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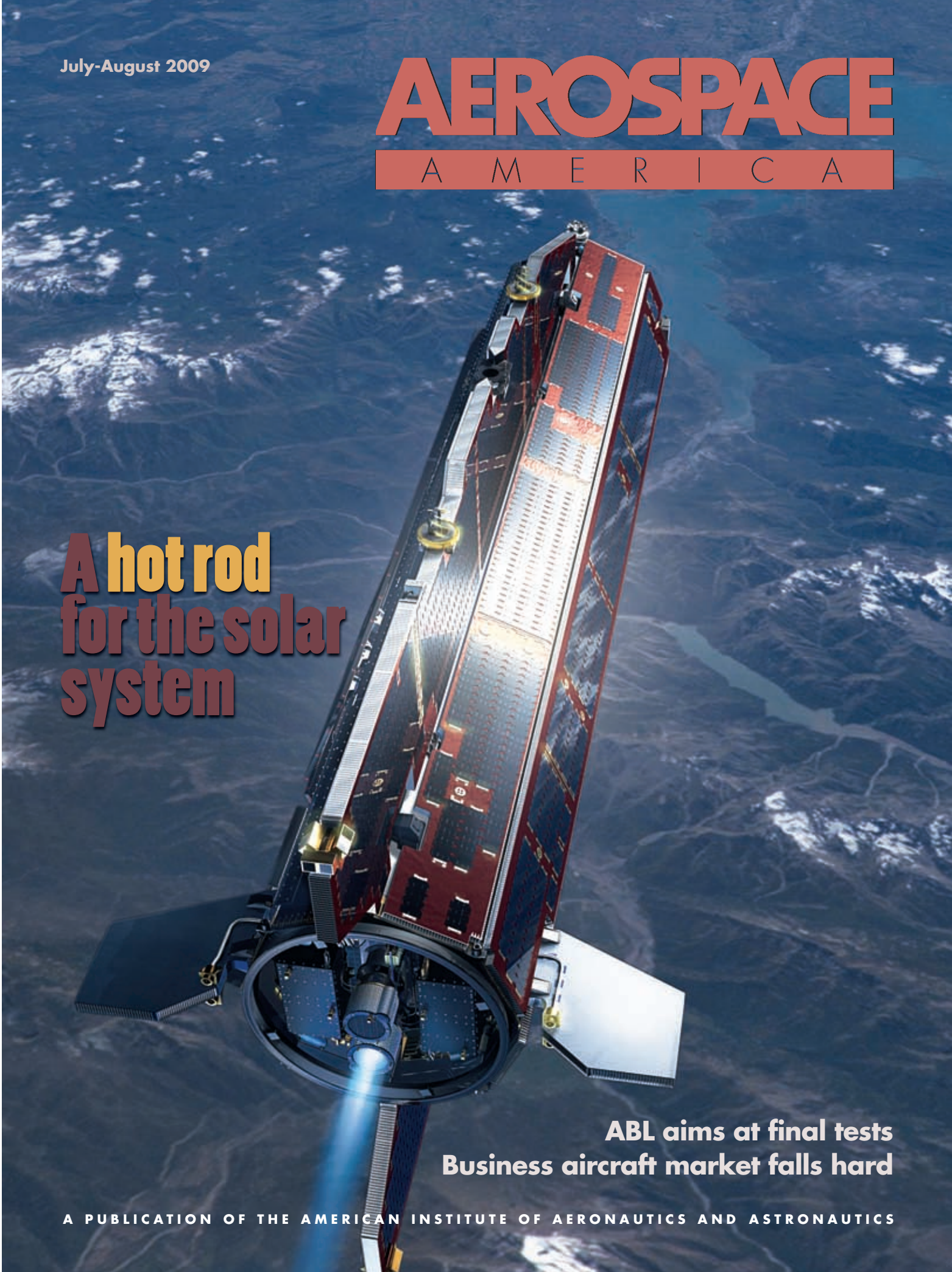

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Four test flights that boosted Apollo 11

THE DAY APOLLO 11 LANDED, 40 YEARS ago this July, my Baltimore family was in southern California, halfway through a cross-country road trip. Fresh from the beach, the six of us skipped the campground that night and clustered around our motel room TV, watching the ghostly shapes of Neil and Buzz bound across the lunar surface. With billions of others, we witnessed the culminating moment in a series of daring steps mounted by the U.S. since the shocking blow delivered by the 1967 Apollo fire. In fewer than 10 months beginning in the fall of 1968, NASA undertook four challenging test flights whose successes led directly to the achievement of President Kennedy's Moon-landing goal.

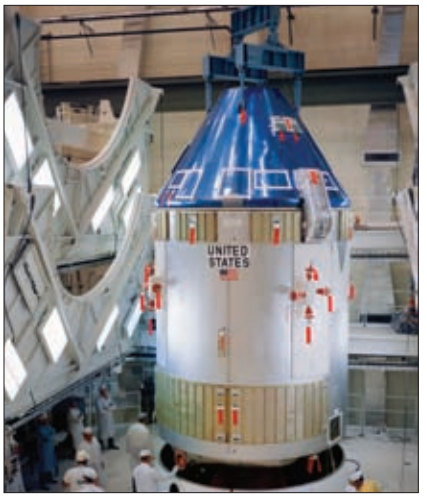
Apollo 11's triumph did not occur in isolation. It built on a string of ambitious missions of ever-increasing complexity, each venturing into unexplored dimensions of operational risk. A serious failure in any of the four Apollo missions preceding the landing would probably have caused NASA to miss JFK's 1970 deadline. Consider: Had events gone only slightly differently, the USSR might have notched the first manned flight around the Moon, and made a more vigorous bid to preempt Apollo with a robotic sample return and an eventual manned landing. Instead, the Soviets could do little but watch as NASA marched inexorably toward its lunar goal. The lessons of that test flight series are useful today as the agency grapples with technical and managerial challenges every bit as daunting as Apollo's.

Rising from the ashes

The January 1967 Apollo 1 fire brought NASA's new lunar program to a standstill. The entire Apollo command and service module (CSM) design had to be reviewed and revalidated. Astronaut Walt Cunningham, originally assigned to Apollo 2 with Wally Schirra and Don Eisele, had backed up Apollo 1's Virgil Grissom, Edward White, and Roger Chaffee. "We on Apollo 7 were beneficiaries of that thorough scrub—any possible defect related to the fire was eliminated," he says. Earlier, unmanned flight tests had proven some of the Apollo CSM systems, but Schirra, Eisele, and Cunningham would fly what was practically a brand new spaceship.

Their 11-day mission, launched October 11, 1968 from the same pad where the Apollo 1 crew had perished 21 months before, tested fuel cells, life support systems, computers, navigation systems, and the all-important service propulsion system (SPS) engine. The 20,500-lb-thrust SPS would get future crews into and out of lunar orbit, and it had to work: A failure could leave an orbiting crew stranded in space. Cunningham reports that before Apollo 7, Wally Schirra had insisted on an extra ground test firing of the SPS; no one was taking any chances.

Technicians move the Apollo 7 CSM into position for mating with the spacecraft LM adapter.



Once in orbit, the crew ran docking approaches to the Saturn IB's expended S-IVB second stage. The SPS then got a thorough workout, passing with flying colors, as did every systems test.

"I never heard of a test flight that had so little go wrong," says Cunningham today. "It was confirmation of what we'd all done to get ready." Their face-to-face debrief to the Apollo 8 crew took just a single day, and it was mostly "negative reporting," he says—"we mostly told them what didn't go wrong."

A lunar gamble

In August 1968, two months before Apollo 7 flew, Apollo spacecraft program manager George Low proposed to his colleagues that Apollo 8 should fly a lunar orbit mission. The audacious idea was based on three factors. First, the lunar module (LM) was behind schedule and would not be ready to fly with Apollo 8; why waste a mission repeating the Apollo 7 mission profile? Second, intelligence reports indicated the Soviets were

The crew of Apollo 7, ready for takeoff: Don Eisele, Wally Schirra, and Walt Cunningham (L.-r.).

Apollo 8 launches from Kennedy Space Center, December 21, 1968.

readying a revamped Soyuz for launch, perhaps to loop around the Moon. Such a success by the Russians would undercut the prestige of a later Apollo lunar mission, even one that entered lunar orbit. Finally, sending Apollo 8 to the Moon would prove software, navigation, and operations techniques for the later landing missions, an invaluable jump in deep space experience.

Some thought the risks too great. When Chris Kraft's flight control team met in August to weigh the mission's pros and cons, someone objected that the flight plan's timing dictated a night splashdown. According to *A Man on the Moon* author Andrew Chaikin, commander Frank Borman answered with characteristic bluntness: "What the hell difference does it make?…If the parachutes don't open, we're dead anyway, whether it's day or night."

In a series of such frank discussions, managers hammered out a decision in early November: Apollo 8 would shoot for the Moon.

The Apollo 8 crewmembers stand in the doorway of their recovery helicopter aboard USS Yorktown, following their splashdown on December 27, 1968. Left to right are Frank Borman, James A. Lovell Jr., and William A. Anders.

On December 21, 1968, Borman, Jim Lovell, and Bill Anders thundered moonward on the first manned Saturn V launch. The previous Saturn V test, Apollo 6, had barely staggered into orbit, suffering multiple engine failures. Worse, its third stage had failed to reignite for a simulated translunar injection. But Wernher von Braun's booster team at Marshall stated confidently they understood the failures—and fixed them in time for Apollo 8.

Late in their second Earth orbit, 186 km up, Apollo 8's crew commanded ignition of the S-IVB's J-2 engine. For 5 min 18 sec, it powered the stack out of Earth orbit, building its speed to 10.82 km/sec on a free-return path around the Moon. Chris Kraft radioed the crew: "You're on your way—you're really on your way now!"

The rest of the mission unfolded like clockwork. On December 24, Apollo 8 swung behind the Moon, firing the SPS to slow into an initial 311 x 112-km orbit. Each revolution took 2 hr.

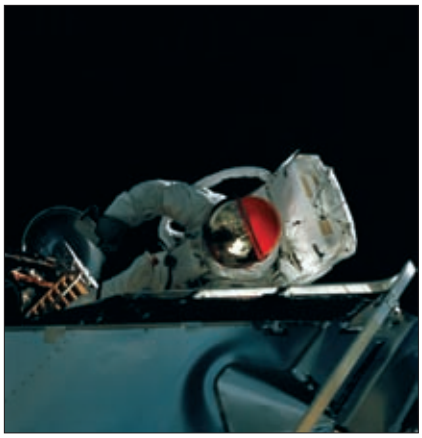
In the new book, *Apollo: Through the Eyes of the Astronauts*, Frank Borman recalls that first lunar orbit: "…The first view of the Moon was mesmerizing, as we were aware that no other humans had seen the far side of the Moon directly. The Earth, however, captured my attention. It was the only object in the universe that we could see that had color. It was beautiful—blue with white clouds—serene, and majestic. It was home."

For nearly an entire day the crew scrutinized landing sites, proved out communication and navigation routines, and later televised a moving Christmas Eve broadcast, reading from the Book of Genesis. Just after midnight on Christmas Day, on the lunar far side, the crew fired the CSM's SPS engine for the burn that had to work. When Apollo 8 reappeared from behind the Moon's trailing limb, Jim Lovell's voice confirmed that the SPS had done its job: "Houston, Apollo 8….Please be informed there *is* a Santa Claus."

Gumdrop and Spider

Apollo 8's safe return removed any worries about a Soviet Moon surprise and proved the Apollo spacecraft and ground team could handle lunar operations. But a landing still depended on a crucial test

The Apollo 9 crew, James McDivitt, David R. Scott, and Russell L. Schweickart, smile for the camera.



Apollo 9 LM pilot Rusty Schweickart stands in "golden slippers" on the LM porch on March 6, 1969.

of a spacecraft that had never carried astronauts: the lunar module.

Flown unmanned just once, the LM would now get a workout in LEO from the Apollo 9 crew: Jim McDivitt, Rusty Schweickart, and Dave Scott. Aboard their command ship Gumdrop, they were hurled into orbit by the fourth Saturn V on March 3, 1969. Three hours after orbit insertion, the crew turned the CSM around and docked gently with the LM, named Spider, nestled inside the top of the S-IVB third stage. Extracting the LM from the Saturn, the crew conducted test firings of the SPS engine to evaluate the structural integrity of the joined spacecraft.

Schweickart recalls: "We did a somewhat hairy structural test of the CSM/LM tunnel by purposely 'sawtoothing' the SPS engine back and forth during a burn. We also fully tested the ability of the LM to control the docked CSM/LM configuration…although that was never intended to be used." Schweickart finds it ironic that just over a year later, "many of the things we tested which seemed either incidental or even somewhat silly turned out to be essential to Apollo 13's successful return."

On the fourth flight day, he and McDivitt in the LM donned their lunar surface suits. Schweickart opened Spider's forward hatch, gingerly exiting onto the "front porch" platform for the EVA.

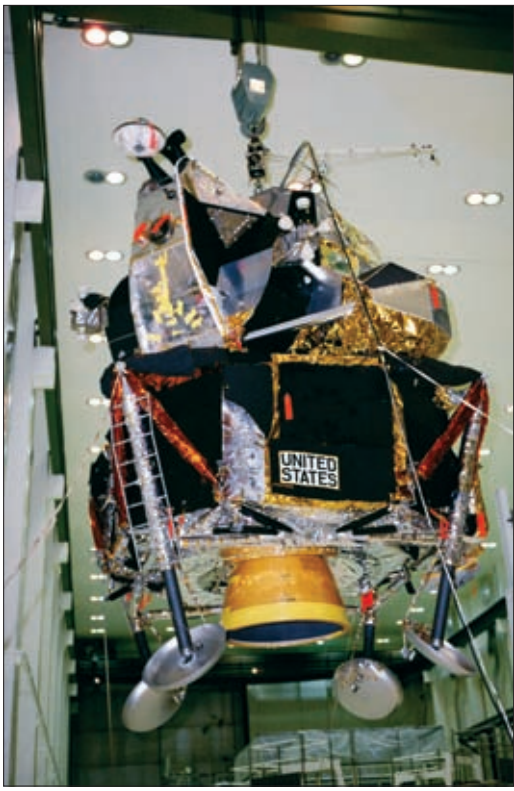
His spacewalk almost didn't happen. Schweickart had experienced space motion sickness on flight day 3, and the crew prudently canceled the planned EVA—getting sick inside a space helmet would be disastrous. Schweickart was crestfallen, but the next morning, he recalls, "based on my looking fine, and following a very brief discussion, Jim [McDivitt] pressed the transmit button and said 'Houston, we're going ahead with the EVA.'" He calls McDivitt's move "the most courageous command decision I've ever seen in operations."

Schweickart's hour-long spacewalk proved the life support backpack would perform under lunar conditions; CSM pilot Dave Scott, using umbilical suit connections, monitored and photographed Schweickart while standing in Gumdrop's open hatch.

The next day, Schweickart and McDivitt powered away from Gumdrop in the LM, the first independent flight of a piloted spacecraft without a heat shield for Earth return. For nearly 7 hr the men wrung out the LM systems, easing out to more than 179 km from Gumdrop. Both Spider's descent and ascent engines functioned well, as did the staging mechanisms to cut loose the lower stage of the lander. The pair returned in the ascent stage to dock with Gumdrop, proving the LM was ready. Schweickart says proudly that "Apollo 9 was rightly called the great engineering test flight of the program."

Snooping the Moon

NASA launched Apollo 10 on May 18, 1969, the fourth Apollo test in seven months. Astronauts Tom Stafford, John Young, and Gene Cernan embarked on a lunar orbital flight that was to rehearse every aspect of a Moon landing except the final descent and touchdown. Flight controllers would work simultaneously with the CSM and LM in lunar orbit. Swooping low over the Moon in their



Snoopy is moved for mating with the spacecraft lunar module adapter.

In June 1969, the crews of Apollo 10 and Apollo 11 conduct a debriefing session in Houston on the Apollo 10 "dress rehearsal" flight results. Clockwise, from left foreground, are Michael Collins, Edwin E. Aldrin Jr., Eugene A. Cernan, Thomas P. Stafford, Neil A. Armstrong, and John W. Young.

LM, Snoopy, astronauts Stafford and Cernan would reconnoiter the planned landing site for Apollo 11.

The command and service module, Charlie Brown, with Snoopy attached, dropped smoothly into lunar orbit three days after launch. On May 22, John Young backed away in Charlie Brown while Stafford and Cernan prepared Snoopy for the simulated landing approach. The pair fired the LM descent engine for 27 sec, dropping their perilune to only 15.7 km, or 50,000 ft above the Moon (an overburn of just 2 sec would have sent the LM crashing into the surface).

From the cockpit they watched the landscape rise impressively toward them: The stark rims of impact craters loomed above the horizon, and gigantic boulders dotted the rugged hills of the lunar highlands. To capcom Charlie Duke, Cernan radioed his excitement: "We is GO and we is down among 'em, Charlie!"

Stafford reported that Apollo 11's landing area looked acceptably smooth, but much as he and Cernan might have wanted to pull off that first touchdown, Snoopy was too heavy to make the attempt. Completing their reconnaissance, they prepared to jettison the descent stage and fire up the ascent engine for rendezvous.

Aboard Charlie Brown, Young was enjoying his solo piloting stint. He had tracked Snoopy in his sextant, photographed landing sites, and studied the Moon's geology. "The back side of the Moon is an incredible sight, full of impact craters," Young says. On Charlie Brown, he had readied a backup rendezvous maneuver, just in case Staf-ford and Cernan were stranded down low. "I was set up to go get 'em," he recalls.

For a few seconds it looked as if he might have to do just that. Just before Stafford jettisoned the descent section, the LM gyrated wildly. "Son of a bitch!...What the hell happened?" asked Cernan. But the scare, the result of a bad switch setting, was momentary: Stafford regained control within 20 sec. The rendezvous and docking with John Young were normal. Racing home after nearly 62 hr in lunar orbit, Apollo 10 hit Earth's atmosphere at a record-setting 11.08 km/sec. "We made the fastest entry in Apollo," says Young, "and landed within a couple of miles of the recovery ship, the USS Princeton."

Apollo 10 approaches splashdown.

Cernan says his crew was never disappointed at not being assigned the first lunar landing. In *Apollo*, he argues that "...we painted the white line in the sky so Neil [Armstrong] wouldn't get lost!"

Testing NASA

Armstrong, Aldrin, and Collins indeed found their way to the Moon and back, following the trail blazed by the preceding four flights. Apollos 7 through 11 followed a building-block approach toward the ultimate goal, each flight building on the lessons of the last. Every piece of vital hardware was thoroughly tested, as were the people and their complex, far-flung organization.

Walt Cunningham hopes that today's astronauts will participate as closely in the design and testing of Orion as his crew did in the dark days after the Apollo fire. "I believe Apollo was so successful because the astronauts *lived* with their spacecraft. We worked constantly with the engineers, looked at the drawings, sat on all the change boards, and made our inputs. We were amazingly well-listened-to. Everyone was interested in our thinking."

During 1968-1969, the fast-moving Apollo test series was based on reasoned decisions by a NASA leadership that successfully weighed risk against the national directive to accomplish a landing before 1970. During that time, NASA's managers made all the right calls, measuring the length of each forward step against that presidential deadline, opportunities enabled by previous successes and, to some extent, what the Soviets might do.

The NASA Constellation team is preparing its first flight, the Ares I-X flight, for early this fall. Pending the results of the Augustine review panel and the administration's budget choices, NASA's Exploration Systems Mission Directorate will mount future Ares/Orion tests to support the new spacecraft's first piloted orbital mission.

The value of the clear-eyed approach taken by Apollo's managers, flight controllers, engineers, and crews is inescapable. Their decisions are a model for success today, and a reminder that testing shortcuts, whether imposed by constrained budgets or demands to shorten "the gap," are counterproductive. Now more than ever, it is essential to remember that thorough testing and prudent decision-making will be keys to making our next giant leap successful.

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