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Curiosity on the move

Declassifying the space race: Part 2

High stakes for human-rating spacecraft

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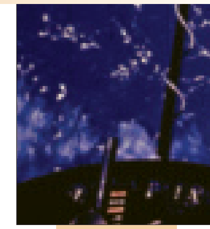


Gemini: Blazing the trail to the Moon

A 10-STORY-TALL TITAN II BOOSTER certainly makes an impression on a 10-year-old Cub Scout. Touring the Martin Marietta factory in Middle River, Maryland, in the summer of 1965, I craned my neck to look up 100 ft at a pair of silver and black Titans in their vertical test cells. I was captivated. Here were the rockets that would carry Gemini 7 and 8, and they were being built right in my hometown. Someday, I hoped to learn enough to join my neighbors who were building the Titans; if my wildest dreams came true, someday I'd ride on a rocket like that.

Forty-seven summers later, I'm still impressed with the Martin Baltimore team that assembled and launched the Titans powering the Gemini crews to orbit. I'm more curious than ever about how they did it—how they pulled off a dozen successful launches in a row, and in paving the way to the Moon, captured the lead in spaceflight from the Soviet Union.

Martin's Baltimore plant in Middle River, Maryland, conducted assembly and checkout of the Titan IIs selected for Gemini. Gemini-Titan GT-2 (the second unmanned Gemini launch) stands in the test cell in D building in 1964. It flew on January 19, 1965. Courtesy: Glenn L. Martin Maryland Aviation Museum.

Preserving that legacy is the Glenn L. Martin Maryland Aviation Museum in Baltimore, located on the site of that factory that performed final assembly and test of the Gemini-Titans before they were shipped to the Cape for their rendezvous with their astronaut crews, and with history.

Last fall the museum hosted a daylong symposium on the Martin Gemini effort, and attendees met a number of space veterans from the 1962-1966 program. The experts discussed the historical importance of Gemini, the technical challenges of human-rating the Titan II and operating the spacecraft, and their personal reflections on blazing a trail to the Moon.

On the shoulders of Titans

The 10 piloted Gemini missions, said Smithsonian National Air and Space Museum historian Michael J. Neufeld, gave the U.S. the undisputed lead in the space race. Neufeld recounted Gemini's major achievements: orbital maneuvering (to include rendezvous, proximity operations, and docking); a demonstration of astronaut endurance and productivity on missions lasting up to two weeks; successful EVA techniques and space suits; and experience in complex space/ground mission operations. All these combined to give NASA the confidence and depth of experience necessary to attempt Apollo's lunar landing missions.

Martin engineer Harry E. Mettee recalled that the Baltimore plant, which during WW II had turned out thousands of B-26 Marauder medium bombers and Navy flying boats, later fell on hard times. By the early 1960s, most of the aircraft manufacturing work was gone, and the workforce had dwindled far below the wartime peak of 53,000.

Salvation came when NASA designated Titan II as the Gemini booster. Most Titan manufacturing was done at Martin's Denver plant, far removed from surprise bomber or missile attack; Baltimore built the tank domes, skirts, midsections, and other Titan components. But NASA didn't want its Gemini launcher playing second fiddle at Denver, which was busy turning out hundreds of Air Force Titan I and II ICBMs. So Baltimore got the job of assembling all Gemini-Titans, including 'man-rating' them for astronaut flight.

Mettee recalled that the first Titan stages shipped to Baltimore required more than 200 weld repairs. Bastian 'Buz' Hello, Martin's Gemini program director, soon had Baltimore sending its own people to Denver to select only the best Titan stages. Manufacturing responsibility in Baltimore was in the capable hands of Francis O. 'Fuzz' Furman, a Martin factory legend. The 'Buz and Fuzz show' ran a tight ship.

NASA constantly chided Martin about the rigorous quality standards needed to man-rate the Titan. Furman, who helped institute consistent high quality throughout Martin's WWII manufacturing operations, was lectured yet again by a young NASA executive, who stressed that "men will be riding on this rocket." Furman shot back, "Who the hell do you think has been riding in all those airplanes we built over the past 30 years—monkeys?"

In 1966, Martin Baltimore technicians hoist the second stage of the Gemini IX Titan II into position for test. A dozen of the Air Force ICBMs were modified for Gemini launch duties; the Middle River-assembled Titans had a perfect flight record. Courtesy GLMMAM.

Martin built a high bay for vertical testing in D building, once a seaplane assembly line. Plastic bubbles served as clean rooms for critical Titan subassemblies, and Furman religiously enforced standards. He told one group of workers, "Be sure you're clean when you come in here. Some of you might have to take a shower more than once a week."

After vertical assembly and checkout of the Titans, the two-stage, 109-ft boosters were destacked and shipped to Cape Canaveral in Air Force C-133, or Pregnant Guppy, transports. Martin's record was near-perfect: Although Gemini VI-A did suffer a last-second engine shutdown on Pad 19 in 1965, it later launched successfully, as did the other 11 Gemini-Titans.

Riding the Titan II

One astronaut particularly grateful for Martin's attention to quality was Gemini XI pilot (and later Apollo 12 crewmember) Dick Gordon. At the symposium, Gordon recalled the thrilling experience of his Titan II launch riding next to commander Pete Conrad.

The Titan II's central mission was to place a 9-megaton thermonuclear device on the most hardened strategic sites in the Soviet Union, using a high-thrust, high-acceleration ascent profile. The first stage fired its twin-nozzled Aerojet LR87 engine (430,000 lb of thrust) for 2.5 minutes, subjecting the crew to 6 *g*s of acceleration at burnout. Titan II's second-stage LR91 engine ignited while still attached to the first stage, a sequence aptly called 'fire in the hole.'

Gordon, who says that "nothing important in spaceflight happens without an explosion," remembers that staging vividly. "We went from 6 *g*s to zero instantaneously. Then—CRASH!—the separation pyros fired, the second stage lit, and we accelerated away." Three more minutes at 100,000 lb of thrust pushed the 8,400-lb Gemini and its crew aggressively up to orbital speed. Plastered into his couch by more than 7 *g*s, a single question dominated Gordon's thoughts: "When is this mother going to quit?" Titan II took just five and a half minutes to reach orbit; by comparison, each of my space shuttle ascents lasted more than three minutes longer.

Gemini XI lifts off from Cape Canaveral's launch complex 19 on September 12, 1966. The Titan II shot astronauts Charles 'Pete' Conrad Jr. and Richard F. Gordon Jr. into their first-orbit rendezvous demonstration. Courtesy: NASA.

Proving rendezvous

A critical objective on Gemini XI was demonstrating a first-orbit rendezvous with the Agena target vehicle, which had launched earlier on the morning of September 12, 1966. Once blasted from the Moon, the Apollo lunar module ascent stage would have just nine hours of battery and consumables life. Conrad and Gordon had to prove they could catch an orbiting target well within that window. With a launch window only two seconds long, the Titan II thundered off Pad 19 just a half-second late.

Riding that fast break, Conrad and Gordon locked onto the Agena with their Westinghouse rendezvous radar, rippling off a rapid series of rendezvous burns. Their onboard radar and rendezvous charts worked accurately enough to dispense with the solutions from Houston's mainframes. In an impressive show of sighting, calculating, and precision flying, Gemini XI pulled up to the Agena just prior to the California coast, less than 94 minutes after launch. Another Gemini objective for Apollo was in the bag.

Westinghouse radar expert Ralph Strong recounted how Gemini XII's antenna electronics mysteriously failed, fortunately *after* the final Agena rendezvous. Telemetry revealed the cause to be electrical arcing, previously thought impossible in a vacuum. Engineers discovered there was just enough rarefied atmosphere in orbit to get electrons bouncing between conductors, cascading back and forth until a spark jumped the gap. His team verified and fixed the problem, but Strong says it confirmed his belief that "a random failure is simply one that you are unwilling to spend the energy on to understand."

Secrets of spacewalking

One of the biggest challenges for Gemini was EVA, crucial to the Apollo program's plans for surface exploration and emergency spacecraft repairs. Gordon recounted how NASA came away from Ed White's Gemini IV spacewalk with unwarranted confidence. Few guessed the challenges posed by working (not just floating) outside while battling a semirigid suit in the free-fall, vacuum environment. Gene Cernan's exhausting EVA on Gemini IX had come close to disaster; and when Gemini X's Mike Collins again struggled with fatigue when tackling seemingly simple tasks, NASA finally heard the wake-up call.

Enter Sam Mattingly, who in the early 1960s ran the Baltimore engineering firm Environmental Research Associates (ERA). Sam and his partner Harry Loats had been evaluating early space station airlock and hatch designs for NASA Langley; they soon concluded that 1-*g* crew evaluations could never yield accurate results. Mattingly, Loats, and Langley's Otto Trout decided they should evaluate the hardware under water, wearing a pressure suit weighted to produce neutral buoyancy, thus mimicking the challenges of movement in free fall.

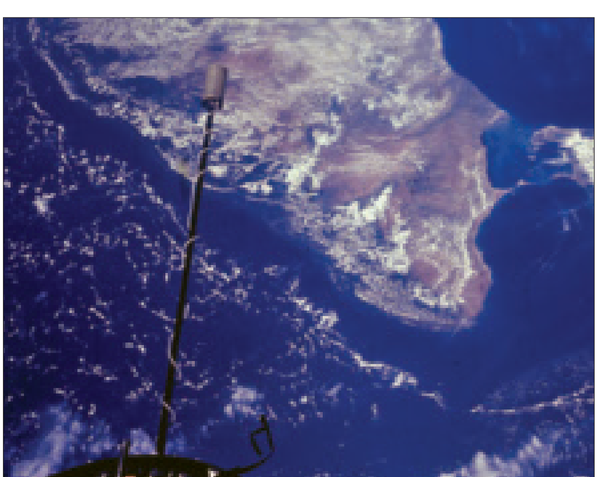
Borrowing a training suit from Norfolk NAS, Mattingly and his small team submerged the airlock mockup on the bottom of the swimming pool at the McDonogh School, just down the road from ERA's offices in northwest Baltimore. In July 1964, Mattingly donned a pressure suit and slipped beneath the surface, pouches of lead shot strapped to his limbs. Soon he and his colleagues were conducting extended simulations of various EVA tasks: hatch opening, airlock translation, and tool use.

ERA's neutral buoyancy tests on what later became the Skylab space station concept came to the attention of Gemini troubleshooter Dan Jacobs. He arranged an ERA demo of the Gemini X spacewalk tasks. "We ran that script under water and showed that some tasks weren't doable—unless you had three hands," says Mattingly. Collins' frustrating experiences in orbit confirmed the pool prediction—without handholds and anchors to free an astronaut's hands, even the simplest tasks outside proved daunting.

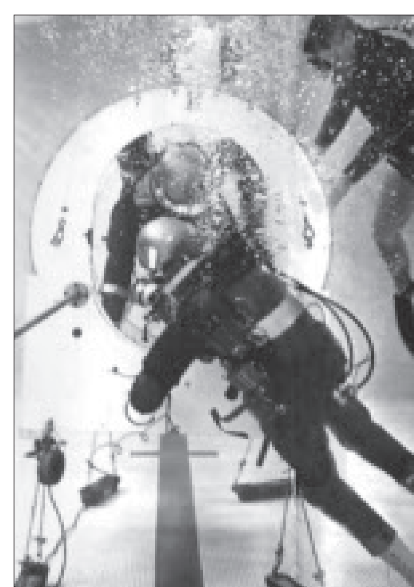
Jacobs sent Mercury veteran Scott Carpenter up to McDonogh. Armed with a power tool, Carpenter tried his hand at releasing 57 hatch bolts from a Saturn third stage 'wet workshop.'

"In 30 minutes he got maybe one bolt off," says Mattingly. Stiff suit gloves and a constant struggle to hold body position defeated Carpenter's best efforts. Over the intercom, Mattingly heard him lament, "I can't bend my [expletive] finger anymore!"

Cernan also came up to Baltimore, trying to understand what factors had undermined his Gemini IX EVA. Mattingly and company were able to show him that doing those tasks while 'free floating' was simply beyond any astronaut's capabilities—no one could have succeeded. A relieved and grateful Cernan took time out at McDonogh to give a pep talk to a star-struck audience of students watching from the pool bleachers.



Gemini XI soared above the southern tip of India, with island of Sri Lanka, and the Arabian Sea and Bay of Bengal. The Agena docking vehicle antenna mast projects into image; Conrad and Gordon had fired the Agena's engine to soar to a then-record height of 1370 km.



For early 1964 ERA neutral buoyancy studies, ERA cofounder Sam Mattingly was dressed in an Arrowhead pressure suit; he evaluated the problems involved with entering, traversing, and exiting a 4x6-ft airlock while 'weightless.' Success in these simulations enabled NASA to overcome Gemini's EVA challenges. Photo courtesy Sam Mattingly.

Gordon had used NASA's KC-135 aircraft to practice his Gemini XI EVA in brief, 25-sec bursts of free-fall, but "that was deceptive in that the airplane and helpers always gave you a stable starting point." ERA filmed their underwater simulation of the Gemini XI tasks, but Gordon's frenetic training pace kept him from seeing the movie before his September 1966 launch.

In orbit, Gordon was to rig a 30-m tether from the Agena to the Gemini docking bar, but could not stabilize his body over the Agena docking cone. The stiff suit prevented his legs from effectively straddling the Agena, and with one hand needed just to hold on, it was nearly impossible to connect the tether. His eyes stinging and nearly blinded from sweat coating his face, Gordon struggled to position his body.

He quickly realized that translating back to the Gemini adapter section for a power tool evaluation was out of the question. "I might have gotten there," he says, "but I would have killed myself in doing it." Just 30 minutes after Gordon left the cockpit, Conrad brought the exhausted astronaut back inside. "I knew it was going to be harder, but I had no idea of the magnitude," Gordon later reported.

Mattingly and his colleagues had seen it all coming. Soon another guest arrived at McDonogh: Gemini XII's Buzz Aldrin, intent on proving that EVA was doable. Training on a Gemini adapter section submerged in the McDonogh pool, Aldrin ran through a series of 2-hour exercises, working out how to use foot restraints, handrails, tethers, and simple tools. "He was a quick study," Mattingly recollects, "the smoothest of anyone who came in."

On November 13, 1966, Aldrin conducted a 2-hr, 6-min EVA, the second of the final Gemini flight. Using tethers, handholds, and the techniques developed in Baltimore, he retrieved a micrometeoroid detector, translated with ease to the rear adapter section, anchored himself in foot restraints, and proceeded to cut metal, torque bolts, and maneuver his suit with ease. Back at the Agena, he mated and demated electrical connectors and tested

Gemini XI astronaut Dick Gordon straddles the Agena spacecraft docking collar during his second EVA, on Sept. 13, 1966. Gordon struggled to complete his spacewalking tasks because of insufficient handholds and tethers outside, a problem finally resolved on Gemini XII. Courtesy: NASA.

an Apollo torque wrench. He finished up by wiping down the outside of commander Jim Lovell's window, prompting Lovell to ask, "Hey, would you change the oil, too?"

At the museum, Gordon acknowledged Aldrin's achievements: "Failure may be your best teacher. My failures helped make Buzz's EVAs a success."

Gemini lessons

Looking back on the significance of Gemini, Gordon reflected that the fast pace of the program, with a launch every two months, reduced NASA's ability to learn the utmost from each flight. "We would have liked to stretch out the launch interval to properly apply those lessons." But Apollo—and the Soviets—wouldn't wait. Even so, Gordon says firmly, "Gemini made possible Apollo's success."

A year has passed since the U.S. gave up its ability to launch its own astronauts to LEO. May's SpaceX/Dragon success at ISS shows that the U.S. is making slow but sure progress in resurrecting that capability. What NASA did 50 years ago is still doable today: The agency inaugurated Gemini in January 1962, and just over three years later, in March 1965, launched the first crew, Gus Grissom and John Young, into orbit. A commitment today to matching that performance would honor Gemini's accomplishments and restore a vital national capacity we unwisely let slip away. In 2012, rocket technology is still important, but steady leadership on policy and budgetary matters is what makes success in space possible.

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With the untimely passing of Neil Armstrong on August 25, America lost not just an intrepid Gemini veteran, but its most brilliant link to the heroic exploits of Apollo, when we reached out confidently to touch the face of another world. Armstrong was our exemplar of piloting skill and unassuming modesty, universally admired by the astronaut family. His career reminds us of the talents called forth by Apollo, and the serious leadership and steady determination we will need to stride beyond the bootprints of Armstrong and his colleagues.

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