to undergo debris avoidance maneuvers and shelter in their escape pods in case of a breach of the Station’s protective shields.

Along with the glory and awe engendered by spaceflight missions, we must wrestle with the resulting space clutter’s effects in low-Earth orbit, namely pollution and threats of danger. Through a small-scale analysis of secondary sources and *Washington Post* public opinion articles in connection to orbital debris and spaceflight in the



↑ Computer-generated image of orbital debris as of 1 January 2019. (Image credit: NASA Orbital Debris Program Office)

 Watch a video modeling all tracked orbital debris items in 2019.

The Public's Understanding of the Problem of Space Debris (continued)

United States, I have identified several prevalent themes. First, many writers have stated the facts of the issue for public consumption and condemn the state of Earth's orbit, making calls to action. Second, as much as NASA and the public are aware of the presence of potentially damaging debris in orbit, there are still estimated millions of tiny particles that are untraceable by current technology. Even small items like paint flecks can cause critical damage! Third, there are currently no legally binding measures in place on an international scale to limit the amount of debris that goes into space, and any strategies to remove what is already there are not yet available for use.

Although the problem of orbital debris does not affect the average person on a day-to-day basis like other environmental crises we face, it is undoubtedly a growing concern with the potential to affect all people indiscriminately. In the last several years, we have seen more awareness portrayed in popular media. The fictional movie *Wall-E* (2008)

depicts a future where Earth and its orbit are so cluttered with debris that the entire population of the planet is forced to leave and wander the space landscape. *Gravity* (2013) is a fictional illustration of the "Kessler Effect" or "Kessler Syndrome," a term coined to describe a never-ending cycle of debris-creating collisions. In the movie, two astronauts working in low-Earth orbit struggle to return to Earth after debris from a destroyed satellite sets off a cascade of destruction. While these films are indeed fictional, the depictions represent real fears for Earth and its space neighborhood among non-experts.

Despite the media's coverage of the dangers of orbital debris, it may be surprising to learn that there seems to be little effect on the opinion of the pursuit of space exploration among Americans. Although we are conscious of the problems created by launching additional objects into orbit, rather than stop the direct cause of the problem, launches into orbit—which would be the simplest solution—we push for new, innovative

While these films are indeed fictional, the depictions represent real fears for Earth and its space neighborhood among non-experts.

ways to ensure a future in space. The analysis of these public opinions is important for many reasons, but most of all, the expression of opinions regarding orbital debris has the power to persuade governments to take action and work toward mitigation solutions. ■

Endnote

- 1 While many of the needles are believed to have deorbited, as of 2022, clumps of needles from the 1961 launch remain in orbit. See <https://www.orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv17i4.pdf>.

Remote Sensing: A Breakthrough Technology for Archaeology (continued)

is often criticized for the credibility of the users utilizing the data, the potential for significant discoveries is increased with the growing participation of the public. With access to new remote sensing technologies, we can continue to discover and document archaeological sites of civilizations in the past. These sites can contribute to our knowledge of past civilizations, which can, in turn, help us make informed decisions for the betterment of society. ■

Endnotes

- 1 Richard S. Williams and William Douglas Carter, *ERTS-I: A New Window on Our Planet*, USGS Professional Paper 929 (Washington, DC: U.S. Government Printing Office, 1976).
- 2 Pola Lem, "Peering Through the Sands of Time: Searching for the Origins of Space Archaeology," NASA Earth Observatory, <https://earthobservatory.nasa.gov/features/SpaceArchaeology> (accessed 11 November 2022).
- 3 Thomas Sever and James Wiseman, *Conference on Remote Sensing: Potential for the Future* (Mississippi: National Aeronautics and Space Administration, Earth Resources Laboratory, National Space Technology Laboratories, 1985), p. 1.
- 4 Massie Santos Ballon, "Tom Sever, Archaeologist," 25 May 2008, <https://scicom.ucsc.edu/publications/QandA/2008/sever.html> (accessed 5 December 2022).

News from NASA's Centers

NASA Headquarters

Washington, DC

» By Michele Ostovar

On 1 November 2022, Bob Jacobs, the Director of the History and Information Services Division of the NASA Office of Communications, happily announced the selection of Dr. Brian Odom as the Agency's new Chief Historian. Brian had been serving as NASA Marshall Space Flight Center's historian since 2016, and then as the Acting Chief Historian since August 2020, after the retirement of former Chief Historian Bill Barry. We are pleased to welcome Brian in his well-deserved promotion to this new permanent role. Congratulations, Brian!

NASA History Publications Update

» By **Stephen Garber**, NASA Headquarters, and **James Anderson**, NASA Ames Research Center

Roger Launius's *NACA to NASA to Now: The Frontiers of Air and Space in the American Century* will be published early in 2023. This one-volume survey history of NASA and the National Advisory Committee for Aeronautics (NACA) is the long-awaited successor to Roger Bilstein's *Testing Aircraft, Exploring Space* (Johns Hopkins University Press, 2003) and will serve as an excellent, up-to-date overview of the Agency's storied history.

After a significant delay, the fiscal year (FY) 2020 Aeronautics and Space Report of the President, an annual

congressionally mandated report detailing the U.S. Government's aeronautics and space activities, has been completed and is now available on the [NASA History website](#). Inputs have also been received from nearly all 12 contributing government agencies for a combined FY 2021 and 2022 report that will be available in the spring.

Also due to be published in 2023 is *A Wartime Necessity*, which focuses on the research efforts of the NACA as well as aeronautical research organizations outside of the United States during World War II, paying particular attention to how these organizations attempted to innovate at the time. Alex Spencer, an aeronautics curator at the National Air and Space Museum, has edited this collection of essays on a notable, if not well-covered, topic. The manuscript has been copyedited, is being prepared for layout, and likely will be published as an e-book in the new year.

Another publication currently in the works is a history of NASA's Discovery Program. The late Dr. Susan Niebur did a great deal of outstanding research and wrote the first draft before David Brown recently revised the manuscript. This book is scheduled to be published in fall 2023, around the time of the [Discovery@30, New Frontiers@20 history symposium](#). (See page 23 for more details.)

The NASA History program is also moving forward with another NACA-related publication called *Reflections on the NACA*. Originally developed

from a symposium, this manuscript features insightful essays about the NACA's culture, methods of research, accomplishments, and role in broader aerospace history from a variety of top-flight (pun intended!) aeronautics historians. It is also being envisioned as an e-book, complemented with a special web-based photo essay.

Finally, Bob Arrighi at NASA's Glenn Research Center is completing an updated history of NASA's wind tunnels, with a historic preservation slant and multiple illustrations. This manuscript should be ready for copyediting and layout early in 2023.

Armstrong Flight Research Center (AFRC)

Edwards Air Force Base, California

» By Christian Gelzer

Historian Christian Gelzer and a colleague have been examining newly acquired records of the Bell X-1 and its first supersonic flights, which Ed Saltzman gathered and preserved, beginning in 1961. (Read more about Saltzman in the [Summer 2022 issue of News & Notes](#).) Among the material is a handwritten list of X-1 flights with annotations. Two of the flights have no data ("folder missing"). There are also Mach number corrections for three of the flights, but no explanation of how the engineers corrected the initial data. Between 29 August and 4 November 1947, an unnamed pilot (records suggest it was Chuck Yeager) flew the X-1 15 times. At least six of these flights were supersonic. After Yeager's first

News from NASA's Centers (continued)

supersonic flight on 14 October 1947, the records show that the X-1 went supersonic on 28, 29, and 31 October and 3 and 4 November. If Yeager made all these flights, he did so with the broken ribs he sustained two nights before

his record-breaking flight. Most lists show James T. Fitzgerald, Jr., as the second pilot to go supersonic on 24 February 1948.

The material will eventually be added to the Center's historical reference collection. ■

Recent Aerospace History Publications

Please note that this list of recent commercially published works is not comprehensive and does not represent an endorsement by NASA.



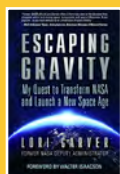
Fred Haise, *Never Panic Early: An Apollo 13 Astronaut's Journey* (Smithsonian Books, April 2022).



Maura Mackowski, *Life in Space: NASA Life Sciences Research During the Late Twentieth Century* (University of Florida Press, May 2022).



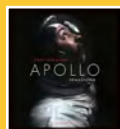
Govert Schilling, *The Elephant in the Universe: Our Hundred-Year Search for Dark Matter* (Harvard University Press, May 2022).



Lori Garver, *Escaping Gravity: My Quest to Transform NASA and Launch a New Space Age* (Diversion Books, June 2022).



Colin Burgess, *Soviets in Space: Russia's Cosmonauts and the Space Frontier* (Reaktion Books, July 2022).



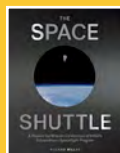
Andy Saunders, *Apollo Remastered: The Ultimate Photographic Record* (Black Dog and Leventhal Publishers, September 2022).



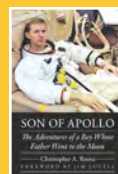
Andy Bruno, *Tunguska: A Siberian Mystery and its Environmental Legacy* (Cambridge University Press, October 2022).



Jim Bell, *The Art of the Cosmos: Visions from the Frontier of Deep Space Exploration* (Union Square, November 2022).



Roland Miller, *The Space Shuttle: A Mission-by-Mission Celebration of NASA's Extraordinary Spaceflight Program* (Artisan Books, November 2022).



Christopher A. Roosa, *Son of Apollo: The Adventures of a Boy Whose Father Went to the Moon* (University of Nebraska Press, November 2022).



Mary Jane Rubenstein, *Astrotopia: The Dangerous Religion of the Corporate Space Race* (University of Chicago Press, November 2022).



Becky Smethurst, *A Brief History of Black Holes: And Why Nearly Everything You Know About Them Is Wrong* (Macmillan U.K., November 2022).



Margaret Weitekamp, *Space Craze: America's Enduring Fascination with Real and Imagined Spaceflight* (Smithsonian Books, November 2022).

Other Aerospace History News

Call for Papers for Discovery@30, New Frontiers@20: A Symposium on the History of NASA's Discovery and New Frontiers Programs

Date: November 2023

Location: Washington, DC

Congress approved NASA's Discovery Program in 1993, initiating a new era of lower-cost, competed missions to explore the solar system. Like NASA's older Explorer program of astronomy and astrophysics missions, these missions were to be developed and led by principal investigators. In 2002, based on the model of Discovery but recognizing a need for medium-class science missions to tackle questions identified in the decadal survey, NASA initiated the New Frontiers Program. Over the past 30 years, missions from these two programs have transformed our understanding of our solar system and have accomplished historic firsts. They have also redefined the role of science and scientists in the development of planetary science missions, even as this willingness to experiment with innovative

management approaches created a tension with an often risk-averse NASA.

The NASA History Office and the Smithsonian's National Air and Space Museum invite proposals for papers to be presented at a two-day symposium to be held in November 2023 in Washington, DC. We welcome diverse voices and perspectives to examine the history of the Discovery and New Frontiers Programs, their successes and failures, and their impact on knowledge and the practice of planetary science. The symposium will be a combination of panel discussions, keynote talks, and group discussion. The intention is to publish an anthology of selected papers.

Visit the [Call for Papers web page](#) to see a list of potential topics for papers.

Submission Procedure

If you wish to present a paper, please send the title, an abstract of no more than 400 words, and a short biography or curriculum vitae, including affiliation, by 1 May 2023 to [Dr. Brian C. Odom](#), NASA's Chief Historian. Questions about the symposium are also welcome.

2023 Forum on Philosophy, Engineering, and Technology

The 2023 Forum on Philosophy, Engineering, and Technology (fPET 2023) will be held at the Technical University of Delft in the Netherlands on 19–21 April 2023. The conference will bring together engineers and philosophers to address the challenges of engineering in a changing world. We are currently witnessing disruptive changes due to climate change, pandemics, and war. Technological developments in, for example, geo-engineering, artificial intelligence, biotechnology, and neurotechnology may contribute to such disruptions but also help to better deal with them.

fPET 2023 will provide the opportunity to meet like-minded researchers and present and discuss research on the intersection of engineering and philosophy, addressing the theme of technology and engineering in a changing world, broadly understood. The conference will be a daring attempt to provide a forum to discuss engineering and philosophy in general, to meet and mingle, and to ignite the debate on a novel research perspective that draws from fields hitherto (largely) unconnected to the philosophy and engineering debate. It will also try out a new format and attempt to spur interdisciplinary collaboration. For details on the conference, including the Call for Papers and information about previous fPET meetings, see <https://www.fpet2023.org/>. ■



This artist's rendering shows the Discovery Program's Psyche spacecraft near the surface of the Psyche asteroid. (Image credit: Maxar/ASU/Peter Rubin)

Apollo Astronaut James McDivitt Dies at Age 93

» Reprinted from NASA Press Release 22-107

Former NASA astronaut James A. McDivitt, who commanded the Gemini IV and Apollo 9 missions, died Oct. 13. McDivitt passed away peacefully in his sleep surrounded by his family and friends in Tucson, Arizona. He was 93 years old.

McDivitt was born June 10, 1929, in Chicago. He graduated from Kalamazoo Central High School, in Kalamazoo, Michigan, before going on to receive a Bachelor of Science degree in Aeronautical Engineering from the

University of Michigan, graduating first in his class in 1959.

He joined the Air Force in 1951 and retired with the rank of Brig. General. He flew 145 combat missions during the Korean War in F-80 and F-86 aircraft. He was a graduate of the U.S. Air Force Experimental Test Pilot School and the U.S. Air Force Aerospace Research Pilot course and served as an experimental test pilot at Edwards Air Force Base, California. He logged more than 5,000 flying hours during his piloting career.

McDivitt was selected as an astronaut by NASA in September 1962 as part of NASA's second astronaut class.

He first flew in space as commander of the Gemini IV mission in June 1965. McDivitt was joined by fellow Air Force pilot Ed White on the program's most ambitious flight to date. During Gemini IV, White would become the first American to venture outside his spacecraft for what officially is known as an extravehicular activity (EVA) or as the world has come to know it, a spacewalk. In the following years, it was a skill that allowed Apollo explorers to walk on the Moon and American astronauts and their partners from around the world to build the International Space Station. The mission's four-day duration nearly doubled NASA astronauts' previous time in space to



↑ Astronaut James A. McDivitt, commander of Gemini IV, suited in preparation for weight and balance tests. (Photo credit: NASA)

that point, with the longest American spaceflight previously being Gordon Cooper's 34-hour Mercury 9 mission.

McDivitt's second spaceflight as the commander of Apollo 9 played a critical role in landing the first humans on the Moon. This was the first flight of the complete set of Apollo hardware and was the first flight of the Lunar Module. The mission launched from NASA's Kennedy Space Center on March 3, 1969, with Commander James McDivitt, Command Module Pilot David Scott, and Lunar Module Pilot Russell Schweickart. After launch, Apollo 9 entered Earth orbit and the crew performed an engineering test of the first crewed lunar module, nicknamed "Spider," from beginning to end. They simulated the maneuvers



↑ 1964 portrait of NASA astronaut James A. McDivitt. (Photo credit: NASA)

Apollo Astronaut James McDivitt Dies at Age 93 (continued)

that would be performed during actual lunar missions. During the mission, the astronauts performed a series of flight tasks with the command and service module and the lunar module. The top priority was rendezvous and docking of the lunar module with the command and service module. The crew also configured the lunar module to support a spacewalk by McDivitt and Schweickart. On Flight Day 10, March 13, 1969, the Apollo 9 capsule re-entered Earth's atmosphere and splashed down in the Atlantic Ocean, within three miles and in full view of the recovery ship, the USS Guadalcanal, about 341 miles north of Puerto Rico.

McDivitt logged more than 14 days in space.

After Apollo 9, he became manager of lunar landing operations, and led a team that planned the lunar exploration program and redesigned the spacecraft to accomplish this task. In August 1969, he became manager of the Apollo Spacecraft Program, guiding the program through Apollo 12, 13, 14, 15 and 16.

McDivitt retired from the U.S. Air Force and left NASA in June 1972, to take the position of executive vice-president, corporate affairs for Consumers Power Company. In March 1975, he joined Pullman, Inc. as executive vice-president and a director. In October 1975 he became president of the Pullman Standard Division, The Railcar Division, and later had additional responsibility for the leasing and engineering and construction areas of the company. In January 1981 he joined Rockwell International as senior vice president, government operations, and Rockwell International Corporation, Washington, D.C.

His numerous awards included two NASA Distinguished Service Medals and the NASA Exceptional Service Medal. For his service in the U.S. Air Force, he also was awarded two Air Force Distinguished Service Medals, four Distinguished Flying Crosses, five Air Medals, and U.S. Air Force Astronaut Wings. McDivitt also received the Chong Moo Medal from South Korea, the U.S. Air Force Systems Command Aerospace Primus Award, the Arnold Air Society JFK Trophy, the Sword of Loyola, and the Michigan Wolverine Frontiersman Award. ■

Upcoming Meetings

5–8 JANUARY 2023

American Historical Association 137th Annual Meeting
Philadelphia, Pennsylvania

<https://www.historians.org/annual-meeting>

23–27 JANUARY 2023

2023 American Institute of Aeronautics and Astronautics SciTech Forum

National Harbor, Maryland, and online

<https://www.aiaa.org/scitech>

8–10 MARCH, 2023

American Astronautical Society's Annual Robert H. Goddard Memorial Symposium

Laurel, Maryland

<https://astronautical.org/events/goddard/>

22–26 MARCH 2023

American Society for Environmental History Annual Meeting
Boston, Massachusetts

<https://www.aseh.org/Events>

28–30 MARCH 2023

International Astronautical Federation Spring Meetings 2023
Paris, France

<https://www.iafastro.org/events/iaf-spring-meetings/iaf-spring-meetings-2023.html>

30 MARCH–2 APRIL 2023

Organization of American Historians Annual Meeting
Los Angeles, California

<https://www.oah.org/meetings-events/oah23>

12–15 APRIL 2023

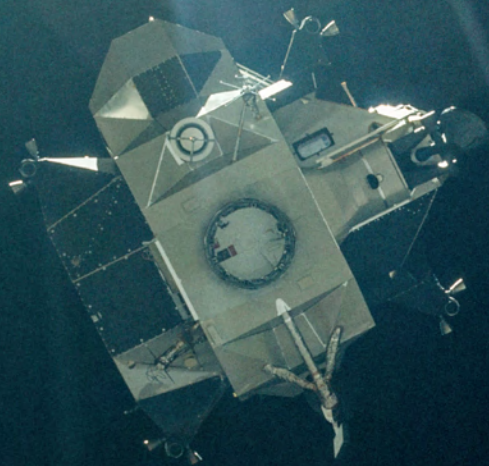
National Council on Public History Annual Meeting
Atlanta, Georgia

<https://ncph.org/conference/2023-annual-meeting/>

19–21 APRIL 2023

2023 Forum on Philosophy, Engineering, and Technology
Delft, Netherlands

<https://www.fpet2023.org/>



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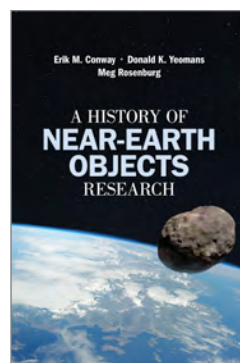
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Ron Evans captured this view of the Apollo 17 Lunar Module in orbit around the Moon prior to its docking with the Command and Service Module on 14 December 1972. (Photo credit: NASA)

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