Wright Brothers

Official Map and Guide

Wright Brothers National Memorial
North Carolina

National Park Service
U.S. Department of the Interior

The Wright Cycle Company occupied part of this building in Dayton, Ohio, where Orville *(right)* and friend Ed Simms are shown working in 1897.

The Wrights of Dayton

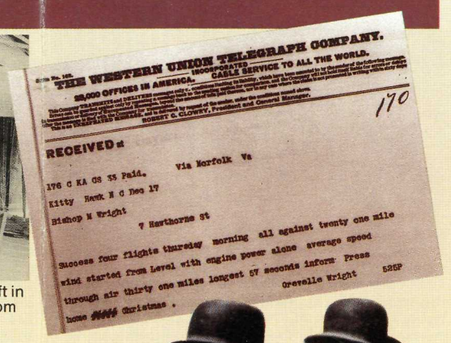
In the early 1890s the Wright Brothers had settled into a respectable life as proprietors of a small business in Dayton, Ohio. But the brothers nurtured a dream, which at the time was barely respectable: the possibility of flight. Wilbur, four years older, was quiet and intense, a dreamer who could lose himself in books. Orville was outgoing, talkative, and an immaculate dresser. Both combined intuitive mechanical ability with analytical intelligence.

In 1892 they opened a bicycle shop. While they prospered in their business, they were restless, particularly Wilbur. Their energies were focused by two events of 1896: the death of Otto Lilienthal, the celebrated German glider experimenter, in a flying accident, and the successful unmanned powered model flights of Samuel Langley. The Wrights' serious work in aeronautics began in 1899 when Wilbur wrote the Smithsonian for literature. Dismayed that so many great minds had made so little progress, the brothers were also exhilarated by the realization that they had as much chance as anyone of succeeding. Wilbur took the lead in the early stages of their work, but Orville was soon drawn in as an equal collaborator. They quickly developed their own theories, and for the next four years devoted every spare moment to the goal of human flight.

Kill Devil Hills: We Take to the Air

The Wrights learned to fly on a stretch of beach near the Kill Devil Hills. It provided isolation, high dunes, strong winds,and soft landings.

At their 1902 camp the Wrights shared their living quarters with the glider. They slept aloft in burlap slings hung from the rafters.



THE WESTERN UNION TELEGRAPH COMPANY.

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Bishop M Wright

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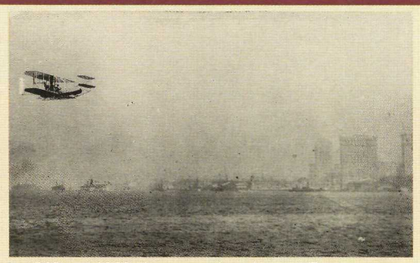
Success four flights thursday morning all against twenty one mile wind started from Level with engine power alone average speed through air thirty one miles longest 57 seconds inform Press home Christmas .

Orevelle Wright

The brothers were dressed in coats and ties that December morning—a touch of private ceremony for an event that would alter the world. The pools around their camp were icing up, and the break in the weather might be their last chance of the season. Words were impossible over the engine's roar, so they shook hands and Orville positioned himself on the flyer. Then, on this remote, sandy beach, in the year 1903, he broke our bond to the earth. He flew. It lasted only 12 seconds, and the distance of the flight was less than the length of an airliner. But for the first time, a manned, heavier-than-air machine left the ground by its own power, moved forward under control without losing speed, and landed on a point as high as that from which it started. Within two generations we had taken to the air for routine travel, seen an aircraft break the sound barrier, and watched a man walk on the moon.

The Wrights labored in relative obscurity, while the experiments of Samuel Langley of the Smithsonian were followed in the press and underwritten by the War Department. Yet Langley, as others before him, had failed to achieve powered flight. They relied on brute power to keep their theoretically stable machines aloft, sending along a hapless passenger and hoping for the best. It was the Wrights' genius to see that humans would have to *fly* their machines, that the problems of flight could not be solved from the ground. In Wilbur's words, "It is possible to fly without motors, but not without knowledge and skill." With over a thousand glides from atop Big Kill Devil Hill, the Wrights made themselves the first true pilots. These flying skills were a crucial component of their invention. Before they ever attempted powered flight, the Wright brothers were masters of the air.



In 1908 and 1909, the Wrights performed for awestruck crowds in America and Europe. Hundreds of thousands of New Yorkers cheered Wilbur's 20-mile circuit from Governors Island up the Hudson to Grant's Tomb and back. At Pau, France, the *Flyer* soars over nervous horses.

Smithsonian Institution

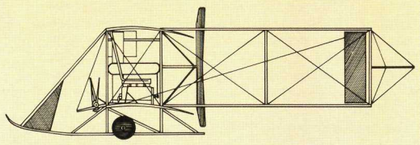
Showing the World

"They have done it! Damned if they ain't flew!" said a witness to the first human flight. But so often had this claim proven hollow that the public was skeptical of yet another, especially after the spectacular failure of Langley's flying machine 9 days earlier. Undismayed, the Wrights built an improved flyer and refined their flying skills over a field in Ohio, making 105 flights in 1904. In the 1905 flyer—the first practical airplane—circling flights of up to 38 minutes became routine. But when the Wrights offered the flyer to the U.S. Army, that institution, dubious of their achievement, refused to meet with them. Unwilling to show their control system without a contract in hand, the Wrights did not fly for another 3 years.

Despite the break in their progress, the gap between the Wrights and European aviators remained substantial. After 1903, the French built gliders based on the Wright 1902 Glider. But by 1906, none had remained aloft for more than a few seconds of ragged flight. Not until 1907 did a European plane stay in the air as long as the Wrights had in 1903.

But the Wrights' refusal to fly caused even early believers to doubt their success. By 1908, a French pilot had flown for over 20 minutes. The Wrights finally signed a contract with the U.S. Army and France that year and showed the world what they could do—Wilbur in France, Orville in America. After Wilbur flew a circle under good lateral control and landed gently, no one questioned that the Wrights had truly mastered flight. The French attempts were still shaky, on the edge of control. What Wilbur had done was effortless, graceful, decisive. In other flights he flew over two hours and reached an altitude of 360 feet, demonstrating the Flyer's reliability and endurance. "We are as children compared with the Wrights," said one French pilot.

By 1910 the rest of the world had caught up. The French rapidly introduced refinements to the Wright design: monoplane wings, closed body, front propeller, rear elevator, single stick control, wheels, and ailerons. But the principle behind the Wrights' control system was unchanged. A 1911 Wright Model B (below) reflecting some of these changes is the prototype for every plane in the air today.



Orville and Wilbur Wright

About Your Visit

We suggest that you stop first at the visitor center, where the story of the Wright brothers is told through exhibits and full-scale reproductions of the 1902 glider and the 1903 flying machine.

A large granite boulder at the first flight area near the reconstructed 1903 camp buildings marks the spot where the first airplane left the ground. Numbered markers indicate the distance of each of the four flights made on December 17, 1903. One of the 1903 camp buildings duplicates the one used by the brothers as a hangar for the 1903 Flyer. The other is similar to the one used as a workshop and living quarters in 1903. It is furnished with items much like those the Wrights used when they were here.

Kelly Culpepper

The Wright Brothers Monument *(left)* crowns Kill Devil Hill, a 90-foot dune of once-shifting sand that has been stabilized with grass. The 60-foot monument, constructed of gray granite from Mount Airy, N.C., honors the Wright brothers and marks the site of the hundreds of glider flights that preceded the first powered flight.

First Flight Airstrip
This 3,000-foot paved airstrip was added to the park in 1963 to accommodate small planes. Parking at the airstrip's limited tie-down area is restricted to 24 consecutive hours or a total of 48 hours during any 30-day period. Pilots who wish to stay longer for other purposes may tie down at the Dare County Regional Airport, where gas and rental cars are available.

For Your Safety
Please exercise common sense and caution. Help protect Kill Devil Hill by staying on the paths. Off the path there are sand spurs and prickly pear you will want to avoid. Remember that Kill Devil Hill is highly exposed to lightning during thunderstorms. Bicycles are permitted only on the established roads, not on paths, and skateboards are prohibited.

Wright Brothers National Memorial is located on the Outer Banks of North Carolina in the town of Kill Devil Hills, about midway between Kitty Hawk and Nags Head on U.S. 158, between mileposts 7 and 8.

For More Information
Outer Banks Group
1401 National Park Drive
Manteo, NC 27954
252-473-2111
www.nps.gov/wrbr

Wright Brothers National Memorial is one of more than 380 parks in the National Park System. The National Park Service cares for these special places saved by the American people so that all may experience our heritage. Visit www.nps.gov to learn more about parks and National Park Service programs in America's communities.

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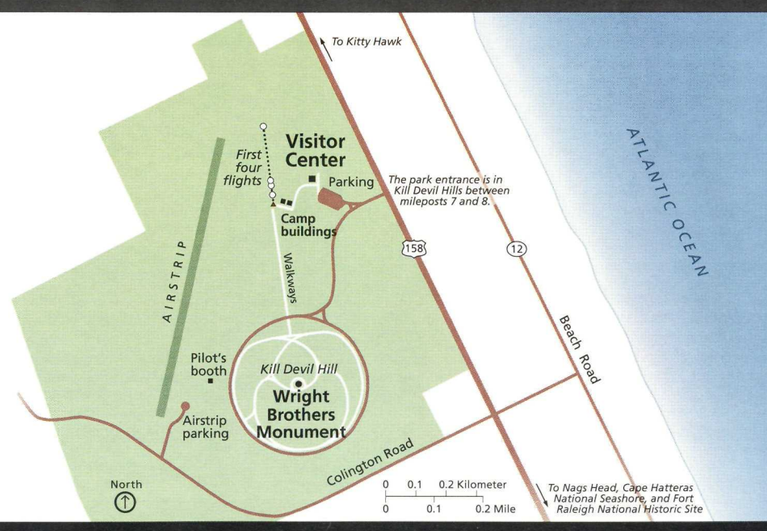
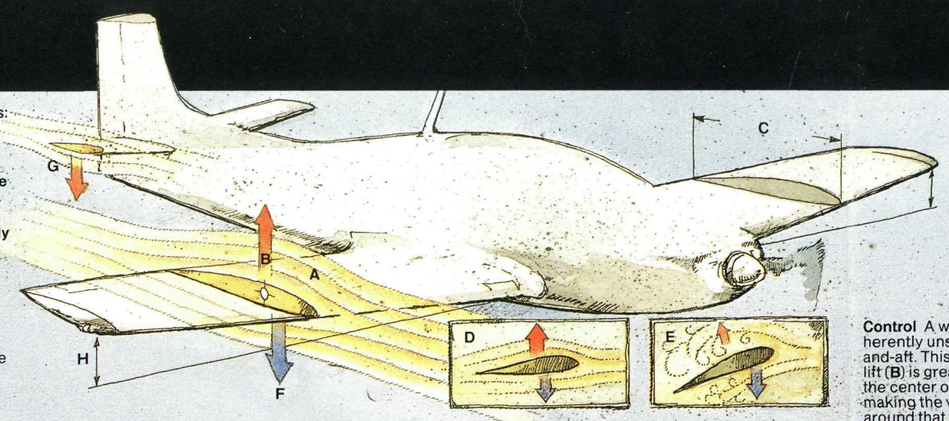


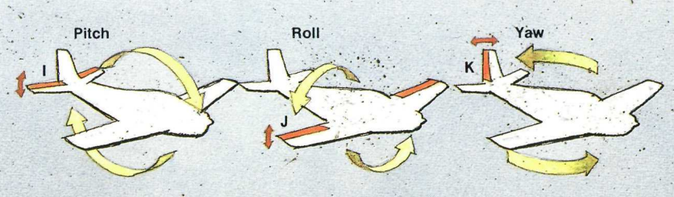
Solving the Problems of Flight

Principles of Flight

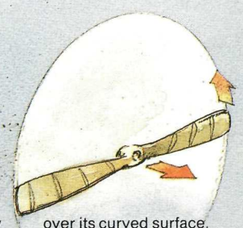
Any aircraft design has to solve three critical problems: lift—generating an upward force greater than the weight of the plane; thrust—propelling the plane forward; and control—stablizing and directing the plane's flight. Any number of approaches can achieve these results, but natural selection eliminated the early designs that failed to meet the requirements of efficiency, reliability, and durability. The design rapidly evolved into the familiar, basic configuration that virtually all airplanes share. *Illustration by Richard Schlecht*



Lift Air passing over the arched, or cambered, upper surface of a wing (**A**) must travel farther than the air passing beneath the wing. It thus has to move faster, making the air pressure drop relative to the pressure under the wing. Upward lift (**B**) is created. The degree of curvature of the upper surface and the ratio of the wing span to its chord (distance from the front to the back of the wing) (**C**) affect lift. The angle of attack—the angle at which the wing meets the air (**D**)—also affects lift. The greater the angle, the greater the lift—up to a point. Past a certain angle, the smooth flow of the air over the wing suddenly becomes turbulent (**E**) and "stalling" occurs. That is, lift is lost. At higher speeds, less angle is needed to generate the same amount of lift.



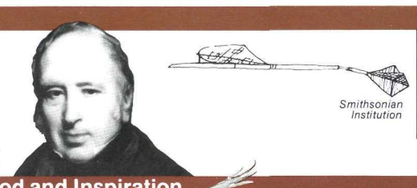
Control A wing is inherently unstable fore-and-aft. This is because lift (**B**) is greatest behind the center of gravity (**F**), making the wing rotate around that point. The nose pitches down, the tail comes up. To counteract this, the horizontal stabilizer (**G**) acts as an inverted wing, creating negative lift to hold the tail down. Lateral stability of the plane is affected by the amount of dihedral (**H**): the deflection from horizontal built into the wings. Movable control surfaces produce the three movements needed for maintaining control of the aircraft and changing direction. The elevator (**I**) produces ***pitch*** (up-and-down movement of the nose), for longitudinal control. Ailerons (**J**) produce ***roll*** (rotation of the wings), for lateral control. The rudder (**K**) produces ***yaw*** (right and left movement), for directional control. These movements in combination turn the aircraft.



Thrust Just as air flow over the wings generates lift, air flow over the rapidly turning blades of a propeller-driven plane produces thrust, or forward motion. Each blade of the propeller acts as a small airfoil, or wing. As the blade rotates, air flows over its curved surface. The resulting horizontal "lift" propels the aircraft forward. Because the velocity of the blade increases from hub to tip, the blade is twisted, providing the most efficient angle of attack at each point along its length.

Predecessors

George Cayley (1773-1857) was the father of aerodynamics. His 1804 glider model incorporated most design elements of a modern airplane.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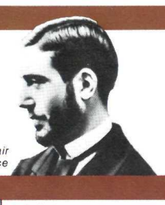
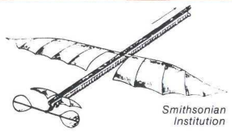
Alphonse Penaud (1850-80) built a rubber band powered "planophore" model. Its 131-foot flight was the first of an inherently stable aircraft.


Musee de l'air et de l'espace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Otto Lilienthal (1848-96) was the first true glider pilot. Inspired, the Wrights took up his quest to get on "intimate terms with the wind."


Library of Congress

Smithsonian Institution

Octave Chanute (1832-1910) gathered and disseminated aeronautical knowledge. He encouraged the Wrights, who used his biplane glider design.


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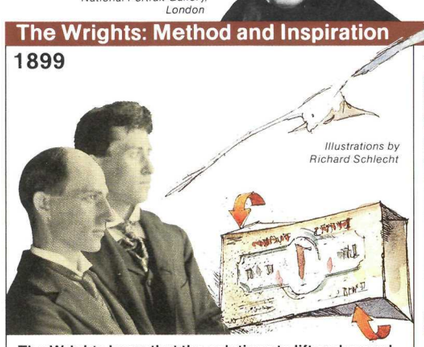
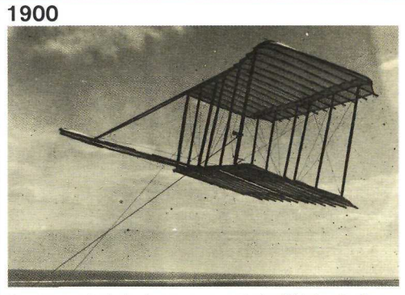
The Wrights: Method and Inspiration

1899


Illustrations by Richard Schlecht

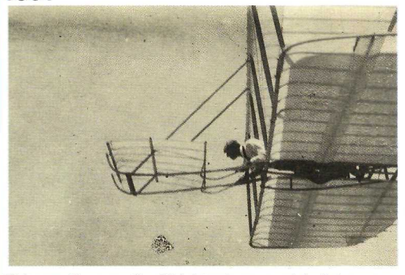
The Wrights knew that the solutions to lift and propulsion needed only refining, but no one had achieved lateral control. Rejecting the principle of inherent stability—the conventional wisdom—they wanted control to depend on the pilot. Wilbur hit upon the idea of warping the wings—sparked by his observation of birds and the idle twisting of a box—to rotate the wings and stabilize flight. They tested wing-warping—the forerunner of ailerons—on a 5-foot biplane kite.

1900

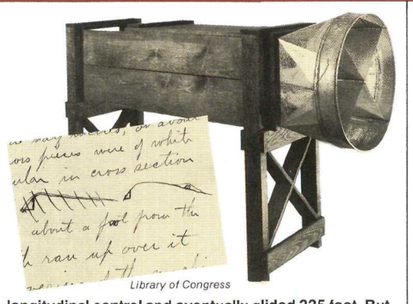


Confident their design was sound, the Wrights built a 17-foot glider with an unusual forward elevator. They went to Kitty Hawk hoping to gain flying experience, but the wings generated less lift than expected, and they flew the glider mostly as a kite, working the control surfaces from the ground. Wilbur's time aloft in free flight totaled only 10 seconds. They went home somewhat discouraged, but convinced they had achieved lateral and longitudinal control.

1901



This was the year the Wrights sharpened their focus. Trying to overcome the lift problem, they increased the camber of the 1901 glider. They also lengthened its wingspan to 22 feet, making it the largest glider anyone had attempted to fly. But at their new Kill Devil Hills camp, lift was still only a third of that predicted by the Lilienthal data upon which the wing design was based. And the glider pitched wildly, climbing into stalls. When they returned to the earlier camber, they achieved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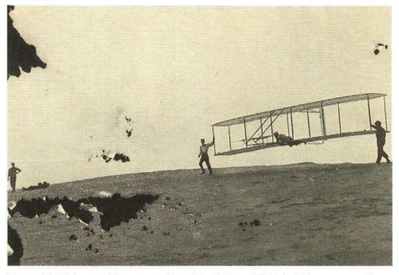
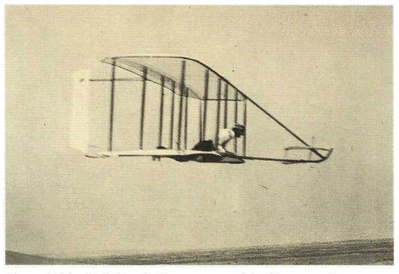
longitudinal control and eventually glided 335 feet. But the machine was still unpredictable. When the pilot raised the left wing to initiate the expected right turn, the machine instead tended to slip to the left (adverse yaw). This failure, and the realization that their work had relied on false data, brought them to the point of quitting. Instead they built a wind tunnel and produced their own data.

1902



The 1902 machine embodied the Wrights' research. They gave it efficient 32-foot wings and added vertical tails to counteract adverse yaw. The pilot moved a hip cradle to warp the wings. Some 400 glides proved the design workable, but still flawed. Sometimes, when the pilot tried to raise the lowered wing to come out of a turn, the machine instead slid sideways toward the wing and spun into the ground. Orville suggested a movable tail to counteract this tendency. After Wilbur

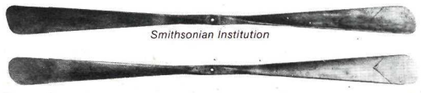


thought to link the tail movement to the warping mechanism, the plane could be turned and stablized smoothly. If others had thought about steering at all, it was by rudder—a marine analogy unworkable in the air. The Wrights saw that control and stability were related, that a plane turned by rolling. Six hundred more glides that year satisfied them that they had the first working airplane.

1903

Now the Wrights had to power their aircraft. Gasoline engine technology had recently advanced to where its use in airplanes was feasible. Unable to find a suitable lightweight commercial engine, the brothers designed their own. It was cruder and less powerful than Samuel Langley's, but the Wrights understood that relatively little power was needed with efficient lifting surfaces and propellers. Such propellers were not available, however. Scant relevant data could be derived from marine propeller theory. Using their air tunnel data, they designed the first effective airplane propeller, one of their most original and purely scientific achievements.

Returning to the Kill Devil Hills, they mounted the engine on the new 40-foot, 605-pound *Flyer* with double tails and elevators. The engine drove two pusher propellers with chains, one crossed to make the props rotate in opposite directions to counteract a twisting tendency in flight. A balky engine and broken propeller shafts slowed them, until they were finally ready on December 14. Wilbur won the coin toss, but lost his chance to be the first to fly when he oversteered with the elevator after leaving the launching rail. The flyer climbed too steeply, stalled, and dove into the sand. The first flight would have to wait on repairs.


Smithsonian Institution

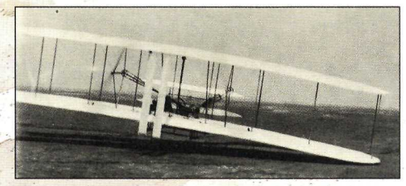
Propellers
The Wrights dismissed the traditional view of a propeller as an "air screw," seeing it instead as a rotary wing

December 17, 1903

Three days later, they were ready for the second attempt. The 27-mph wind was harder than they would have liked, since their predicted cruising speed was only 30 to 35 mph. The headwind would slow their groundspeed to a crawl, but they proceeded anyway. With a sheet they signaled the volunteers from the nearby lifesaving station that they were about to try again. Now it was Orville's turn.

Remembering Wilbur's experience, he positioned himself and tested the controls. The stick that moved the horizontal elevator controlled climb and descent. The cradle that he swung with his hips warped the wings and swung the vertical tails, which in combination turned the machine. A lever controlled the gas flow and airspeed recorder. The controls were simple and few, but Orville knew it would take all his finesse to handle the new and heavier aircraft.

At 10:35 he released the restraining wire. The flyer moved down the rail as Wilbur steadied the wings. Just as Orville left the ground, John Daniels from the lifesaving station snapped the shutter on a preset camera, capturing the historic image of the airborne aircraft with Wilbur running alongside. Again the flyer was unruly, pitching up and down as Orville overcompensated with the controls. But he kept it aloft until it hit the sand about 120 feet from the rail. Into the 27-



mph wind the groundspeed had been 6.8 mph, for a total airspeed of 34 mph. The brothers took turns flying three more times that day, getting a feel for the controls and increasing their distance with each flight. Wilbur's second flight—the fourth and last of the day—was impressive: 852 feet in 59 seconds.

This was the real thing, transcending the powered hops and glides others had achieved. The Wright machine had flown. But it would not fly again; after the last flight it was caught by a gust of wind, rolled over, and damaged beyond easy repair. Their flying season over, the Wrights sent their father a matter-of-fact telegram reporting the modest numbers behind their epochal achievement. *Illustration by Richard Schlecht*

The First Four Flights