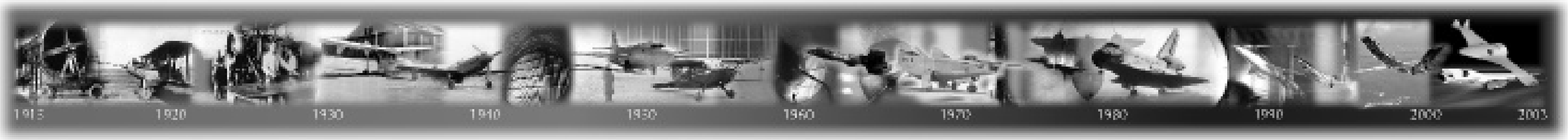
The First Century of Flight: NACA/NASA Contributions to Aeronautics



http://www.aerospace.nasa.gov

Introduction

This poster highlights the contributions made to aeronautics by the National Advisory Committee for Aeronautics (NACA), now the National Aeronautics and Space Administration (NASA), during the first century of powered flight. Created as NACA in 1915 and transformed into NASA in 1958, the organization has contributed substantially to flight technology. The front of this poster is a timeline highlighting significant aeronautical events and contributions this organization has made over the past 85-plus years to create a safe, efficient, and cost-effective method of transportation. The back contains a brief history of NACA/NASA, a summary of current aerospace technology activities, possibilities for the future of flight, and general and educational resources available to the public and educators.

Timeline Poster Inside

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Aerospace Technology Enterprise

The NASA Aerospace Technology Enterprise's charter is to pioneer advanced technologies that will meet the challenges facing air and space transportation, maintain U.S. national security and preeminence in aerospace technology, and extend the benefit of our innovations throughout society.

To benefit fully from the revolution in communication and information technology, we also need a revolution in mobility. To open the space frontier to new levels of exploration and commercial endeavor, we must reduce cost and increase the reliability and safety of space transportation. Both the economy and our quality of life depend on a safe, environmentally friendly air transportation system that continues to meet the demand for rapid, reliable, and affordable movement of people and goods.

Working with our partners in industry, Government, and academia, we have developed four bold goals to sustain future U.S. leadership in civil aeronautics and space transportation. These goals are as follows:

- revolutionize aviation;
- advance space transportation;
- pioneer technology innovation; and
- commercialize technology.

Revolutionize Aviation

NASA's goal to revolutionize aviation will enable the safe, environmentally friendly expansion of aviation in the following areas:

- Increase safety—Make a safe air transportation system even safer by reducing the aircraft accident rate by a factor of 5 within 10 years and by a factor of 10 within 25 years.
- Reduce emissions—Protect local air quality and our global climate.
- Reduce NO_x emissions of future aircraft by 70 percent within 10 years and by 80 percent within 25 years (from the 1996 ICAO Standard for NO_x as the baseline).
- Reduce CO_2 emissions of future aircraft by 25 percent and by 50 percent, respectively, in the same timeframes (from 1997 subsonic aircraft technology as the baseline).
- Reduce noise—Lower the perceived noise levels of future aircraft by a factor of 2 (10 decibels) within 10 years, and by a factor of 4 (20 decibels) within 25 years. The baseline is 1997 subsonic aircraft technology. The word "perceived" is key to the intended interpretation of this noise reduction goal. In subjective acoustics, a 10-decibel reduction is perceived as "half" as loud, hence, the stated interpretation of the goal.
- Increase capacity—Enable the movement of more air passengers with fewer delays.
- Double the aviation system capacity within 10 years and triple it within 25 years. The baseline is 1997 levels.
- Increase mobility—Enable people to travel faster and farther, anywhere, anytime.
- Reduce intercity door-to-door transportation time by half in 10 years and by two-thirds in 25 years.
- Reduce long-haul transcontinental travel time by half within 25 years.

Advance Space Transportation

NASA's goal to advance space transportation is to create a safe, affordable highway through the air and into space.

- Mission safety—Radically improve the safety and reliability of space launch systems. Reduce the incidence of crew loss to less than 1 in 10,000 missions (a factor of 40) by 2010 and to less than 1 in 1,000,000 missions (a factor of 100) by 2025.
- Mission affordability—Create an economical highway to space.
- Reduce the cost of delivering a payload to low-Earth orbit (LEO) to $1,000 per pound (a factor of 10) by 2010 and to $100 per pound (an additional factor of 10) by 2025.
- Reduce the cost of interorbital transfer by a factor of 10 within 15 years and by an additional factor of 10 by 2025.
- Mission reach—Extend our reach in space with faster travel. Reduce the time for planetary missions by a factor of 2 within 15 years and by a factor of 10 within 25 years.

Pioneer Technology Innovation

NASA's goal to pioneer technology innovation is to enable a revolution in aerospace systems.

- Engineering innovation—Enable rapid, high-confidence, and cost-efficient design of revolutionary systems.
- Within 10 years, demonstrate advanced, full-life-cycle design and simulation tools, processes, and virtual environments in critical NASA engineering applications.
- Within 25 years, demonstrate an integrated, high-confidence engineering environment that fully simulates advanced aerospace systems, their environments, and their missions.
- Technology innovation—Enable fundamentally new aerospace system capabilities and missions.
- Within 10 years, integrate revolutionary technologies to explore fundamentally new aerospace system capabilities and missions.
- Within 25 years, demonstrate new aerospace capabilities and new mission concepts in flight.

Commercialize Technology

The NASA Commercial Technology Program enables the transfer of NASA technologies to the private sector to create jobs, improve productivity, and increase U.S. competitiveness. NASA provides assistance to a wide variety of companies, with special emphasis on small businesses.

NACA/NASA History in Brief

The first important instance of Federal action to foster aerospace research and development came as a rider to the Naval Appropriations Act of 1915. In this legislation, Congress established the National Advisory Committee for Aeronautics (NACA) "to supervise and direct the scientific study of the problems of flight, with a view to their practical solution." This became an enormously important Government research and development organization for the next half century, materially enhancing the development of aeronautics.

All research projects undertaken by the NACA sought to compile fundamental aeronautical knowledge applicable to all flight, rather than working on a specific type of aircraft design, because that looked too much like catering to a particular aeronautical firm. Scientists or engineers on the Federal payroll accomplished most NACA research "in-house." The results of these activities appeared in more than 16,000 research reports distributed widely for the benefit of all. As a result of this work, the NACA received the coveted Robert J. Collier Trophy a total of five times between 1929 and 1954.

The NACA's research was conducted in Government facilities, and its Government scientists and engineers developed a strong technical competence, a commitment to collegial in-house research conducive to engineering innovation, and a definite apolitical perspective. While it never had more than about 8,000 employees and an annual budget of $100 million, the NACA maintained a small Washington headquarters staff; three major research laboratories—the Langley Aeronautical Laboratory established in 1917, the Ames Aeronautical Laboratory formed near San Francisco in 1939, and the Lewis Flight Propulsion Laboratory built in Cleveland, Ohio, in 1940; and two small test facilities, one at Muroc Dry Lake in the high desert of California and another at Wallops Island, Virginia. This NACA organization remained a significant entity until it was transformed into NASA in 1958.

The National Aeronautics and Space Act of 1958 created the National Aeronautics and Space Administration (NASA) and gave it a broad mandate to "plan, direct, and conduct aeronautical and space activities"; to involve the Nation's scientific community in these activities; and to disseminate information about them widely. NASA became the preeminent organization in conducting aerospace research and development during the 1960s, even as it engaged in a broad-based space exploration program that included several diverse elements.

NASA began to conduct space missions within months of its creation, and during its 40-year history, it has had many accomplishments:

- Human space flight initiatives—Mercury's single-astronaut program (flights during 1961–63) to ascertain if a human could survive in space; Project Gemini (flights during 1965–66) with two astronauts to practice space operations, especially rendezvous and docking of spacecraft and extravehicular activity (EVA); and Project Apollo (flights during 1968–72) to explore the Moon.
- Robotic missions to the Moon (Ranger, Surveyor, and Lunar Orbiter), Venus (Pioneer Venus), Mars (Mariner 4, Vikings 1 and 2), and the outer planets (Pioneers 10 and 11, Voyagers 1 and 2).
- Remote-sensing Earth satellites for gathering information (Landsat satellites for environmental monitoring); applications satellites for communications (Echo 1, TIROS, and Telstar) and weather monitoring.
- Skylab, an orbital workshop for astronauts.
- The Space Shuttle, a reusable spacecraft for traveling to and from Earth orbit.
- The International Space Station, enabling the scientific understanding necessary to explore the solar system.

The ultimate accomplishment of NASA during its first decade was Project Apollo and the landing of the first astronauts on the Moon on July 20, 1969. Following this accomplishment, NASA has developed the Space Shuttle and collaborated on the International Space Station, reached by the first crew in 2000.

At the same time, building on its NACA roots, NASA continued to conduct many types of cutting-edge aeronautics research on aerodynamics, wind shear, and other important topics using wind tunnels, flight-testing, and computer simulations. NASA's highly successful X-15 program involved a rocket-powered airplane that flew above the atmosphere and then glided back to Earth unpowered, providing Shuttle designers with much useful data. The watershed F-8 digital fly-by-wire program laid the groundwork for such electronic flight in many other aircraft in the 1970s, including the Shuttle and high-performance airplanes that would have been uncontrollable otherwise. NASA has also done important research on such topics as lifting bodies (wingless airplanes) and supercritical wings to dampen the effect of shock waves on transonic aircraft.

Additionally, NASA has launched a number of significant scientific probes that have explored the Moon, the planets, and other areas of our solar system. NASA has sent several spacecraft to investigate Mars, including the Viking and Mars Pathfinder spacecraft. The Hubble Space Telescope and other space science spacecraft have enabled scientists to make a number of significant astronomical discoveries about our universe.

NASA also has done pioneering work in space applications satellites. NASA helped bring about new generations of communications satellites such as the Echo, Telstar, and Syncom satellites. NASA's Earth science efforts have literally changed the way we view our home planet; the Landsat and Earth Observing System spacecraft have contributed many important scientific findings. NASA technology has also resulted in numerous "spinoffs" in wide-ranging scientific, technical, and commercial fields. Overall, while the tremendous technical and scientific accomplishments of NASA demonstrate vividly that humans can achieve previously inconceivable feats, it also humbles many to consider that Earth is such a tiny "blue marble" in the cosmos.

NACA/NASA Research and Development Projects That Received the Collier Trophy

In 1911, the National Aeronautic Association established the Robert J. Collier Trophy, awarded annually for great achievement in aeronautics and astronautics in America. It represents the most prestigious award offered in the United States for excellence in aerospace research and development and recognizes key advances in the performance, efficiency, or safety of air or space vehicles. NACA/NASA has received this award a total of 19 times. The projects for which NACA/NASA received the Collier Trophy are as follows:

1929: NACA, for the development of low-drag cowling for radial air-cooled aircraft engines.

1946: Lewis A. Rodert of Ames Aeronautical Laboratory, for the development of an efficient wing de-icing system.

1947: John Stack of the Langley Memorial Aeronautical Laboratory, for research to determine the physical laws affecting supersonic flight. Lawrence D. Bell and Chuck Yeager also shared in this trophy for their work on supersonic flight.

1951: John Stack and associates at the Langley Memorial Aeronautical Laboratory, for the development and use of the slotted-throat wind tunnel.

1954: Richard Travis Whitcomb of the Langley Memorial Aeronautical Laboratory, for the development of the Whitcomb area rule, according to the citation, a “powerful, simple, and useful method of reducing greatly the sharp increase in wing drag heretofore associated with transonic flight, and which constituted a major factor requiring great reserves of power to attain supersonic speeds.”

1961: Joseph A. Walker of NASA’s Flight Research Center (along with Robert M. White, A. Scott Crossfield, and Forrest Peterson), for the scientific advances resulting from the X-15 test program.

1962: NASA’s original seven astronauts, for the Project Mercury flights.

1965: NASA Administrator James E. Webb and Deputy Administrator Hugh L. Dryden, for effective management of a large-scale research institution.

1968: NASA astronauts Frank Borman, James A. Lovell, and William A. Anders, for the Apollo 8 lunar orbital mission.

1969: NASA astronauts Neil A. Armstrong; Edwin E. Aldrin, Jr.; and Michael Collins, for the Apollo 11 lunar landing mission.

1971: David R. Scott, James B. Irwin, Alfred M. Worden, and Robert T. Gilruth, for the Apollo 15 lunar mission as the most prolonged and scientifically productive mission of Project Apollo.

1973: NASA’s Skylab program, with special recognition to William C. Schneider, program director, and the Skylab astronauts, for the production of scientific data about long-term space flight.

1974: John F. Clark of NASA and Daniel J. Fink of General Electric, representing the NASA/industry team, for the development of Landsat, proving the value of U.S. space technology in the management of Earth’s resources and environment.

1980: Edward C. Stone and NASA’s Voyager mission team, for the spectacular flyby of Saturn and the return of basic knowledge about the solar system.

1981: NASA and the industry team that developed the Space Shuttle and proved the concept of reusable spacecraft, with special recognition to astronauts John W. Young, Robert L. Crippen, Joe H. Engle, and Richard H. Truly.

1984: NASA and Martin Marietta, for the development of the Manned Maneuvering Unit (MMU), and the NASA team that rescued three disabled satellites, with special recognition to astronaut Bruce McCandless II; NASA’s Charles E. Whitsett, Jr.; and Martin Marietta’s Walter W. Bollendonk.

1987: NASA’s Lewis Research Center and the NASA/industry advanced turboprop team, for the development of a new fuel-efficient turboprop propulsion system.

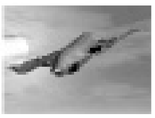
1988: NASA Administrator Richard H. Truly, for success in returning America to human space flight.

1993: NASA’s Hubble Space Telescope Recovery Team, for repair of the telescope in December 1993. The citation honored the team “for outstanding leadership, intrepidity, and the renewal of public faith in America’s space program by the successful orbital recovery and repair of the Hubble Space Telescope.”

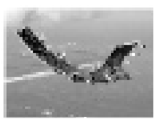
Can You Imagine the Future of Flight?

Here are a few stories illustrating concepts that would be enabled by NASA technology research.

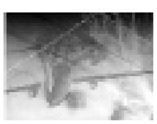
Getting from Here to There Fast: Small Aircraft Transportation System
Imagine being able to plan an entire trip, not just the flights like this one, on the Internet. You drive to the airport, not the major airport hub of today, but a local airport; board a small, twin-engine jet aircraft; and, in a matter of a few hours, arrive at your destination. Impossible? Not if NASA has anything to do with it. NASA is currently involved in a research project to determine the possibility of a Small Aircraft Transportation System (SATS) that will create a safe alternative for both business and personal air travel. Smaller aircraft would be used to carry people as well as products safely and affordably from one local community airport to another. Delays and travel time would be reduced as a result of creating access to more communities in less time. SATS would offer you, the flying public, high-speed travel at no more than current airline ticket prices.



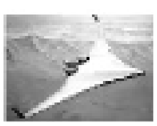
Fly Like an Eagle: The Morphing Project
In many wooded areas of our country, you can see the majestic eagle soaring overhead in clear blue skies. You may even notice the wings of this bird taking on a different shape and angle as it prepares to land on a treetop. NASA researchers are involved in a very long-term project in which airplanes will be able to change shape in flight as an eagle does. With unparalleled safety and efficiency, this will permit the plane to adapt to a wide variety of flight conditions as well as to unforeseen problems. It is known as the Morphing Project. To allow for more flexibility, the wings of this new airplane will be made of materials that cause the airplane's wings to be shaped more like a bird's than those of the airplanes on which we now fly. These airplanes of the future will have wings that bend and twist like those of a bird in flight. The airplane will be able to fly very fast or very slow and even hover over the ground. It is even possible that people will one day have their own morphing aircraft to fly just as they drive their automobiles today. Such an airplane would require a wing large enough to fly over large distances safely, but small enough to fit into a garage. Morphing planes controlled from the ground could fly in "flocks" on various missions. These flocks could aid in fire fighting, disaster relief, and search-and-rescue missions. Because morphing materials are lightweight and flexible, these technologies may also be used in a variety of other ways, such as medical sensors monitoring a patient's heartbeat or tiny sensing probes used during surgery. They also can be used to reduce vibrations in home appliances like washers, dryers, and dishwashers.



High-Flying Eyes in the Sky: Helios Prototype
Get great coffee thanks to high-flying, solar-powered aircraft. Coffee growers on Kauai are able to determine which coffee fields contain ripe, under-ripe, or overripe coffee cherries. With this knowledge, coffee growers know which fields to harvest and when in order to get the best coffee. Part of NASA's ongoing experiments with pilotless airplanes is the Helios Prototype, which is remotely piloted from the ground. The goal of this research project is to fly the Helios Prototype, a giant flying wing, at an altitude above 50,000 feet for at least four days using only solar energy for power. In 2001, the Helios Prototype aircraft flew at a world record height of 96,863 feet. Fitted with digital aerial cameras and other scientific instruments, this high-flying wing can detect ripe coffee fields and assist other farmers who grow a variety of crops. It can also act as a relay platform for telecommunications systems, enhance weather observation, and provide a disaster-monitoring and emergency-response communications relay. And this same technology may be applicable on the roadways as well.



Looking Through Pea Soup: Synthetic Vision
Have you ever driven in very thick, "pea soup" fog, where you can only see a few short feet ahead of you? As you inch along, you become concerned that there may be an object in the road that you cannot see, which could then cause an accident. Guess what? You're not alone! The single greatest contributor to the most fatal worldwide airline and general aviation crashes is limited visibility. It's why many private pilots try to avoid flying in bad weather. NASA's revolutionary virtual-reality cockpit display system, called Synthetic Vision, could help prevent deadly aviation accidents. Synthetic Vision gives pilots a clear, electronic picture of what is beyond their windows, regardless of the weather or time of day. New NASA technology, featuring super-accurate terrain databases and graphic displays, would draw 3-D moving scenes that would show terrain, ground obstacles, air traffic, landing and approach patterns, runway surfaces, and other relevant information to the flight crew.



The Big Plane: Blended Wing Body
Boeing's largest commercial airplane, the Boeing 747, carries between 300 and 570 passengers for up to 8,450 miles at a maximum speed of 555 miles per hour. NASA, in partnership with Boeing, is researching a futuristic airplane body that could carry between 450 and 800 passengers for up to 7,000 miles at a maximum speed of 560 miles per hour while consuming 20 percent less fuel than today's jetliners. That could mean cheaper airline tickets. The Blended Wing Body is an aircraft design that uses a type of flying wing shape as well as the standard features of today's airplane. The wingspan of this kind of aircraft would be just slightly wider than that of a conventional Boeing 747 and could operate from existing airport terminals.

Additional Resources

NASA has numerous resources in history of use to both students and teachers. The bulk of these materials may be downloaded from the Internet. Please check out the following World Wide Web sites for information.

- The Main NASA Home Page: *http://www.nasa.gov*. The central entry point to the massive amount of material available on the Internet from NASA.
- The NASA History Home Page: *http://history.nasa.gov*. This page contains information on aeronautics and astronautics; space projects such as Mercury, Gemini, Apollo, Skylab, and Shuttle; astronaut and other key personnel biographies; and online historical publications. It also has a search engine to ease use.
- The NASA Office of Aerospace Technology Home Page: *http://www.aerospace.nasa.gov*.
- NASA Spacelink: *http://spacelink.nasa.gov/.index.html*. This site is a central clearinghouse of educational materials produced by NASA.
- NASA Image Exchange: *http://nix.nasa.gov/*. This page has free photographs available in a variety of resolutions for downloading and use by all.
- U.S. Centennial of Flight Commission Home Page: *http://www.centennialofflight.gov*.

There are also several recently published books appropriate for high school and undergraduate students. These include the following:

- Baker, David. *Flight and Flying: A Chronology*. New York: Facts on File, 1993.
- Baker, David. *Spaceflight and Rocketry: A Chronology*. New York: Facts on File, 1996.
- Bilstein, Roger E. *The Enterprise of Flight: The American Aviation and Aerospace Industry*. Washington, DC: Smithsonian Institution Press, 2001.
- Bilstein, Roger E. *Flight in America: From the Wrights to the Astronauts*. Baltimore, MD: Johns Hopkins University Press, 2001 (revised paperback edition).
- Corn, Joseph J. *The Winged Gospel: America's Romance With Aviation, 1900–1950*. Baltimore: Johns Hopkins University Press, 2002 (revised paperback edition).
- Crouch, Tom D. *The Bishop's Boys: A Life of Wilbur and Orville Wright*. New York: W.W. Norton and Co., 1989.
- Ethell, Jeffrey L. *Frontiers of Flight*. Washington, DC: Smithsonian Books, 1992.
- Gwynne-Jones, Terry. *Farther and Faster: Aviation's Adventuring Years, 1909–1939*. Washington, DC: Smithsonian Institution Press, 1991.
- Heppenheimer, T.A. *A Brief History of Flight: From Balloons to Mach 3 and Beyond*. New York: John Wiley & Sons, 2001.
- Jakab, Peter L. *Visions of a Flying Machine: The Wright Brothers and the Process of Invention*. Washington, DC: Smithsonian Institution Press, 1990.
- Kirk, Stephen. *First in Flight: The Wright Brothers in North Carolina*. Raleigh, NC: John F. Blair, Publisher, 1995.
- Kolb, Rocky. *Blind Watchers of the Sky: The People and Ideas That Shaped Our View of the Universe*. Reading, MA: Helix Books, Addison-Wesley Publishing Co., 1996.
- Launius, Roger D. *Frontiers of Space Exploration*. Westport, CT: Greenwood Press, 1998.
- Logsdon, John M., general editor. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*. Washington, DC: NASA Special Publication-4407, 5 volumes, 1995–2001. Available from the U.S. Government Printing Office.
- Lopez, Donald S. *Aviation: A Smithsonian Guide*. New York: Macmillan, 1995.
- Pearcy, Arthur. *X-Plus: History of NACA/NASA Aircraft from 1915 to 1990*. Shrewsbury, England: Airlife Publishing, Ltd., 1992.
- Peebles, Curtis. *Dark Eagles: A History of Top Secret U.S. Aircraft Programs*. Novato, CO: Presidio Press, 1995.
- Spangenburg, Ray, and Diane Moser. *The Story of America's Air Transportation*. New York: Facts on File, 1992.
- Vincenti, Walter G. *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History*. Baltimore, MD: Johns Hopkins University Press, 1990.
- Wohl, Robert. *A Passion for Wings: Aviation and the Western Imagination, 1908–1918*. New Haven, CT: Yale University Press, 1994.

NASA Aerospace Technology Enterprise Education Projects on the Web

NASA's Office of Aerospace Technology sponsors a broad range of professionally designed learning activities and materials for students and teachers at all grade levels. These projects have been produced in close consultation with the educational community and are designed to support the national standards for mathematics, science, geography, and technology education. They are developed and implemented by the Education Offices at the following locations:

NASA Headquarters	Ames Research Center
Dryden Flight Research Center	Glenn Research Center
Langley Research Center	Marshall Space Flight Center

Visit the NASA Aerospace Technology Education Web site for a complete list of resources.
http://aerospace.nasa.gov/edu

The NASA "Sci" Files Video-Web Series (3–5)
Students use a problem-based approach to solve scientific mysteries with the treehouse detectives in NASA's "Sci" Files Club.
http://whyfiles.larc.nasa.gov/treehouse.html

NASA CONNECT Video-Web Series (5–8)
Establish the connection between the mathematics, science, and technology learned in school and that used every day by NASA researchers.
http://connect.larc.nasa.gov

Exploring Aeronautics CD-ROM (5–8)
An interactive exploration of how airplanes work and how NASA tests them.
http://catalog.core.nasa.gov/core.nsf/item/400.0-91

Earth to Orbit: Engineering Design Challenges Curriculum Supplement (6–9)
Use specially prepared activity guides to investigate NASA engineering challenges.
http://eto.nasa.gov

Flight Testing Newton's Laws, CD-ROM, Videos, Educator Guide (9–12)
Fly with NASA test pilots and perform research with NASA engineers with this interactive multimedia package.
http://trc.dfrc.nasa.gov/trc/ntps

Virtual Skies Web Site (9–12)
Students use NASA air traffic management techniques to make real-life decisions in aeronautics, geography, mathematics, and meteorology.
http://quest.nasa.gov/aero/virtual

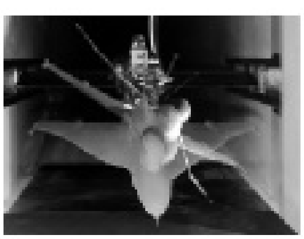
NASAexplores Web Site (K–12)
Weekly educational activities and informational updates on cutting-edge NASA aerospace technology research.
http://www.nasaexplores.com

The Wright Way Web Site (K–12)
Join with NASA to celebrate the 100th anniversary of flight.
http://wright.nasa.gov

Centennial of Flight Posters (K–12)
Attractive and informative tools for celebrating a century of flight.
http://www.centennialofflight.gov/education/posters.htm

Mobile Aeronautics Education Laboratory (K–12)
Learn how to establish an Aeronautics Learning Lab in your community.
http://www.grc.nasa.gov/WWW/MAEL

Destination Tomorrow, Video-Web Series (All Ages)
NASA research—past, present, and future— highlighted in a magazine-style format, with segments ranging in length from 3 to 8 minutes.
http://destination.larc.nasa.gov



NASA Resources for Educators

NASA's Central Operation of Resources for Educators (CORE) was established for the national and international distribution of NASA-produced educational materials in multimedia format. Educators can obtain a catalog and an order form by one of the following methods:

Mail:
NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074-9799
Phone: 440-775-1400
Fax: 440-775-1460
Toll-Free Fax Line: 1-866-775-1460
E-mail: *nasaco@leeca.org*
Home Page: *http://core.nasa.gov*

Educator Resource Center Network (ERCN)
To make additional information available to the education community, NASA has created the NASA Educator Resource Center (ERC) network. Educators may preview, copy, or receive NASA materials at these sites. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area. A list of the centers and the regions they serve includes the following:

AK, Northern CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
NASA Ames Research Center
Mail Stop 253-2
Moffett Field, CA 94035-1000
Phone: 650-604-3574

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
NASA Glenn Research Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, OH 44135
Phone: 216-433-2017

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
NASA Goddard Space Flight Center
Mail Code 130.3
Greenbelt, MD 20771-0001
Phone: 301-286-8570

CO, KS, NE, NM, ND, OK, SD, TX
Space Center Houston
NASA Educator Resource Center for
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058
Phone: 281-244-2129

FL, GA, PR, VI
NASA Educator Resource Center
NASA Kennedy Space Center
Mail Code ERC
Kennedy Space Center, FL 32899
Phone: 321-867-4090

KY, NC, SC, VA, WV
Virginia Air and Space Center
NASA Educator Resource Center for
NASA Langley Research Center
600 Settlers Landing Road
Hampton, VA 23669-4033
Phone: 757-727-0900 x 757

AL, AR, IA, LA, MO, TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
One Tranquility Base
Huntsville, AL 35807
Phone: 256-544-5812

MS
NASA Educator Resource Center
NASA Stennis Space Center
Building 1200
Stennis Space Center, MS 39529-6000
Phone: 228-688-3338

CA
NASA Educator Resource Center for
NASA Jet Propulsion Laboratory
Village at Indian Hill
1460 East Holt Avenue, Suite 20
Pomona, CA 91767
Phone: 909-397-4420

AZ and Southern CA
NASA Educator Resource Center
NASA Dryden Flight Research Center
P.O. Box 273, Mail Stop 4839
Edwards, CA 93523-0273
Phone: 661-276-5009

Eastern Shores of VA and MD
NASA Educator Resource Center
GSFC/Wallops Flight Facility
Visitor Center Building J-17
Wallops Island, VA 23337
Phone: 757-824-2298

Regional Educator Resource Centers (ERCs) offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as regional ERCs in many States. A complete list of regional ERCs is available through CORE, or electronically via NASA Spacelink at *http://spacelink.nasa.gov/ercn*

NASA's Education Home Page serves as the education portal for information regarding educational programs and services offered by NASA for the American education community. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts, Field Center offices, and points of presence within each State. Visit this resource at *http://education.nasa.gov*

NASA Spacelink is one of NASA's electronic resources specifically developed for the education community. Spacelink serves as an electronic library to NASA's educational and scientific resources, with hundreds of subject areas arranged in a manner familiar to educators. Using Spacelink Search, educators and students can easily find information among NASA's thousands of Internet resources. Special events, missions, and intriguing NASA Web sites are featured in Spacelink's "Hot Topics" and "Cool Picks" areas. Spacelink may be accessed at *http://spacelink.nasa.gov*

NASA Spacelink is the official home to electronic versions of NASA's Educational Products. A complete listing of NASA Educational Products can be found at the following address: *http://spacelink.nasa.gov/products*

The First Century of

1915 1920 1930 1940

March 3, 1915—A rider to the Naval Appropriations Act established the National Advisory Committee for Aeronautics (NACA). The Committee was instituted to "supervise and direct the scientific study of the problems of flight, with a view to their practical solution."

1916–1917—NACA called the first joint meeting of the aircraft industry and Government agencies. This conference was instrumental in the creation of the Manufacturers Aircraft Association and in the recommendation for the formation of the Aircraft Production Board for WWI aircraft production.

June 11, 1920—Wind Tunnel 1 at NACA Langley was formally dedicated. It was the first of many now-famous NACA and NASA wind tunnels. Although this specific wind tunnel was not unique or advanced, it led NACA engineers and scientists to advanced wind tunnel concepts.

1924–1960s—Compressibility research, the study of air's behavior as a high-speed compressible fluid began in the 1920s and enabled researchers to solve control problems later experienced by WWII airplanes.

1928—NACA Cowling Wind Tunnel research began. This research led to a series of component drag studies that resulted in aircraft drag reduction, which increased aircraft speeds and range.

1930—Atmospheric Wind Tunnel (AWT) became operational at NACA Langley. Research performed in the AWT produced an important knowledge base and essential design data relative not only to basic performance, but also to aircraft stability and control, power effects, flying qualities, aerodynamic loads, and high-lift systems.

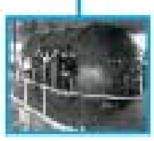
1936–1945—Thermal Ice Prevention Systems at NACA were created to investigate effective countermeasures to the problems of ice formation on aircraft.

January 23, 1941—NACA Aircraft Engine Laboratory in Cleveland, Ohio, later named Lewis Research Center, currently NASA Glenn Research Center, was founded.

1944—Ames 40x80 full-scale wind tunnel became operational. It allowed whole aircraft to be wind-tunnel-tested, as compared to models at low flight speeds, and expanded testing capabilities to larger and faster aircraft.

April 2, 1915—President Woodrow Wilson appointed the first 12 members of the National Advisory Committee for Aeronautics (NACA). Orville Wright was a member from 1920 to 1948.

July 17, 1917—Langley Memorial Aeronautical Laboratory, the site for NACA's first experimental aeronautical facility, was founded. These facilities and their successors contributed to the advancement of aeronautics and space flight for the indefinite future.



1922—Variable Density Wind Tunnel (VDT) was constructed. The VDT brought a new concept to wind tunnel design by employing high-pressure air, compressed to a higher density in an airtight chamber, to better simulate flight conditions with scale models.

May 23, 1925—First NACA Aircraft Engineering Research Conference was held. Government promoted the transfer of technology and expertise to industry.

1929—Construction began on 30x60 full-scale wind tunnel. This wind tunnel allowed testing of actual aircraft, including manufacturing details that led to important "drag cleanup" improvements.

1933—NACA Report 460, "The Characteristics of 78 Related Airfoil Sections from Tests in the Variable-Density Wind Tunnel," the culmination of 10 years of research, was published. The report included a groundbreaking systematic study of airfoils and produced the airfoil numbering system of today.

April 18, 1940—Ames Aeronautical Laboratory in Moffett Field, California (later renamed NASA Ames Research Center), was formed.

1941—Report NACA R755, "Requirements for Satisfactory Flying Qualities of an Airplane," by R.R. Gilruth, was published. This document defined a set of requirements for the handling characteristics of an aircraft. Up until this point, no set of guidelines for pilots and aircraft designers existed.

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f Flight: NACA/NASA Contribut

1950 1960 1970

September 1946—NACA Langley sent personnel to Muroc Army Airfield, in the Mohave Desert of California, to support flight research, forming the basis for what was to become NASA Dryden Flight Research Center.

1949—National Unitary Wind Tunnel Act of 1949 enabled NACA to erect supersonic tunnels at each of its three research centers, with priority utilization reserved for industry testing. The new facilities proved their worth almost immediately with the discovery of the "Area Rule."

1951—The Slotted Throat Transonic Wind Tunnel, a revolutionary step in the field of aerodynamics, demonstrating much less wall interference and providing reduced "choking" effects, became operational. Experiments were run in 1947 on 12-inch models of the tunnel to verify the concept.

1951—H. Julian Allen of Ames Research Center near San Francisco, California, develops blunt-body reentry theory. The foundation of all reentry vehicles, this theory showed that a blunt body would survive the harsh environment of reentry, experimentally verified in 1953.

1953—D-558-2, flown by Scott Crossfield, was the first aircraft to break Mach 2, or twice the speed of sound. The achievement culminated a joint Navy/NACA high-speed flight research program.

October 1, 1958—National Aeronautics and Space Administration (NASA) was formed. The 1958 Space Act was signed, establishing NASA as the organization responsible for both aeronautics and astronautics. NACA formed the core of this new space agency with other organizations from the Army and the Navy.

1963–1976—Lifting Body Vehicles Research Program. The program consisted of multiple operations that flight-tested the concept of using a vehicle body as compared to wings to generate lift.

1972—F-8C Digital-Fly-By-Wire Control System was tested. The use of electrical and mechanical systems to replace hydraulic systems for aircraft control surface actuation was flight-tested.

1974–1981—Powered Lift Technology Quiet Short-haul Research Aircraft (QSRA) program developed and demonstrated technologies necessary to support short-takeoff and high-lift cargo aircraft. These technologies were employed on the C-17 Globemaster III.

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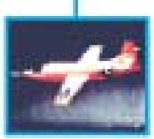
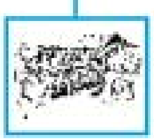
...obert T. Jones ...l in the U.S. the ...ng Concept, in ...identified the ...ce of swept-...gs in efficiently ... and maintain-...speed flight.

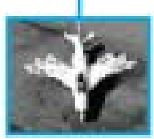


1947—X-1 was the first piloted supersonic aircraft to "break the sound barrier." Chuck Yeager flew the air-launched, rocket-powered first "X" series experimental aircraft faster than the speed of sound, ushering in the era of supersonic flight.



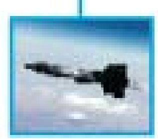
1950–1960—Engineers at the Lewis laboratory pursued development of an axial flow compressor for jet engines that improved efficiency by an order of magnitude. This research became the basis of the modern high bypass jet turbofan.

1951—Richard T. Whitcomb of NACA Langley Research Center determined the transonic "Area Rule" that explained the physical rationale for transonic flow over an aircraft. This concept is now used in designing all transonic and supersonic aircraft.



1952—Variable sweep research began. A variation of the swept wing theory, the variable sweep wing mechanically adjusted to different sweep angles to conform to either subsonic or supersonic flight.

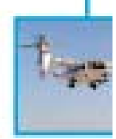
1953—NACA Report R1135, "Equations, Tables, and Charts for Compressible Flow," a bible for compressible flow aerodynamics, was published.



1959–1969—During this time, 199 flights were made by three X-15 aircraft. On August 22, 1963, flight reached an all-time altitude record of 354,000 feet. On the flight of October 3, 1967, a record speed of Mach 6.7 was reached. This program produced invaluable data on aerodynamic heating, high-temperature materials, reaction controls, and space suits.

1970—Richard T. Whitcomb invented the Supercritical Airfoil to delay the drag rise that accompanied transonic airflow.

1974–1997—The NASA 737 research aircraft was used for flight-testing a variety of large transport aircraft technologies, such as "glass cockpits," airborne wind shear detection, microwave landing systems, and head-up displays.



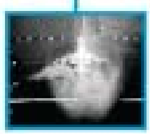
1976–1978—The Army-Bell XV-15 t... research aircraft h... (1976) and then d... strated conversio... forward flight (19... the first tilting roto... cle to solve the pr... of "prop whirl." It... cess directly led t... V-22 Osprey develo...

tions to Aeronautics

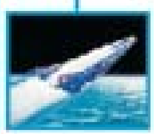
79–1980—Winglets, small wings, which re applied at the tips the aircraft's main ng to improve vehicle rodynamics, were first wn. Originally used on -135 aircraft to prove fuel efficiency, ey are now universally cepted.

1981—STS-1, first flight of the Space Shuttle, a partially reusable space vehicle. First flown aerodynamic winged vehicle to reenter from space, employing technologies developed over 30 years.

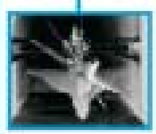
1981–1990—X-29 Flight Research Aircraft demonstrated forward swept wing technology and provided data on aeroelastic tailoring, active controls, and canard effects. First flight was December 14, 1984.



1984—National Transonic Facility (NTF) became operational. It enables experimentation at full-scale flight Reynolds number by testing in super-cold (cryogenic) environment.



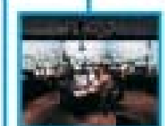
1986–1994—X-30 National AeroSpace Plane (NASP) program, conceived to develop operational space planes, never advanced beyond its technology development period but produced advanced technologies in materials, propulsion, and other fields.



1986–1994—Laminar Flow Control project research on active flow control over all speed regimes was developed to produce laminar flow over 65 percent of the wing of the aircraft, generating less drag and promoting better fuel efficiency.

1993–1995—Flight control from engine thrust was developed and flight-tested for aircraft control using only engine thrust and no control surfaces.

1997–Ongoing—Environmental Research Aircraft and Sensor Technology (ERAST) project was established. Remotely piloted, solar-powered "Helios" vehicle flew to the record-breaking altitude of 96,863 feet in 2001, leading the way for future high-altitude, long-duration, solar-powered aircraft.



1999–Ongoing—Future Flight Central is a full-scale airport operations simulator that can create a functionally accurate physical and software replication of a control tower or operations center (current or future). With NASA experts, airport staff can plan new runways, test new ground traffic and tower communications procedures, validate air traffic planning simulations, and perform cost-benefit studies for new airport requirements and designs.

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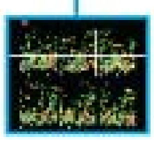
1979–1983—Highly Maneuverable Aircraft Technology (HiMAT) introduced on first unpiloted subscale flight-test vehicle. The outcome was used to validate technologies for future fighter aircraft. The extensive uses of composites, winglets, and canards appeared on other aircraft.

1981–Ongoing—ER-2 high-altitude aircraft is used for atmospheric research, observation, and mapping.



1984—"Riblets," or small V-shaped grooves, were discovered to reduce aerodynamic drag. This technology has been used on many aircraft and sailing vessels.

1985–1989—Mission Adaptive Wing (MAW) was tested on flight F-111 ATFI. The wing of the F-111 was modified so that the curvature of the leading and trailing edges could be varied in flight.

1986–1993—NASA/FAA Wind Shear Program, a joint study on the cause of and corrective action for encounters with wind shear outcome procedures and technologies, began.

1987–1998—F-18 High Alpha Research Vehicle (HARV). The program was to validate computer codes and wind tunnel test results relating to high angle of attack aerodynamics, flight controls, and airflow phenomena.

1994–2000—Improvements in the configuration of aircraft to reduce sonic boom intensity were formulated in a sonic boom study.

1999–Ongoing—Neural network technology for aircraft control was invented to help aircraft recover from loss of control.

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