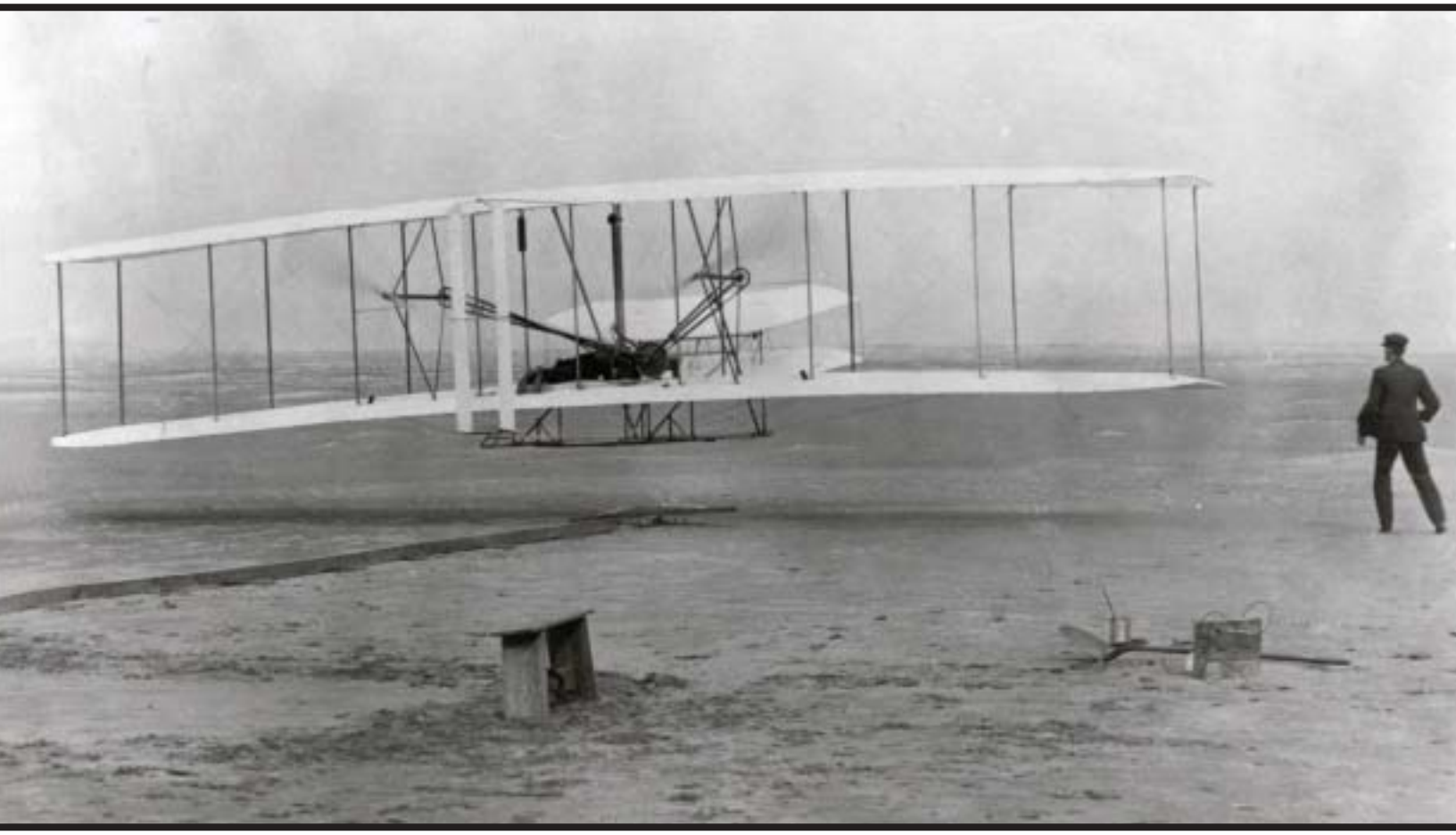

Celebrating
a Century
of Flight
PROPELLERS

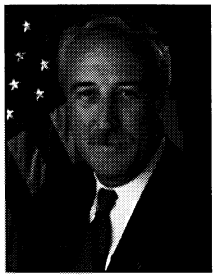


■ This photograph of the first flight at Kitty Hawk, North Carolina, on 17 December 1903 is one of the most recognized in the world. With Orville Wright at the controls, lying prone on the lower wing with his hips in the cradle that operated the wing-warping mechanism, the first successful powered flight took place. Wilbur Wright, seen running alongside to balance the machine, has just released his hold on the forward upright of the right wing. The starting rail, the wing rest, a coil box, and other items needed for flight preparation are visible behind the machine. This flight was the result of years of experiments and design by the Wright brothers, who were operators of a bicycle repair shop and factory in Dayton, Ohio. The brothers continued their flying experiments in Ohio and in Fort Myer, Virginia, and were granted a patent for the plane in 1906. In 1908 and 1909, they traveled to Europe and drew attention to their invention by flying in France, Italy, England, and Germany. In 1909, they started a company to manufacture Wright airplanes and began their successful fight against patent suits by Glenn Curtis and other competitors. Wilbur died of typhoid fever in 1912, and Orville sold his interest in the Wright Airplane Company in 1915. The Wright brothers were aware of the important relationship of photography to their work, both scientifically and historically. Accordingly, they recorded their experiments photographically and, later, on film. The Wrights asked John T. Daniels of the Kill Devil Hills Life Saving Station, who was among the spectators, to snap the camera for them just at the moment the machine had reached the end of the takeoff rail and had risen two feet into the air. Before attempting the flight, Orville had placed the camera on a tripod, aimed at a point he hoped the machine would reach when it left the track. The shot was successful, and the negative was developed by Orville on his return to Dayton. (Courtesy of the Library of Congress, Negative LC-W861-35)

Cover photo: Since 1915, the National Advisory Committee for Aeronautics (NACA), transformed into NASA in 1958, has performed cutting-edge research to solve the problems of flight. Using a Grumman F4F-3 Wildcat during World War II, NACA engineers at the Langley Aeronautical Laboratory (now Langley Research Center) in Hampton, Virginia, used this aircraft to investigate the cuffs on the propeller blades to determine their efficiency. While not built to the full production standard of other Grumman Wildcats, research on this aircraft, the second F4F-3, proved most successful in advancing knowledge of the aerodynamics of this engine and propeller system. This photo shows a close-up of the propeller blades with Curtiss Electric Propellers' logo.

Acknowledgments: writers/historians/reviewers, Judy Baker, Roger Launius, Tom Crouch, Ned Preston,Roger Miller, Louise Alstork, Tony Springer, John Childress, Bill Anderson, Sherry Foster, Phil Milstead, Steve Garber, Leslye Mogford, and Mike Gorn; brochure concept, Thom Pinelli; editors, Susan Hurd and Lisa Jirousek; photo researcher, Mark Sutton; designers, Heather Grimstead and Melissa Kennedy. Printed fall 2002.

Celebrating a Century of Flight



Thirty-three years ago, when astronauts Neil Armstrong and "Buzz" Aldrin skillfully piloted the lunar module Eagle to a soft landing on the Moon, they paid tribute to America's aviation heritage by bringing with them a piece of the original Wright Flyer's fabric and propeller. That incredible summer day in 1969, our moonwalkers demonstrated for all time that the sky's no longer the limit.

As flight's second century begins, the United States is still boldly pioneering the air and space frontier. And the National Aeronautics and Space Administration, NASA, is a proud leader in this effort.

Fittingly, NASA's roots extend back to aviation's infancy. In 1915, our predecessor, the National Advisory Committee for Aeronautics, NACA, was formed to help improve aircraft performance, efficiency, and safety. Today, NASA scientists, engineers, and test pilots continue to push the envelope of flight technology.

NASA's vision for the next century of flight—to improve life here, extend life to there, and find life beyond—compels us to improve and create all types of aircraft, better understand Earth's climate, probe the universe's mysteries, and send explorers to the planets. This celebration of the centennial of flight reminds all of us how privileged we are to be engaged at just the start of an adventure without end.

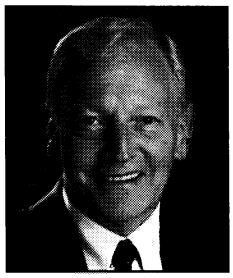
—Sean O'Keefe, Administrator, NASA

One hundred years ago, the promise of flying machines and powered airships was found exclusively in the minds of dreamers. Most believed powered flight was a far-fetched idea, the stuff of myths and legends. On 17 December 1903, Orville and Wilbur Wright dispelled those myths and propelled us into a new era of exploration and innovation. Flying a biplane made of wood and cloth from a Kitty Hawk sand dune, they transformed our dream of flight into a breathtaking reality.

Since that first 20-second flight, the achievements of civilian and military aviation have far surpassed the dreams of those early visionaries. Airmen have revolutionized travel and commerce, pioneered the development of groundbreaking technologies, redefined the way we defend our interests, and helped shape a world in which our nation's safety and prosperity would flourish. Powered flight is and will continue to be one of humankind's most significant accomplishments. If properly guided and nourished—with the same vision that characterized its creators—the second century of flight will further advance the peaceful and productive interaction of nations, continue to protect our cherished freedoms, and provide for the benefit of all mankind.

The United States Air Force joins the world in celebrating the spirit of the Wright brothers' creativity and our nation's aviation pioneers. As we reflect on a century of flight, we reaffirm our commitment to continue the dream started by those first airmen. We've come a long way in our first 100 years of flight . . . imagine where the next 100 years will take us.

—John P. Jumper, General, USAF Chief of Staff



From the sands of Kitty Hawk in 1903 to the outer edges of our solar system in 2003, no invention has made such an indelible imprint on our world as the airplane. Crafted by two ordinary men who were driven to achieve extraordinary results, the 1903 Wright Flyer represents an achievement of creativity, determination and courage. The national *Centennial of Flight: Born of Dreams—Inspired by Freedom* commemoration celebrates the human desire for freedom, the power of dreams and the astonishing realities they can create.

Let us use the story of flight to build a new level of enthusiasm for perseverance and resolve in the quest for ingenuity. The U.S. Centennial of Flight Commission is committed to providing educational material on the history and influence of flight. As you read this brochure, I hope that you find the information both informative and inspiring. Ask yourselves, and those around you, "If we can fly, what can't we do?" It is through this spirit of adventure and determination that we will create the next century of aviation milestones.

—J.R. Dailey, Chairman, U.S. Centennial of Flight Commission

The most beautiful dream that has haunted the heart of man since Icarus is today reality. —Louis Blériot

3500 B.C.
King Etena of Babylonia was pictured on a coin, flying on an eagle's back.

2500 B.C.
An Inca Founder (Auca) was "winged and could fly."

1000 B.C.
The Chinese invented kites that carried scouts on reconnaissance missions.

1162
A man in Constantinople fashioned sail-like wings from a fabric gathered into pleats and folds. He plummeted from the top of a tower and died.

1783
June 4 Montgolfier brothers launched the first public balloon flight.

November 21 Pilâtre de Rozier and the Marquis D'Arlandes were the first humans to fly in an untethered balloon.

2560 B.C. Great Pyramid of Khufu built | 1100 Gunpowder used to build rockets | 1400 Printing press invented

Up, Up, and Away...

■ Human beings have dreamed of flight for centuries, but the first creatures to venture aloft in a balloon were a duck, a sheep, and a rooster. An enormous crowd joined the King of France, Louis XVI, his Queen, Marie Antoinette, and their children at the Versailles palace on 19 September 1783. The occasion was the flight of these three hapless animal passengers aboard a hot-air balloon constructed by brothers Joseph and Etienne Montgolfier. After an aerial voyage lasting only eight minutes and covering some two miles, the first three air travelers returned safely to Earth, none the worse for wear.

The Montgolfier brothers, natives of Annonay, in the south of France, belonged to one of the leading paper-making families of France. Fascinated by new discoveries in science, Joseph Montgolfier had begun to experiment with paper and fabric bags filled with hot air in the early 1780s. With his younger brother Etienne, he launched a balloon measuring ten feet in diameter from the town square on 4 June 1783.

When news of what the two brothers had achieved in distant Annonay reached Paris, a prize was offered to the individual who could repeat the Montgolfier experiment. Not sure how the brothers had accomplished the feat, J. A. C. Charles, a popular lecturer on scientific topics, constructed the first balloon filled with hydrogen, a gas very much lighter than air. He launched the first gas balloon in Paris on 27 August 1783, near the spot where the Eiffel Tower now stands. Not to be outdone, the Montgolfiers hurried to the capital and arranged the flight from Versailles in September.

The Prehistory of Flight

■ Human beings have always wanted to fly. Evidence of our ancient desire to join the birds in the sky can be found in our earliest legends of winged gods and heroes, flying horses, and magic carpets. Then there are the hazy tales of real human beings who were carried aloft by kites or who sought to fly with wings of their own design. All too often, these intrepid souls suffered broken bones or worse.

When the age of flight finally did arrive, it came from an unexpected direction that had nothing to do with wings. The invention of the balloon created a wave of excitement that swept across Europe and America. Although the balloon would be put to good use by science and the military, it could only travel where the wind blew it. The age-old dream of wings remained very much alive.

Daedalus and Icarus

■ The story of Daedalus and Icarus is the most famous of all flight myths. Minos, the King of Crete, hired the talented craftsman Daedalus to design a Labyrinth, or maze, in which to imprison the Minotaur, a half-man, half-bull creature. Each year, young people were sacrificed to appease the monster. When Daedalus helped Theseus, a young hero selected for the sacrifice, to kill the Minotaur and escape, Minos imprisoned the inventor and his son, Icarus. Realizing that flight was the only way in which he and Icarus could free themselves, Daedalus fashioned wings out of feathers and wax to carry them across the sea, away from King Minos.

Daedalus carefully instructed his son to fly "a middle course," safely between the water that might weigh down the feathers if it sprayed on them and the Sun, which could melt the wax that held the feathers in place. Icarus, thrilled by the freedom of his flight and curious to explore the heavens above him, soared higher and higher, until the heat of the Sun destroyed his wings and he plunged to his death in the sea. The story of Icarus and Daedalus was told and retold through the centuries, inspiring human beings to fly and cautioning those who dared to dream of trespassing on the domain of the gods.

Hindu mythology tells of the bird deity Garuda, often depicted in art as having the body of a man but the head and wings of an eagle. This great and powerful flying god-bird lent his body as a vehicle to the Hindu god Vishnu, with whom he is worshiped. Garuda's image can be seen in sculpture, paintings, and architecture, especially that of royal residences.

1784
June 4 Elisabeth Thible was the first woman to make a balloon flight.

June 24 In a tethered flight from Baltimore, Maryland, thirteen-year-old Edward Warren was the first to fly in a balloon from American soil.

1785
January 7 Dr. John Jeffries, an American physician living in London, accompanied the French aeronaut Jean-Pierre Blanchard on the first flight across the English Channel.

1775 American Revolutionary War began

1797 First parachute jump

With public enthusiasm approaching a peak, the Montgolfier brothers designed a large balloon that carried the first human passengers aloft. On 21 November 1783, Pilâtre de Rozier and the Marquis d'Arlandes fed a fire of burning straw that filled the canopy of the balloon with hot air, lifting them about 330 feet into the Paris skies. Their flight lasted under 30 minutes. J. A. C. Charles and a companion, M. N. Robert Millbrook, became the first people to fly aboard a gas balloon on 1 December 1783.

Balloons captured the imagination of Europeans and Americans alike. Peter Carnes, a lawyer and tavern keeper in Bladensburg, Maryland, sent the first American, thirteen-year-old Edward Warren, into the air on a tethered flight from Baltimore, Maryland, in June 1784. Early the following year, another American, Dr. John Jeffries, accompanied aeronaut Jean-Pierre Blanchard on the first flight across the English Channel.

Gas balloons continued in use throughout the nineteenth and twentieth centuries, offering scientists a means of exploring the upper atmosphere and providing military officers with an aerial perch from which to observe the enemy.

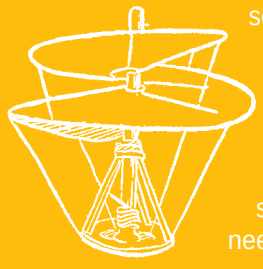
Hot-air balloons became popular once again after World War II, when the advent of new materials and propane-fired burners offered sportsmen a new way to venture aloft. In 1999, after a twenty-day, nonstop flight, Bertrand Piccard and Brian Jones became the first balloonists to complete a nonstop circumnavigation of the globe. The last solo balloon hurdle was crossed in 2002 when Steve Fossett circumnavigated the world by balloon alone. Today, colorful hot-air balloons of fanciful designs are seen floating in the skies all over the world. Those who see them might agree with Joseph Montgolfier, who long ago instructed his brother to prepare the materials for their first balloon—"and you will see one of the most incredible things in the world."

A Montgolfier-type balloon is depicted at the time of launch in Paris in 1783.

National Air & Space Museum #93-2342 ©2002 Smithsonian Institution

Winging It

■ For hundreds of years, human beings attached all manner of wing-like structures to their arms, flung themselves from the tops of towers and other high places, and attempted to fly. Most of these would-be aviators sought to fly with ornithopters, machines that beat their wings like birds. Even the brilliant Italian artist, scientist, and engineer Leonardo da Vinci, who understood some of the basic principles of flight as early as the 1480s, could only dream of flying ornithopter and helicopter designs that could never have left the ground. He and others of his time failed to realize that human beings lacked the necessary muscle power to imitate bird flight.

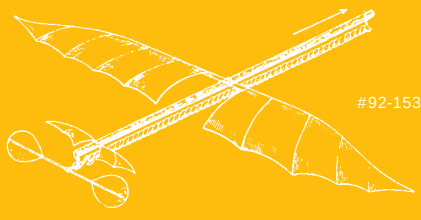


#74-3837

Almost four hundred years after Leonardo, French inventor Gustave Trouvé designed an ornithopter that was powered by an internal combustion engine. In 1870, Trouvé's model successfully flew a distance of 70 meters in a demonstration before the French Academy of Sciences. Another Frenchman, Alphonse Pénaud, pioneered the use of rubber-band-powered motors in a small ornithopter built and flown in 1874. Today, ornithopter designs are still on the minds, as well as the drawing boards, of adventurous and imaginative people determined to achieve the old dream of flight with flapping wings.

Drawings, left to right: da Vinci air screw sketch, Pénaud sketch.

National Air and Space Museum ©2002 Smithsonian Institution



#92-15369

1794
June 26 The French used a tethered balloon to observe a battlefield and direct artillery fire.

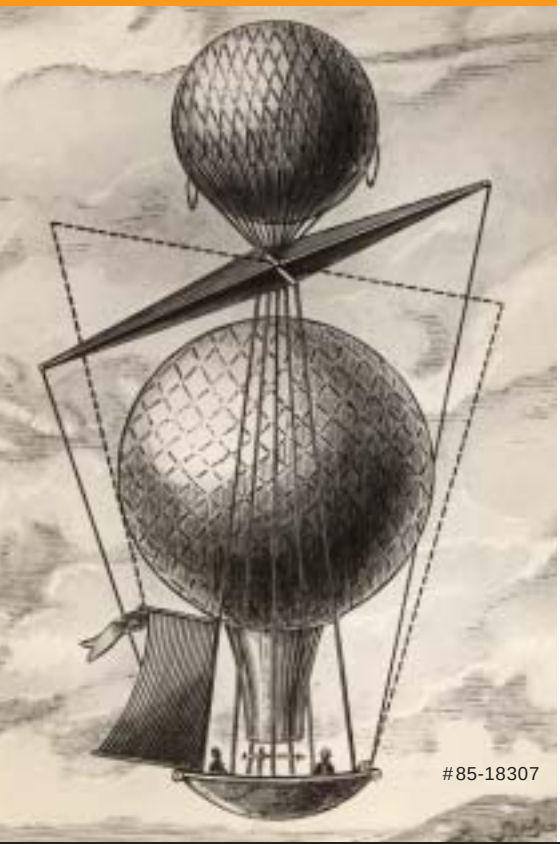
1804
Sir George Cayley, England's "father of aeronautics," built and flew the world's first successful model glider.

1813 Steam locomotive invented

Inventing Wings

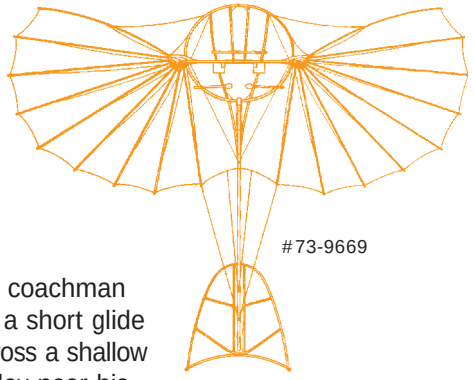
■ Early in the nineteenth century, the age of dreams had given way to serious attempts to understand the principles of flight and to apply the lessons learned to the design of real flying machines. Cautious experimenters tested their ideas with powered models, while the more daring sampled the delights and the dangers of gliding flight. Their successes and their failures helped move human beings toward what some considered impossible and others considered inevitable—piloted, powered flight.

Above, left to right:
Sir George Cayley (1773–1857);
Octave Chanute (1832–1910);
Otto Lilienthal (1848–1896).
Below: Sketch by George Cayley.



#85-18307

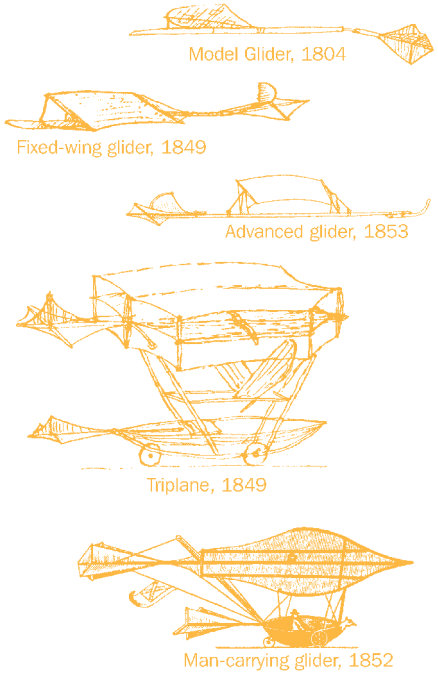
Aviation Pioneers



#73-9669

■ Sir George Cayley, a nineteenth-century English baronet, richly deserves to be remembered as the "father of aeronautics." His insatiable curiosity led him to conduct the first real experiments designed to uncover the basic principles of flight. He discovered that the arched shape of a bird's wing was one of the secrets of bird flight and reasoned that a similar shape on a fixed-wing machine might likewise allow it to fly.

Cayley designed, built, and flew the world's first model glider in 1804. He continued his experiments throughout his long life and is said to have sent his coachman on a short glide across a shallow valley near his home, Brompton Hall, in 1853. Legend has it that the frightened servant resigned on the spot, explaining that he had been hired to drive, not to fly.



Above: George Cayley's sketches show a variety of glider designs.

Sir George Cayley's many contributions to aviation include the understanding that a successful heavier-than-air flying machine would have to feature separate systems for lift, propulsion, and control. He explained the importance of streamlining, described the way in which stability and control could be achieved, and underscored the need for a lightweight power plant. The first person to link the evolving processes of science and engineering with aviation, he opened the door to the future.

Otto Lilienthal built on both the experiments and information provided by Sir George Cayley. He published the results of his ground-based research, "Birdflight as the Basis of Aviation," in 1890; he then began to apply what he had learned to the design of the gliders with which he would continue his work. Between 1890 and the time of his death in a glider crash in August 1896, Lilienthal made as many as 2,000 flights in eighteen different designs, including both monoplanes (single-wing) and biplanes. All his craft were hang gliders, controlled in the air by movements of the pilot's body, which hung beneath the machine. The work of Otto Lilienthal provided the starting point for the experimenters who would take the final critical steps toward the invention of the airplane.

1868
Matthew Boulton obtained a British patent on a design for ailerons as control surfaces.

1878
Bishop Wright gave his sons, Orville and Wilbur, a toy helicopter.

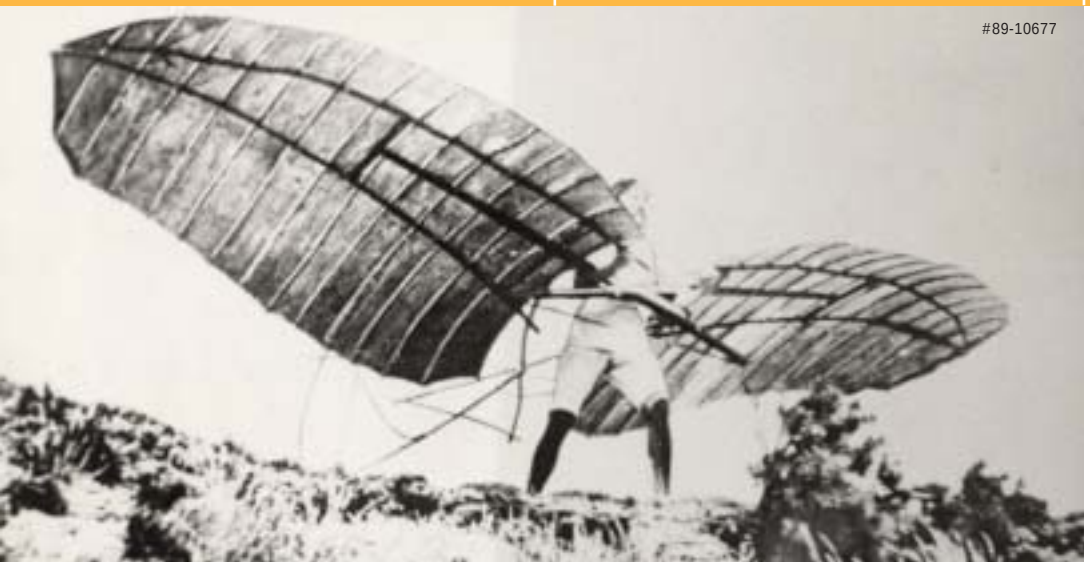
1884
Horatio Phillips of England designed a wing with a curved airfoil shape.

1896
May 6 Samuel P. Langley launched the first reasonably large, steam-powered model aircraft.

1899
May 30 Wilbur Wright wrote the Smithsonian Institution and affirmed his belief that human flight was possible.

1900
The Wright brothers flew their first of several gliders, a biplane that soared for 300 feet.

1868 First transcontinental railroad | 1897 Spanish-American War | 1899 Aspirin first manufactured

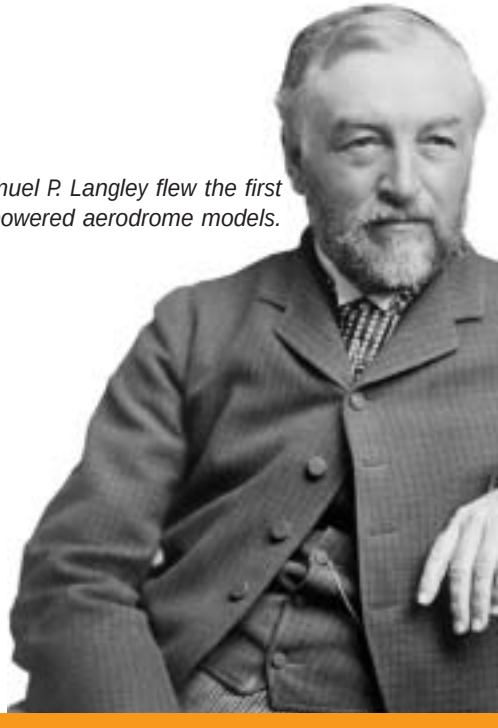


Above left: Lilienthal blueprint depicting the glider Lilienthal considered the most successful. Above: Otto Lilienthal on one of his gliders. National Air and Space Museum ©2002 Smithsonian Institution

Octave Chanute, a self-taught American engineer, became interested in aeronautics in the 1870s. Corresponding with flying machine experimenters around the globe, he quickly emerged as the focal point of an international community of engineers who were attempting to fly. An admirer of Lilienthal, Chanute sponsored a series of glider trials on the sand dunes at the southern tip of Lake Michigan in the summer of 1896. The trials produced a triplane/biplane hang glider that represented a distinct improvement over the Lilienthal designs. A passionate promoter of aviation who believed in the importance of collecting information about the progress being made in the field and then sharing it with others who could carry on its development, Chanute inspired and stimulated other aviation experimenters, including a pair of brothers from Dayton, Ohio.

Octave Chanute attracted the American scientist Samuel P. Langley to aeronautics. Appointed Secretary of the Smithsonian Institution in 1887, Langley conducted extensive research into the principles of flight, then began his design experiments with small rubber-band-powered models that he called "aerodromes." In 1896, Langley completed two flights of up to 4,200 feet with model steam-powered aerodromes. While the aerodromes were too small to carry a pilot and could not be controlled, they were the first powered, significantly large models to fly.

The War Department then provided Secretary Langley with $50,000 to design and build a full-scale aerodrome capable of carrying a pilot. He tested his machine in October and December of 1903. On both occasions, the structure collapsed when catapulted into the air from a houseboat anchored in the Potomac River. It flew, one reporter observed, "like a handful of mortar." Pilot Charles Manly survived both trials, but the aeronautical career of Samuel Langley was at an end.



Samuel P. Langley flew the first powered aerodrome models.

Interesting Reading

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, MD: 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.

Heppenheimer, T. A. *A Brief History of Flight: From Balloons to Mach 3 and Beyond*. New York: John Wiley & Sons, 2001.

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.

Lopez, Donald S. *Aviation: A Smithsonian Guide*. New York: Macmillan, 1995.

Millbrooke, Ann. *Aviation History*. Englewood, Colorado: Jeppeson, Sanderson, 2000.

Spangenburg, Ray, and Diane Moser. *The Story of America's Air Transportation*. New York: Facts on File, 1992.

Wohl, Robert. *A Passion for Wings: Aviation and the Western Imagination, 1908–1918*. New Haven, CT: Yale University Press, 1994.

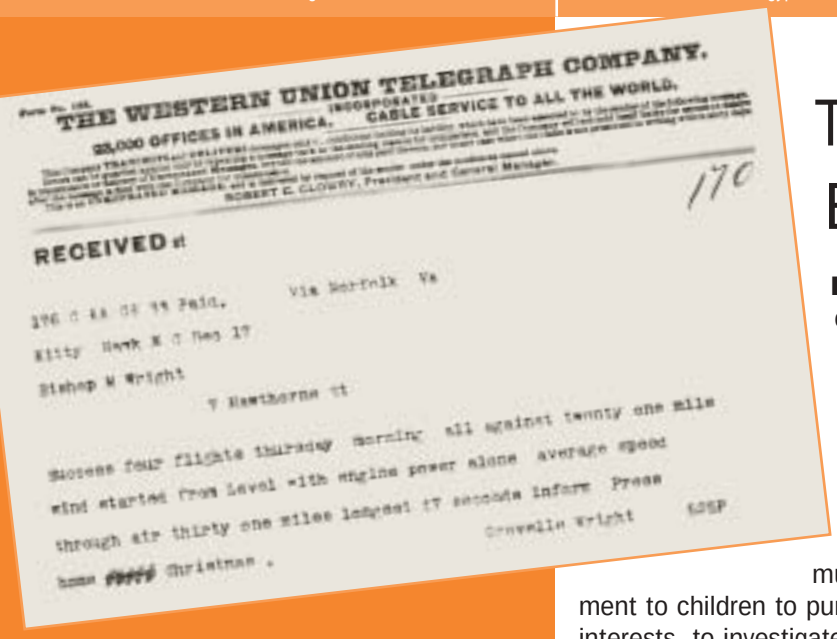
1901
Using existing aerodynamics tables, the Wright brothers constructed new wings for a larger glider. However, its flight was marginal, so they tested the tables by analyzing model wings in a wind tunnel. The tables proved to be wrong, and the Wrights painstakingly computed new ones.

1902
Using tables created in 1901, the Wrights built a glider that had almost twice the efficiency of their previous ones and made more than 1,000 flights that year at Kill Devil Hills near Kitty Hawk, North Carolina.

1903
December 8 Samuel P. Langley's man-carrying Great Aerodrome collapsed right after takeoff.

December 17 The Wright brothers completed the first powered, piloted, heavier-than-air, controlled flight.

1901 First transatlantic radio signal | 1902 Aswan Dam in Egypt completed | 1903 Ford Motor Company founded


THE WESTERN UNION TELEGRAPH COMPANY.
OFFICES IN AMERICA. INCORPORATED CABLE SERVICE TO ALL THE WORLD.
ROBERT C. CLOWRY, President and General Manager.
RECEIVED at
Via Norfolk Va
Kitty Hawk N C Dec 17
Bishop M Wright
7 Hawthorne St
Success four flights thursday morning all against twenty one mile wind started from level with engine power alone average speed through air thirty one miles longest 57 seconds inform Press
Orevville Wright
home Christmas .

Above: Facsimile of the telegram sent by Orville Wright on 17 December 1903, reproduced in commemoration of the ninetieth anniversary of piloted, controlled, powered flight. Note the error in the spelling of Orville Wright's name and the error in listing the air time. The longest flight was actually 59 seconds.

Success!

■ The great moment arrived on a windy winter morning on a North Carolina beach, the result of the work of two brothers with a passion for bicycling and an insatiable curiosity. The Wright brothers introduced the era of powered flight, and men and women everywhere were anxious to follow them into the air. Steady improvements in the design of engines and aircraft structures produced a new generation of aircraft capable of flying higher, faster, and farther.

Two Ordinary Men, One Extraordinary Dream

■ Orville Wright once explained that he and his brother, Wilbur, were lucky to have grown up "in an environment where there was always much encouragement to children to pursue intellectual interests, to investigate whatever aroused curiosity." The sons of a church bishop and his mechanically inclined wife, the Wright boys first became interested in flight as children when their father presented them with a rubber-band-powered helicopter toy of the sort designed by Alphonse Pénaud. Although neither of them attended college, Wilbur and Orville Wright were intellectual, intuitive, confident, and mechanically gifted. As young men, they operated both a print shop and a bicycle shop in their hometown of Dayton, Ohio. Still, their curiosity and technical skills drove them to pursue other challenges. The death of Otto Lilienthal reignited their boyhood passion for wings.

The brothers launched their own aeronautical effort in 1899 after corresponding with both the Smithsonian Institution and Octave Chanute. They realized that their first challenge was finding a way to control a machine in the air. They tested their notion of a wing-warping control system on a small kite flown from a hill in Dayton. Between 1900 and 1902, they built three gliders, testing them over the sands of Kill Devil Hills near Kitty Hawk, North Carolina, a location that was ideal because of its high winds and tall dunes, with plenty of sand for soft landings.

Disappointed with the performance of their early gliders, the brothers conducted a series of wind tunnel tests in the bicycle shop during the fall of 1901. On the basis of those tests and their experience with the gliders, they designed and built their third full-scale glider in 1902 and completed 1,000 flights with it, remaining airborne for as long as 26 seconds and covering distances of up to 622.5 feet.

Now they were ready to attempt a piloted, powered flight. With assistance from their machinist, Charles Taylor, they designed and built the aircraft and a four-cylinder internal combustion engine that would deliver precisely the amount of power required. They also built the propellers, based on their wind tunnel data, that proved to be the most efficient of the time. Success came on the morning of 17 December 1903. Orville Wright made the first flight at about 10:35 A.M., a bumpy and erratic 12 seconds in the air. A few minutes later, Wilbur flew the plane 175 feet—just a few feet shorter than the wingspan of a Boeing 747. Orville then flew again, a distance of 200 feet. During the final flight of the day, piloted by Wilbur, the Wright Flyer remained airborne for 59 seconds and flew 852 feet.

These four flights marked the first time that a powered, heavier-than-air machine had made a sustained flight under the complete control of the pilot. The Wright brothers were not surprised by their success, for they had meticulously calculated how their machine would perform and were confident that it would fly once they had ironed out all the problems from their previous tests.

Within a few days of these flights, the Wright brothers were the subject of what

1904
Returning to Ohio, the Wright brothers experimented with new planes and motors and flew an improved Flyer II.

1905
The Wrights' Flyer III became the world's first practical airplane but attracted little attention.

1906
The Wrights were granted a patent for the airplane control system.

1907
November 13 Paul Cornu, a French inventor, flew the first helicopter. The flight lasted only 20 seconds and hovered just 1 foot (30 cm) above the ground.

1908
The Wrights finally began to receive credit and attention for their invention. Submitting a bid to the Army for a military flying machine, Orville brought a Flyer to Fort Myer, Virginia; passed the trials; and won a contract for the world's first military airplane. Later that year, the plane crashed after a propeller failure, seriously injuring Orville and killing his passenger, Lieutenant Thomas Selfridge.

1905 Albert Einstein published theory of special relativity | 1906 San Francisco earthquake occurred | 1908 C. F. Cross invented cellophane

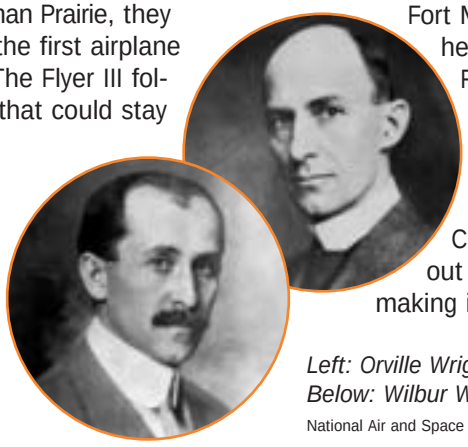
were, for the most part, wild and inaccurate reports on the front pages of major newspapers from coast to coast. When they did not follow up with public flights in 1904, the press assumed that the Kitty Hawk story had been an exaggeration, if not a hoax.

Wilbur and Orville Wright pressed ahead, moving their experiments closer to their Dayton, Ohio, home. There, in 1904, in a meadow called Huffman Prairie, they built the Wright Flyer II, the first airplane to fly a circle in the air. The Flyer III followed in 1905, a plane that could stay in the air for over half an hour, turn, bank, and fly figure eights. The Wrights were determined not to fly in public until they had received the protection of a patent and had signed contracts for the sale of their machine. They ceased flying completely in the fall of 1905 and concentrated on finding buyers for their technology.

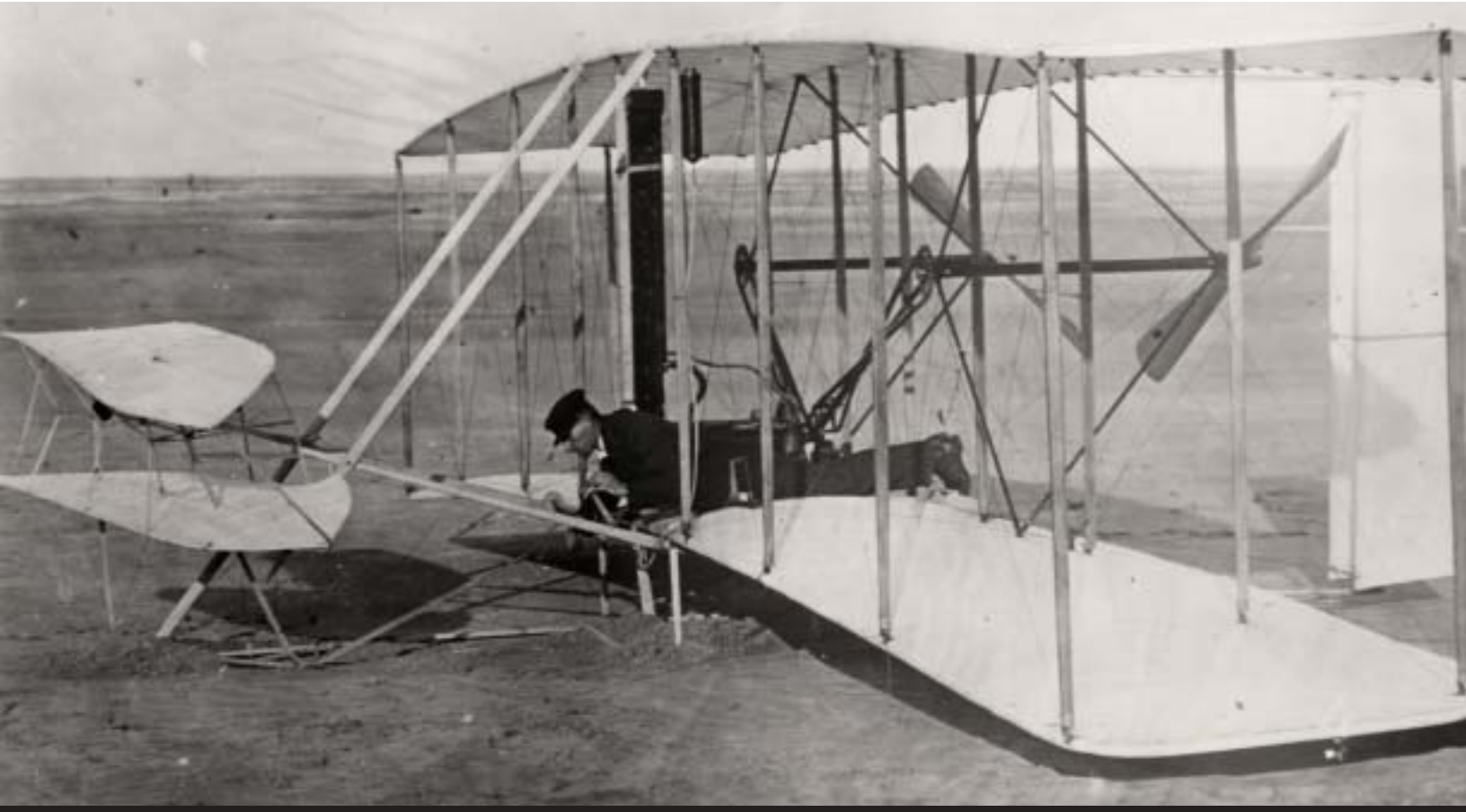
In 1908, the Wright brothers finally received due acclaim when Wilbur made public flights in Europe, amazing spectators with his flying skill and the maneuverability of the Wright Model A biplane. That same year, Orville took a plane to Fort Myer, Virginia, where he demonstrated the Flyer. In 1909, they returned to Fort Myer and sold the world's first military plane.

By 1909, the Wright Company was turning out four planes a month, making it the largest airplane manufacturer in the world. They also formed one of the earliest exhibition teams, flying in various venues where they could publicize and market their planes.

Orville continued to fly through 13 May 1918, six years after Wilbur's death from typhoid fever. He sold his interest in their business in 1915 but remained actively engaged in other related pursuits, among them an ongoing disagreement with the Smithsonian Institution over who had been the first capable of flight, the Wrights or Samuel Langley. The Smithsonian had originally given the nod to Langley but later acquiesced in favor of the Wright brothers. When Orville Wright died in 1948, he had seen many of the advances in aviation that were a direct result of the work he and his brother had accomplished.



Left: Orville Wright; right: Wilbur Wright. NASA Langley Research Center.
Below: Wilbur Wright attempted the first powered flight on 14 December 1903.
National Air and Space Museum #A-38618A ©2002 Smithsonian Institution



1909
July 25 The first flight across the English Channel by Louis Blériot.

The U.S. Army accepted delivery of the first military plane and paid the Wright brothers $30,000 for it.

1911
September 29 Walter Brookins set American record by flying 192 miles from Chicago to Springfield, Illinois, making two stops.

December 10 Cal Rodgers completed the first trans-continental flight in the Wright *EX Vin Fiz.*

1912
April 16 American Harriet Quimby became the first female pilot to fly a plane across the English Channel.

May 30 Wilbur Wright died of typhoid fever.

1909 NAACP founded | 1911 Ragtime popularized for mass audiences | 1912 Girl Scouts chartered

World War I: The First Air War

■ Only eleven years old in August 1914, the fragile airplane in its role as an observer contributed significantly to the murderous carnage that characterized combat in World War I.

The great killer of the war was artillery, and aerial reconnaissance vastly increased artillery's effectiveness. Observation aircraft photographed and mapped trenches and military positions, reported transient targets, and provided direct control for artillery batteries. Further, aircraft photographs and reports enabled commanders to identify the enemy's position, determine his strength, surmise his intentions, and organize their response to best effect.

The need to protect one's own observation aircraft or deny the air to the enemy quickly led to a quest for control of the air. In 1915, an asynchronization or "interrupter" mechanism allowed machine guns to fire through a spinning propeller, enabling the pilot to aim the entire airplane. This ability gave birth to the "pursuit" or fighter. To gain superiority in the air, the airplane now hunted other airplanes. Over time, this new role demanded more sophisticated machines and combat techniques, and the men who flew the machines, as well as the machines themselves, became famous, dramatic symbols of knightly combat.

Soon, the airplane was also used as a bomber. Initially, pilots simply tossed small, handheld bombs or even darts from the cockpit. But the potential of destruction from the air quickly led to larger, more powerful, often multi-engine airplanes designed specifically for bombing. The size of the bombs themselves grew rapidly, and mechanical sights enabled aircraft to hit targets more accurately and from higher altitudes. Most aerial bombardment targeted enemy troops and facilities along the front, but the airplane also allowed the war to be carried to manufacturing and population centers far behind the lines. In 1915, Germany began Zeppelin raids against England. The Zeppelins—large, slow, rigid airships filled with explosive hydrogen gas—ultimately proved vulnerable to aerial defenses and were gradually replaced by giant multi-engine strategic bombers, the vanguard of future war.

By 11 November 1918, the end of the war, commanders had explored almost every role that the airplane would play in the future except global air transport. Although the airplane was not the decisive weapon of World War I, it had demonstrated its potential to change the way wars were fought.

The Fokker was flown by the "Red Baron."

National Air and Space Museum #00046729 ©2002 Smithsonian Institution

The Flying Aces

■ French newsmen crowned Adolphe Pégoud the first "flying ace" in 1915. In France and England, the title came to identify a pilot who had shot down five enemy airplanes. The Germans adopted a similar system that required ten victories. In any case, the airmen, especially the fighter pilots, quickly emerged as the great heroes of an unheroic war. The German airman Manfred von Richthofen, the "Red Baron," led the pack with a total of 80 victories. The French ace René Fonck survived the war with 75 victories. With 58 victories, Edward "Mick" Mannock was England's most victorious ace, despite an infection that had caused him to experience temporary blindness and subsequent trouble seeing out of his left eye. Captain Edward Rickenbacker, a Medal of Honor winner and America's "Ace of Aces," scored 26 victories during a relatively short career as a combat pilot in 1918.

Britain's Sopwith Camel, a single-seat fighter introduced in 1917, was armed with two guns and could also carry four small bombs. The Camel scored more victories against German aircraft than any other Allied plane in World War I. National Air & Space Museum #85-11071 ©2002 Smithsonian Institution

1914
January The St. Petersburg-Tampa Airboat Line became the world's first regularly scheduled airline service.

Two-way radio contact was accomplished between pilot and ground control.

1915
March 3 The National Advisory Committee for Aeronautics (NACA), the first U.S. government-sponsored organization in support of aviation research and development, was formed.

Orville Wright sold his interest in the Wright Company, then retired.

1918
May The United States Post Office inaugurated airmail service from the Polo Grounds, Washington, DC.

Airmail stamps.

1914 Panama Canal opened | 1916 Lincoln Logs invented | 1917 U.S. entered World War I

Flying the Mail

The Origins of Airmail in the United States

■ One of the first federal agencies to recognize the valuable role airplanes could play was the U.S. Post Office. Faster mail delivery and increased reliability were becoming increasingly important to business people across the country, and they pressed the post office for the service.

On 15 May 1918, the first official airmail flight in the U.S. left Washington, DC, heading for New York with 140 pounds of mail on board. Although the flight was not flawless, it proved the concept.

Within two years, a growing structure connected cities along the Atlantic seaboard with Pittsburgh, Cleveland, and Chicago, thereby developing a relatively efficient airmail system in the eastern United States. In 1921, a transcontinental airmail route between San Francisco and New York was also established.

Although these flights between cities occurred routinely, the pilots, flying in open-cockpit aircraft, faced not only difficult weather conditions, but also narrow mountain passes and rugged terrain. They needed to climb thousands of feet above sea level, heights at which sudden snowstorms, erratic winds, subzero temperatures, and mountain peaks meant that only the most diligent of pilots would prevail.

While it may sound romantic, even exciting, this was a very inefficient way to deliver the mail, and by the mid-1920s, with the advent of effective navigational aids, better and more reliable communications and weather reporting systems, and enclosed aircraft with greater ceilings and all-weather capability, things began to change. The emphasis was on safety and reliability as well as expansion as the postal service worked to increase efficiency. Their next step was to undertake night operations, which required special searchlights to guide pilots, aircraft wingtip flares for forced landings, landing fields large enough to ensure adequate room for landings, searchlights actually mounted on airmail airplanes, and radio communications and other flight instruments. By 1924, the first coast-to-coast, day-and-night airmail service had been established.

In 1930, Congress passed legislation that allowed President Herbert Hoover's Postmaster General, Walter Folger Brown, to reshape the air routes. Exercising near-dictatorial powers, Brown engineered the merger of several carriers to create a national air system. From these mergers, the four major U.S. airlines—TWA, American Airlines, United Airlines, and Northwest Airlines—emerged and established an integrated transcontinental route system.

Income from airmail contracts breathed life into the country's fledgling commercial aviation industry in the 1920s and 1930s. Despite the Great Depression, the expansion continued through the World War II era, partly as a result of technological improvements in aircraft that allowed more economical operations.

Today, airmail is still an important market for the air transport industry, and airliners continue to carry mail as part of their cargo.

NACA: A Tradition of Excellence

■ Spurred by the beginning of World War I and a heightened interest in aviation research, the United States Congress created the National Advisory Committee for Aeronautics (NACA) in 1915. In its early days, the NACA concentrated on problems related to military aviation. When the war ended, however, the engineers of the newly constructed Langley Memorial Aeronautical Laboratory in Hampton, Virginia, turned their attention to the solution of a broad range of problems in flight technology.

During the 1920s and 1930s, NACA engineers built a reputation for excellence in research and achieved a host of critical breakthroughs resulting in increased performance. The NACA contributed to victory in WWII and pioneered the postwar research that transformed the airplane into a high-speed, high-altitude aerospace vehicle.

NACA would expand to encompass three research centers: Langley, Ames Research Center in California, and Lewis Research Center in Ohio; by 1958, these would employ over 8,000 people with a budget of over $117 million. They would contribute to the development or improvement of every American aircraft produced during this time. NACA engineers and scientists were responsible for the basic and applied research that led to the development of aircraft structures, safety, fluid dynamics, aerodynamics, ground test facilities (including the slotted-throat wind tunnel), flight-testing, high-speed flight from theory to practice (including the area rule to the X-1 and lifting body aircraft). The NACA was to make advancements and contributions in every field associated with aeronautics and the fledgling field of spaceflight.

1920
February 22 The first transcontinental mail service arrived in New York from San Francisco.

1921
June 15 Bessie Coleman became the first African American woman to receive a Fédération Aéronautique Internationale (FAI) pilot's license.

1923
May 2–3 First nonstop coast-to-coast airplane flight took place between New York and San Diego—26 hours, 50 minutes.

June 27 First in-flight refueling occurred over San Diego, California.

The Spirit of St. Louis.
NASA Langley Research Center

The Golden Age of Aviation

■ Once airplanes became an accepted part of both the American and the European landscapes, appreciated primarily for what they could do, a different kind of flying fever began to spread. The focus shifted to practical uses for airplanes. As adventurous men and women soon learned, planes could accomplish a lot of things.

Planes could be very entertaining. They could spin, dive, and fly upside down. Daredevil men and women walked on their wings and hung from underneath them, tempting fate and thrilling spectators who watched, amazed, from the grandstands. The skepticism so prevalent just a few years earlier was over, and the race was on.

Competitions offered cash prizes and trophies for speed, distance, and altitude. World records were set and broken, often by women competing not just against each other but also against men. A number of these men and women were made famous by their flying exploits—Charles Lindbergh, Amelia Earhart, Wiley Post, Jimmy Doolittle, and Jacqueline "Jackie" Cochran.

This new love affair with flying even inspired songs, poems, posters, and (later) movies. Everyone, it seemed, was caught up in the excitement.

It was also an era of more firsts. Planes were now flying coast to coast, across the Atlantic, over the North Pole, then the South Pole, then around the world—a world that was getting smaller with each fantastic feat. During its golden age, aviation gleamed as brightly as anyone could have imagined, and the airplane had become as versatile as it was indispensable.

Lindbergh and his exploits inspired movies, books, plays, musical compositions, and all manner of other memorabilia. Poems were written, and hundreds of songs such as "Lucky Lindy" became popular.

Bella Landauer Sheet Music Collection, SIL7-1-023a
National Air and Space Museum ©2002 Smithsonian Institution

Lindbergh—An American Eagle

■ Charles Lindbergh was only 22 months old in 1903 when the Wright brothers lifted their Wright Flyer off the ground at Kill Devil Hills, North Carolina. That event shaped Lindbergh's life. Twenty-four years later, Lindbergh forever changed aviation—and the world's passion for flying—when he became the first person to fly solo nonstop across the Atlantic Ocean.

When he made the 3,600-mile flight from New York to Paris, the young man from Minnesota became an instant hero. He landed his high-wing monoplane, the *Spirit of St. Louis*, in Paris on 21 May 1927 to the cheers of 100,000 people. Blessed with movie-star good looks, resolute courage, and a passion for aviation, Lindbergh captured the world's imagination. His love for flying was infectious, and its impact on popular culture was legendary.

Lindbergh and his exploits inspired everything from clocks and lamps to movies, books, plays, musical compositions, tapestries, and all manner of other memorabilia. A popular dance called the "Lindy Hop" was also named after him.

There is no doubt about Lindbergh's instant fame. Following his flight, Lindbergh chose to use his newfound fame to promote what he was most passionate about—aviation. After returning from Paris, he flew the *Spirit of St. Louis* across the United States for three months to promote aviation and inspire support for its development.

Later that year, he toured Central and South America for Pan American Airways with the same mission; while in Mexico, he met his future wife, Anne Morrow.

In the mid-1930s, the U.S. government asked Lindbergh to travel to Germany to learn about German air power, and the famed aviator sent back detailed information.

During World War II, he was a technical advisor in the South Pacific. While there, he also flew in a number of combat missions and conducted training sessions for Marine pilots.

After the war, Lindbergh became a consultant to several commercial airlines and aided in the development of commercial aviation. Later, in Europe, he examined enemy aircraft.

Charles A. Lindbergh, the "Lone Eagle," set records and affected popular culture as no other flyer did.

National Air and Space Museum #89-10
©2002 Smithsonian Institution

Right: Collier trophy.

1924
September 28 The first round-the-world flight was completed in Seattle, Washington, by three two-seat Douglas World Cruisers of the U.S. Army Air Service.

1926
May 9 Commander Richard E. Byrd and pilot Floyd Bennett announced the first flight over the North Pole.

March 16 Robert Goddard built and flew the world's first liquid propellant rocket near Worcester, Massachusetts.

1927
May 20–21 Charles Lindbergh made the first solo flight across the Atlantic aboard the *Spirit of St. Louis*.

1928
May 31–June 9 Charles Kingsford Smith and Charles T. P. Ulm made the first trans-Pacific flight from California to Australia.

1924 First Winter Olympics

1926 First Winnie-the-Pooh book published

1927 Television invented

Air Racing: Flying's Golden Age

Bendix Trophy.

National Air and Space Museum
#93-5512 ©2002 Smithsonian Institution

Thompson Trophy.

National Air and Space Museum
#93-5513 ©2002 Smithsonian Institution

■ Rheims, France, provided the setting for the first international aviation meet in 1909, a competition that attracted numerous flyers from Europe and one American entry, Glenn Curtiss, who had his eye on the Gordon Bennett Trophy.

In his Rheims Racer, Curtiss set a new world record, making his speed run at 46.5 miles per hour. By beating his closest competition, Frenchman Louis Blériot, by a mere six seconds, Curtiss won the trophy he desired.

Other air races and trophies beckoned other pilots. In 1913, the Schneider Trophy lured high-speed seaplanes to a course that covered 350 kilometers. With an average speed of 46 miles per hour, France won the first of these races. American Jimmy Doolittle won in 1925 with a speed of 233 miles per hour. When Great Britain won the trophy in 1931, the average speed had increased to 340 miles per hour. The drive to win helped propel technical improvements and the development of sleeker, faster aircraft.

The Pulitzer races of the 1920s were a showcase for the U.S. Armed Forces, but it was the Bendix races in the 1930s that gave female aviators their chance to shine and, in some cases, to outshine their male competitors. In 1936, Louise Thaden flew between Los Angeles and Cleveland in just under 15 hours to take the prize. Jackie Cochran won the race in 1938, beating nine men.

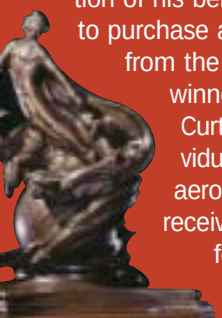
Between 1929 and 1949, the Cleveland Air Races attracted such names as Charles Lindbergh, Jimmy Doolittle, Jackie Cochran, Amelia Earhart, and Wiley Post to the skies over this Ohio city's airport. There, giants of the air competed for the Thompson and Bendix trophies, thrilling the crowds and helping to define aviation during its golden age. Air races are still held throughout the world today.

Tickets and programs like these were prized by aviation fans throughout the 1920s and 1930s.

National Air and Space Museum
#93-15838, #2000-2373
©2002 Smithsonian Institution

For the Greatest Achievement:

■ The Collier Trophy was established in 1911 by Robert J. Collier, publisher and early president of the Aero Club of America. The trophy is awarded annually for "the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year." It represents the most prestigious award offered in the United States for excellence in aerospace research and development and is administered by the National Aeronautic Association. It is named after Robert J. Collier, who stated, "The flying machine should be unselfishly and rapidly developed to its potential for America's economic advancement." As a demonstration of his belief, he was the first person to purchase an airplane for private use from the Wright brothers. The first winner of the trophy was Glenn Curtiss, followed by the top individuals and organizations in the aerospace industry. NACA received its first trophy in 1929 for its research and development of a new cowling.



1928
June 28–29 Albert Hegenberger and Lester Maitland accomplished the first nonstop crossing of the Pacific.

1929
November 28–29 Commander Richard E. Byrd completed the first flight over the South Pole.

1929
Fritz von Opel of Germany flew the first rocket-powered plane for 1 minute, 15 seconds.

William Green developed the first automatic pilot used on an airliner.

1931
June 23–July 1 Wiley Post and Harold Gatty completed the first circumnavigation of the world by a lone aircraft.

1932
May 20–21 Amelia Earhart became the first woman to fly solo across the Atlantic.

1928 First scheduled television broadcast

1929 Great Depression began with stock market crash

1931 Empire State Building completed

U.S. government accepted the Wright aircraft in 1909. © Wright State University

Origins of the U.S. Air Force

■ U.S. Army leaders were never as backward about accepting aviation as tradition claims. Many, in fact, had long maintained an interest in lighter-than-air and heavier-than-air craft. The Signal Corps established a balloon section in 1892 and deployed a balloon to Cuba in 1898 during the Spanish-American War. Signal Corps balloonists competed in contests and set records. Notably, Lieutenant Frank Lahm won the first Gordon Bennett balloon race in 1906. The Army also developed semi-rigid dirigibles beginning with Signal Corps Dirigible No. 1 in 1908.

As for heavier-than-air craft, Army leaders gave Samuel P. Langley $50,000 for construction of a full-sized "aerodrome" in 1898. Langley failed to fly, but Army interest in aviation continued. Its leaders began correspondence with the Wright brothers in May 1907, established an Aeronautical Division in August, and prepared requirements for a military airplane in December. The Army accepted the Wrights' bid in February 1908. Trials began later in the year, but a crash delayed the results. The U.S. Army ultimately accepted Signal Corps No. 1 on 2 August 1909.

Today's global U.S. Air Force grew from the Aeronautical Division and this first airplane, but the road to independence was tortuous. The U.S. Army established the Air Service in May 1918, and in 1926, the Air Service became the U.S. Army Air Corps. Creation of the U.S. Army Air Forces in 1941 provided the autonomy necessary for victory during World War II. The U.S. Air Force achieved full independence on 18 September 1947.

First Ladies of Flight

■ The role women have played in the progress of aviation is punctuated by the achievements, many of them "firsts," of hundreds of brave and determined aeronautical pioneers.

These pioneers included women like Juanita Pritchard Bailey, the first woman to fly a plane solo from the United States to Panama, and Evelyn "Bobbi" Trout, who, in 1929, became the first woman to complete an all-night flight.

The following year, Amy Johnson, considered by many to be Britain's most famous female pilot, became the first woman to fly alone from England to Australia. In 1931, Anne Morrow Lindbergh, wife of Charles Lindbergh, became the first woman to receive a glider pilot's license.

But even before the considerable accomplishments of these women, Alabama-born Katherine Stinson was well on her way to a series of "firsts" all her own. In 1912, Stinson became the fourth woman to be issued a pilot's license. In 1913, she became the first woman to carry the U.S. mail; in 1915, she became the first woman to perform an aerial loop-the-loop. That same year, Stinson became the first woman to skywrite.

The honor of being the first woman to fly across the Atlantic belongs to Amelia Earhart, although on the first trip, she was a passenger. In 1932, however, she was at the controls and became the first woman to make the trip solo. Later, she was also the first woman to earn the Distinguished Flying Cross.

Amelia Earhart, nicknamed "Lady Lindy," proved her skill by becoming the first woman to fly solo across the Atlantic. National Air and Space Museum #381-1431 ©2002 Smithsonian Institution

1935
November 22 Pan American Airways made the first Pacific mail service route, leaving San Francisco with 111,000 letters.

1935
December The first Douglas DC-3 flew. By 1938, it carried the bulk of American air traffic.

December 1 The first airway traffic control center went into operation.

1939
June 28 Pan American Airways flew the first transatlantic passenger service.

1935 Watson Watt built RADAR device | 1936 Margaret Mitchell wrote *Gone with the Wind* | 1939 World War II began

Left: Bessie Coleman became the first African American female pilot when she received her pilot's license from the Fédération Aéronautique Internationale.
National Air and Space Museum #80-12873 ©2002 Smithsonian Institution

Right: Eileen Collins was the first female pilot of the Space Shuttle (missions STS-63 and STS-84) and the first female commander of the Space Shuttle (mission STS-93).

In 1937, Earhart embarked upon a journey that, had it been successful, would have given her the distinction of being the first woman to fly around the world. The mystery of her disappearance during that flight, along with that of her navigator and plane, remains to this day a matter of debate. It was Geraldine Mock who, in 1964, flying a single-engine Cessna 180, completed this circumnavigation, becoming the first woman to do so.

Amelia Earhart also has the distinction of being the first president of The Ninety-Nines, an organization that was formed in 1929 and still exists today. The name comes from the total number of the group's charter members, licensed female pilots who came together to create an entity that would help advance aviation and provide a vehicle for female pilots to support each other. Today, The Ninety-Nines, Inc., boasts over 6,500 members worldwide.

Jackie Cochran, a former beautician from Florida, served as president of the Ninety-Nines between 1941 and 1943. She was also the first female pilot to ferry a bomber across the Atlantic, and in 1943, she was appointed director of the Women's Airforce Service Pilots (WASPs). The WASPs were approximately 1,000 civilian women who, as the United States entered World War II, delivered aircraft to combat areas all over the world. Though the program was deactivated only sixteen months after its inception, it was and still is considered a success. Cochran was awarded the Distinguished Service Medal and the USAF Legion of Merit for her service.

Rightfully called America's leading female pilot, Cochran is also remembered as the first woman to break the sound barrier; she did that in 1953.

Years before this, in 1921, Bessie Coleman broke the color barrier and became the first African American female pilot. Texas-born Coleman, who had grown up amidst poverty and discrimination, overcame two major hurdles in her goal to become a pilot: she was a woman and she was African American. Undeterred, she went to France, where a more liberal outlook prevailed. In 1921, the Fédération Aéronautique Internationale awarded her the pilot's license she had dreamed about.

For Earhart, Cochran, Coleman, and the many other women who achieved so much in aerospace—from Valentina Tereshkova, the first woman in space, to Eileen Collins, the first female pilot and commander of the Space Shuttle—perhaps it is Harriet Quimby to whom they all owe a debt of gratitude. In 1911, Quimby became the first American woman to receive a pilot's license. In 1912, she was the first woman to fly across the English Channel, a trip she made in just over an hour.

Today, of the approximately 635,000 pilots in the United States, over 37,000 of them are women, enthusiastically taking up the challenges to which Harriet Quimby opened the door. Each of them has helped prove what President Roosevelt said in 1935 when Amelia Earhart became the first woman to successfully fly from Hawaii to California: "Aviation is a science which cannot be limited to men only." And it hasn't been.

Jackie Cochran was awarded medals for her work with the WASPs. Referring to her experience with the group, she said, "We landed planes like the Hurricane and the Spitfire in fields where I wouldn't land my Lodestar today if I could avoid it."
National Air and Space Museum #80-16081 ©2002 Smithsonian Institution

General Motors FM-1 Wildcat.

National Air and Space Museum
#76-1722

1941
June 20 The United States Army Air Forces were formed.

The Tuskegee Airmen, the first Black fighter squadron in the United States Armed Forces, was formed. Until that time, Blacks had been forbidden to receive pilot training.

1941 Cheerios invented

Air Power in World War II

Tokyo Raiders: The Doolittle Raid

■ After the surprise attack on Pearl Harbor, War Department planners hit upon the idea of bombing Japan by launching B-25 bombers from an aircraft carrier. In April 1942, as flight crews boarded the carrier USS *Hornet*, planes were being lashed to the decks. When Navy radar spotted Japanese ships ahead of the carrier, Lieutenant Colonel Jimmy Doolittle was ordered to launch even though the ship was 700 miles from Japan, instead of the planned 400.

The mission successfully hit targets in Tokyo, Yokohama, Kobe, and Nagoya before turning toward landing fields in China. With low fuel reserves and strong head winds, the crews knew they wouldn't reach the designated landing fields. Fifteen of the sixteen planes crashed or ditched at sea with one diverting to Russia. Of the eighty fliers, three died in landings, eight were captured by the Japanese, and the crew that landed in Russia was interned before eventually escaping. All the others bailed out over China and eventually found their way to safe haven in Chungking.

America had hit back. News reports stateside flashed word that Doolittle and his Raiders had struck Tokyo, and morale started rocketing upward.

■ Air power played a crucial role in almost every aspect of World War II. Germany's air force, the Luftwaffe, supported the Nazi ground forces early in the war as they devastated western Europe. The scream of Stuka dive-bombers heralded Blitzkrieg, which dominated the early war conflict. The Luftwaffe was ill-equipped to fight England, however, and the tide began to turn when Britain's Royal Air Force (RAF) defeated it during the now-famous Battle of Britain. "Achtung, Spitfire!" became terrible words for German pilots.

The United States entered World War II on 7 December 1941, when the Japanese conducted a surprise air attack on the American naval base at Pearl Harbor, Hawaii. However, although the Japanese drew the U.S. into the war, early planning made Germany the primary foe.

The RAF began with a bombing campaign conducted mostly at night against German cities. It was soon joined by the mighty Eighth Air Force of the U.S. Army Air Forces (USAAF), which specialized in high-altitude, daylight attacks on German industrial targets. Over the skies of northwest Europe, great bomber fleets of the Combined Bomber Offensive attacked the Third Reich, with B-17s, B-24s, and RAF Lancasters and Wellingtons pounding Germany's industry, transportation, and communications around the clock. The strategic bombing campaign devastated the Nazi transportation system and cut the enemy's oil production. In February 1944, during "Big Week," the Luftwaffe contested the European skies, and as a result, the American escort fighters took a heavy toll on the German Air Force—a turning point in the air war over Europe.

Moreover, allied strategic and tactical air forces, as Supreme Commander Dwight D. Eisenhower emphasized, made safe the invasion of the Continent on 6 June 1944 by defeating the Luftwaffe prior to D-Day and by reducing the enemy's ability to reinforce the battlefield. In his words, "Unless we had faith in air power as a fighting arm to intervene and make safe that landing, it would have been more than fantastic, it would have been criminal."

In addition to the strategic bombing campaign, the Allied tactical air forces made a major contribution to the European victory through their enormous support of the ground forces as they fought their way eastward into Germany. Victory in Europe on 8 May 1945 was in so many ways a victory for air power.

Not all bombs that fell from airplanes during the war were destructive. One in particular, the "Monroe Bomb," named after its inventor, U.S. Army Air Force Captain James Monroe, employed the weapons of psychological warfare—propaganda leaflets—dropping hundreds of thousands of them over broad areas from planes like the B-17 and B24.

"By Day and by Night, with United Strength," from the World War II propaganda leaflet collection of Hans Moonen; see http://www.cobweb.nl/jmoonen/

1942
July 19 The Messerschmitt 262, the world's first operational jet-powered fighter, took to the air with Fritz Wendel at the controls.

1942 Electronic computer developed in U.S.

1943
January Franklin D. Roosevelt boarded a Boeing 314 flying boat in Miami, Florida, and became the first chief executive to make a wartime flight while in office.

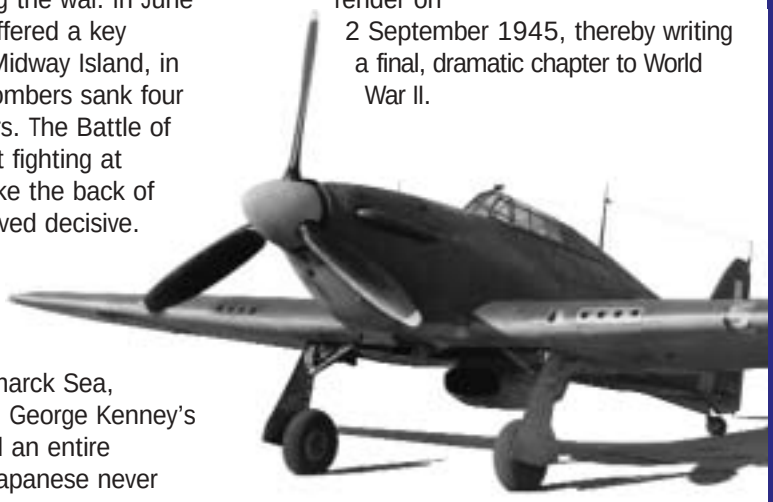
The Women's Airforce Service Pilots (WASP) was formed to ferry military planes and perform other noncombat operations for the U.S. military in World War II.

1943 Slinky toy invented

Although outnumbered in the early months of the war in the Pacific, American airmen of the USAAF and U.S. Navy fought gallantly against the Japanese in the Philippines and the Southwest Pacific. On 18 April 1942, the U.S. struck back when Lieutenant Colonel Jimmy Doolittle led sixteen USAAF B-25s from the deck of an aircraft carrier and bombed Japan. Meanwhile, in China, the American Volunteer Group, the "Flying Tigers," under General Claire Chennault, flying shark-mouthed Curtiss P-40s, bested the Japanese air force. It was in China, too, that U.S. transport aircraft flew "the Hump" over the highest mountains of the world, keeping China in the war and dramatizing the importance of global air transport, perhaps the greatest development of air power during the war. In June 1942, the Japanese suffered a key defeat in the Battle of Midway Island, in which U.S. Navy dive bombers sank four Japanese aircraft carriers. The Battle of Midway and subsequent fighting at Guadalcanal, which broke the back of Japanese air power, proved decisive.

During the first week of March 1943, Japan was dealt a crushing blow in the Battle of the Bismarck Sea, when aircraft of General George Kenney's Fifth Air Force destroyed an entire Japanese convoy. The Japanese never really recovered from this defeat. Subsequently, General Kenney's Allied Air Forces, under theater commander General Douglas MacArthur, supported the drive north and westward along the north coast of New Guinea and then played a major role in the invasion of the Philippines. This was the famous "island-hopping" campaign, which left substantial Japanese forces isolated on islands, only to "wither on the vine."

The final act was the bombing of the Japanese homeland by B-29 Superfortresses, a strategic offensive that, along with the naval blockade, brought Japan to the brink of catastrophe in the summer of 1945. With the dropping of atomic bombs by B-29s on Hiroshima and Nagasaki, Japan was forced to surrender on 2 September 1945, thereby writing a final, dramatic chapter to World War II.



The Hawker Hurricane is a British fighter plane.

The Tuskegee Airmen

■ In July 1941, the Army Air Corps began a program to train Black Americans as military pilots. The military selected Tuskegee Institute to train pilots because of its commitment to aeronautical training. The program was titled the "Tuskegee Experiment." Once a cadet completed primary training, he was sent to nearby Tuskegee Army Air Field to complete flight training and transition to combat-type aircraft. "Tuskegee Airmen" included pilots, navigators, bombardiers, maintenance and support staff, instructors, and all the personnel who kept the planes in the air.

The Tuskegee Airmen exemplified courage, skill, and dedication in combat. They flew more than 15,000 sorties, completing over 1,500 missions during the war. Equipped with their red-tailed P51 Mustangs, the pilots of the 332nd Fighter Group never lost an escorted bomber to enemy fighters—a record only the Tuskegee Airmen can claim.

American bomber crews reverently referred to them as "The Black Redtail Angels" because of the identifying red paint on their tail assemblies. Feared and respected by the Germans, the Airmen were known as the "Schwartze Vogelmenschen"—Black Birdmen.

At the end of the war, the Tuskegee Airmen returned home with numerous awards for gallantry. Their heroics in the air and dignity on the ground won them the highest honors.

National Air and Space Museum #00186467

Eye on the Sky

■ During World War II, the aircraft spotter provided an invaluable service on the ground. These volunteer civilians kept a close watch for enemy aircraft that might appear in the skies overhead, skies that were sometimes filled with planes flying from one point to another on training missions or to and from bases. It was an important aspect of defense to be able to distinguish quickly and accurately between friendly and enemy aircraft. Spotters used "spotter cards" to help them do the job.

Because spotters never knew from which direction airplanes would come, they were trained to quickly look for the shape of the wing, the number of engines, the forward profile, and any other markings on the plane that would enable them to quickly identify it.

Each spotter card showed several perspectives of the plane it represented, along with the plane's markings.

1944
V-2 rocket first used in combat.

1945
August 6 B-29 *Enola Gay* dropped an atomic bomb on Hiroshima.

1947
September 18 United States Air Force formed as a separate service.

October 14 Captain Charles E. Yeager flew faster than the speed of sound for the first time in the rocket-powered Bell X-1.

1948
The Berlin Blockade and airlift proved the power of airplanes to help resolve diplomatic crises.

1949
March 2 *Lucky Lady II:* This Boeing B-50A made the first nonstop around-the-world flight.

1945 World War II ended

1950 Korean War began

F86-Sabre.

Into the Jet Age

■ With the advent of jet technology, the world of aviation was again on the edge of change. This time, the changes would revolutionize military as well as civilian aircraft and turn the business of passenger transport into a race to see which airline could carry the most people the greatest distance in the least amount of time.

Both the Allies and the Germans were engaged in building jets as World War II was drawing to a close; by the time the Korean conflict began in 1950, the speed of jet fighters was considered a necessity to win air combat engagements.

Engineers continually worked to modify these planes, each change allowing the aircraft to fly higher and faster while also improving its stability and maneuverability. These developments eventually led to supersonic bombers like the B-58 and wide-body cargo planes with the capacity to carry troops, tanks, and tons of supplies into battle.

One of the greatest beneficiaries of jet development was commercial aviation, and by the 1960s, passenger jets were eclipsing ships and trains as the dominant mode of passenger transport.

Choppers. Copters. Whirlybirds.

■ No matter what nickname they go by, modern helicopters are amazingly versatile aircraft with the ability to lift directly off the ground and fly without the need for a runway.

The concept of vertical flight can be traced to the Chinese top, a toy first used around 400 B.C. By the mid-1500s, Leonardo da Vinci was sketching helicopter-like machines.

In 1907, French engineer Paul Cornu managed to lift a helicopter he designed into the air for 20 seconds. Though not a long flight, it was enough to stimulate other designers, who made great advances in helicopter design.

It was not until 1939 that the first successful helicopter flight took place in the United States. Igor Sikorsky, a Russian-born U.S. citizen who is known as the "Father of the Helicopter," flew his VS-300 and launched a lucrative business that provided helicopters for World War II, Korea, and Vietnam.

Today, helicopters are used for transporting accident victims, crop seeding, traffic reports, aerial photography, fighting forest fires, rescues at sea, lifting heavy construction materials for skyscraper construction, and hundreds of other practical applications. This fascinating machine that can take off and land vertically; hover in midair; and fly forward, backward, sideways, or straight up and down is as indispensable as it is versatile.

In 1939, the first successful flight of a helicopter was accomplished in the United States by Igor Sikorsky.

National Air and Space Museum #00089138 ©2002 Smithsonian Institution

1953
November 20 Scott Crossfield became the first pilot to fly at Mach 2 in the D-558 research plane.

Jackie Cochran became the first woman to fly faster than sound.

1954
The U.S. Air Force Academy was created.

July 15 The Boeing "Dash 80" (prototype of 707) first test flight occurred.

1955
August 4 The U-2 reconnaissance prototype first flew.

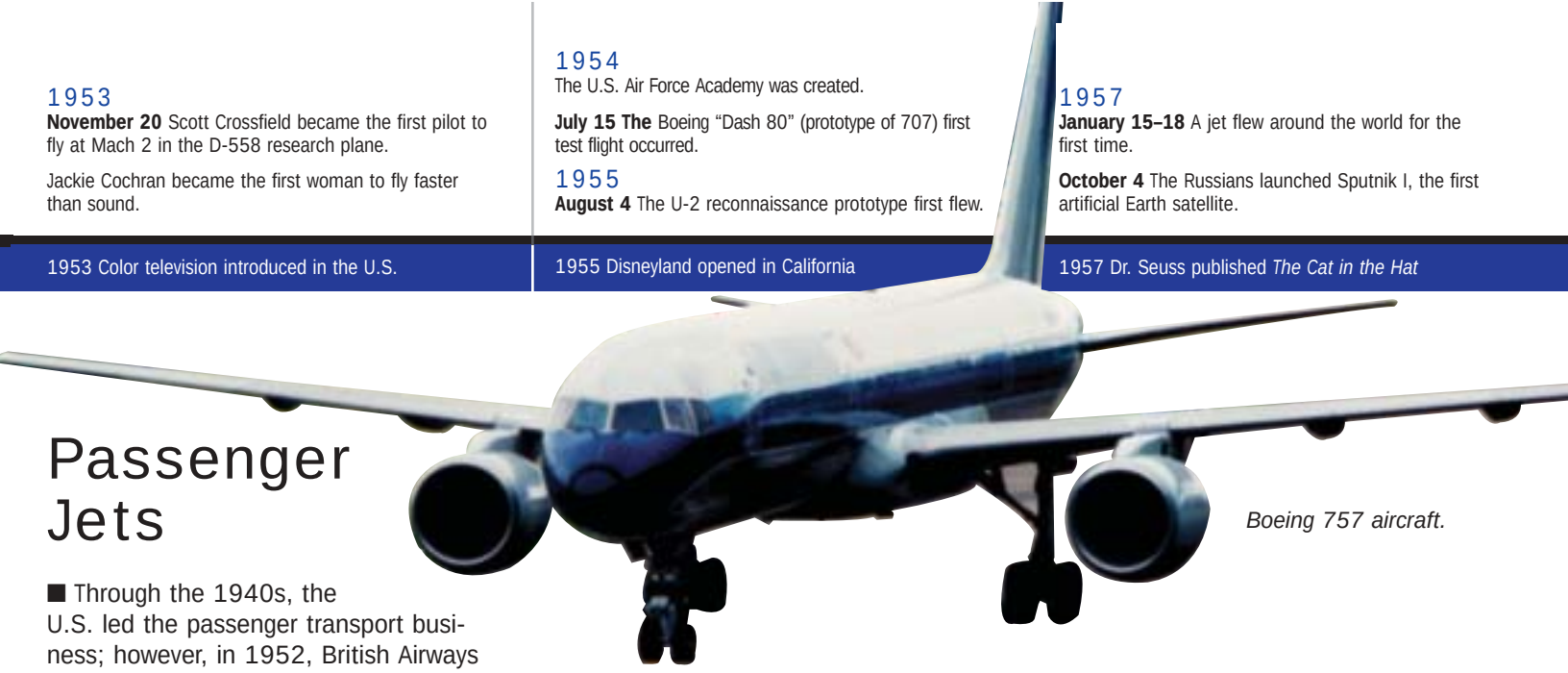
1957
January 15–18 A jet flew around the world for the first time.

October 4 The Russians launched Sputnik I, the first artificial Earth satellite.

1953 Color television introduced in the U.S.

1955 Disneyland opened in California

1957 Dr. Seuss published *The Cat in the Hat*



Boeing 757 aircraft.

Passenger Jets

■ Through the 1940s, the U.S. led the passenger transport business; however, in 1952, British Airways challenged that lead with the introduction of the world's first jet airliner.

The Comet was designed to fly at 35,000 feet and higher, thus dramatically reducing fuel consumption. But at these altitudes, there was another problem to be solved: creating a pressurized cabin in which passengers could breathe without oxygen masks. Once the issue of cabin pressurization was resolved, the Comet was ready to be introduced to the public, and they loved it. The original Comet's lifespan was cut short because of structural problems.

The Boeing 707, based on a jet tanker design built for the U.S. Air Force, followed the Comet in 1954, not only addressing the structural problems that doomed the first jetliner, but also boasting a newly designed airframe that offered a smoother, faster ride with room for more passengers. This airliner sparked Douglas Aircraft to produce the DC-8, a plane with greater range and more cabin width, which allowed an extra passenger seat in each row.

With a seating capacity of up to 550 passengers, Boeing's 747 was the world's first and largest commercial jumbo jet, a plane over 230 feet long with a wingspan of almost 200 feet.

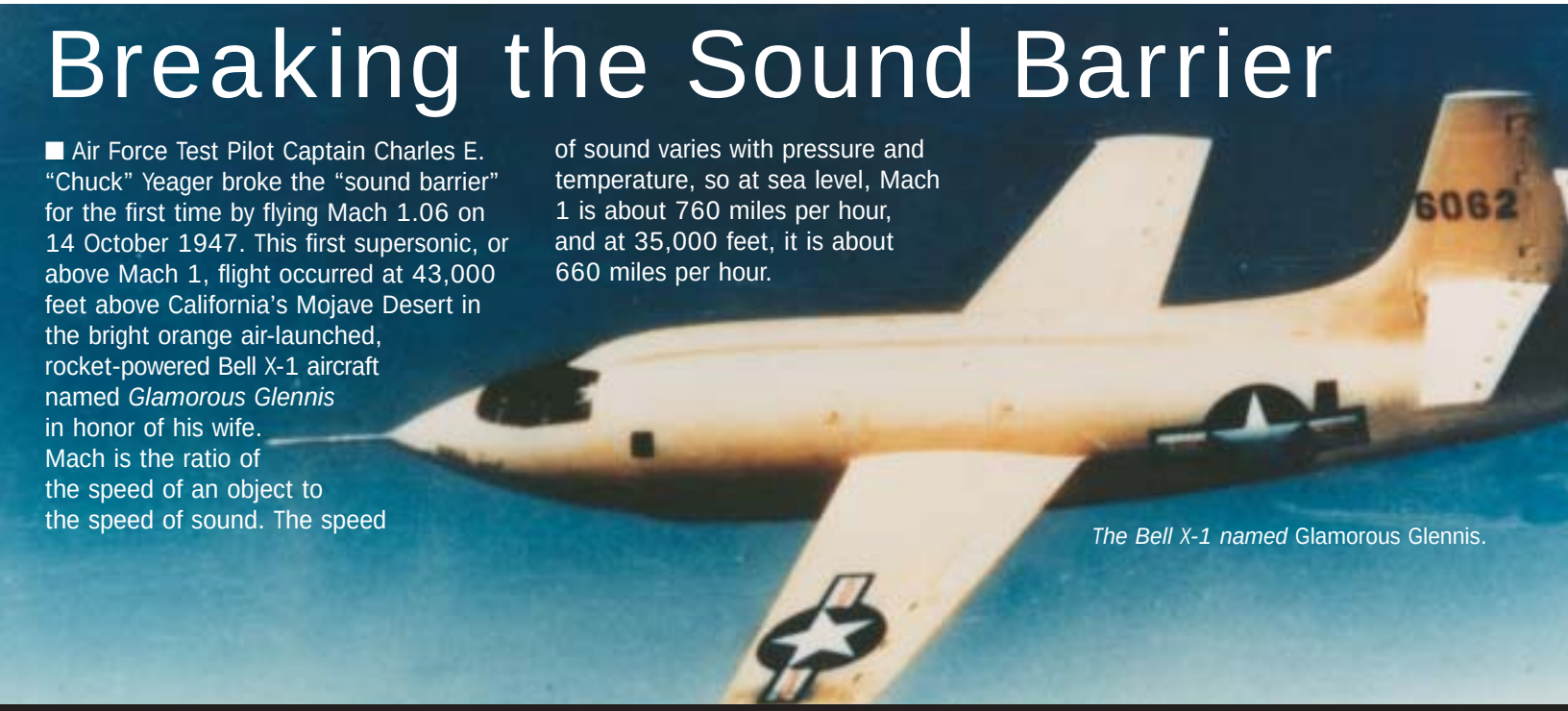
The Lockheed L-1011, McDonnell Douglas DC-10, and Airbus A300 followed. The Boeing 777 is the most recent entrant into the wide-body aircraft market.

The Concorde supersonic transport was the result of a partnership between the French and British governments. Only 16 Concordes were built, but given its ability to travel at Mach 2.2 (over twice the speed of sound) at an altitude of 50,000 feet, flying the Concorde became an incredible experience for its passengers.

Today, aircraft manufacturers continue to adapt their machines to the market's desire to get there faster, more efficiently, and more comfortably.

Breaking the Sound Barrier

■ Air Force Test Pilot Captain Charles E. "Chuck" Yeager broke the "sound barrier" for the first time by flying Mach 1.06 on 14 October 1947. This first supersonic, or above Mach 1, flight occurred at 43,000 feet above California's Mojave Desert in the bright orange air-launched, rocket-powered Bell X-1 aircraft named *Glamorous Glennis* in honor of his wife. Mach is the ratio of the speed of an object to the speed of sound. The speed of sound varies with pressure and temperature, so at sea level, Mach 1 is about 760 miles per hour, and at 35,000 feet, it is about 660 miles per hour.



The Bell X-1 named Glamorous Glennis.

The flying machines will eventually be fast; they will be used in sport, but they should not be thought of as commercial carriers. —Octave Chanute, 1910

1958

January 31 Explorer 1 successfully orbited Earth.

October 1 NASA was established.

December 19 First voice radio broadcast from space occurred.

1958 Public schools integrated in Little Rock, Arkansas

The X-15 rocket-powered aircraft under the wing of a B-52, waiting to be air-launched. This photo was taken from an observation window in the B-52 shortly before dropping the X-15.

Dawn of the Space Age

■ The National Aeronautics and Space Administration (NASA) was formed with President Dwight D. Eisenhower's signing of the National Aeronautics and Space Act of 1958. The NACA and parts of other agencies formed its core; its purpose was research and development for the exploration of space. NASA also emerged in some measure because of the pressures of national defense during the Cold War with the Soviet Union, a broad contest over the ideologies and allegiances of the nonaligned nations of the world in which space exploration emerged as a major area of contest.

The space age actually began before the creation of NASA. From the latter 1940s, the Department of Defense pursued research, rocketry, and upper atmospheric sciences as a means of ensuring American leadership in technology. A major step forward came when President Eisenhower approved a plan to orbit a scientific satellite as part of the International Geophysical Year (IGY), a cooperative effort to gather scientific data about Earth, for an eighteen-month period from 1957 to 1958. The Soviet Union quickly followed suit, announcing plans to orbit its own satellite.

The Naval Research Laboratory's Project Vanguard was chosen on 9 September 1955 to support the IGY effort, largely because it did not interfere with high-priority ballistic missile development programs, while an Army proposal to use the Redstone ballistic missile as the launch vehicle waited in the wings. The technological demands upon the Vanguard program were too great and the funding levels too small to ensure success.

A full-scale crisis resulted when the Soviets launched Sputnik 1, the world's first artificial satellite, on 4 October 1957. This had a dramatic effect on American public opinion, creating an illusion of a technological gap, and provided the impetus for increased spending for aerospace endeavors, technical and scientific educational programs, and the chartering of new federal agencies to manage research and development.

The United States launched its first Earth satellite on 31 January 1958, when Explorer 1, launched atop a modified Redstone, documented the existence of radiation zones encircling Earth. These zones, shaped by Earth's magnetic field, came to be called the Van Allen Radiation Belt. This mission began a series of flights to the Moon and planets.

JPL Director William Pickering, astrophysicist James Van Allen, and rocketeer Wernher von Braun hold up a mock-up of Explorer 1.

The X-15: Bridging the Gap

■ In the X-15 program, the Air Force, NASA, Navy, and North American Aviation embarked upon a new frontier—exploring the possibilities of a piloted, rocket-powered, air-launched aircraft capable of speeds about five times that of sound.

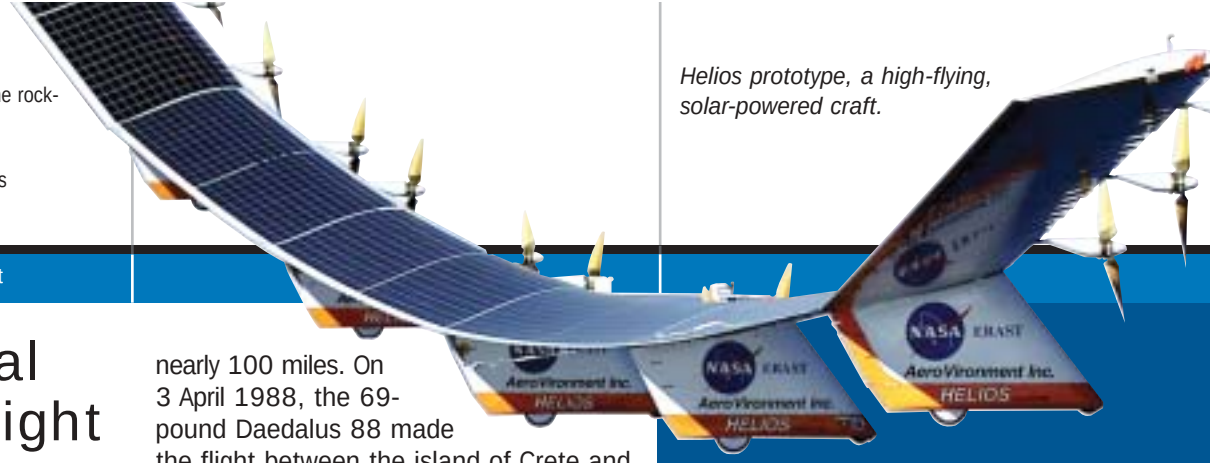
Between 1959 and 1969, in 199 flights, the X-15 program demonstrated the human desire to fly higher, faster, and beyond Earth's atmosphere. On 22 August 1963, the X-15 set an altitude record of 354,200 feet (67 miles). Four years later, the aircraft set a speed record of Mach 6.7 (4,520 miles per hour).

The vehicle provided the platform for many scientific and technological studies. With an exterior skin of a nickel-chrome alloy that could withstand extreme heat, (over 1,000˚F) and a structure specially designed for the harsh unknown environment encountered at hypersonic speeds, the vehicle was able to carry out scientific research and survive. This research helped prove that a pilot could master the skills required for flight into space, even the ability to function in a weightless environment. The program also resulted in the first full-pressure suit to protect pilots in space, metal alloys that could survive high temperatures, new electronic and control methods including a reaction control system to effect maneuvering in the thin atmospheres of near space, and knowledge of high-speed flight.

1959
September 15 Scott Crossfield first flew the fastest and highest flying aircraft in history, the rocket-powered X-15.

1960
May 17 YF4H-1 Phantom fighter and Douglas DC-8 were unveiled.

1960 John F. Kennedy elected U.S. President



Helios prototype, a high-flying, solar-powered craft.

Unconventional Methods of Flight

■ A bird's ability to fly, powered by its own unique musculoskeletal system, has, for thousands of years, inspired humanity's desire to fly and especially to achieve flight without the use of anything other than muscle power.

Paul B. MacCready envisioned, designed, and built the human-powered Gossamer Condor, a 70-pound craft with a wingspan of 96 feet, made of aluminum, mylar, corrugated cardboard, and styrene foam. In 1977, the Condor flew 1.35 miles in just under eight minutes, its average speed between 10 and 11 miles per hour.

In 1979, the Gossamer Albatross was "pedaled" from England to France, making it the first completely human-powered aircraft to cross the English Channel.

Inspired by the Greek myth of Daedalus and Icarus, the Daedalus Project was conceived to fly a human-powered aircraft nearly 100 miles. On 3 April 1988, the 69-pound Daedalus 88 made the flight between the island of Crete and the island of Santorini, a distance of 115.11 kilometers, or 71.53 miles.

Over the next 15 years, the lightweight human-powered aircraft evolved into lightweight, high-altitude, solar-powered aircraft. This series of research aircraft set numerous records, culminating in the recordbreaking flight of the Helios aircraft to 96,863 feet over Hawaii during 2001. This lightweight, unpiloted, propeller-driven, solar-powered, 247-foot-long aircraft is a prototype for future long-duration, high-altitude flights spending days aloft using only the Sun for power, either directly or through new advanced fuel cells that store the Sun's energy. This high-flying wing could significantly enhance scientific missions studying Earth, assist farmers, act as a telecommunication platform, enhance weather observation, and provide disaster monitoring and emergency response.

Testing the Boundaries

■ A desire to expand the capabilities of aircraft led airplane designer Burt Rutan to the ambitious idea of building an airplane that could fly around the world without refueling. His Voyager achieved the task.

Rutan used an ultralight graphite composite for the plane, designing it with long, knifelike wings that would, along with other frame areas, be filled with fuel. In fact, three-fourths of the Voyager's total weight was composed of fuel.

On 23 December 1986, Voyager completed a nine-day flight that ended in California. The Voyager had circumnavigated the world, a nonstop trip of 25,000 miles, without refueling.

A Typical Day in Space

■ Surprisingly enough, many aspects of a typical day in the life of an astronaut are quite similar to those of a typical day at a more Earthly job. Being in orbit does, of course, present some different challenges, as well as different perks. There is the weightlessness to consider, but the views are amazing.

According to former astronaut Dr. Guion "Guy" Bluford, the first African American in space, each astronaut's day is heavily scheduled by ground control. "Every minute is accounted for," said Dr. Bluford, "and each astronaut is responsible for multiple tasks, whether it's deploying a satellite, conducting experiments, helping to fly the Shuttle, or maintaining the vehicle."

In addition to the time allotted for work, there is also time set aside for sleeping, exercising, doing nothing (yes, "breaks" are also scheduled), and eating.

Some astronauts even like the food, though it does have to be reconstituted from its dehydrated state. Menu items like shrimp cocktail, scrambled eggs with bacon, and beefsteak burritos are pretty normal fare while in orbit.

Being an astronaut means being well trained and ready to perform whatever task the mission commander assigns. Just like jobs on Earth, there's a boss. This one, however, probably doesn't mind too much when employees are seen staring off into space.

Guy Bluford served on four Shuttle missions—STS-8, STS-61-A, STS-39, and STS-53.

1960
April 1 Tiros I was the first weather satellite launched.

1961
April 12 The first human being to travel in space (Major Yuri Gagarin) completed one full orbit of Earth.

May 5 Alan Shepard was the first American in space.

1963
August 22 The X-15 aircraft set an altitude record of 67 miles.

1966
March 16–17 Neil Armstrong and David Scott performed the first orbital docking.

1967
Astronauts Gus Grissom, Roger Chaffee, and Ed White died in the Apollo 1 capsule fire during a ground test in preparation for their launch.

1968
December Apollo 8 circumnavigated the Moon.

1961 DNA molecule structure determined

1963 President Kennedy assassinated

1968 Civil rights activist Martin Luther King assassinated

USAF test pilot school in the 1950s. (USAF)

Test Pilot School

■ The U.S. Air Force Test Pilot School at Edwards Air Force Base in the Mojave Desert was established to improve weapon systems testing. The fundamental key to success in aerospace flight testing and evaluation is the capability, knowledge, and skill of the flight test pilot. Without him—and, increasingly, her—the work of the Air Force Flight Test Center would be impossible.

It is through flight testing that test pilots determine whether an aircraft will be suitable for its intended mission. The school teaches flight test techniques for evaluating aircraft performance, flying qualities, and systems characteristics. Today's test pilots are responsible for determining the viability of a new generation of extremely sophisticated aircraft weapon systems that include lasers capable of destroying missiles, unpiloted craft that drop bombs and eavesdrop inside enemy lines, and aircraft that fly like cargo planes but take off like helicopters.

As part of their training, pilots and engineers fly about twenty different aircraft. Graduates will fly the newest prototype Air Force aircraft and weapon systems, including fighter, attack, bomber, reconnaissance, cargo, and helicopter aircraft. Some alumni become NASA astronauts. The U.S. Navy operates a similar school in Maryland.

To the Moon: Apollo

■ As an effort to offset world perception of Soviet leadership in space and technology, President John F. Kennedy made a public commitment on 25 May 1961 to land an American on the Moon by the end of the decade. Following the devastating Apollo 1 capsule fire in January 1967, the first Apollo mission of public significance was the circumlunar flight of Apollo 8.

As that mission orbited the Moon on Christmas Eve 1968, the nation united as one, if only for a few moments, to witness this epochal event.

The flight of Apollo 11, lifting off on 16 July 1969, made the epic voyage to land on the Moon. On 20 July 1969, the Lunar Module, with astronauts Neil A. Armstrong and Buzz Aldrin aboard, landed on the lunar surface while Michael Collins orbited overhead in the Apollo command module. These astronauts were the first humans ever to reach another world. Armstrong was first to set foot on the surface, telling millions on Earth who saw and heard him that it was "one small step for [a] man—one giant leap for mankind." Aldrin soon followed him out, and the two plodded around the landing site in the lunar gravity ($^1/_6$ of Earth's) and planted an American flag.

Five more landing missions followed at approximately six-month intervals through December 1972 (in addition to the aborted Apollo 13 flight), each of them spending an increasing amount of time on the Moon. The scientific experiments placed on the Moon and the lunar soil samples returned have provided grist for scientific investigations ever since.

Apollo left several important legacies: it accomplished its political goals; it was a triumph of management in meeting the enormously difficult systems engineering and technological integration requirements; and it enabled the people of the world, for the first time, to see their home from afar—a tiny, lovely, and fragile "blue marble" hanging in the blackness of space.

Buzz Aldrin on the Moon during the Apollo 11 mission, July 1969.

1969
The Concorde prototype and Boeing 747 first flew.

July 20 Apollo 11 landed on the Moon.

March 2 The first Concorde flight occurred.

1969 Woodstock Pop Festival held in upstate New York

Higher and Faster

■ Flight has fired the world's imagination with two words: speed and altitude, the pantheon of flying. The attainment of these feats depends on multiple complex factors. Generally, the reasons to strive for faster planes capable of greater altitude are practical, rather than heroic or poetic.

After the first successful supersonic flight in 1947 by the X-1, a series of milestones were accomplished by research pilots flying aircraft designed to test the boundaries of speed and altitude. Later, the Navy and NACA developed the D-558, which first flew Mach 2 on 30 November 1953.

With the Bell X-2 of the mid-1950s, pilots had a vehicle whose powerful rocket engine could reach speeds in excess of Mach 3. At such high speeds, air friction heats the aircraft's skin to high temperatures; therefore, it was made of an advanced, lightweight, heat-resistant steel alloy. The X-2 reached a record peak altitude of 125,907 feet. X-2 research resulted in new construction techniques that contributed to the development of advanced materials for high-speed aircraft such as the XB-70 bomber, the SR-71 spy plane, and the Space Shuttle.

One of the most unusual research efforts was the "lifting body"—a vehicle with no wings that flew because of the aerodynamic lift generated by the body. Beginning in the early 1960s, NASA partnered with the Air Force and other organizations and developed and flew a series of prototypes or models of future spacecraft that could land like an airplane after enduring the searing heat of reentry from space—as the Space Shuttle does today.

The lifting body configurations varied considerably. Some of these configurations pushed the limits of both design engineers' and test pilots' capabilities. This work led to the Space Shuttle of today.

Pilot Bill Dana looks up at the B-52 "mothership" cruises over the HL-10 lifting body on Muroc Dry Lake in California.

Air Power and the Cold War

■ The Cold War began in the aftermath of World War II as a struggle between the Soviet Union and the United States over the future of Europe, and ultimately spread to most parts of the globe. The opponents sought to influence events through non-military means, but at times, as in Korea in the early 1950s and Vietnam in the 1960s, it flared into armed conflict. Throughout, air power played a defining role.

U.S. air power and its ability to deliver nuclear weapons counterbalanced the massive Soviet ground forces. Following World War II, the U.S. continued to develop the strategic air power that had dominated the skies over Europe and Japan. The massive B-36 provided early deterrence, giving way during the 1950s to the B-47, B-52, B-58, and, much later, the swing-wing B-1 and stealthy B-2. Intercontinental Ballistic Missiles (ICBMs) began entering service in the late 1950s, and rockets like Atlas, Titan, Minuteman, and Peacekeeper played roles in deterrence.

Air power served the U.S. as a platform for electronic and photographic intelligence. Aircraft flew at the periphery of the Soviet Union, photographing installations, collecting signals, and locating radar systems. Aircraft like the U-2 and SR-71 achieved fame until reconnaissance satellites during the 1960s took responsibility for many of these dangerous missions.

The U.S. also developed global air transport, enabling it to project power around the world and provide humanitarian airlift to peoples in distress using C-130, C-141, and giant C-5 aircraft. Global air transport demonstrated its importance early during the Berlin Airlift in 1948–49, when it gave the West its first great victory of the Cold War.

The U.S. nuclear advantage and development of air power allowed the economies of the western nations to grow without the excessive burden of military spending faced by the Soviet Union and its satellites, which maintained huge ground armies throughout the Cold War and, at the same time, attempted—with considerable success—to match U.S. strategic power. The Soviets achieved military parity by the 1970s, but at terrible cost to the Soviet economy. Militarization of the Soviet Union and its satellites stunted economic development and undermined political stability. The decision of the U.S. and its allies to entrust their security to nuclear weapons and air power paid off with the collapse of the Soviet bloc and end of the Cold War in 1991.

Right: Titan II ICBM rocket.

1970
April Apollo 13 became a "successful failure" when, despite a ruptured oxygen tank that crippled the spacecraft, the crew returned safely.

October 24 The X24A lifting body exceeded Mach 1.

1971
April 19 Soviet Union placed the world's first space station, Salyut 1, in orbit.

1972
NASA launched Landsat 1, the first remote sensing satellite.

1973
NASA launched the Skylab orbital workshop into orbit.

1975
Soviet and American spacecraft docked in orbit during the Apollo-Soyuz Test Project.

1970 Bar codes introduced for retail use in England

1972 2.5-million-year-old human skull discovered

1973 TCP/IP (Internet protocol) designed

X-45 Uncrewed Combat Air Vehicle (UCAV).

The Future of Flight

■ Today, visionaries around the world are working on innovative technologies that will determine the future of flight. This exciting work is leading to new types of aircraft and aircraft systems and will greatly improve the way we fly.

Working with airlines and industry leaders, NASA is developing new technologies that will bring about improved safety and larger aircraft that transport more passengers using less fuel. New systems and tools for pilots and air traffic controllers will enable airlines to increase the number of flights while dramatically decreasing delays. Business and personal travel could benefit from this change with more choices and lower fares. Improvements to systems that support small and personal aircraft could lead to a future in which personal planes are used much like today's automobiles.

At the other end of the spectrum are unpiloted aerial vehicles such as the Helios Prototype (p. 19) and uncrewed combat air vehicles whose use could prevent losses of personnel in extremely hazardous situations. Additionally, the "Morphing Project" is exploring highly adaptable airplanes with flexible, bird-like wings that will allow for even greater safety, efficiency, and versatility.

The future of flight is as full of promise and excitement as it must have been decades ago, to those who first took to the skies in powered flight. The possibilities are boundless.

Small, Personal Aircraft

■ Imagine being able to plan an entire trip, home to destination, on the Internet: you drive to your local airport—not the major hub of today; board a small jet aircraft; and, in a matter of hours, arrive at your destination. NASA and industry are currently involved in a research project to determine the possibility of using small, personal aircraft to create a safe alternative for both business and personal air travel. At the 99 percent of all airports that are currently underused, small aircraft could be used to carry people and products safely and affordably from one local community airport to another. Delays and travel time would be reduced as a result of creating greater air access into more communities in less time. This provides the flying public with jet-like performance at an affordable cost.

The future: new small, efficient jet airplanes that are easy to fly like the Eclipse 500.
© Eclipse

Morphing Aircraft

■ The future of flight may include aircraft capable of responding to changes in speed or environmental conditions by altering or "morphing" their shape. The wings of these aircraft would sweep back and reconfigure to minimize drag and sonic boom. The engine inlets and nozzles would change to adapt to new conditions. Small jets of air and feather-like surfaces would provide additional control.

Morphing would include small and large changes using structures and fluids for control. NASA and industry researchers are looking closely at the characteristics of flight in birds to develop a new generation of flying machine that changes itself to fly more efficiently. This new type of aircraft would be capable of various modes of flight from supersonic to hover.

Some of the current areas of research include developing smart materials, adaptive structures, and biologically inspired flight systems. Instead of the traditional jet engine location on an aircraft's body or wings, scientists are investigating the effects of using multiple small engines to power these aircraft. The results from this research may provide technologies for aerospace vehicles that efficiently adapt to the diverse and varying conditions of flight.

Airplanes of the future will have wings that change shape for greater efficiency, mimicking the flight of birds.

1977
The Gossamer Condor became the first human-powered airplane.

1978
October 30 The Airline Deregulation Act was signed into law.

1979
June 13 The Gossamer Albatross human-powered aircraft crossed the English Channel.

The F-16 became the first production military aircraft to incorporate a fly-by-wire flight control system.

1977 The movie *Star Wars* was released

1979 M. Thatcher first female elected Prime Minister (U.K.)

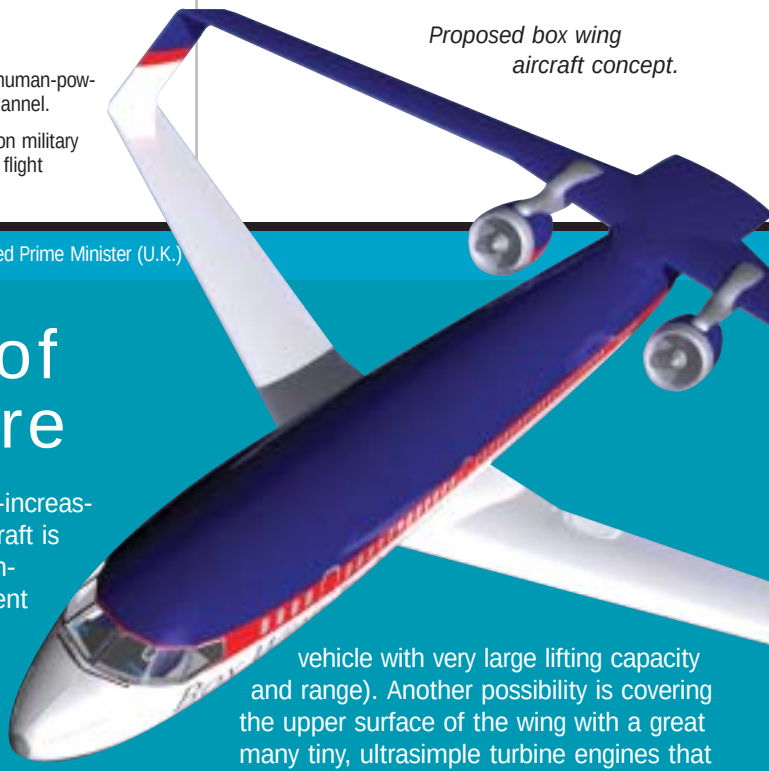
F22 Raptor. (USAF)

F-22 Raptor

■ The most advanced fighter aircraft in the world, the F-22 Raptor, is now being tested at Edwards Air Force Base. The Raptor is a revolutionary leap in aircraft technology that unites advanced capability with reduced maintenance costs and support requirements. The F-22's combination of stealth, advanced avionics, and maneuverability will give pilots a first-look, first-shot, first-kill capability against the aircraft of any potential enemy.

The F-22 combines advanced supersonic flight with the ability to fly at slow speeds during combat, pointing its nose in any direction without loss of control. Integrating systems like radar and friend-or-foe identification into one cohesive platform, the Raptor is designed to provide air superiority and dominance to allow quick, decisive victories with few U.S. and allied casualties. This impressive aircraft will replace the F-15 as America's front-line air fighter.

Biplane of the Future

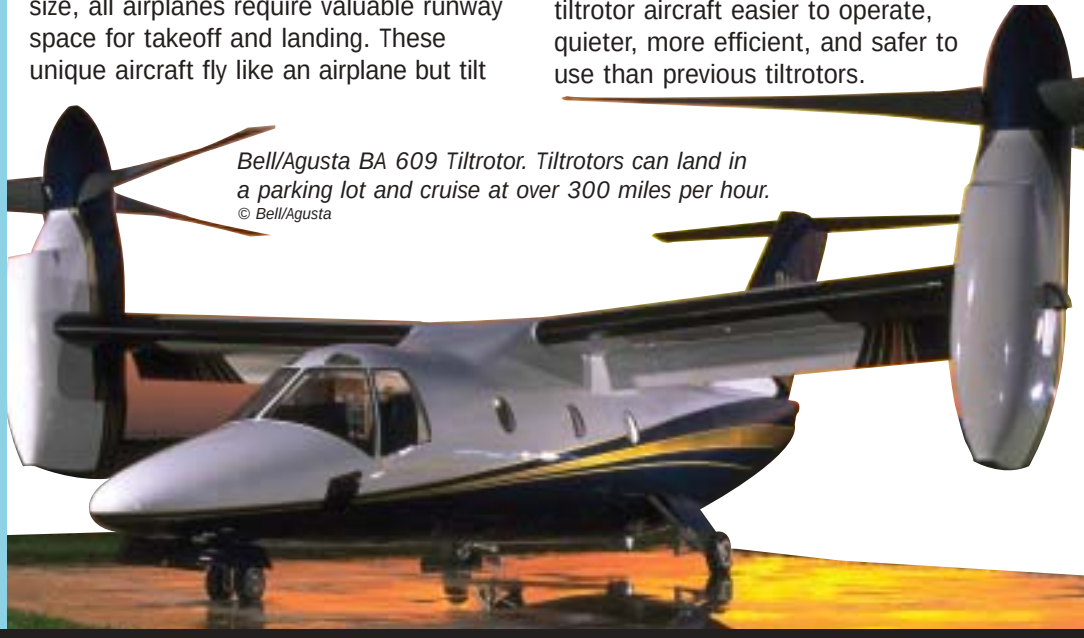


Proposed box wing aircraft concept.

■ One of many efficiency-increasing designs for future aircraft is the box wing. This modern-day biplane is more efficient than today's aircraft; at the same time, it provides a higher level of comfort and safety. It could also take up less space at the gate than conventional planes because of its shorter wingspan. Other designs include the blended wing body (a large, nearly all-wing vehicle with very large lifting capacity and range). Another possibility is covering the upper surface of the wing with a great many tiny, ultrasimple turbine engines that can run on compressed hydrogen. Theoretically, by using these many hydrogen-burning engines, they could allow a 747 to take off in an extremely short distance.

Looking Up

■ As the nation's air traffic increases, the ability of the airspace system to handle the traffic is being stressed. Realizing that we will soon be operating at capacity, NASA and the aviation industry are investigating solutions to the problems of airspace and runway congestion. The Civil Tiltrotor aircraft may provide an answer. Regardless of size, all airplanes require valuable runway space for takeoff and landing. These unique aircraft fly like an airplane but tilt their wing-mounted engines and propellers, enabling them to take off and land much like a helicopter, thereby reducing the need for runway space to become airborne. The versatility of tiltrotors would meet the needs of short-haul and commuter flights and would free up valuable time on the runway for large aircraft. NASA and industry have developed advanced technologies to make tiltrotor aircraft easier to operate, quieter, more efficient, and safer to use than previous tiltrotors.



Bell/Agusta BA 609 Tiltrotor. Tiltrotors can land in a parking lot and cruise at over 300 miles per hour.

1981
April 12–14 The first Space Shuttle orbiter, *Columbia*, flew into Earth orbit.

1983
Sally Ride became the first American woman to fly in space; Guy Bluford became the first African American to fly in space.

1984
December 14 The X-29 forward swept wing aircraft's maiden flight occurred.

1986
January 28 Space Shuttle *Challenger* exploded 73 seconds into its flight, killing seven crewmembers.

1986
December 23 Voyager aircraft completed the first nonstop flight around the world.

1988
April 22 Daedalus 88, human-powered aircraft, flew from Crete to Santorini.

1981 IBM introduced the first personal computer

1984 Macintosh computer with mouse released

1988 CDs outsold vinyl records for the first time

Artist's conception of a proposed launch vehicle.

Future Launch Systems

■ In the early days of flight in the twentieth century, the U.S. government fostered aviation. As the nation marks the hundredth anniversary of powered flight, NASA is continuing this historic tradition with an investment in the development of future launch systems. This will ultimately help move the nation from the pioneering era of the Mercury, Gemini, Apollo, and Space Shuttle programs to a future in which people are more routinely traveling, working, and living in space.

NASA's goal is to design a safe, more affordable, more reliable reusable space transportation system that can accommodate the needs of the nation's space-science-driven missions and provide technologies beneficial to commercial industry and the Department of Defense. The Shuttle has been flying for more than twenty years, and it will continue to fly until a new system is ready. This research will lead to a new generation of launch technologies for a complete space transportation system while advancing the technologies needed to build and operate that system.

Early next decade, a new generation of launch vehicles could be flying. These new vehicles will significantly reduce cost and dramatically increase safety for the human exploration and development of space.

Flying to and from Earth Orbit: The Space Shuttle

■ As the Apollo lunar landing missions came to a close, NASA's major effort in human spaceflight involved the development of a reusable Space Shuttle that could travel back and forth between Earth and space more routinely and economically than had ever been done before. After nearly a decade of development, on 12 April 1981, the first operational orbiter, *Columbia*, was launched from the Kennedy Space Center, Florida. Five short years later, in 1986, NASA had chalked up twenty-four successful Shuttle flights. With each flight, NASA increased the number of people who could fly in space and contribute to a revolution in scientific understanding of the effects of long-duration, near-weightless conditions on all types of organisms.

Unfortunately, during the twenty-fifth Shuttle launch on 28 January 1986, a leak in the joints of a Solid Rocket Booster attached to the *Challenger* orbiter detonated the main liquid fuel tank. Seven astronauts died in this tragic accident. Out of this tragedy, an extensive evaluation and redesign effort placed the Space Shuttle on the road to becoming the safest and most reliable space system.

The redesigned Space Shuttle system returned to flight on 29 September 1988. Since returning to flight, the four orbiters, *Atlantis*, *Columbia*, *Discovery*, and *Endeavour*, have made more than eighty-five flights into space. Throughout the Shuttle era, the four orbiters have been workhorses of space exploration for both international and domestic projects.

The Space Shuttle has launched numerous scientific satellites and undertaken scientific and technological experiments ranging from Spacelab to a dramatic three-person spacewalk to retrieve a multimillion-dollar communications satellite and deploy it for use. The Shuttle is also instrumental in the servicing of the Hubble Space Telescope. Between April 1981 and the end of 2002, the Space Shuttle carried approximately 2.9 million pounds of cargo and more than 800 major payloads into orbit.

In the beginning of the twenty-first century, the Space Shuttle is still the only vehicle in the world with the capability to deliver and return large payloads to and from orbit. It is the most reliable launch system now in service, with a success rate of better than 99 percent. The Space Shuttle remains one of the most successful and impressive technologies in American history. It is a reliable, mature, and flexible system on which stunning scientific experiments are launched and conducted.

Launch of the Space Shuttle Columbia.

1989
The B-2 Stealth bomber made its first flight.

1990
September 29 The first flight of the YF22 fighter prototype was made by Lockheed test pilot Dave Ferguson.

October 11 The first flight of the X-31, YF22, and YF23 took place.

1991
August 27 The first flight of the YF23 V-22 Osprey tiltrotor occurred.

September 17 The first flight of the McDonnell Douglas C-17 military cargo transport took place.

1989 Berlin wall opened; torn down in 1990

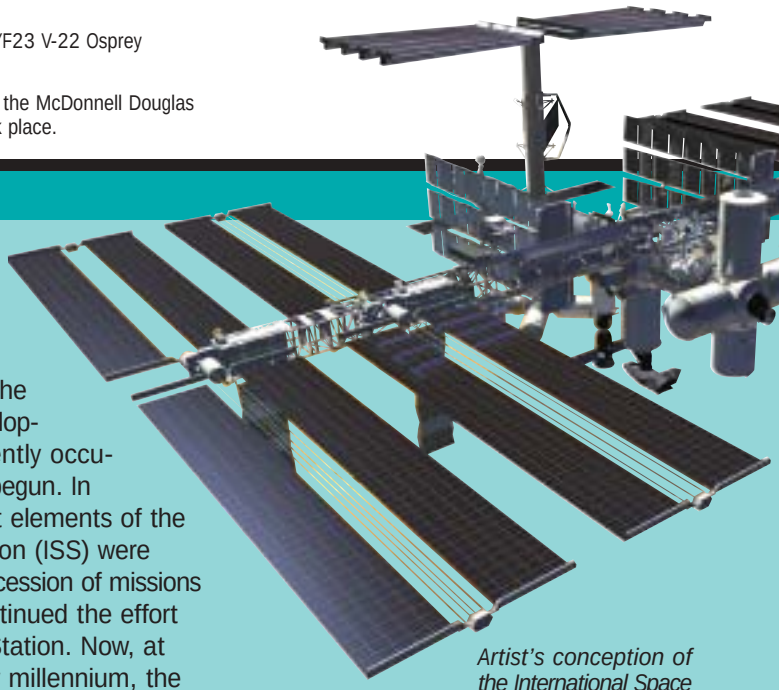
1991 Gulf War began

The International Space Station

■ From virtually the beginning of the twentieth century, those interested in the exploration of space viewed as central the building of a massive Earth-orbital space station to serve as the jumping-off point for travel to other planets and to the Moon. Always, space exploration enthusiasts believed, a permanently occupied space station was a necessary outpost in the new frontier of space.

NASA deferred this dream during Project Apollo, but on 14 May 1973, it launched a small orbital space platform, Skylab. Skylab became home to three crews during 1973–74 for periods of 28, 59, and 84 days, respectively. In orbit, the crew conducted solar astronomy and Earth resources experiments, as well as medical studies. At the conclusion of the Skylab 4 mission, the orbital workshop was powered down and allowed to burn up on reentry in 1979.

Skylab served as a predecessor for a full-fledged space station. In 1984, as part of an effort to reinvigorate the space program, the development of a new, permanently occupied space station was begun. In December 1998, the first elements of the International Space Station (ISS) were assembled in orbit. A succession of missions since that time have continued the effort to construct the Space Station. Now, at the beginning of the new millennium, the United States has joined with fifteen other nations to make into reality the long-held vision of a space station in Earth orbit. On 31 October 2000, the first crew left Earth to set up residence aboard the ISS, and with this accomplishment, the spacefaring nations of the world intend that no future generation will ever know a time when there is not some human presence in space. Once in orbit, this Space Station will enhance human understanding of the rigors of spaceflight as no other research laboratory has been able to do.



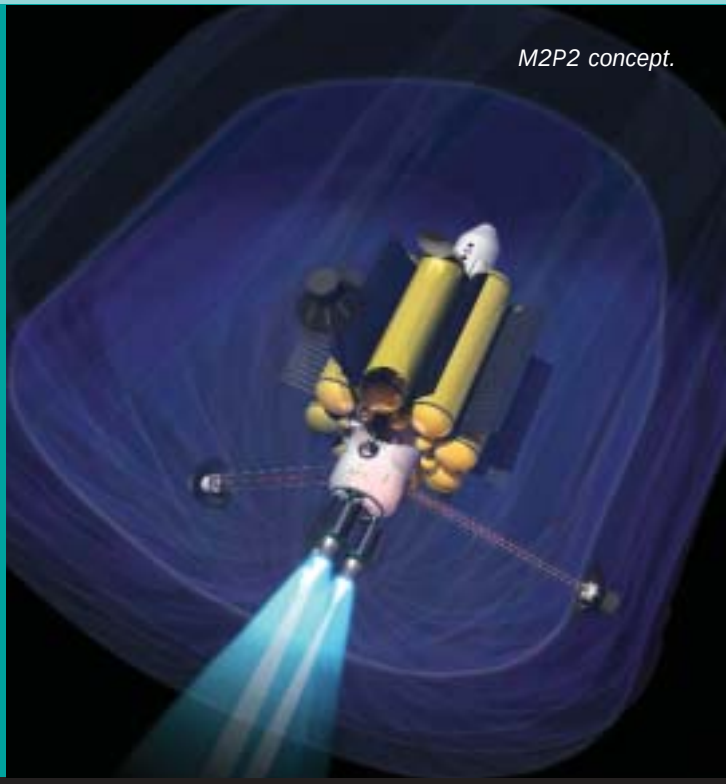
Artist's conception of the International Space Station in orbit.

The International Space Station promises to become the anchor tenant of a research park in space, contributing critical knowledge necessary to make life on Earth more rewarding and to aid humanity's movement beyond this planet. It is an idea whose time has come.

Space Frontiers

■ There are certain ideas that many believe to be inherent in the human psyche and integral to American culture: ambition for progress, curiosity about the unknown, the need to pose profound questions and to answer them, the concept of new frontiers that—once achieved—promise a better quality of life for all people. Space is such a frontier: Earth orbit, the Moon, Earth's neighborhood, Mars and the asteroids, eventually the moons of the giant planets of the outer solar system, and someday, more distant worlds—these are collectively the endless, ever-expanding frontier of the night sky under which the human species evolved and toward which the human spirit is inevitably drawn.

As part of NASA's vision to "improve life here, extend life to there, and find life beyond," NASA is studying advanced technologies that enable the safe, rapid, and affordable exploration of our solar system by humans and robots. Mini-Magnetospheric Plasma Propulsion (M2P2) is an example of a transportation technology that not only attains much higher speeds than are now possible, but also provides an artificial magnetic field to protect the vehicle and its crew from harmful radiation.



M2P2 concept.

1994
Jeannie Flynn, the first female combat pilot in the U.S. Air Force, finished flight training in the F-15.

1995
Norm Thagard was the first American astronaut to serve on the Russian space station Mir.

1996
January 4 The Boeing Sikorsky Comanche helicopter was unveiled.

March 22 Shannon Lucid began her historic journey to Mir. Her stay established the United States single-mission space-flight endurance record.

1997
May 17 The first flight of a subscale remotely piloted X-36 tailless research aircraft took place.

1998
The first elements of the International Space Station were assembled in orbit.

1994 South Africa held first interracial national election | 1997 First Harry Potter book published in the U.K. | 1998 Frank Sinatra died

Revolution in Space Science

■ Since the dawn of the space age, NASA has sent numerous scientific probes to all of the planets of the solar system (except Pluto) and peered into the depths of space to discover galaxies, black holes, and planets outside our solar system. These explorations will change how science textbooks are written.

The first probes went to the Moon, Mars, and Venus in the 1960s; since that time, succeeding generations of scientific spacecraft have made revolutionary discoveries. For instance, Mars has been the target of several missions, including two Viking spacecraft landings in 1976 that yielded a wealth of scientific information, the 1996 analysis of the Martian meteorite that suggests that past life might have existed on Mars, and the Mars Pathfinder mission that landed on 4 July 1997. Pathfinder's rover provided the first-ever in situ measurements of Mars rocks and raised questions about other aspects of the planet's global system of transporting volatiles such as water vapor, clouds, and dust. Later Mars probes, especially Mars Global Surveyor (1997) and Mars Odyssey (2001), have confirmed that the red planet was once a watery place where life may have flourished.

NASA has also been involved in several robotic expeditions to the outer planets. For example, Voyagers 1 and 2, launched in 1977, conducted a "grand tour" of our solar system, returning stunning knowledge about those giant worlds and their moons. They discovered rings around Jupiter, volcanoes on Io, shepherding satellites in Saturn's rings, new moons around Uranus and Neptune, and geysers on Triton. One striking image was Voyager 1's portrait of most of the solar system, which showed Earth and six other planets as sparks in a dark sky lit by a single bright star, the Sun. Additionally, beginning in 1995, the Galileo probe has spent years studying the physical characteristics of Jupiter. The result promises a reinterpretation of humanity's understanding of the largest planet in our system and its moons.

HST Cone Nebula. NASA, H. Ford [JHU/APL], G. Illingworth

More recently, the Hubble Space Telescope, although initially impaired, has returned exceptional images providing critical data on the origins and development of the universe. As only one example of the Hubble's important contributions, in early 1997, NASA scientists announced the discovery of three black holes in three normal galaxies, suggesting that nearly all galaxies may harbor supermassive black holes which once powered quasars (extremely luminous nuclei of galaxies).

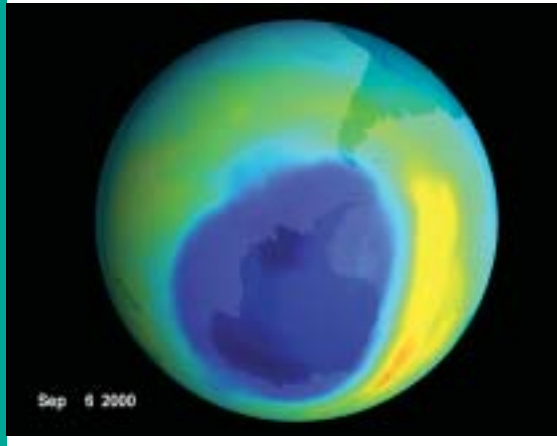
At the beginning of the twenty-first century, several key spaceflight missions are seeking to answer age-old astronomical questions. As part of the "NASA Origins Program," a series of missions will collectively seek to answer such questions as how the universe was formed, what evolutionary process it has followed, and whether we are alone in the cosmos. The future is exciting, for humanity has, for the first time in its history, the tools necessary to explore the answers to these enticing questions more thoroughly than ever before.

Understanding

■ Why do weather patterns function as they do? Why are there cycles of hot and cold, wet and dry seasons? How is the climate changing over time? What are the causes and consequences? These and myriad other questions have motivated scientific study about this planet for centuries. With the advent of the space age, however, new space-based instruments—especially remote sensing satellites—have allowed humans to monitor Earth as never before.

Using Earth-observing satellites, scientists have produced immense benefits to the nation, yielding new knowledge for improved weather forecasting, agriculture, urban and land-use planning, and many other related areas. In concert with other agencies, the global research community, and commercial partners, space-based resources have provided the scientific foundation needed for complex policy choices leading to sustainable development.

Meteorological science has also benefited greatly from the opportunity to study the Earth with satellites. The perspective afforded by satellite imaging was a great boon to scientists, who were then able to locate distribution and types of cloud formations, find and measure weather



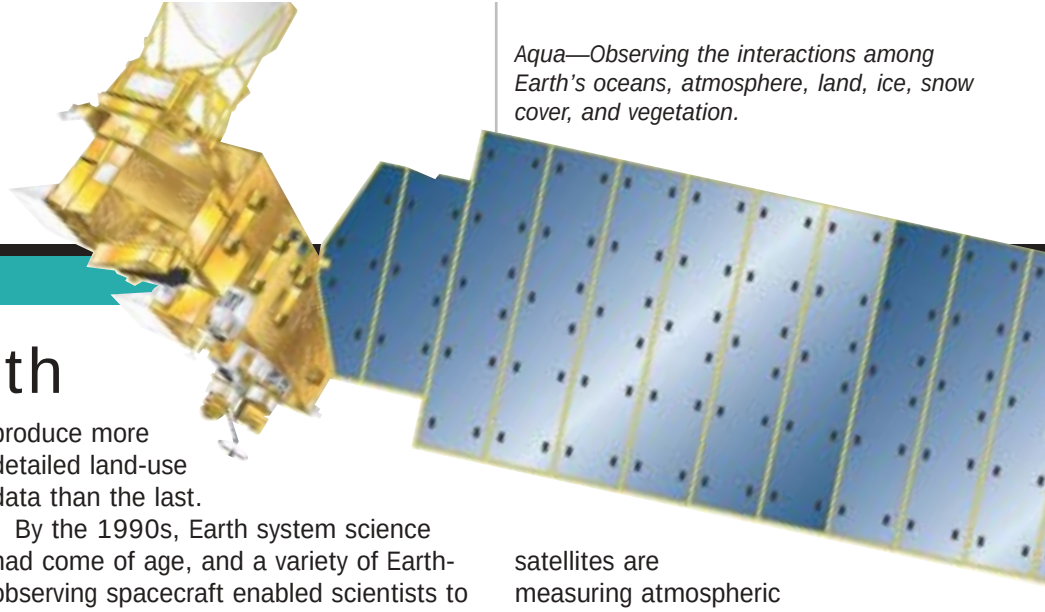
TOMS image of largest-ever ozone hole over Antarctica.

NASA, TOMS Science Team, and GSFC Science Visualization Studio

1999
March 20 The first nonstop circumnavigation of the globe via a balloon took place.

2000
The first crew of the International Space Station arrived in orbit.

2000 Closest presidential election in U.S. history



Aqua—Observing the interactions among Earth's oceans, atmosphere, land, ice, snow cover, and vegetation.

the Changing Earth

disturbances, and track movements and patterns. It provided new levels of precision to the evaluation of pressure fronts and air masses that are so critical in weather forecasting. Likewise, meteorological research beyond weather forecasting took on new life as climatological research contributed significant insights to our understanding of Earth.

NASA launched the first Earth science satellite, Landsat 1, on 23 July 1972 to provide data on vegetation, insect infestations, crop growth, and associated land-use information. Since that time, six more Landsat spacecraft have been placed in orbit, each with greater capabilities to produce more detailed land-use data than the last.

By the 1990s, Earth system science had come of age, and a variety of Earth-observing spacecraft enabled scientists to obtain sophisticated data about this planet's physical characteristics. Among others, these spacecraft include the Upper Atmosphere Research Satellite (UARS) missions, the QuikScat and TOPEX/Poseidon ocean studies missions, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) mission, Tropical Rainfall Measuring Mission (TRMM), and the ACRIMSAT. Instruments from these satellites are measuring atmospheric chemistry, biomass burning, and land surface changes in regions as diverse as Greenland and the Pacific Ocean. With the launch of Terra in 1999, NASA was on its way to deploying Earth's first simultaneous view of all the major components of the Earth system—to understand and protect our home planet.

Space Research

■ Throughout most of history, we human beings viewed gravity as an inescapable constant in anything we designed or did. Even from the start, gravity profoundly affected the way life on Earth evolved. But with the dawn of the space age, access to the microgravity environment of Earth orbit allowed scientists to cancel most of gravity's effects and conduct unprecedented research, thus providing a new tool to apply to long-standing questions in science and technology. Space also poses physical challenges to explorers, who must find ways to withstand space environment hazards for which our evolution on Earth never prepared us.

To meet these opportunities and challenges, NASA has led the world in peer-reviewed, interdisciplinary, fundamental, and applied research in microgravity. Throughout, NASA and its science teams have been guided by two fundamental questions:

- What is gravity's role in biological and physical processes?
- What must we do to enable humans to live and work safely in Earth orbit and to venture beyond Earth orbit?

In the search for answers to these questions, NASA has sponsored a multitude of experiments to increase our understanding of both the human experience and nature's forces in space. We also devote part of our budget to education and outreach to help inspire and educate the next generation of scientists.

Our total effort is transforming the technological foundations not only of the space program, but also of our society. Knowledge from space will make a difference in the health industry. Advances in biology, medicine, physics, and chemistry; associated analytical tools; and information systems are opening an era of unprecedented opportunities to benefit human life on Earth and to extend our reach into space.

Representation of DNA struck by radiation, a key concern for long-duration space travel.

Wanted:
Online Adventure Seekers

http://spacelink.nasa.gov/celebratingflight

Hot Topics

Cool Picks

The Library

Search

Site Map & Information

Where am I? → NASA Spacelink Home → The Library → Instructional Materials → Curriculum Support → Physical Science → Aeronautics and Aerospace → Celebrating Flight

Join NASA for investigations Celebrating 100 Years of Flight: Past, Present and Future! The runway is clear -- so fasten your seatbelt and take off into these Cool Sites and Hot Activities.

Celebrating Flight

The Wright Brothers - Wilbur and Orville Wright made the first manned, heavier than air, powered flight on December 17, 1903. Resources that bring this event to life can be discovered here!

Designing Tomorrow's Space Ships Today - NASAexplores offers this article and set of activities about the Space Launch Initiative -- designing and flying the next generation of spacecraft.

Aviation for Little Folks - Learn the parts of an airplane and how to fold a super-duper paper airplane.

U.S. Centennial of Flight Commission - This web site is filled with information and activities for aviation enthusiasts, educators, and students to celebrate the Wright Brothers' first powered flight centennial.

Play the Plane Game - Test your knowledge about aeronautics, propulsion and how an airplane works while flying across the globe!

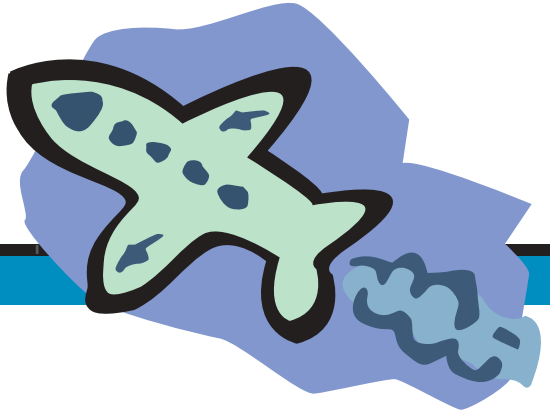
A Century of Firsts - Research facts about the history of spaceflight in the 20th Century and answer questions about historic events.

Design a Mars Airplane - Explore the aeronautics behind flying an airplane on Mars. Use the problem-based learning challenge to design an airplane that can fly in the atmosphere of Mars.

The Wright Way - Learn how you can join in NASA's celebration of the 100th anniversary of flight. This site will serve as a central location for information on all NASA educational programs, learning activities, and services related to the Centennial of Flight.

NASA Education Home Page - Describes NASA's overall education program and provides links to the major NASA educational web sites.

Aviation Fun!



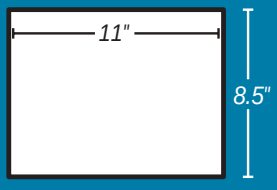
Do You Wonder Why?

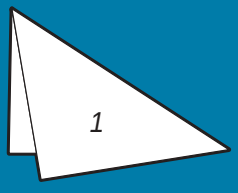
1. Why do they push the plane from the gate?
2. Why do we need oxygen masks in case of emergency?
3. Why do my ears pop as we go up to and come down from cruising altitude?
4. Why do we need to have tray tables up and seats in their upright position for takeoff and landing?

(Find answers at bottom of page.)

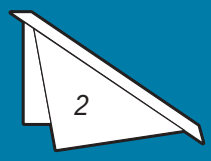
Ring Wing Glider

This wing demonstrates the great room there is for aeronautics innovation. Can you design a better wing?

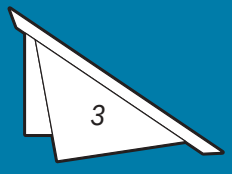




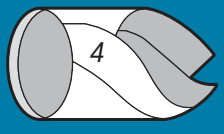
1. Fold 8.5 x 11-inch paper diagonally as shown.



2. Make a half-inch fold along the previously folded edge.



3. Make a second half-inch fold.



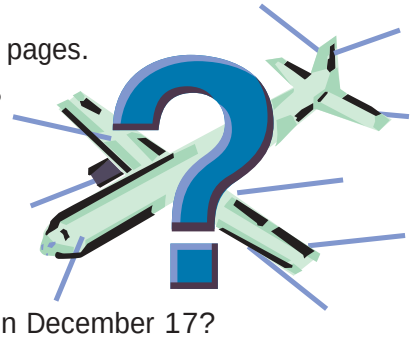
4. Curl the ends of the paper to make a ring and tuck one end into the fold of the other.

5. Gently grasp the “V” between the two “crown points” with your thumbs and index fingers and toss the glider lightly forward.

The folds in the paper make an airplane wing where the front end is heavy and the back end is light. Curling the ends to make a ring changes the shape of the wing and improves the wing’s flight performance.

Scavenger Hunt!!

Find the answers to each of these in the previous pages.



- Why was Kitty Hawk, North Carolina, chosen for the test flights of the Wright brothers?
- What type of flying vehicle is credited to the “father of aeronautics?”
- Who was the first African American woman to receive a Fédération Aéronautique Internationale (FAI) license?
- Who pioneered rubber-band-powered motors called aerodromes in the 1800s?
- What total distance did the first four powered flights of the Wrights’ 1903 flyer travel on December 17?
- What is the name of the remotely piloted aircraft that is being developed to fly at a high altitude for a long duration?
- How long was Lindbergh’s flight across the Atlantic?
- Name two early flight pioneers who used birds as the inspiration for flights using solar power.
- Who were the first passengers aboard a hot air balloon?
- Who was the first person to step on another world and when?
- What was the first commercial jet aircraft?

Answers 1. Most airplanes do not move in reverse and so they need a push. 2. There is less oxygen in the atmosphere at higher altitudes. Airplanes are airtight and pressurized so passengers have the correct mix of air in the cabin. If there is a sudden change in the aircraft’s pressurization, a mask would drop to give passengers needed oxygen. 3. Even though the cabin is pressurized, there are still slight changes in pressure as the airplane’s altitude changes. 4. So you and others in your row could exit the row and airplane quickly and safely in an emergency.

http://www.nasa.gov

http://www.centennialofflight.gov

http://www.centennialofflight.af.mil

NASA Publication SP-2002-09-511-HQ

National Aeronautics and Space Administration
Office of Aerospace Technology
NASA Headquarters
Washington, DC 20546

ISBN 0-16-067541-3

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512-1800; DC area (202) 512-1800
Fax: (202) 512-2250 Mail: Stop SSOP, Washington, DC 20402-0001

ISBN 0-16-067541-3

NASA and its predecessor, the National Advisory Committee for Aeronautics, have charted the course of aviation and space technology since 1915. NASA's world-renowned achievements, representing a successful investment in the future of all Americans, are accomplished using less than one percent of the Federal budget. *http://www.nasa.gov*

In its more than 50 years of existence, the Air Force has become the world's premier aerospace force. Its mission is simple in words, yet awesome in meaning—defend the nation through the control and exploitation of air and space. To learn more about opportunities within the Air Force, call 1-800-423-USAF or visit *http://www.airforce.com*

The U.S. Centennial of Flight Commission was created by Congress to expand interest in the commemoration of the centennial of powered flight and the Wright brothers' achievement. The Commission is coordinating a national outreach campaign and advising the President, Congress, and federal agencies on the most effective ways to encourage participation in 2003. *http://www.centennialofflight.gov*