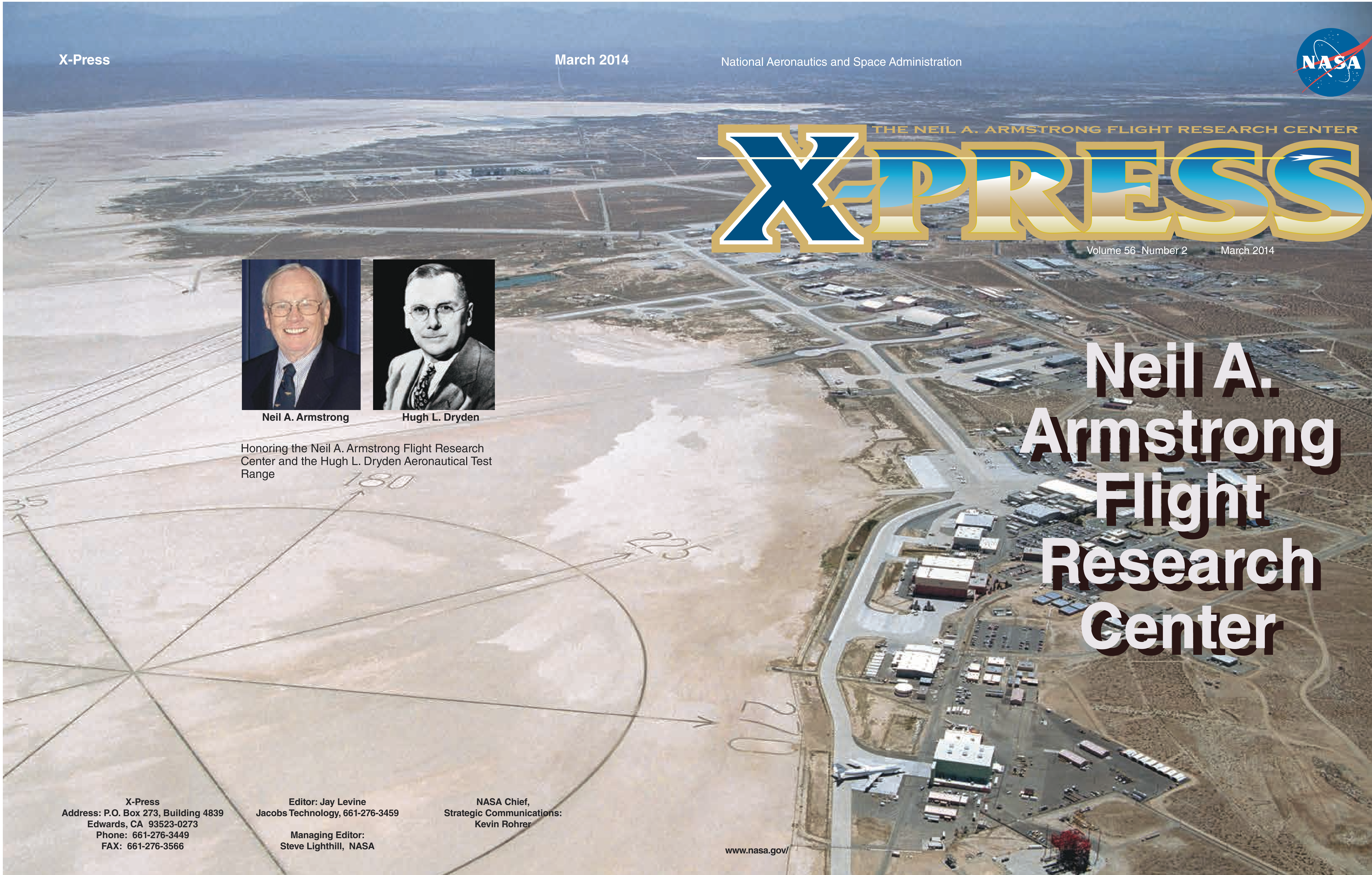

Neil A. Armstrong

Hugh L. Dryden

Honoring the Neil A. Armstrong Flight Research Center and the Hugh L. Dryden Aeronautical Test Range

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THE NEIL A. ARMSTRONG FLIGHT RESEARCH CENTER

X-PRESS

Volume 56 Number 2 March 2014

Neil A. Armstrong Flight Research Center

Index

Cover photo
Center overview by Carla Thomas, ED01-0264-14

ED14-0049-58
NASA/Tom Tschida

It's a time of change, but not of our vision, mission or values

Now is a time for change. It also is an opportunity to recommit to our existing vision, mission and values.

President Barack Obama signed congressional resolution H.R. 667 Jan. 16 changing the name of the Hugh L. Dryden Flight Research Center to the Neil A. Armstrong Flight Research Center. This change is an immense honor for our center. Neil Armstrong was the first man to stand on the moon – he was also an engineer and a research test pilot at this center.

While we are changing our name, we will continue to celebrate Dryden's legacy. The center's Western Aeronautical Test Range will be renamed in his honor. Dryden was the director of the National Advisory Committee for Aeronautics from 1949 to 1958 and the first deputy administrator for NASA until his death in 1965.

Dryden, when asked about the value of flight research with respect to the X-15 program, stated that the purpose is, "to separate the real from the imagined and make known the overlooked and unexpected." To that end, our vision will remain – to separate the real from the imagined through flight. And our mission will remain – advancing technology and science through flight.

We will recommit to our core values of safety, excellence, teamwork and integrity in all that we do.

Throughout our history with the NACA and NASA, our ties to the agency and our sources of funding have changed and evolved over time. But regardless of the changes the work that we do has remained constant as we fulfill a national need with our capabilities and competencies. Our role remains in the integration of complex flight systems and their safe test and flight operations.

Though we have diversified from our core aeronautics base, the work we continue to do in science and space exploration utilizes our ability to understand problems and the connection to flight, to understand the vehicle and to safely clear the flight envelope.

As of March 1, we are working on the transition for the name changes to celebrate these two great men.

We, as the Dryden – and now the Armstrong – team, have the ability to make complex flight systems work safely. That will not change.

David McBride
Neil A. Armstrong Flight Research Center director

Armstrong Director David McBride talks to U.S. Rep. Kevin McCarthy at the Antelope Valley Board of Trade Outlook Conference. It was announced at the conference when the name changes would be official. The background photo of adminis-trative Building 4800 and the X-1E research aircraft is by Carla Thomas, ED07-0296-14.

ED14-0049-58 NASA/Tom Tschida

Armstrong

From Wapakoneta, Ohio, to the moon

Neil A. Armstrong, the first man to walk on the moon, was born in Wapakoneta, Ohio, on Aug. 5, 1930. He began his NASA career in Ohio.

After serving as a naval aviator from 1949 to 1952, Armstrong joined the National Advisory Committee for Aeronautics, or NACA, in 1955. His first assignment was with the NACA Lewis Flight Propulsion Laboratory (now NASA Glenn Research Center) in Cleveland. For the next two decades, he was an engineer, test pilot, astronaut and administrator for the NACA and its successor agency, the National Aeronautics and Space Administration.

As a research pilot at the NACA High Speed Flight Station – now renamed in his honor – he was a project pilot on many pioneering high-speed aircraft, including the X-15 rocket plane. During his life he flew more than 200 different models of aircraft, including jets, rockets, helicopters and gliders.

Armstrong joined the astronaut corps in 1962. He was assigned as command pilot for the Gemini 8 mission. Gemini 8 was launched on March 16, 1966, and Armstrong performed the first docking of two vehicles in space.

As spacecraft commander for Apollo 11, the first manned lunar landing mission, Armstrong became the first man to land a craft on the moon and first to step on its surface.

NASA

Before he was accepted as an astronaut and went to the moon, Armstrong was a research pilot here. One of the aircraft he flew was the rocket-powered X-15 research vehicle. He is seen climbing the stairs to enter the X-15 for a flight.

Armstrong subsequently held the position of deputy associate administrator for aeronautics at NASA headquarters in Washington, D.C. In that position, he was responsible for the coordination and management of overall NASA research and technology work related to aeronautics.

He was a professor of aerospace engineering at the University of Cincinnati in Ohio between 1971 and 1979. Between 1982 and 1992, Armstrong was chairman of Computing Technologies for Aviation Inc., Charlottesville, Va.

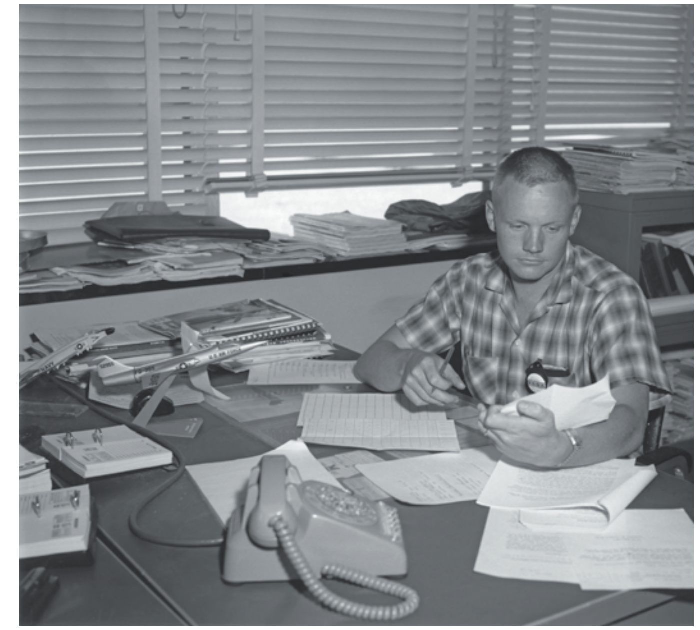
He received an aeronautical engineering degree from Purdue University and an aerospace engineering master's degree from the University of Southern California. He held honorary doctorates from a number of universities.

Armstrong was a fellow of the Society of Experimental Test Pilots and the Royal Aeronautical Society; honorary fellow of the American Institute of Aeronautics and Astronautics and the International Astronautics Federation.

He was a member of the National Academy of Engineering and the Academy of the Kingdom of Morocco. He served as a member of the National Commission on Space from 1985-1986, as vice-chairman of the Presidential Commission on the Space Shuttle Challenger Accident in 1986 and as chairman of the Presidential Advisory Committee for the Peace Corps from 1971-1973.

Seventeen countries decorated Armstrong. His special honors included the Presidential Medal of Freedom; the Congressional Gold Medal; the Congressional Space Medal of Honor; the Explorers Club Medal; the Robert H. Goddard Memorial Trophy; the NASA Distinguished Service Medal; the Harmon International Aviation Trophy; the Royal Geographic Society's Gold Medal; the Federation Aeronautique Internationale's Gold Space Medal; the American Astronautical Society Flight Achievement Award; the Robert J. Collier Trophy; the AIAA Astronautics Award; the Octave Chanute Award and the John J. Montgomery Award.

Armstrong passed away on Aug. 25, 2012, following complications resulting from cardiovascular procedures. He was 82.



NASA

Neil Armstrong is pictured at his desk in the pilots' office in 1960.

NASA

Neil Armstrong, from left, Joe Engle and Bill Dana pose in front of a Robert McCall painting at the center. Armstrong and Engle were here to honor Dana, who in 2005 received his astronaut wings for reaching the edge of space in the rocket-powered X-15.

Flying a big part Armstrong's life

Peter Merlin
Armstrong Public Affairs

When Neil Armstrong joined the National Advisory Committee for Aeronautics (NACA), NASA's predecessor, in 1955, he was already an accomplished aviator. Armstrong was fascinated with aviation from an early age, experiencing flight for the first time at age 5, when he was taken for a ride in a Ford Tri-Motor. At 15 he was taking flying lessons at a small airport near his home in Wapakoneta, Ohio, and obtained his private pilot's license at 16.

While studying aeronautical engineering at Purdue University on a Naval scholarship, Armstrong was called to active duty by the Navy in 1949, earning his wings flying jets. He deployed to Korea with a naval fighter squadron in 1951 and flew 78 combat missions in an F9F-2 Panther from the U.S.S. Essex.

Armstrong joined the NACA at what was then known as the Lewis Flight Propulsion Laboratory (now the NASA Glenn Research Center) upon his discharge from the Navy. A few months later, he transferred to the NACA's High-Speed Flight Station at Edwards Air Force Base, serving as an aeronautical research scientist and then as a test pilot at the facility that would one day bear his name, before joining the NASA astronaut corps in 1962.

While at the station, which was renamed the Flight Research Center in 1959, Armstrong flew 48 different experimental research, flight test and mission support aircraft. He performed stability and control research, flew chase and support missions, and developed a technique for surviving a launch mishap in an experimental space plane. He flew a wide variety of conventional aircraft, but he is better known for his seven research missions in the rocket-powered X-15, reaching speeds in excess of Mach 5 and altitudes above 207,000 feet. He eventually amassed more than 2,450 flight hours during his seven years at the center, part of the more than 6,000 hours he recorded in piloting more than 200 aircraft.

After joining the astronaut corps at the Manned Spacecraft Center (now NASA's Johnson Space Center) in Houston, Armstrong flew the Northrop T-38A Talon and the Bell Aerosystems Lunar Landing Training Vehicle. Following his NASA career he continued to fly numerous aircraft from sailplanes to the supersonic B-1B bomber. In 1979 he participated in five record-setting flights in a Gates Learjet.

With the NACA and NASA at Edwards, he flew the following types of aircraft:

Experimental Research Aircraft – Bell X-5, Bell X-1B, North American Aviation X-15, NASA Paraglider Research Vehicle (Parasev), Lockheed NT-33A Variable Stability Trainer, Convair NC-131B Flying Simulator

Fighters – Convair F-102, Convair F-106, Douglas F5D-1, Lockheed F-104, North American Aviation F-86D, North American Aviation F-100, McDonnell F-4, McDonnell F-101, Republic F-105, North American Aviation F-51.

Bombers – Boeing B-47, Boeing B-29

Trainers – Cessna T-37, Lockheed T-33

Transports – Douglas C-47, Beechcraft C-45, Boeing KC-135

General Aviation – Cessna L-19 Bird Dog, Piper PA-23 Apache, Lockheed JetStar

Helicopters – Hiller H-23, Piasecki H-21

Dryden

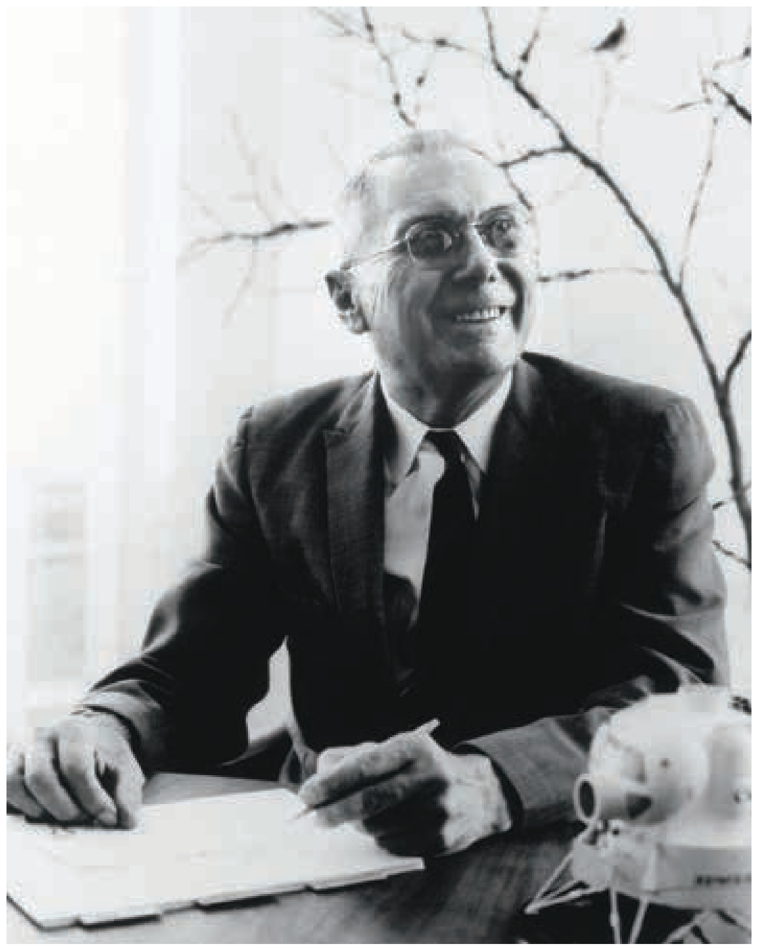
Separating the real from the imagined

By Christian Gelzer
Armstrong historian

The Hugh L. Dryden Aeronautical Test Range is named for a man who was one of America's most prominent aeronautical engineers. Dryden was a driving force for aeronautics, the National Advisory Committee for Aeronautics, or NACA, NASA and the agency's plan to go to the moon.

Of significance to Neil A. Armstrong Flight Research Center employees, during Dryden's career he approved of the establishment of a permanent aeronautics center here.

From an early age it was clear that Dryden was extraordinary. He entered Johns Hopkins University when he was 14, graduated with honors three years later and earned a master's degree in physics at the age of 17. He took a job at the National Bureau of Standards, or NBS, then one of only three federally funded research agencies in the U. S. Dryden continued taking additional graduate courses at Johns Hopkins in fluid dynamics and earned his doctorate in applied physics at 20 years old in 1919 to become one of the youngest students to ever to receive such a degree from that institution.



NACA

Hugh L. Dryden was a key figure in Aeronautics research and a driving force behind the National Advisory Committee for Aeronautics, or NACA, NASA and the plans for the moon mission. This image shows Dryden when he was serving as director of the NACA.

Dryden soon became head of the Aerodynamics division of the NBS where "he and [Dr. Lyman] Briggs obtained the first U.S. wind-tunnel data showing lift and drag for airfoils above the speed of sound," wrote former center historian Michael Gorn. It helped establish the young man's reputation in the field, but it also portended his leadership as well, he added. Some of Dryden's work in the mid-1920s investigated airfoil characteristics at air speeds at and just beyond the speed of sound. Dryden also is credited with coining the word transonic to describe airflow at speeds approaching Mach 1, or about 600 to 761 mph depending on altitude, temperature and atmospheric conditions. The fastest aircraft then flying could reach less than 300 mph. His data was used by the NACA and contributed to development of the laminar flow wings used on the famed P-51 Mustang fighter of World War II.

By 1934 Dryden was named chief of the Mechanics and Sound Division of the NBS, which included his own Aerodynamics Section. In 1935 he was one of three Americans invited to participate in the Fifth Volta Congress in Rome. Eastman Jacobs, of the NACA's Langley Aeronautical Memorial Laboratory, and Theodore von Kármán were the other two.

The Volta Congresses gathered extraordinary minds for presentations and discussions. The fifth congress focused on high speeds in Aviation and drew 38 of the world's greatest minds in the field, including Jacob Ackert, Ludwig Prandtl, Geoffrey Ingram Taylor and Adolf Busemann.

In 1938 Dryden was invited to present the Wilbur Wright Lecture at the Institute of Aeronautical Sciences. He read, "Turbulence and the Boundary Layer," a summary of the research to that point, including his own work. The onset of World War II brought Dryden new responsibilities in both research and leadership and he eventually led the Navy's Bureau of Ordinance Experimental Unit. There, his group successfully developed the Bat, an aircraft-launched gravity bomb capable of self-correction in flight, or a guided missile. The Bat was the only American guided missile used in combat during the war, which was credited with sinking several enemy vessels. Starting in late 1945 Dryden joined von Kármán in Europe where, now wearing military uniforms, they were part of advance teams visiting recently uncovered flight research laboratories. For his meticulous and laborious work documenting their discoveries, Dryden was awarded the National Medal of Freedom.

In 1946 Dryden became assistant director of the Navy's ordinance bureau, followed in six months by his appointment as associate director. Within another six months, he was selected to succeed George W. Lewis as the NACA's director of aeronautical research. The former Lewis Flight Propulsion Laboratory was named for him and the NASA facility is now called the Glenn Research Center.

By 1949 Dryden had become the first person to hold the new position of director of the NACA. Then, the NACA had about 6,000 personnel in major facilities at the Ames, Lewis, and Langley research laboratories, at Wallops Island, Va., and at what was then the High-Speed Flight Research Station at Muroc, Calif., now known as the Armstrong Flight Research Center.

Gorn described Dryden as, "perhaps the most influential civilian figure in American flight research," a characterization that held fast until the end of his life. From the start of his tenure he saw the need for – and followed through on the delivery of – new facilities for supersonic and hypersonic as well as high altitude research and the participation in such research with a raft of new and exotic aircraft.

Many of the aircraft were flown from the flight research center that shared Dryden's name for more than 30 years. One of the most famous of these aircraft was the North American Aviation X-15. An air-launched rocket plane designed to reach 200,000 feet and hypersonic speeds, the three X-15A research vehicles eventually reached Mach 6.7 and 354,200 feet. It became the first vehicle to exit Earth's atmosphere, fly back to a landing, and fly back again to space during the flight research program from 1959 through 1968. During a preliminary review of that program in 1956, Dryden laid out the X-15's purpose: "… to separate the real from the imagined problems [of hypersonic flight] and to make known the overlooked and the unexpected problems."

NACA

NACA Director Hugh L. Dryden presented the NACA Exceptional Service Medal to the flight and ground crew of the X-1A rocket plane research project at the NACA High Speed Flight Station on Nov. 26, 1956. From left are Dryden, X-1A research pilot Joe Walker, B-29 mothership pilot Stan Butchart and X-1A crew chief Richard Payne.

The launch of Sputnik alarmed neither Dryden nor his immediate colleagues. This may not have been to his benefit in the end, however, at a time when hysteria swept the nation. That was particularly true with the launch of Sputnik II barely a month after the first satellite went up. Many looked for someone to blame: Dryden seemed an ideal culprit. It did not help that he remained unflappable in the face of all this; so did President Eisenhower, but the blame could be more easily fixed on Dryden. The president only reluctantly gave into pressure from a host of special interests for some visible reaction to the Sputniks, and signed legislation creating a new agency to lead the nation's response, the National Aeronautics and Space Administration. NASA unfolded from the NACA in October 1958.

Although Dryden was instrumental in its creation, and should be credited as one of the forces ensuring it be a civilian agency that emerged, his association with the NACA was more than Congress could accept when it came to selection of the new administrator. That job went to T. Keith Glennan, then president of Case Institute of Technology – who accepted the job only on the condition that Dryden would be his deputy. Despite relegation to a less prominent position, Dryden remained unwavering in support for both aeronautics and space and understood well the importance that going to the moon and back represented, even when others around him saw it with less vision.

Dryden said in the early 1960s: "It is important to realize that the real values and purposes are not in the mere accomplishment of man setting foot on the moon, but rather in the great cooperative national effort in the development of science and technology which is stimulated by this goal. This national enterprise … is an activity of critical impact on the future of this nation as an industrial and military power and as a leader of the free world."

Dryden became NASA's revered elder statesman of science and shared with the administrator the management of a multi-billion dollar program to develop space vehicles, advance space-related sciences, enable humans to travel out to the moon and back and carry out extensive aeronautical research. Dryden also served as chief U.S. negotiator for early historic agreements with the Soviet Union on the peaceful use of space.

Dryden succumbed to illness in December 1965. President Lyndon Johnson, long an admirer of Dryden, stated publicly: "Whenever the first American space man sets foot on the moon or finds a new trail to a new star, he will know that Hugh Dryden was one of those who gave him knowledge and illumination." The center once named for Dryden now is named for Neil Armstrong, the first human to set foot on the moon and an immediate benefactor of much of Dryden's knowledge in aeronautics, hypersonics and spaceflight.

Reaction Control System

Keeping control of an aircraft at the edge of space required new thinking – enter the HSFS engineering staff

By Curtis Peebles
Special to the X-Press

Reaction control systems used on the X-15, the space shuttles and most spacecraft and satellites have their roots in the Mojave Desert. Reaction control systems allow maneuvering in space and low-Earth orbit.

A group of National Advisory Committee for Aeronautics engineers at the High Speed Flight Station, now known as the Armstrong Flight Research Center, had an idea in 1956 to control an aircraft at the edge of space.

In order to begin investigating the advanced concept, Richard Day, Joe Weil, Donald Reisert, Wendell Stillwell and several other NACA engineers at the HSFS knew they would need a sophisticated computer to power a flight simulator. The engineers convinced the Air Force to acquire and maintain a Goodyear Electronic Differential Analyzer, or GEDA, analog computer on base and allow them to use it.

Day and Weil developed the simulator that featured the world's first reaction control system. RCS consisted of small thrusters that fired to stabilize or redirect a vehicle in a vacuum. At that time no human had left the atmosphere. But the X-15 was on the way and the engineers knew that at its planned peak altitude – expected to be 200,000 feet (it eventually reached 354,200 feet) – there would be such low dynamic pressure that it would effectively be in space. Reaction controls were going to be essential. All this was new – what to use for fuel, how much thrust was needed, what were the effects of system lag, what was the control effectiveness and even how the control stick would work. With NACA pilots in the loop, the engineers ran simulations of the Bell X-1B on the GEDA to see how it might look.

Satisfied with the initial tests, the engineers saw to the construction of the Iron Cross simulator late in 1956, two long steel I-beams balanced on a universal joint and ballasted to the same inertial ratios as the X-1B. The center of gravity was at the pivot point while the "cockpit" was located a similar distance from the center of gravity as the X-1B's cockpit. The pilot's seat was perched on the I-beam.

NACA

Neil A. Armstrong pilots the Iron Cross simulator in 1956.

NACA

Engineers gather in 1956 to see a Iron Cross simulation.

NACA

The X-1B reaction control system thrusters are tested in 1958.

The pilot had a heading indicator, an artificial horizon and a sideslip indicator. Control came from nitrogen jets mounted in opposing pairs: two pointing up and down (for pitch control), two more pointing right and left (for yaw control) – all on the rear arm of the Iron Cross; two roll jets, pointing up and down, mounted on the right arm. At the end of each arm was a crash bar, a steel strip with a skid at its end to keep the Iron Cross from pranging on the hangar floor.

Stan Butchart and the other High Speed Flight Station pilots began flying the Iron Cross, among them a relatively new member to the pilot's group, Neil A. Armstrong. In time the engineers had an aluminum box added to the cockpit, eliminating visual cues so the pilots could only fly on instruments. But if they were to go beyond the theoretical they would have to put their idea onto an airplane.

They selected the Bell X-1B, a second-generation design that used the same wing, horizontal tail and XLR11 rocket engine as the first generation X-1 rocket plane, but with a fuselage just over four-and-a-half feet longer (the maximum length that would still fit in the bomb bay of the B-29 launch aircraft). Work on the X-1B's RCS installation began in February 1957, which had to be shoehorned into the aircraft since it wasn't part of the initial design. A single pair of roll thrusters was mounted in the left wingtip; the yaw thrusters were in the rear fuselage, placed ahead of the tail assembly. Pitch thrusters were oddly located: one under the forward fuselage, the other just above the rocket nozzle. The thrusters were powered by 90 percent concentrated hydrogen peroxide, forced over silver-coated stainless steel screens. The hydrogen peroxide decomposed into 1,300 degree Fahrenheit steam that blasted out the nozzle to produce thrust.

By July 1957, preparations were underway to begin the RCS research flights; at this point Armstrong joined Butchart as pilot on the research project. Armstrong transferred to the HSFS from the NACA's Lewis facility (now Glenn) in 1955 and over the next two years flew a wide range of aircraft at the facility. He had been flying the F-51 chase plane when the X-1A exploded, had been the co-pilot on the P2B-1S launch aircraft on March 22, 1956, when engine number 4 lost a propeller that then took out engines numbers three and two in the process, but Armstrong had not yet flown a rocket plane.

Armstrong made his first X-1B flight on Aug. 15, 1957, during which the number two rocket chamber failed to light after the aircraft was released from the launch aircraft. Despite this, he reached a speed of Mach 1.32 at an altitude of 45,000 feet on the remaining three cylinders.

Armstrong's next tests of the RCS came early in January 1958. But there were problems getting pressure readings from either the hydrogen peroxide tank or the RCS itself. In the X-1B cockpit, nestled in the bomb bay at some 25,000 feet, he fired the thrusters. Observers inside the B-29 and in the chase plane confirmed they worked, and so the crew decided to continue the mission but to launch closer to Rogers lakebed; that way, if Armstrong was unable to start the rocket engines he could glide to a lakebed landing.

On Jan. 16 the release was made directly over the intended landing area and Armstrong successfully ignited the XLR11. During the climb he fired each of the six RCS thrusters in turn for one second. Reaching 45,000 feet, he began the pushover to level flight, flew a relatively low-altitude/low Mach profile, shut down two of the four

NACA

The Iron Cross simulator was encased to eliminate a pilot's visual cues in order to focus on the instrumentation.

chambers, then a third soon after, followed by a complete set of RCS firings. After shutting down the final chamber Armstrong again fired all the RCS rockets. He noted that although the X-1B was flying at a relatively high dynamic pressure during all of the thruster firings, RCS effectiveness was pronounced. He made a successful deadstick landing on the lakebed.

The resumption of the X-1B RCS flights was originally scheduled for May 28, but a preflight inspection of the aircraft found four cracks in the bottom of the liquid oxygen, or LOX, tank. These were welded closed. X-rays of the LOX tank were taken on June 4, and when they were examined, internal cracks were found again. It was time to park the airplane permanently and find another platform to continue testing RCS.

The choice was the F-104A, which soon became the JF-104A in recognition of its temporary modification. Chief pilot Joe Walker made the first RCS flight on July 31, 1959, taking it to an altitude of 30,000 feet, a speed of Mach 0.8. By the time the JF-104 flights were drawing to a close, the X-15 was beginning its early research flights. The relationship between the data collected from the JF-104 RCS flights and the final design of the X-15's RCS was clear: the latter had eight yaw and pitch thrusters located on the nose while two roll thrusters were positioned near each wing tip.

Because a failure of the RCS at high altitude would lead to the loss of the X-15, the thrusters were divided into two separate, redundant systems. During the JF-104 flights, a reaction augmentation system (RAS) was tested to increase the stability of the aircraft at low dynamic pressure. North American Aviation, the X-15's builder, proposed an RAS be added to the aircraft: Armstrong and Walker flew a simulation of the RCS and agreed that it made the simulation easier to fly. In 1963 an RAS was added to X-15s numbers one and two. By this time, human spaceflight had become a reality and RCS was an essential part of every space-bound vehicle.

Armstrong was an integral member of the team that developed RCS from the Iron Cross onward. "If I have seen further," said Isaac Newton, "it is by standing on the shoulders of giants." Those who travel safely in space do so on the shoulders of people like Butchart, Day, Weil, Reisert, Stillwell, Walker and Armstrong.

Apollo 11

First steps on the moon

Apollo 11 astronauts Neil Armstrong, Buzz Aldrin and Michael Collins sat atop a Saturn V at the Kennedy Space Center on July 16, 1969. The three-stage 363-foot tall rocket with 7.5 million pounds of thrust was used to propel the astronauts into space and into history.

The engines fired and Apollo 11 cleared the tower. About 12 minutes later, the crew was in Earth orbit.

After 1½ orbits, Apollo 11 received the green light to head for the moon. Three days later the crew was in lunar orbit. A day after that, Armstrong and Aldrin climbed into the lunar module Eagle and began the descent, while Collins orbited in the command module Columbia.

When it came time to land Eagle in the Sea of Tranquility, Armstrong improvised, manually piloting the ship past an area littered with boulders. During the final seconds of descent, Eagle's computer was sounding alarms.

The computer was fine – just challenged by the big workload. Aldrin noted, "Unfortunately it came up when we did not want to be trying to solve these particular problems."

When the lunar module landed, only 30 seconds of fuel remained. Armstrong radioed, "Houston, Tranquility Base here. The Eagle has landed." Mission control erupted in celebration as the tension broke and a controller told the crew, "You got a bunch of guys about to turn blue, we're breathing again."

NASA

Crater 308 stands out in this photo from lunar orbit.

Armstrong later confirmed that landing was his biggest concern, saying, "the unknowns were rampant," and "there were just a thousand things to worry about."

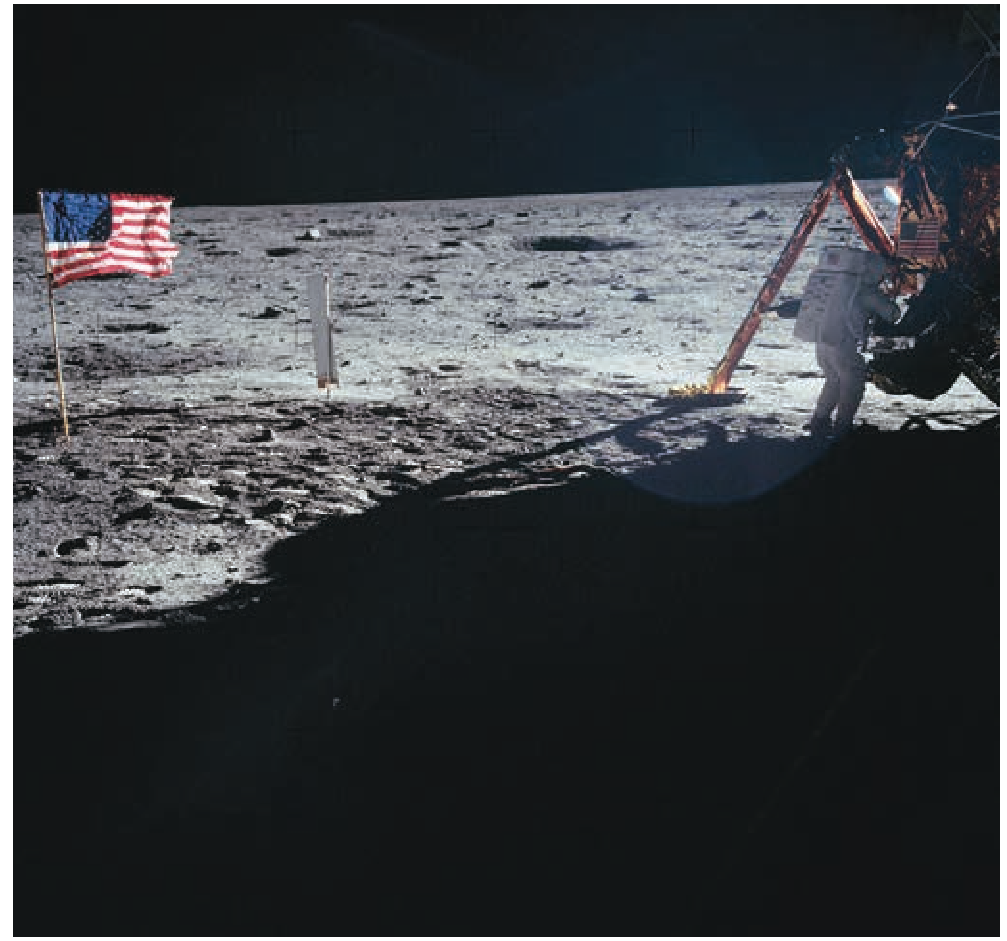
Once on the moon, Armstrong was ready to make the first human footprint on another world. More than half a billion people watched on television as Armstrong climbed down the ladder and proclaimed: "That's one small step for a man, one giant leap for mankind."

Aldrin joined him and offered a simple but powerful description of the lunar surface: "magnificent desolation." They explored the surface for 2½ hours, collected samples and took photographs.

They left behind an American flag, a patch honoring the fallen Apollo 1 crew and a plaque on one of Eagle's legs. On the plaque is, "Here men from the planet Earth first set foot upon the moon. July 1969 A.D. We came in peace for all mankind."

Armstrong and Aldrin blasted off and docked with Collins in Columbia.

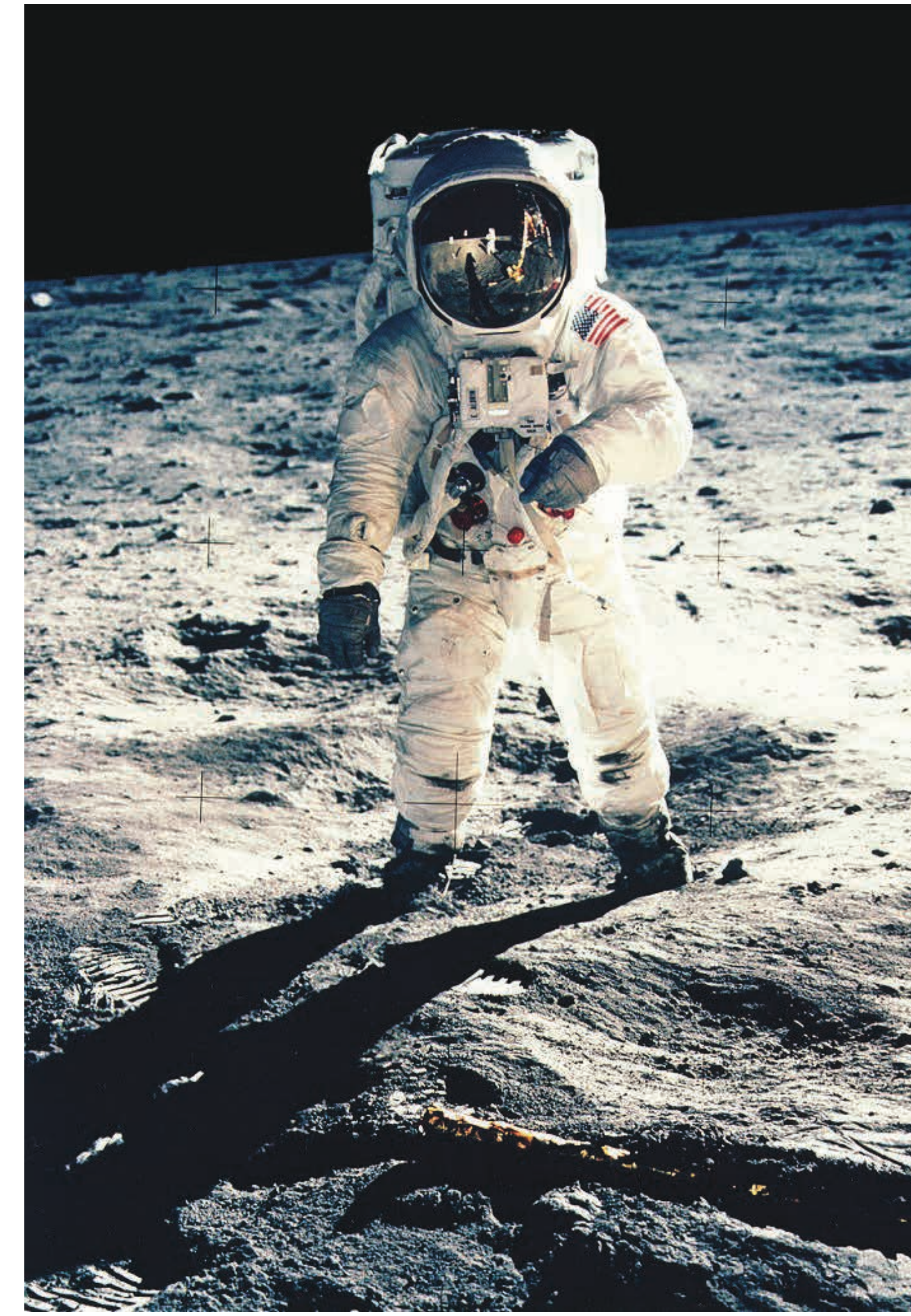
Apollo, page 19



NASA

Above, *Apollo 11 Commander Neil Armstrong works at an equipment storage area on the lunar module. This is one of the few photos that show Armstrong during the moonwalk.* ***Below,*** *Armstrong is in the lunar module following his historic moonwalk.*

NASA

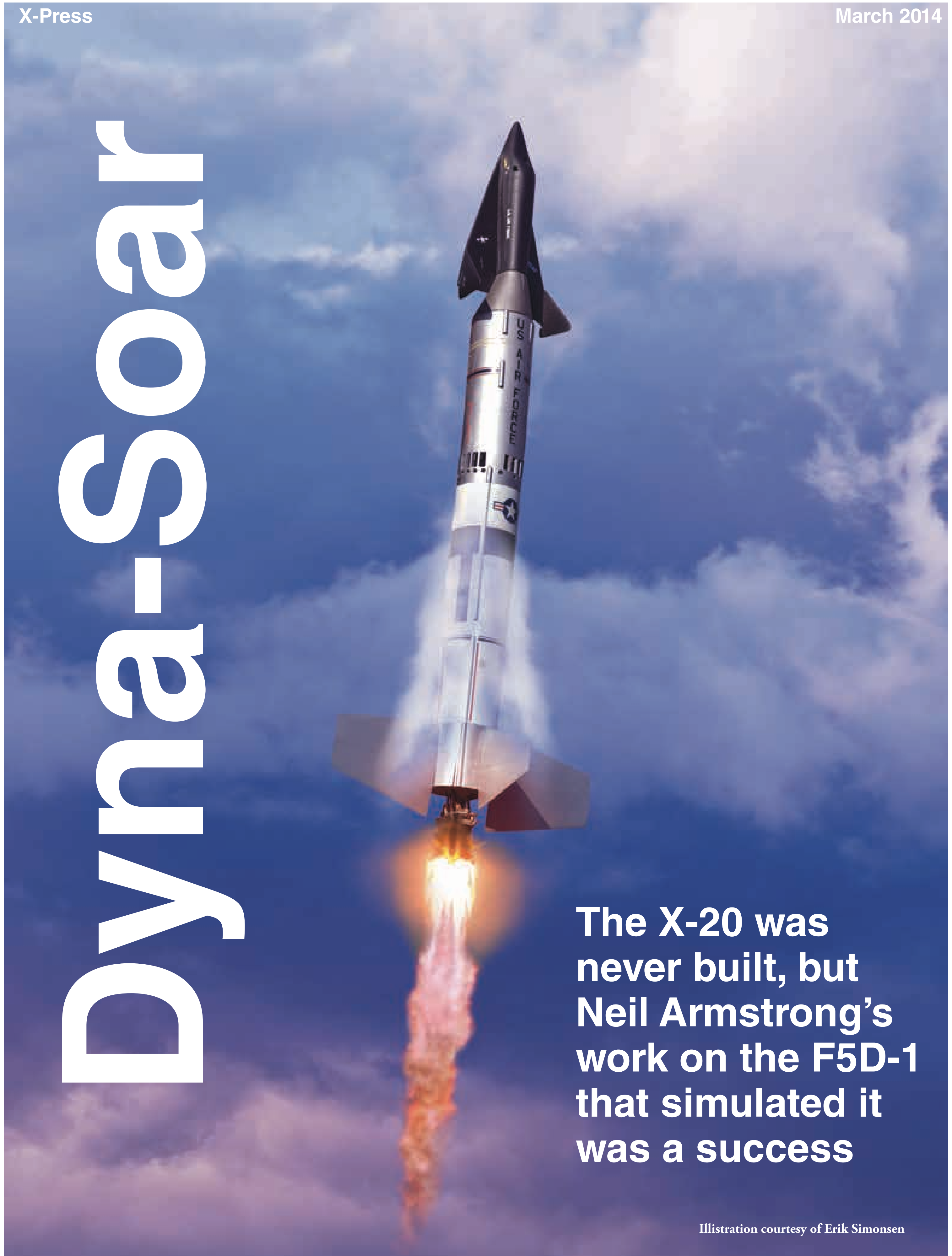


NASA

NASA

Above, *Buzz Aldrin poses for a portrait taken by Neil Armstrong, who can be seen reflected on the visor.* ***At left***, *Smoke and flames signal the opening of a historic journey as the Saturn V clears the launch pad.* ***Below***, *is Aldrin's footprint on the moon.*

NASA



Dyna-Soar

The X-20 was never built, but Neil Armstrong's work on the F5D-1 that simulated it was a success

Illustration courtesy of Erik Simonsen

Peter W. Merlin
Armstrong Public Affairs

Long before Neil Armstrong earned his astronaut wings he helped develop techniques for flying an advanced human crewed spacecraft that nearly surpassed the space shuttle as the first operational winged reentry vehicle. Although the project was cancelled before ever flying into space, lessons learned from Armstrong's research may yet be applicable to future spacecraft development.

Two weeks after the Oct. 4, 1957, launch of Russia's Sputnik, the world's first artificial satellite, U.S. Air Force officials proposed a bold plan to develop a delta-winged craft that would carry astronauts into orbit atop a rocket and return to Earth for a runway landing like a conventional aircraft. Several disparate projects for developing a hypersonic boost-glide vehicle were woven together into a single program called Dyna-Soar, short for dynamic soaring. Its goal was to design and test a spacecraft that would eventually be capable of performing space-based reconnaissance, satellite repair and maintenance, rescue or military missions. The first phase of the program was to be a demonstration of related technologies during flight tests of a research vehicle called the X-20.

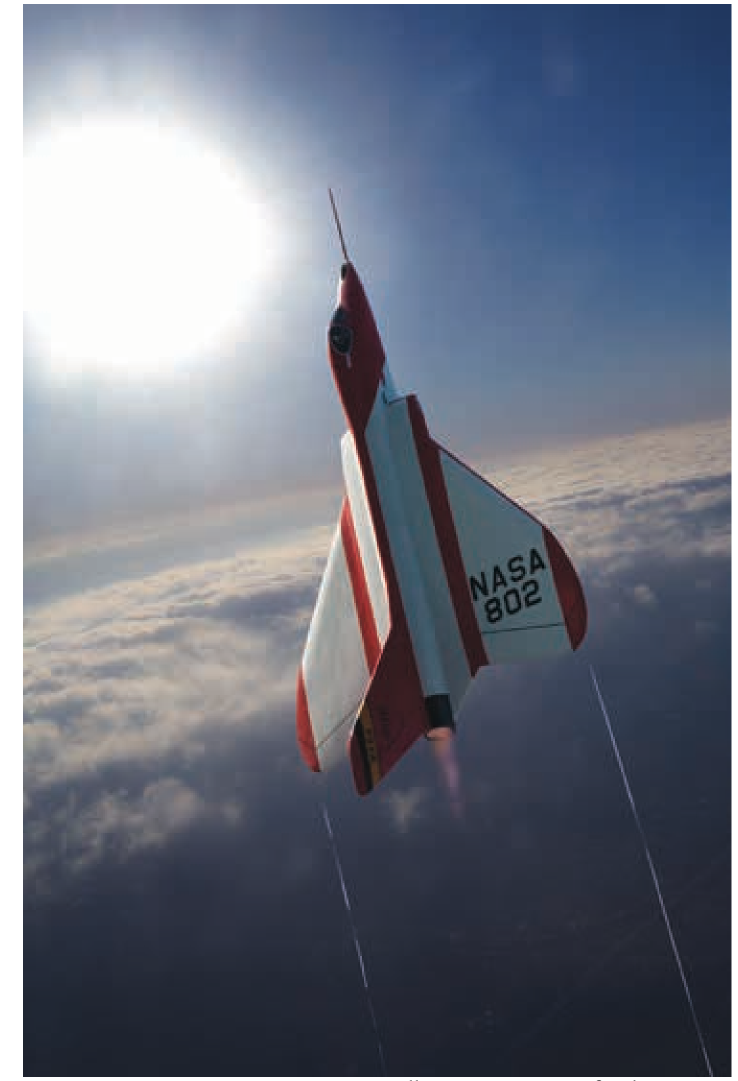


Illustration courtesy of Erik Simonsen

This illustration shows the F5D-1 simulating the profile of the X-20 Dyna-Soar. Neil Armstrong flew this profile during his days as a Dryden research pilot.

Several major aircraft manufacturers submitted design proposals with Boeing ultimately selected as the winning contractor. The Air Force was responsible for overall direction and funding, and NASA agreed to provide technical advice and assistance. One important aspect of this was participation by two NASA research pilots – Armstrong and Milton O. Thompson – on a six-member pilot-engineer consulting group that helped develop Dyna-Soar flight control systems and piloting techniques.

Armstrong was tasked with working on the cockpit layout, and with devising procedures for use with a launch escape system in case of an emergency shortly after liftoff. While much of this work took place in ground-based simulators, he also flew a series of subsonic maneuvers in a delta-winged F5D-1 Skylancer to simulate typical off-the-pad escape and landing maneuvers.

The X-20 design was optimized for hypersonic flight at high altitudes and had a very low lift-to-drag, or L/D, ratio. In the event of a mishap during launch the pilot would have to separate the craft from its launch vehicle, transition from vertical to horizontal flight and glide to a safe landing on the nearest available contingency runway. The low L/D severely limited the unpowered craft's range, particularly at low altitudes. Further complicating the pilot's task was the necessity to design the cockpit windows to withstand the expected environmental conditions during launch and re-entry. Thermal-structural considerations dictated that window areas be minimized, thus limiting the pilot's view of his surroundings, a potential problem during the critical final moments of the landing approach.

In order to simulate Dyna-Soar flight conditions Armstrong initially drew upon his experience flying low L/D approaches in a delta-winged F-102 jet fighter. Although the Flight Research Center, now the Armstrong Flight Research Center, had an F-102 it was soon to be returned to the Air Force, but two Navy Skylancers had recently become available to NASA. The F5D-1 was a single-seat, delta-winged fighter powered by an afterburning turbojet engine. Its wing planform was a good match to that proposed for the X-20. Most important, the Skylancer was equipped with landing gear that could fully extend and lock safely into position at speeds in excess of 300 knots, or 345 mph.

Armstrong had the opportunity to check out in the F5D-1 at NASA's Ames Research Center, Moffett Field, Calif., in September 1960. In a 2003 interview with biographer James Hansen, Armstrong described making several flights at Moffett Field. "I went out and fiddled with the airplane to see what initial conditions I could get, what airspeed I could match and how soon I could get the gear down to produce the drag for the L/D that I needed."

The airplane's flight characteristics were nearly ideal for the Dyna-Soar landing simulations and throttle modifications made it possible to further lower the L/D ratio by reducing idle thrust from 500 pounds to slightly less than 200 pounds. In July 1961 Armstrong performed a series of constant-speed, wings-level gliding approaches to ascertain how L/D varied with airspeed. By October he had developed an effective abort maneuver for use with the X-20.

He simulated launch and escape by making a high-speed run at about 1,000 feet above the ground, then pulling up into a steep climb to 7,000 feet. While in a vertical attitude, he chopped the throttle to idle and extended the speed brakes. As his velocity bled off to 260 knots Armstrong pulled back on the control stick until the aircraft went inverted and extended the landing gear. He then rolled into an upright, level attitude, pushed the nose over, accelerated to approach speed and landed on a specially marked airstrip on Rogers Dry Lake.

Armstrong repeated the maneuver numerous times using different speed and altitude combinations to simulate a variety of launch escape scenarios and four other NASA and Air Force pilots took turns evaluating his technique. During most of these

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ED13-0303-04 NASA/Ken Ulbrich

The full moon shines above the Hugh L. Dryden Aeronautical Test Range Communications Facility.

The Range

The Hugh L. Dryden Aeronautical Test Range supports everything that flies here, the Air Force and space communications

By Jay Levine
X-Press editor

It's not something people consciously think about every day as they drive past the antenna farm, communication buildings and telemetry dishes near the entrance to the center.

It's not even in focus walking past the control rooms, or looking up before walking into work and seeing the latest in flight research projects cruising across the sky.

However, NASA's Hugh L. Dryden Aeronautical Test Range, formerly known as the Western Aeronautical Test Range, supports everything that flies from here, said Darryl Burkes, range project manager.

The range assets also are used to assist a number of Air Force research sorties with voice communications, long-range optics and radar. The range also provides communication in space between Earth and the International Space Station, the Russian Soyuz spacecraft on multi-nation missions and NASA's commercial partners on missions to resupply the orbiting space station.

The range is located at the Neil A. Armstrong Flight Research Center, formerly was known as the Dryden Flight Research Center, and is a part of the Edwards Air Force Base complex.

Although the control rooms and communication assets are the most visible signs of the range's operations, most of the work is behind the scenes.

"We do everything from collecting the initial requirements, to determining what's required of the range, what systems they need to use and if we need to develop new displays in the control room for them. Sometimes we have to complete range upgrades to the systems to meet the customer's requirements, or software upgrades to the MCC (mission control center) processing."

There is a lot of setup time to make sure everything is working before the mission actually occurs, Burkes said. Another key function is ensuring the systems data is acquired and merged from multiple sources in various formats to a single, time-correlated, composite stream for processing, distribution, real-time display and archival storage.

ED13-0365-07 NASA/Tom Tschida

Communications technician Richard Batchelor, top, and team lead Mike Yettaw of Dryden's Range Operations Branch use a complex array of equipment to monitor and relay data telemetry to and from the International Space Station and voice communications with its crew.

ED13-0126-1 NASA/Tom Tschida

The gold control room is active during a flight of the the center's Gulfstream-III Adaptive Compliant Trailing Edge flap test bed aircraft.

The researchers need to be able to monitor real-time data to gain clearance to proceed with flight maneuvers. The MCC works to ensure pilot and aircraft safety during missions, which is especially important during envelope expansion flights.

"The researchers need to be able to see the data after their flight so they can analyze that data and create reports and write technical papers," Burkes said.

A lot of coordination is critical with project staff and instrumentation engineers. Communication also is important with the Air Force and the base control tower to ensure frequencies are approved to transmit the data.

Another important and sometimes challenging part of the range's work is determining the customer's requirements.

"Sometimes the requirements are at a very high level and we have to assist with details to build up the range or control rooms to support mission objectives," he added.

For Burkes, the best part of his job is easy to identify: "I like to see it all come together and to see the flights occur. It's encouraging to see our support lead to some fantastic research objective being met to fly what others only imagine. It's the great part about working here."

The recent Sierra Nevada Corporation Dream Chaser captive carry and release from a helicopter at Armstrong is a solid example of how many of the range's assets are put to use on a single project.

"Dream Chaser used most of the range's assets such as the fixed and mobile telemetry systems, radar systems, video systems, fixed and mobile control rooms and range safety systems to support numerous ground tests, captive carry tests and free flight," Burkes said.

The range staff also is looking forward to the challenges of the upcoming Adaptive Compliant Trailing Edge flap project on the Gulfstream-III research aircraft. The experimental flight research project for the Aeronautics Research Mission Directorate is expected to fly near the end of 2014.

That project is a joint effort of NASA and the U.S. Air Force Research Laboratory to determine

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if advanced flexible trailing-edge flaps can improve aircraft aerodynamic efficiency and reduce airport-area noise.

An average project for the range takes three to six months to plan, depending on the complexity. However, for Burkes several past projects come to mind for their excitement and challenges. Two hypersonic X-43A vehicles on two separate flights were air launched successfully from a rocket released from the NB-52B in 2004. The Orion launch abort system test on the Pad Abort-1 rocket flew from the U.S. Army White Sands Missile Range in 2010.

The X-43A project researched an integrated supersonic combustion ramjet, or scramjet, engine that propelled the aircraft to two speed records – the first flight at Mach 7 and the second approached speeds near Mach 10.

Photo courtesy Mike Yettaw

"Coordination and setting up agreements with the Point Mugu Naval Station was first. Then scheduling operations and interfacing with Point Mugu personnel for developing and testing the data links used to send telemetry data, radar data, video and voice communications between here and Point Mugu was necessary," he said.

The Pad Abort-1 effort had challenges of its own in researching the potential escape system for astronauts that will travel one day in the Orion capsule.

"Our challenges included the development of a mobile operations facility, or MOF, to meet the customer's display requirements. We also worked to interface with White Sands Missile Range personnel for data connections from White Sands' systems to the MOF to allow the monitoring necessary to conduct the numerous ground tests and Pad Abort-1 launch," Burkes explained.

When the shuttles were active, the range supported space communications. That task continues now for the International Space Station. Long-range communications are the most common support to the ISS when spacecraft visit, including the Russian Soyuz and cargo deliveries from NASA commercial partners such as Orbital Science Corp.'s Cygnus cargo freighter and Space X's Dragon spacecraft.

The range assisted the NASA 747SP Stratospheric Observatory for Infrared Astronomy, or SOFIA, with initial envelope expansion research for the telescope cavity door that is closed to protect the world's largest flying telescope and opens to collect the science. Before the NASA 747SP could fly missions, the aerodynamics of the door needed to be examined. Range personnel also assist with post-flight processing of the SOFIA research data.

In addition to manned aircraft, the range features special accommodations for unmanned air vehicles and systems.

"We have a range safety station here for UAVs. We are making sure they are operating safely and if they have to activate a flight termination system that they have the ability to use it safely," he said.

Range personnel want their customers to succeed.

"We are committed to meeting the customer's requirements and making sure they are successful," Burkes said. "We really come together as a team to meet the objectives and we have the expertise to upgrade our systems. We also are continually looking to improve our capabilities, not just maintain them."

For example, the recent upgrade of the seven-meter, triplex telemetry antenna with a C-band tracking capability will create more options for additional frequencies required for flying research missions.

Recent control room upgrades included new software versions, updated workstations and front end processing software upgrades. These changes significantly increased the processing capabilities. High definition monitors are now in the control rooms for higher quality video.

Regardless of what project comes next, one thing is clear – the range will be ready.

Range support detailed

NASA's Hugh L. Dryden Aeronautical Test Range, formerly known as the Western Aeronautical Test Range, supports flight research operations and low Earth-orbiting missions.

The range supplies a comprehensive set of resources for controlling and monitoring of flight activities, real-time acquisition and reduction of research data, and effective communication of information to flight and ground crews.

Precision radar provides tracking and space positioning information on research vehicles and other targets, including satellites. Fixed and mobile telemetry antennas receive real-

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Center name changes not uncommon

Peter Merlin
Armstrong Public Affairs

Although the redesignation of NASA's Dryden Flight Research Center as the Armstrong Flight Research Center may take some getting used to for long-time employees, it is hardly a unique event. In fact, the center has undergone no fewer than 10 name changes since it was first established by the National Advisory Committee for Aeronautics (NACA), NASA's predecessor, on Sept. 30, 1946.

The facility had humble beginnings as a detachment of the NACA Langley Memorial Aeronautical Laboratory in Hampton, Va., that was deployed to Muroc Army Air Field (now Edwards Air Force Base) at Rogers Dry Lake in the heart of California's Mojave Desert. The NACA Muroc Unit was comprised of scarcely more than a dozen members: engineers, technicians, pilots and administrative personnel assigned to test the Bell X-1, the first supersonic airplane.

The remote desert post was initially intended to be temporary but on Sept. 7, 1947, NACA director of aeronautical research Hugh L. Dryden officially established a permanent facility named the NACA Muroc Flight Test Unit. For the next two years it was managed by Langley until becoming independent on Nov. 14, 1949, at which time it was renamed the NACA High-Speed Flight Research Station.

Increasing numbers of projects and personnel necessitated relocating the entire facility to the northern end of the lakebed. The new location was inaugurated on July 1, 1954, as the NACA High-Speed Flight Station. Establishment of the National Aeronautics and Space Administration on Oct. 1, 1958, mandated a simple name change to the NASA High-Speed Flight Station. A much more significant change on Sept. 27, 1959, amended the name to the NASA Flight Research Center, elevating the facility to full center status and reflecting the broader scope of aeronautical research being undertaken there.

On March 26, 1976, it was formally named the NASA Hugh L. Dryden Flight Research Center in honor of Hugh Dryden's substantial contributions to aeronautics and his efforts to transform the former NACA into the core of the new agency, ensuring that NASA would become a worldwide leader in air and space exploration.

Five years later, in response to congressional budget cuts, some of the agency's aeronautics organizations were consolidated. As a result, the center lost its independent status and became the Ames-Dryden Flight Research Facility under the management of NASA's Ames Research Center at Moffett Field, Calif., on Oct. 1, 1981.

This institutional pairing ended on March 1, 1994, when Dryden Flight Research Center once again became independent. NASA administrator Dan Goldin explained that this change reflected the agency's commitment to reduce layers of management and empower organizations to better carry out their missions.

Exactly two decades later on March 1, 2014, NASA redesignated the center as the Neil A. Armstrong Flight Research Center and the center's test range as the Hugh L. Dryden Aeronautical Test Range, honoring the legacies of two men without whom NASA as we know it today might not have existed.

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time data and video signals from the research vehicle and relay these data to telemetry processing areas. The processed data are displayed at the engineering stations in the mission control center and archived in a post-flight storage area.

Audio communication networks support range research operations, covering a broad frequency spectrum for transmitting and receiving voice communications and flight termination signals for unmanned aerial vehicles. Video monitoring provides real-time and recorded data for the control and safety of flight test missions.

Telemetry

Range telemetry tracking systems consist of multiple fixed antennas at the Neil A. Armstrong Flight Research Center and a fleet of mobile systems for deployment to specified locations. The antennas support downlinked telemetry and video signals in C-, L-, and S-bands and can transmit uplinked commands in either L- or S-bands. The antennas track targets from horizon to horizon and are certified for full on-orbit capability. Downlinked telemetry may be received in either analog or digital format. Mobile operations provide telemetry tracking for test missions outside local airspace boundaries.

Communications

The Radio Frequency (RF) communications facility provides more than 30 ultra-high-frequency (UHF) transceivers, 10 very-high-frequency (VHF) transceivers, 2 high-frequency (HF) transceivers and 2 Broadband (100-1,000 MHz, AM and FM) transceivers. In addition, the facility also provides an International Space Station emergency communications system and 4 UHF Inter Range Instrumentation Group/Enhanced Flight Termination Systems transceivers. An extensive range intercommunication Digital Integrated Communication Electronics System consisting of more than 100, 24-channel-communication panels, links to multiple NASA centers, extensive ground-based fiber optics and interfaces with the RF communication system.

Radar

Two high-accuracy, C-band instrumentation radars provide time-space positioning information on research aircraft and Earth-orbiting spacecraft to the test range mission control center. Each radar can track targets out to a distance of 3,000 nautical miles with accuracies to 0.0006 degrees in angle and 30 feet in range. The radar antennas accept acquisition data in various formats, record it onsite, and provide post-flight radar data in the appropriate engineering parameters. The range operates a Differential Global Positioning Satellite ground station to uplink error corrections to research vehicles. Downlinked GPS information embedded in the aircraft telemetry signal provides positioning information to ground controllers. Federal Aviation Administration radar data is also available in the range's mission control center.

Video

Numerous fixed and mobile camera systems acquire video data for flight monitoring, safety and mission control. Range video systems include a long-range, broadcast-quality, high-definition optical system providing day and night visual and infrared coverage of local airspace. Other video systems provide coverage of the flight line ramp areas and runways. Mobile video vans provide coverage in remote areas, with the capability to relay live-action imagery via microwave links to the mission control center or other facilities.

Digital Fly By Wire

Armstrong influence seen in modern controls

By Christian Gelzer
Armstrong historian

"I felt at home. I felt like I was flying something I was used to and it was doing the things that it ought to be doing." So said Neil Armstrong in 1972 during a panel discussion of Apollo astronauts when he described how it felt to take control of the Eagle Lunar Module in the final stages of the descent to the moon's surface in 1969.

He had trained in three simulators in preparation for that moment: the Lunar Landing Training Facility at Langley Research Center in Hampton, Va., a giant structure from which a lunar module mockup was suspended via cables and which an astronaut flew to a landing; a desk-based, or fixed base, simulator; and the Lunar Landing Training Vehicle, a free flying, six-degree of freedom simulator. It was the LLTV which Armstrong credited in 1972 when he said: "I felt at home" because it, more than any other simulator, provided him and the other Apollo astronauts with genuine, lifelike training for landing on the moon.

Others who landed on the moon felt similarly. Pete Conrad, for example, remarked: "In my case, there were a couple of times I had to get [the LLTV] stopped and I only had 60 seconds to do it: it's not a question of saying 'reset the simulator; I blew that one.' There is no other way you can get that confidence." Gene Cernan, who commanded the last Apollo mission to the moon, concluded: "LLTV training was very valuable because it really put your tail out on the line. It was not a simulator you could make a mistake in and then reset. If you made a mistake, you busted your butt, quite frankly."

What made the LLTV unique among aircraft flying in the world at that time was not merely what it did, it was its control system: three analog computers, for redundancy, that made it a pure fly-by-wire vehicle. There was no backup control system for emergencies.

The LLTVs were more refined and capable versions of the two earlier Lunar Landing Research Vehicles that arrived at the Flight Research Center, or FRC, (now Armstrong) in 1964. During the next 2½ years, engineers learned how to work with a pure fly-by-wire aircraft, gaining both experience and confidence in the system. By 1970 a cluster of engineers from the center wanted to apply what they had learned to a winged aircraft. They initially planned on an analog computer, then settled on a digital computer – but by the time FRC engineers Mel Burke and Cal Jarvis travelled to NASA headquarters to appeal for project funding they still did not have a suitable computer.

The first stop was the Office of Advanced Research and Technology, or OART, then run by none other than Neil Armstrong, who was deputy associate administrator for aeronautics. Told that they still did not have a suitable computer, and keen to advance the transfer of Apollo technology from NASA to industry, Armstrong had the ideal computer, and said: "I just went to the moon and back with one." Moreover, by 1970 there were several computers readily available. Armstrong referred to the Apollo Guidance Computer, or AGC, one of which operated the lunar module and and another the command module. Built for the Apollo program by Draper Laboratories, these computers had the highest mean time between failure rates of any portable digital computers then in existence.

NASA

The F-8 Digital Fly-By-Wire aircraft flew in 1972. The background image, at left, is the computer that powered the controls concept common on today's aircraft.

NASA

It is what was on the inside that counted on the F-8 Digital Fly-By-Wire aircraft.

Designed in the early 1960s, the AGC was the pinnacle of its kind at the time, with a total memory of 38k, of which 36k was read only. That's about the memory of a modern day text document. For what the engineers at the center planned it was entirely acceptable and before long an AGC, with the necessary display and keyboard, was on its way to California for installation in an F-8.

In May 1972 FRC pilot Gary Krier made the first flight in the modified airplane, which now had only a fly-by-wire control system and no hydro-mechanical backup, a world's first. Over the following years

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The crew splashed down near Hawaii on July 24. President John F. Kennedy's challenge was met. Men from Earth walked on the moon and returned safely home.

In an interview years later, Armstrong praised the "hundreds of thousands" of people behind the project. "Every guy that's setting up the tests, cranking the torque wrench, and so on, is saying, man or woman, 'If anything goes wrong here, it's not going to be my fault.'"

In a post-flight press conference, Armstrong called the flight "a beginning of a new age," while Collins talked about future journeys to Mars.

Over the next three-and a-half years, 10 astronauts followed in their footsteps. Gene Cernan, commander of the last Apollo mission left the lunar surface with these words: "We leave as we came and, God willing, as we shall return, with peace and hope for all mankind."

This Earthrise view was captured from the lunar orbit prior to a moon landing.

NASA

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tests the airplane's canopy was fitted with an amber Plexiglas mask, reducing the pilot's field of vision to a comparable degree with that of the X-20's cockpit. While wearing a blue visor, the pilot could only see through the cut out portions of the mask, but with the visor raised the amber transparency allowed nearly complete visibility.

On Oct. 3, 1961, Armstrong demonstrated the simulated X-20 launch escape maneuver for Vice President Lyndon B. Johnson, who was visiting Edwards Air Force Base for a special tour. The future seemed bright for the orbital space plane and Armstrong's involvement with the design phase would have almost certainly assured him an opportunity to fly the craft into space.

Unfortunately, the Dyna-Soar was doomed to extinction. Secretary of Defense Robert McNamara questioned whether the project should be funded, changing program requirements caused challenges and some officials saw more promise in using the less costly Gemini capsule. Finally, in December 1963, McNamara cancelled the Dyna-Soar program. By that time, Armstrong had already been accepted for astronaut training and taken his first steps on a path to the moon.

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the F-8 Digital Fly-By-Wire aircraft would fly with upgraded computers.

From this aircraft and the program's technology came the first production fly-by-wire aircraft, the General Dynamics F-16 (albeit with analog computers). Then came airliners with elements of fly-by-wire control. Finally the first all fly-by-wire airliner, the A-320, made its first flight on Feb. 22, 1987, and began service the following year. In addition, the technology recently has migrated to automobiles for brakes, cruise control, accelerators and even steering systems.

But here at Dryden Flight Research Center (now Armstrong) digital fly-by-wire made another major contribution in connection with the Space Shuttle Program. The F-8 was used to investigate a control challenge called pilot-induced oscillation that first surfaced with the space shuttle prototype Enterprise on its last free-flight landing after release from a NASA 747 Shuttle Carrier Aircraft. A pilot-induced oscillation happened when a pilot directed the computer what to do and then did it again because of a lag in completing the pilot's directions that caused control challenges. Because Enterprise and the F-8 shared the same flight control computers, an IBM AP-101, Dryden engineers and pilots were able to figure it out and solve the problem.

"NASA expressed little interest in the idea [of DFBW]," wrote historians Richard Hallion and Mike Gorn, until Armstrong, as the deputy director of OART, solved the problem of what computer to use for the program. As sure as Armstrong's footprints endure on the moon, his fingerprints are visible on modern fly-by-wire systems.