National Aeronautics and
Space Administration

ARMSTRONG FLIGHT RESEARCH CENTER 1946-2021

X-PRESS

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NASA Armstrong

75 Years of Advancing Technology and Science Through Flight

@NASAARMSTRONG

Photo Credit: NASA/Carla Thomas

Center Director David McBride

Every first flight of a new technology has its own defining moment and point of validation. From the X-1 to the X-59 Quiet SuperSonic Technology aircraft, a first flight proves something. It's not just the first flights. Every step along the way of completing the flight test plan extends our knowledge.

NASA Armstrong began Sept. 30, 1946, with assisting the U.S. Air Force to break the sound barrier a year later. The technology we are now validating in the X-59 seeks to decrease the intensity of those sonic booms first created when the X-1 succeeded.

The X-59 will provide data that could lead the Federal Aviation Administration to end the prohibition on supersonic flight over land in the United States. Such a change could lead the way to new business opportunities and greatly reduce travel times.

Our mission is advancing technology and science through flight and until you validate advanced designs or concepts through flight, it is not ready for the market. A lot of people think you can design on computers, models, and simulators and then you are done. We have learned that to really validate and prove something, you must take it to flight in the real world.

The following pages contain examples of experimental aircraft and spacecraft prototypes that were huge successes in proving technologies, materials, and designs to reduce risk for industry to use for new innovations. Some of the experimental aircraft have direct links to modern day aircraft that made them safer, more maneuverable, and more efficient. Some experimental vehicles didn't work as planned, but still had value in data for future researchers.

Where I think the next focus will be is on a single-aisle commercial transport aircraft that is more efficient and will reduce carbon emissions. Several designs, which were validated here can improve aircraft efficiency in the 20%, 30%, 40%, or maybe even 50% over today's standard aircraft. That will affect everyone who flies.

One of the biggest long-term legacies that will touch more people than we understand now is the electrified flight. I believe that the next generation of flight will be electrified to some degree, whether it is 100% electric like the X-57, or a hybrid design with an electric generator running electric motors that will increase aircraft efficiency and simplify aircraft maintenance, much like an electric car is now. Application of the technology and proving it works is NASA's role.

I believe we will also lead the way in guiding the aerospace industry forward with some standards for electric flight. That also could reduce costs to enable a whole new market in Urban Air Mobility, urban air taxi services. Transportation and the businesses needed to support those industries will have a huge impact on people's lives and the environment.

As we celebrate our anniversary, we invite you to view our past and present accomplishments and we invite you to keep up with the latest work we are doing to enable a bright tomorrow.

Photo Credit: NASA

Joe Walker and the X-1E

Joe Walker, in a pressure suit, stands beside the X-1E at NASA Armstrong. The dice and "Little Joe" are prominently displayed under the cockpit area. Little Joe is a slang term for two deuces used by dice players.

Walker is shown in the photo wearing an early U.S. Air Force partial pressure suit. This protected the pilot if cockpit pressure was lost above 50,000 feet altitude. Similar suits were used in such aircraft as B-47s, B-52s, F-104s, U-2s, the X-2, and the D-558-II research aircraft. Five years later, Walker reached 354,200 feet altitude in the X-15. Similar artwork reading "Little Joe the II" was applied for the record flight. These cases are two of the few times that research aircraft carried such nose art.

1946-1958

1940s & 1950s

1946

X-1E

D-558-I
Skystreak

D-558-II

X-3

X-4

X-5

1958

Previous

Next

Photo Credit: NASA

X-15 Pilots

In the joint X-15 hypersonic research program that NASA conducted with the U.S. Air Force, Navy, and North American Aviation Inc., the aircraft flew during a period of nearly 10 years and set the world's unofficial speed and altitude records of 4,520 mph (Mach 6.7) and 354,200 feet in a program to investigate all aspects of piloted hypersonic flight. Information gained from the highly successful X-15 program contributed to the development of the Mercury, Gemini, and Apollo piloted spaceflight programs as well as the Space Shuttle Program.

X-15 pilots, from left:
Air Force pilot William J. "Pete" Knight
Air Force Maj. Robert A. Rushworth
Air Force Capt. Joseph H. Engle
NASA pilot Milton O. Thompson
NASA pilot William H. "Bill" Dana
NASA pilot John B. "Jack" McKay

1960s

1960

X-15

Lunar Landing Research Vehicle

M2-F1

HL-10

X-24A

X-24B

1969

Photo Credit: NASA

Heavy Lifting

Science fiction met science fact when “Star Trek” fans succeeded in their campaign for NASA to name the space shuttle prototype Enterprise.

Enterprise never went to space, but its release from the back of a specially modified NASA 747 proved that the unpowered craft could safely land and that its systems worked as intended. Maneuvers were developed during the Approach and Landing Tests at NASA Armstrong that were used during the Space Shuttle Program to manage the energy of reentry from space.

Flight crew members of the space shuttle Enterprise prototype and the host NASA 747 Shuttle Carrier Aircraft are pictured from left: Fitz Fulton, Gordon Fullerton, Vic Horton, Fred Haise, Vincent Alvarez, and Tom McMurtry.

Space shuttle Columbia completed the first mission of the shuttle program with a landing on Rogers Dry Lake, adjacent to NASA Armstrong. The center supported 54 shuttle returns from space during the program.

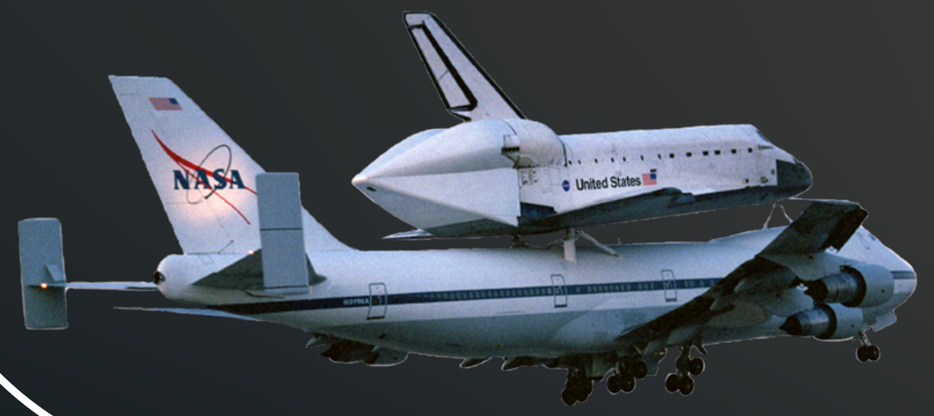
1970–1979

1970s

1970

F-8 Digital Fly-By-Wire

F-8 Supercritical Wing



Approach and Landing Tests

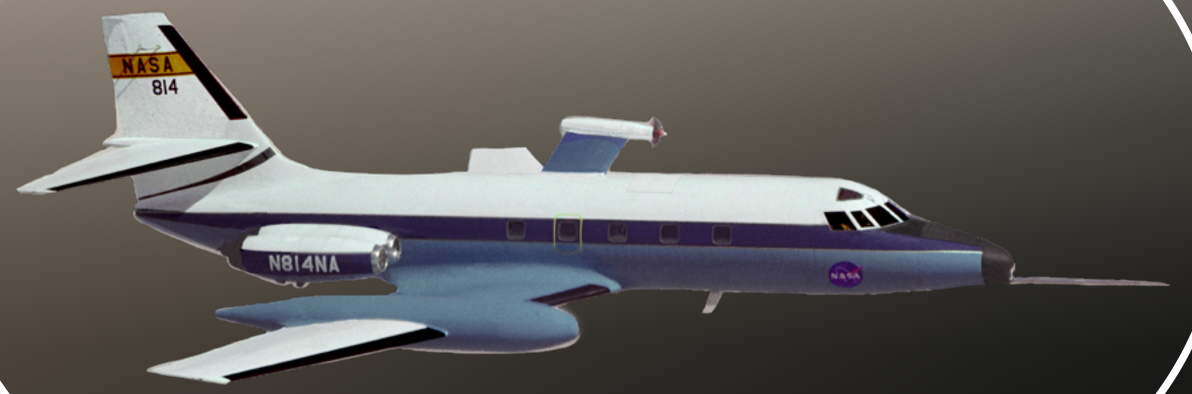
The aircraft innovations of this decade are still seen in modern aviation. The F-8 Digital Fly-By-Wire (DFBW) aircraft demonstrated an electronic fight control system with a digital computer to replace convectional mechanical flight controls. Most modern aircraft use such systems to make aircraft safer, more maneuverable, and more efficient.

Another F-8 was used to show that a supercritical wing, which is flatter on the top and rounder on the bottom with a downward curve at the trailing edge, delayed shock wave formation and reduced drag. The research also showed aircraft using the concept would have increased cruising speed, fuel efficiency, and range. Supercritical wings are common on most modern subsonic commercial transport.

The center also had a key role in the development of the Space Shuttle Program and the approach and landing tests with space shuttle prototype Enterprise. The shuttle was on top of a specially modified NASA 747 when released, then glided to a landing. In addition, it validated automatic flight control and navigation systems. Flights on the F-8 DFBW aircraft proved a control system modification that suppressed potential overcorrection of the digital flight controls by the pilot and incorporated it into space shuttle Columbia before its first flight.

Mate-Demate Device

JetStar



F-104

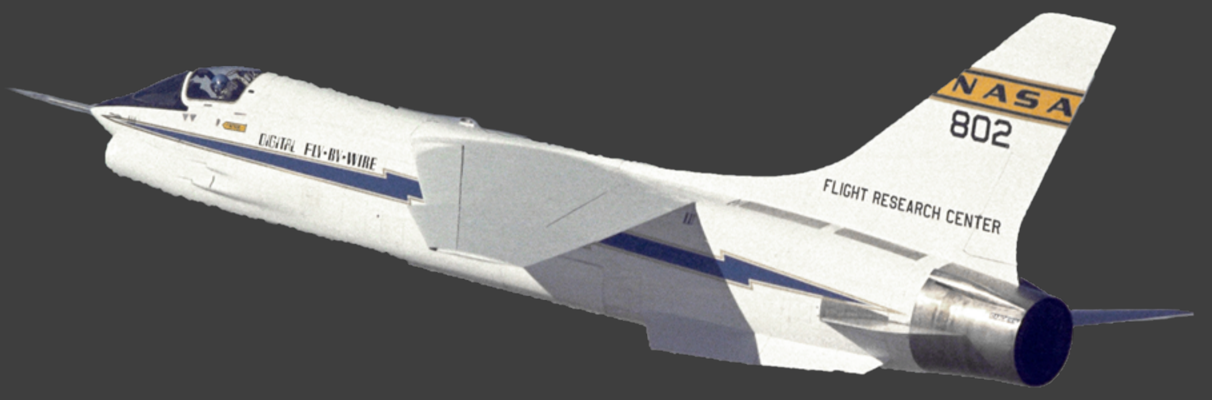
1979

Previous

Next

Photo Credit: NASA

Flight Revolution



The F-8 Digital Fly-By-Wire aircraft changed the way aircraft were controlled, making them safer, more maneuverable, and more efficient. Some members of the team attended the aircraft's retirement in 1985 included from left Ken Szalai (a former center director), Wilton Lock, Bill Peterson, Jim Phelps, Jim Craft, Leo Lett, Dwain Deets, and Cal Jarvis. Another team member who is not pictured, Kevin Petersen (also a former center director), worked on the program as a research engineer.

The F-8 Digital Fly-By-Wire aircraft used an electronic flight control system coupled with a digital computer to replace conventional mechanical flight controls. The first test of the system in l972 was the forerunner of the fly-by-wire flight control systems now used on most modern aircraft.

1980 1989

1980s

1980

AD-1

Space Shuttle Columbia

Controlled Impact Demonstration

NASA Armstrong's work on the space shuttles continued with support of the first landing from space of space shuttle Columbia. The center was the primary landing site for nine of the first 10 missions, and then remained the backup landing site. While the center remained committed to shuttle support, three major aircraft projects explored the way aircraft maneuvered. Two subscale, remotely piloted Highly Maneuverable Aircraft Technology demonstrators flew. The research flights investigated experimental technologies and completed high-risk maneuverability flights without endangering a pilot.

The F-18 High Alpha Research Vehicle was a full-scale, piloted aircraft. Through 385 flights during nine years, the aircraft proved the use of thrust vectoring (using engine thrust to control the aircraft in previously uncontrollable maneuvers), a research flight control system, and forebody strakes (hinged structures on the forward side of the fuselage).The swept wing X-29 was also a piloted aircraft that explored the use of advanced composites in aircraft construction, thin supercritical wings, strake flaps, close-coupled canards, and a computerized fly-by-wire control system to fly the unstable aircraft.

Other interesting flight experiments included the in-flight wing pivoting of the AD-1 and the Controlled Impact Demonstration. The project crashed a remotely piloted aircraft to determine the validity of claims about a fuel additive that was intended to inhibit ignition of fuel and suppress fire in the event of an aircraft accident.

HiMAT

X-29

F-18 HARV

1989

Previous

Next

Photo Credit: NASA/Jim Ross

Shuttle Carrier Aircraft

NASA Armstrong used two modified Boeing 747 jetliners, originally manufactured for commercial use, as Space Shuttle Carrier Aircraft. One is a 747-123 model, while the other was designated a 747-100SR-46 model. The two aircraft are identical in performance as Shuttle Carrier Aircraft (SCA).

NASA tail number 905 was the first SCA, which was obtained from American Airlines in 1974. Shortly after acceptance by NASA, the SCA flew a series of wake vortex research flights at NASA Armstrong, in a study to seek ways of reducing turbulence produced by large aircraft. Pilots flying as much as several miles behind large aircraft have encountered wake turbulence that has caused control problems. The NASA study helped the Federal Aviation Administration modify flight procedures for commercial aircraft during airport approaches and departures.

1990-1999

1990s

1990

CV-990

F-16XL

ERAST

MD-11

X-31

SR-71

1999

Photo Credit: NASA/Tom Tschida

Hypersonic Success

After the X-43A's second flight successfully achieved Mach 6.8 in March 2004, celebration ensued. Relieved and excited with the research flight's results are, from left, mission controller Brad Neal, NASA Associate Administrator for Aeronautics Dr. J. Victor Lebacqz, center X-43A Deputy Program Manager Paul Reukauf, Center Director Kevin Petersen, Ryan Warner (seated), center Chief Engineer Griffin P. "Griff" Corpening, center X-43A manager Joel Sitz, and Robert Shannon (partially hidden).

A third X-43A flight just eight months later in November resulted in a flight of 9.6 Mach, about 7,000 mph at 110,000 feet altitude. It set the current world speed record for an air-breathing vehicle. Compared to rocket-powered vehicles like the space shuttles, supersonic combustion ramjet (scramjet) powered vehicles had more airplane-like operations. The thinking was a scramjet offered increased affordability, flexibility, and safety for ultra-high-speed flights within the atmosphere and into Earth orbit because it only carried its propellant, taking the oxidizer from the atmosphere.

2000s

As the centennial of flight approached in 2003, NASA Armstrong flew the X-53 Active Aeroelastic Wing, a highly modified F/A-18. The aircraft demonstrated roll control through wing twist alone, as the Wright brothers did in 1903. Such a design could reduce wing structure by 20%.

Twice in 2004, the X-43A established new speed records of Mach 6.8 in March and Mach 9.6 in November for an air-breathing vehicle. The NB-52B air launched a stack of a modified Pegasus rocket booster with the X-43A attached on its nose. Once launched, the rocket accelerated and then separated from the aircraft, which fired its supersonic combustion ramjet engine completing its flight with a landing in the Pacific Ocean. The NB-52B was retired in 2004.

Meanwhile, Airborne Science Operations at NASA Armstrong were ramping up. Science aircraft such as the DC-8 flying laboratory, the ER-2 high altitude research aircraft, and the C-20A (the military version of the G-III) were supporting scientists' missions. In April 2009 NASA Armstrong leased Building 703 in Palmdale for housing its science aircraft and as a one-stop shop for preparing for missions. Unmanned aerial systems also continued to mature and demonstrate a variety of capabilities.

2000

F-15A

Airborne Science

X-53 AAW

UAS

X-43A

F-15B

2009

Previous

Next

Photo Credit: NASA/Lauren Hughes

Exploring Supersonic Flight

NASA pilots Nils Larson and Wayne Ringelberg head for a mission debrief after flying a NASA F/A-18 at Mach 1.38 to create sonic booms as part of the Sonic Booms in Atmospheric Turbulence series, or SonicBAT. The flight series, which took place at NASA Armstrong, studied sonic boom signatures with and without the element of atmospheric turbulence.

Once complete, SonicBAT continued at NASA's Kennedy Space Center in Florida to assess the data in a humid environment and to learn more about how people perceive sonic booms. Another such flight series, the *Quiet Supersonic Flights in Galveston, Texas*, also focused on that work. NASA Armstrong has even captured images of how shockwaves interact with each other between supersonic aircraft using a process called *Air-to-Air Background Oriented Schlieren flights.*

The sonic boom research is building the foundation for *NASA's X-59 Quiet SuperSonic Technology (QueSST)* aircraft anticipated to fly in 2022 to validate the technology to make quiet supersonic flight a reality.

2010-2015

Early 2010s

2010

SOFIA

G-III

Dream Chaser

NASA Armstrong oversaw the Stratospheric Observatory for Infrared Astronomy complete significant modifications and a flight test program leading to its first science flights. The flying observatory's 100-inch telescope can peer into the heavens without the water vapor that obscures observations from Earth. It also tests the latest in scientific instruments.

The center's reputation for integration of systems was one reason it was chosen for early Orion work to test an escape system that could move astronauts away from the vehicle on the pad or in the boost phase if there was an emergency. On May 6, 2010, the Orion launch abort system worked flawlessly during the Pad Abort 1 developmental test, proving astronauts could safely escape an emergency on the launch pad. The center completed a complicated integration challenge preparing for the dynamic Ascent Abort-2 test of the system in the boost phase, which was successfully completed on July 2, 2019.

The center also advanced work on its own project, an increasingly complex aircraft called the Preliminary Research Aerodynamic Design to Lower Drag, or Prandtl-D. Featuring a new method of designing an aircraft wing with a twist for control, the aircraft proved it could create acceleration at the wing tips. The result for potential future aircraft: significant increase in fuel efficiency and eliminating the weight of the modern aircraft tail and its flight control surfaces.

Pad Abort 1 (PA-1)

Ascent Abort-2 (AA-2)

Prandtl-D

2015

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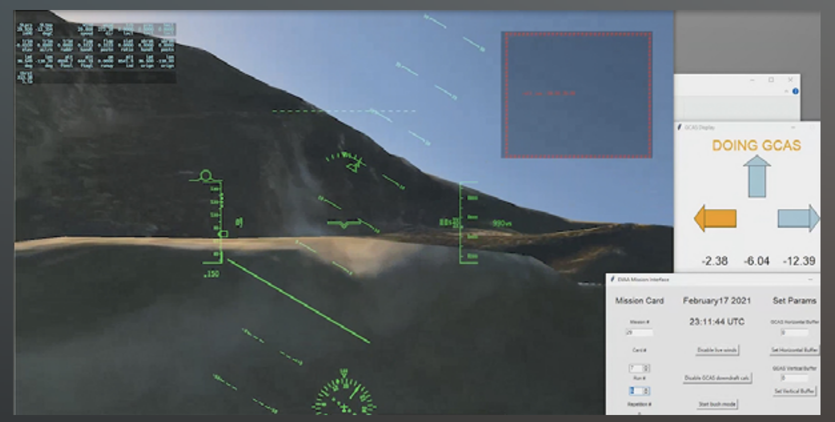
2016-2022

2016 to Today

2016

UAS in the NAS



Resilient Autonomy

AAM

On March 14, 2014, NASA's Hugh L. Dryden Flight Research Center became the Neil A. Armstrong Flight Research Center. The center's new namesake tested experimental aircraft like the X-15 here and was later chosen to become an astronaut and became the first man to walk on the surface of the Moon.

The center had studied remotely piloted and autonomous vehicles, also known as unmanned aerial systems (UAS). Now the focus was developing the technology and procedures to enable them to fly in the National Airspace System (NAS). To do that, the UAS Integration in the NAS project completed a series of technical challenges and demonstrations to develop recommendations to the Federal Aviation Administration for certification of the vehicles and for their operation in the NAS.

The center is continuing its focus on experimental aircraft with a focus on readying two new experimental aircraft for flight, the X-59 Quiet SuperSonic Technology aircraft, and the X-57 Maxwell. The X-59 is expected to demonstrate a quieter sonic boom when it breaks the sound barrier that is acceptable to people on the ground and potentially change the rules to allow supersonic flight over land. The X-57 is NASA's all-electric aircraft that is expected to demonstrate a 500% increase in high-speed cruise efficiency with zero carbon emissions and much less noise than traditional aircraft.

X-56A

X-57

X-59

Today

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Next

2021 and Beyond

A pilot walks out to the *X-59 Quiet SuperSonic Technology* aircraft on the NASA Armstrong flight line at first daylight in this illustration. The experimental aircraft is expected to begin flights in 2022 and seeks to prove technology that could permit supersonic flight over land and enable people to travel long distances at greatly reduced flight times, and new business opportunities.

Off to the side is the *X-57 Maxwell*, a piloted, full-electric aircraft. The distributed electric propulsion-powered aircraft fits into an overarching NASA plan for researching regional air transportation of people and cargo. A principal goal of the X-57 project is to share the X-57 design and airworthiness process with regulators and standards organizations. Another goal is to establish the X-57 as a reference platform for integrated approaches of distributed electric propulsion technologies.

Photo Credit: NASA/Carla Thomas | Composite: NASA/Steve Lighthill

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[NASA Armstrong's 70th Anniversary]

[When the Center Became "Armstrong"]

[NASA Armstrong's Space Shuttle Legacy]

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