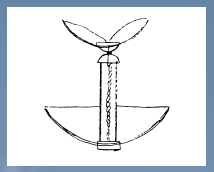
The Wright Way: The Process of Invention

CENTENNIAL OF FLIGHT
1903-2003

Wilbur and Orville Wright
Inventors

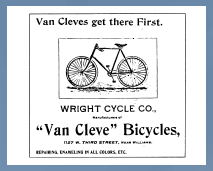
Wilbur and Orville Wright placed their names firmly in the hall of great American inventors with the creation of the world's first successful powered, heavier-than-air machine to achieve controlled, sustained flight with a pilot aboard. The age of powered flight began with the Wright 1903 Flyer on December 17, 1903, at Kill Devil Hills, NC. The Wright brothers began serious experimentation in aeronautics in 1899 and perfected a controllable craft by 1905. In six years, the Wrights had used remarkable creativity and originality to provide technical solutions, practical mechanical design tools, and essential components that resulted in a profitable aircraft. They did much more than simply get a flying machine off the ground. They established the fundamental principles of aircraft design and engineering in place today. In 1908 and 1909, they demonstrated their flying machine publicly in the United States and Europe. By 1910, the Wright Company was manufacturing airplanes for sale. Despite the Wrights' dramatic jump ahead, others quickly caught up to Wilbur and Orville Wright and surpassed their designs. They accomplished their goals by themselves and relied on their own questions, hypotheses, experiments, research, observations, inferences, and conclusions. The Wright brothers tested and failed repeatedly. They endured disappointment and hardships to realize their dream of inventing a flying machine, the airplane. They did not just fulfill their goals but ushered in a new era of air and space exploration.

1878



The Flying Toy: A small toy "helicopter"—made of wood with two twisted rubber bands to turn a small propeller—that the Wright brothers played with as small boys.

1892



The Bicycle Business: The Wright brothers opened a bicycle store in 1892. Their experience with bicycles aided them in their investigations of flight.

1900

The Search for Control: From their observations of how buzzards kept their balance, the Wright brothers began their aeronautical research in 1899 with a kite/glider. In 1900, they built their first glider designed to carry a pilot.

1901

The 1901 Glider: The Wright brothers 1901 Glider enabled them to spend more time in the air and to uncover additional design problems.

1901

The Wind Tunnel: The Wrights tested small model wings in a wind tunnel that enabled them to calculate the wing shape and size that would be required to lift them into the air.

1905

The Wright 1905 Flyer: This Flyer was the world's first practical airplane—a machine that could bank, circle, turn, and fly figure eights.

Huffman Prairie
Dayton, Ohio

1904

The Wright 1904 Flyer: The Wrights' second powered airplane, flown at Huffman Prairie, achieved the first circular flight of an airplane. Stability was still a problem.

Dec. 17, 1903

The Solution: At Kill Devil Hills, NC, in the morning, the Wright 1903 Flyer became the first powered, heavier-than-air machine to achieve controlled, sustained flight.

1902

Controlling the Aircraft: The key to solving the control problem was the addition of a rudder to the glider design. This allowed the Wrights to develop a powered aircraft.

NASA
National Aeronautics and Space Administration

100th Anniversary of Powered Flight 1903-2003

www.centennialofflight.gov

Susan and Milton Wright

Celebrating a Century of Powered Flight

The Wright brothers turned their dreams into reality and revolutionized the world.

About the Poster

This poster was designed to honor the accomplishments of the Wright brothers, two brilliant, self-trained engineers from Ohio who designed, built, and flew the first power-driven, heavier-than-air machine in which humans made free, controlled, and sustained flight.

The centennial of powered flight presents a unique opportunity to focus on the historical significance of the aviation-related events leading up to, and following, December 17, 1903. More importantly, the 100th anniversary of flight will inspire a new generation of inventors, innovators, and dreamers. In the span of a single century, the vision, persistence, and ingenuity of many have taken us from the first powered flight on the sand dunes of North Carolina's outer banks to a permanent presence in space.

In honor of the 100th anniversary of flight, the U.S. Congress established the Centennial of Flight Commission. The Commission encourages, enables, and amplifies the efforts of all the organizations and individuals planning to celebrate the achievements of the Wright brothers and a century of powered flight by serving as a central resource and a catalyst for activities. The Commission is encouraging and promoting national and international participation in the commemoration of the centennial of powered flight by the public; educators and students; Federal, State, and local government officials; the military; members of civic and cultural organizations; and members of the aviation and aerospace industry. A list of organizations that are working with the Commissioners can be found at ***http://www.centennialofflight.gov/partners***

We invite you to visit the U.S. Centennial of Flight Commission's Web site ***(http://www.centennialofflight.gov)***, where you will find a vast array of information about the history of aviation and aerospace. A few examples of what can be found on the site include a searchable calendar that features upcoming events related to aviation and aerospace with a "Submit an Event" button that allows event planners to post information. Essays can be found under the "History of Flight" section of the Web site. Under "For Educators and Students," you will find posters, a downloadable bookmark, and an Educational Resources Matrix with hundreds of aviation and aerospace-related education links. This is where you will be able to locate curriculum materials, information about workshops, scholarships, museums, and much more. Pictures, films, and special collections are located under the Sights and Sounds of Aviation category of the site. New materials are continuously being added to the site so be sure to visit often and check out "What's New."

To the Educator

The purpose of this poster is to help you inspire, educate, and encourage your students to learn about the Wright brothers, the celebration of the 100th anniversary of flight, and the history of aviation and aerospace. The classroom activities are designed to provide hands-on experiences for your students that relate to some of the scientific processes employed by the Wright brothers. The resources listed throughout this poster will help you and your students locate additional information, educational products, and activities related to the Wright brothers and the history of aviation and aerospace.

A Few Questions To Get Your Students Started

The state motto of Ohio is "The Birthplace of Aviation." Why was that motto chosen? Where did the Wright brothers live? What did they do? When did they become interested in aviation? What did they do to further their knowledge about aviation? Read "The Wright Brothers' Story" on this poster to find out why the pictures on the front of this poster are significant.

Why is the State of North Carolina known as "First in Flight." Why did the Wright brothers travel from Ohio to North Carolina? How did they get there? How often did they go to North Carolina? How long did they stay? Where did they live? Were their machines transported from one State to the other, and if so, how?

Although the States of Ohio and North Carolina are well known for early developments in aviation, many people from other States and countries around the world were thinking about flight, building aircraft, and conducting experiments before, during, and after the Wright brothers' involvement in flight. Who were these people? Where did they live? What contributions did they make? Study your State's aviation and aerospace history. Discuss how the advances in aviation and aerospace during the past 100 years have affected you and your family. Imagine what changes will occur in aviation and aerospace in the next 100 years. Design a poster representing the history of aviation and aerospace in your State. Create a calendar with information about significant people, places, and historical aviation and aerospace events in your State. Share your poster and calendar with others in your school, community, or State. Send an electronic copy of your poster and your calendar to the Centennial of Flight Commission's Web site e-mail address: ***centennialofflightadmin@hq.nasa.gov*** Plan your own centennial of flight celebration. If your event meets the criteria for inclusion on the Commission's calendar, complete and submit the electronic form found on the Web site.

The Process of Invention

Orville and Wilbur Wright were masters of inquiry. Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information; planning investigations; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. The Wright brothers used critical and logical thinking skills when considering alternative theories of aviation.

Students should engage in inquiry as they come to know the natural world and eventually develop the capacity to conduct complete inquiries. Students should develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture. Students need to become scientifically literate citizens with an understanding of the nature of science and its relationship to mathematics and technology.

"Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the press and to engage in social conversation about the validity of the conclusions. Scientific literacy has different degrees and forms; it expands and deepens over a lifetime, not just during the years in school. Attitudes and values established toward science in the early years will shape a person's development of scientific literacy as an adult."

History and Nature of Science

What is the nature of science? When do you teach what? What should students be able to understand and do? What is the role of the teacher? How is history important to the understanding of science? Society? Cultures? Technological advances? To find answers to these questions and guidelines to help you develop your students' understanding of science, visit the National Science Education Standards Web site at ***http://www.nap.edu/html/nses/html/***

Poster Credits

This poster was developed by the NASA Headquarters' Education Division, Office of Human Resources and Education, Frank C. Owens, Director of Education. Anne Holbrook, NASA Einstein Fellow, created the poster with oversight from Debbie Gallaway, Assistant Director of Programs for the U.S. Centennial of Flight Commission and William E. Anderson, Partnership Manager for Education, Office of Aerospace Technology. The following individuals were consulted during the development of the poster: Linda Hallenbeck, Teacher in Residence for Governor Bob Taft of Ohio, and Karen Garr, Teacher in Residence for Governor Jim Hunt of North Carolina.

The following individuals and organizations provided images and/or information that were used on "The Wright Way: The Process of Invention" poster:

Fred Fisk, author of *The Wright Brothers from Bicycle to Biplane*, provided the image of the "Wright Bros. Cycle" ad from High School Times, April, 1897.

Ted Huetter, at the Dryden Flight Research Center Education office, provided ideas and aircraft images.

The Library of Congress archives provided the Wind Tunnel image.

The National Air and Space Museum, Smithsonian Institution, provided the images A-4189 and A-442710. Special thanks to Kate Igoe, Thomas Crouch, and Peter Jakab for their wealth of knowledge and assistance.

The National Research Council provided their research and publication of the National Science Education Standards, by the National Academy Press.

Wright State Archives, Dayton, OH, provided images for the poster. Special thanks to Jane Wildermuth and Dawn Dewey for their dedication.

Attention High School Students!
The NASA Summer High School Apprenticeship Research Program (SHARP) and SHARP PLUS are research-based mentorship programs. Check them out! *http://education.nasa.gov/sharp* and *http://education.nasa.gov/sharp.plus*

The NASA Student Involvement Program (NSIP)

Science and Technology Journalism

Grades K–1: Class
Grades 2–4: Class or Teams of 2–4
Grades 5–12: Individuals or Teams of 2–4

The Wright Quest

Celebrate a century of flight!
Discover the past, invent the future!

Reflecting Upon the Adventures of Flight:
What happened on a cold windswept beach near Kitty Hawk, NC, on December 17, 1903? What were the events leading up to this milestone? How did this event change the world? Who are others who have or are exploring the fundamentals of flight? What are the benefits to our world? What is the future of aviation? What research is happening right now? Inventions? Can you predict future aviation milestones?

Learning Objectives:
Share scientific and technical achievements in a manner that is accurate, engaging, and informative—one that speaks to the inner spirit of exploration and discovery.

Procedure:
1. Develop a news report using one of the following media:
   - Print—An article with relevant photos, illustrations, or other graphics, laid out for publication.
   - VHS videotape—A 5-minute report in your choice of format (e.g., newscast, investigative or special report, or documentary).
2. Submit documentation about investigation and production methods.
3. Complete, sign, and send a) an entry form, b) an educator data form, and c) checklists.

Go to NASA for theme resources:
http://www.aerospace.nasa.gov/centuryofflight

Robert E. Lucas Intermediate School,
Cincinnati, OH

For complete details and to obtain an entry form, competition rules, checklist, judging rubric, and resource guide, please visit ***http://education.nasa.gov/nsip***.
Any questions? Send an e-mail to ***info@nsip.net*** or call 1-800-848-8429.

The Wright Brother's Story

The Flying Toy

Wilbur (1867-1912) and Orville Wright (1871-1948) were brothers. They lived in Dayton, OH, at 7 Hawthorn Street. Their older brothers were Reuchlin and Lorin. Katharine was their younger sister. Their father, Milton, was a bishop in the Church of the United Brethren in Christ. Their mother, Susan, the daughter of a wagon maker, made toys for her children and encouraged their curiosity. One day, Bishop Wright brought home a small toy "helicopter" made of wood with two twisted rubber bands to turn a small propeller. Wilbur and Orville played with it until it broke, then made new copies of the toy themselves. They also sold toys to their friends, including handmade kites. The Wright brothers did things together from the time they were small boys.

The Bicycle Business

The Wright brothers went into the printing business together in 1889. Three years later, they opened their first bicycle shop. Initially, they sold and repaired bicycles. They would replace spokes, fix broken chains, and sell accessories. In 1896, they began to build their own brand of bicycles. The Wright brothers' experiences with bicycles aided them in their investigations of flight. They used the technology they learned from their bicycle business in their airplanes: chains, sprockets, spoke wires, ball bearings, and wheel hubs. Their thoughts on balancing and controlling their aircraft were also rooted in their experience as cyclists.

The Search for Control

Orville and Wilbur Wright were convinced of the need to control an aircraft in three axes of motion. An elevator, or horizontal control surface, in front of the wings on their aircraft, enabled the pilot to control climb and descent (pitch axis). The elevator was controlled by a lever in the pilot's left hand. A "wingwarping" system controlled the aircraft in a roll (roll axis). To initiate a roll, the pilot would shift his hips from side to side in a cradle on the lower wing, "twisting" the wings left or right or restoring them to level flight. Orville and Wilbur developed this idea from observing birds in flight. They observed the buzzards keeping their balance by twisting their wings and sometimes curving one wing more than the other. In 1902, the brothers added a vertical rudder to the rear of their machine to control the left and right motion of the nose of the aircraft (yaw axis).

The Kite/Glider Experiments

The Wright brothers began their aeronautical research in 1899. Their first aircraft was a small kite with a 5-foot wingspan that was used to test their notions of aircraft control. In 1900, they built their first machine designed to carry a pilot and chose Kitty Hawk, NC, as a suitable testing ground. With its strong steady winds, open areas, and tall sandy dunes, the area was perfect for their experiments. When their 1900 aircraft produced less lift than expected, the Wright brothers flew it as a kite and gathered information that would enable them to design improved machines. They returned to Kitty Hawk in 1901 with a new glider that did not perform as they expected. While they had learned a great deal with their first two machines, they had also encountered new puzzles and dangers.

The Wind Tunnel

To simulate flight conditions, the Wrights tested small model wings in a wind tunnel they had built. The wind tunnel was a box with a fan at one end that blew a steady stream of air over model wings mounted on a special "balance" inside the tunnel. Using this device, the brothers were able to gather information that could be used to design the wings of the gliders and powered aircraft that would carry them into the air. The wind tunnel provided them with information on the most satisfactory wing shape. It also enabled them to calculate the size of wing that would be required to lift them into the air, the performance of their propellers, and the amount of power that their engine would have to produce. They based the design of their next glider on this information.

Controlling the Aircraft

During the 1901 glider tests, the Wright brothers had discovered that "wingwarping" created unequal drag on the two wings. Key to solving the control problem was the addition of a rudder to the glider design in 1902. They developed a direct linkage between the rudder and warping system. With the success of this system design, the Wrights were ready to move onto a powered aircraft.

The Solution

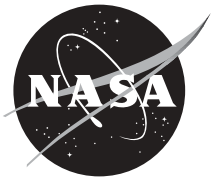
At Kill Devil Hills, NC, at 10:35 am, the Wright 1903 Flyer took off under its own power with Orville as the pilot. It flew 12 seconds and went a distance of 37 meters. Orville and Wilbur took turns making three more flights that morning. Wilbur was at the controls for the fourth and longest flight, traveling 260 meters in 59 seconds. The Wright 1903 Flyer became the first powered, heavier-than-air machine to achieve controlled, sustained flight with a pilot aboard. Today, this amazing flying invention can be viewed as it is suspended overhead, at the National Air and Space Museum in Washington, DC. ***(http://www.nasm.edu/nasm/nasmexh.html)***

The Wright 1904 Flyer

Having achieved success in North Carolina, the Wright brothers decided to continue their experiments closer to home. They built and flew their second powered airplane at Huffman Prairie, a pasture eight miles east of Dayton, OH. Progress was slow without the strong, steady winds of Kitty Hawk, but the brothers did achieve the first circular flight of an airplane on September 20, 1904. This first complete circle flight lasted only 1 minute 36 seconds and covered 1,244 meters. Stability problems still plagued the Wright brothers' invention. The modifications made during 1904 helped but did not solve the stability problem.

The Wright 1905 Flyer

This Flyer was the world's first practical airplane. During more than 40 flights at Huffman Prairie, the machine was repeatedly banked, turned, circled, and flown in figure eights. On two occasions the flight exceeded half an hour. Wilbur and Orville Wright, brilliant self-trained engineers, had overcome complex technical problems that had barred the way to mechanical flight for centuries. Think about how their invention has changed our world!



Activities for Grades K–12

Objectives: The students will construct a flying model glider and determine its weight and balance.

Teacher background:
On December 17, 1903, Wilbur and Orville Wright became the first humans to fly a controllable, powered airplane. To unravel the mysteries of flight, the brothers built and experimented extensively with model gliders. Gliders are airplanes without motors or a power source. Building and flying model gliders helped the Wright brothers learn and understand the importance of weight and balance in airplanes. If the weight of the airplane is not positioned properly, the airplane will not fly. They also learned that the design of an airplane was very important.

The Wright Flyer was the first plane to complete a controlled takeoff and landing. Airplanes use control surfaces to manage flight direction. Elevators are control surfaces that make the nose of the airplane move up and down. A rudder is used to move the nose of the aircraft left and right. On modern airplanes, ailerons are used to roll the airplane into a turn. The Flyer used a technique called wingwarping to initiate a turn.

In research and development, model aircraft are used to develop new concepts, create new designs, and test ideas in aviation. Some models fly by remote control, others are tested in wind tunnels. Information learned from models is an important part of NASA's aeronautical research program. The goals of research are to make aircraft fly safer, perform better, and become more efficient.

This activity is designed to help students learn about basic aircraft design and to explore the effects of weight and balance on the flight characteristics of a model glider. Students will use science process skills to construct and fly a Styrofoam™ glider. Younger students will need to have the pieces traced and cut out for them. They should only move one surface at a time, and only after they have had an opportunity to "play" with their glider. Older students should also have the opportunity to test their gliders to better understand the control surfaces well enough to set up experimentally designed tests. The data will be shared within the group/class via detailed design drawings and graphs. Students should be encouraged to modify the glider for longer/higher/straighter flights.

Building The Glider
K–3 students will need assistance cutting and constructing the glider. Older students could act as mentors and precut the parts. The parts can also be punched out with a plastic serrated knife, poster pin, or sharp pencil.

Construction and Experimentation
Ask students to name some materials that might be used to build a model glider.

Explain to students that Styrofoam™ is lightweight and strong which makes it an ideal material to construct model gliders.

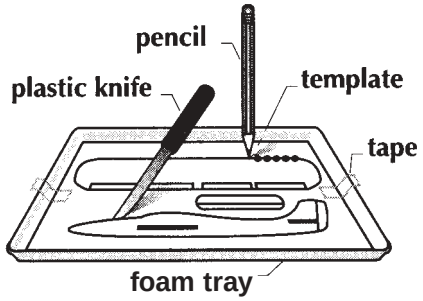
Distribute the materials to each group of students.

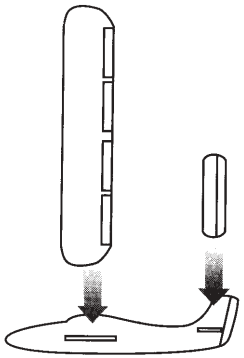
Explain that the template is a guide to cut out the parts for the airplane.

Use sandpaper or an emery board to smooth the edges.

Have the students assemble the glider by inserting the wings and elevator into the fuselage slots.

The students may add personal touches. Civilian aircraft have a letter or letters preceding the aircraft's identification number indicating the country in which it is registered. For example, Mexico uses the letter "X" and the United States is "N." Students may apply N-numbers to their models. Caution the students not to throw gliders toward other students. Eye protection is advisable.





The model glider's weight must be balanced or distributed properly before it will fly well. To demonstrate this, ask a student to launch a glider before adding weight. Have students describe and record the flight characteristics.

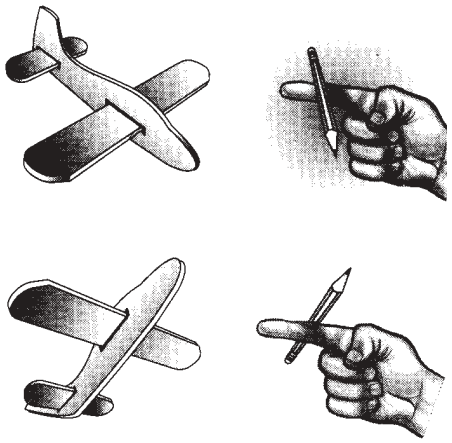
Add weight to the model using paper clips, binder clips, or a penny. Attach the paper clip or glue a penny to the nose of the glider. If a binder clip is used, attach it to the bottom of the fuselage. Ask the students to test fly the glider and observe the flight characteristics.

Move the weight forward or backward on the fuselage to determine the best weight and balance for the glider. Try to find the weight and balance combination that allows the glider to fly the greatest distance.

Discussion
Are weight and balance important on "real" aircraft?

(The total weight of the cargo and passengers of any airplane has certain limits and is distributed to keep the plane properly balanced. Flights should not be attempted if an aircraft is overloaded, or if the cargo distribution makes the plane too "nose heavy" or "tail heavy.")

Using the model glider, the students will explain how they determined the weight and balance for their glider.



Hint: The weight of the model glider must be balanced before it will fly successfully. To determine the "Center of Gravity" of the glider, the model can be balanced much like a pencil on their finger (diagram).

Challenge for older students
Carefully cut out the flaps and ailerons along the solid lines. (figures on panel 7)

The Wright brothers used "wingwarping" to turn their airplane to the right or left. Modern aircraft use ailerons to initiate a roll. Ailerons work in opposition to one another. If the left aileron is in the up position, the right aileron must be in the down position and vise versa. Ask your students to experiment with the ailerons by bending them up or down along the dashed lines.

Bend each flap down along the dashed line into the same position below the wing. How are the flight characteristics of the glider affected with the flaps in the down position?

Set up a course for students to demonstrate the flight characteristics of their gliders. The students may cut off 2 cm of each wing, and record a new series of flight testing data. Develop new wing designs. Research wind tunnels and build one to test various wing lengths, shapes, and sizes.

Use these NASA Educator Resources to teach and reinforce flight concepts:

Grades K–12
The Beginner's Guide to Aerodynamics at *http://www.lerc.nasa.gov/WWW/K-12/airplane/bga.htm*

Grades K–2
Aeronautics: An Educator's Guide with Activities in Science, Mathematics, and Technology Education, EG-2002-06-105-HQ.

Grades 5–8
Exploring Aeronautics, a CD-ROM, includes an introduction to aeronautics, fundamentals of flight, a historical timeline, and different types of aircraft. The CD teaches students to use the tools of aeronautics to test aircraft designs. Developed by NASA Ames Research Center, EC-1998-03-002-ARC.

Grades 9–12
FoilSim, developed at the NASA Glenn Research Center, is interactive simulation software that determines the airflow around various shapes of airfoils. Download from: *http://www.lerc.nasa.gov/WWW/K-12/aerosim/*

Extension Activity

Design a space vehicle to transport people and goods to the International Space Station and beyond—applying aeronautical principles for an aircraft design/model and research project.

If the Wright brothers were living today, they might be researching new forms of power and types of structures, conducting experiments, and designing models to develop the new Space Shuttle. The Space Shuttle is the world's first reusable spacecraft, and the first spacecraft in history that can carry large satellites both to and from orbit. The Space Shuttle launches like a rocket, maneuvers in Earth orbit like a spacecraft, and lands like an airplane. Each of the four Space Shuttle orbiters now in operation—*Columbia, Discovery, Atlantis, and Endeavour*—is designed to fly at least 100 missions. NASA is prepared to continue flying the Shuttle for at least the next decade. What will happen then? Engineers and scientists are busy at work now on Advanced Space Transportation Systems to replace the Space Shuttle.

Apply the principles learned from the glider experiences. Take into account current experimental designs, and the Wrights' work in aerodynamics, stability, flight control, power, and structure. Design and build a model of a new aircraft to transport people and goods to the International Space Station and beyond. Keep in mind that NASA believes in developing safe, reliable, and affordable transportation. Present a report describing your investigation.

To learn more about gliders, visit the following sites:

Shuttle Basics
http://spaceflight.nasa.gov/shuttle/reference/basics/index.html

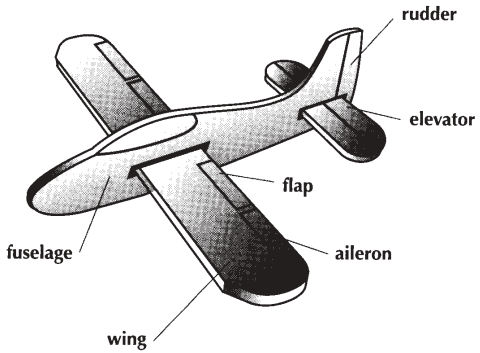
NASA's X-Gliders
http://spacelink.nasa.gov/products/X.Gliders/

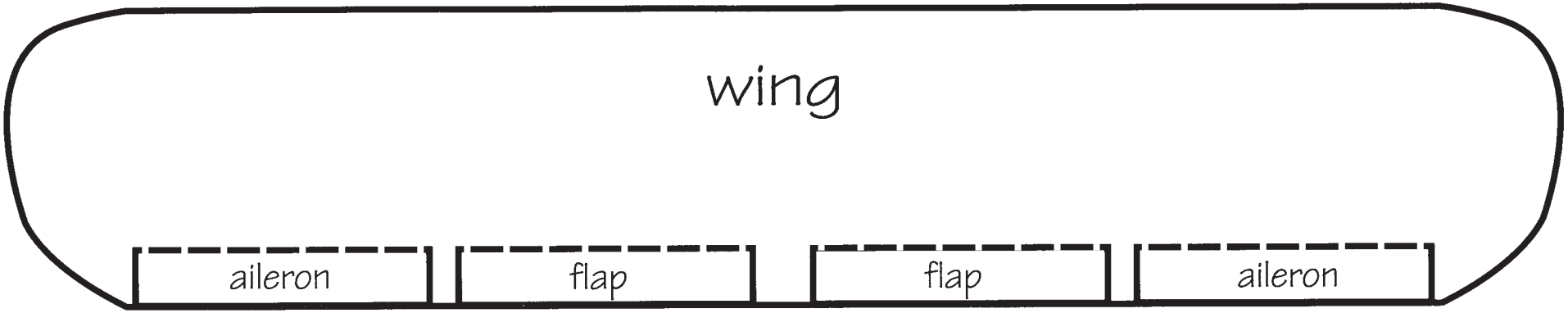
X-Gliders Educational Brief
http://spacelink.nasa.gov/products/X.Gliders/

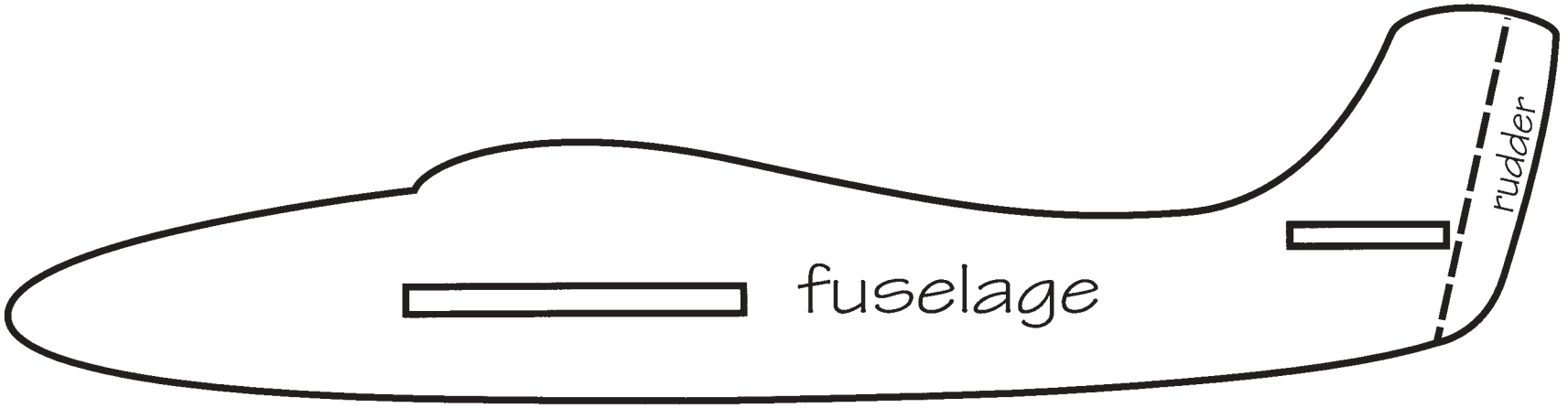
Aerospace-Related Activities, Experiments, and Lesson Plans
http://www.lerc.nasa.gov/WWW/K-12/aeroact.htm

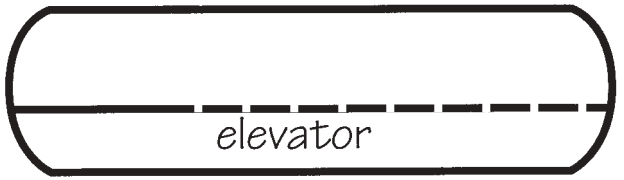
Visit the U.S. Centennial of Flight Commission's Web site (*http://www.centennialofflight.gov***)** to find essays about the prehistory of flight, the Wright brothers, and many additional topics. The essays are located under the "History of Flight" section of the Web site.

NASA Aeronautics Educational Projects
http://www.aerospace.nasa.gov/edu/links.htm









CENTENNIAL OF FLIGHT
1903-2003

NASA

NASA Resources for Educators

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

NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074-9799
Phone: (440) 775-1400
FAX: (440) 775-1460
E-mail: *nasaco@leeca.org*
Home Page: *http://core.nasa.gov*

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

AK, Northern CA, HI, ID,
MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
NASA Ames Research Center
Mail Stop 253-2
Moffett Field, CA 94035-1000
Phone: (650) 604-3574
http://amesnews.arc.nasa.gov/erc/erchome.html

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
NASA Glenn Research Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, OH 44135
Phone: (216) 433-2017
http://www.grc.nasa.gov/WWW/PAO/html/edteachr.htm

CT, DE, DC, ME, MD, MA,
NH, NJ, NY, PA, RI, VT
NASA Educator
Resource Laboratory
NASA Goddard Space Flight Center
Mail Code 130.3
Greenbelt, MD 20771-0001
Phone: (301) 286-8570
http://www.gsfc.nasa.gov/vc/erc.htm

CO, KS, NE, NM, ND, OK, SD, TX
Space Center Houston
NASA Educator Resource
Center for **NASA Johnson Space Center**
1601 NASA Road One
Houston, TX 77058
Phone: (281) 244-2129
http://www.spacecenter.org/educator_resource.html

FL, GA, PR, VI
NASA Educator Resource Center
NASA Kennedy Space Center
Mail Code ERC
Kennedy Space Center, FL 32899
Phone: (321) 867-4090
http://www-pao.ksc.nasa.gov/kscpao/educate/edu.htm

KY, NC, SC, VA, WV
Virginia Air & Space Center
NASA Educator Resource
Center for **NASA Langley Research Center**
600 Settlers Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900 x 757
http://www.vasc.org/erc/

AL, AR, IA, LA, MO, TN
U.S. Space and Rocket Center
NASA Educator Resource
Center for **NASA Marshall Space Flight Center**
One Tranquility Base
Huntsville, AL 35807
Phone: (256) 544-5812
http://erc.msfc.nasa.gov

MS
NASA Educator Resource
Center
NASA Stennis Space Center
Mail Stop 1200
Stennis Space Center,
MS 39529-6000
Phone: (228) 688-3338
http://education.ssc.nasa.gov/erc/erc.htm

CA
NASA Educator Resource
Center for **NASA Jet Propulsion Laboratory**
Village at Indian Hill
1460 East Holt Avenue, Suite 20
Pomona, CA 91767
Phone: (909) 397-4420
http://learn.jpl.nasa.gov/resources/resources_index.html

AZ and Southern CA
NASA Educator Resource
Center **NASA Dryden Flight Research Center**
PO Box 273 M/S 4839
Edwards, CA 93523-0273
Phone: (661) 276-5009
http://www.dfrc.nasa.gov/trc/ERC/

VA's and MD's Eastern Shores
NASA Educator Resource
Center for **GSFC/Wallops Flight Facility**
Visitor Center Building J-17
Wallops Island, VA 23337
Phone: (757) 824-2298
http://www.wff.nasa.gov/~WVC/ERC.htm

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

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

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

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

NASA Television (NTV) features Space Station and Shuttle mission coverage, live special events, interactive educational live shows, electronic field trips, aviation and space news, and historical NASA footage. Programming has a 3-hour block—Video (News) File, NASA Gallery, and Education File—beginning at noon Eastern and repeated four more times throughout the day. Live feeds preempt regularly scheduled programming.

Check the Internet for programs listings at *http://www.nasa.gov/ntv*
For more information on NTV, contact
NASA TV
NASA Headquarters–Code P-2
Washington, DC 20546-0001
Phone (202) 358-3572

NTV Weekday Programming Schedules (Eastern Times)

Video File	*NASA Gallery*	*Education File*
12–1 p.m.	1–2 p.m.	2–3 p.m.
3–4 p.m.	4–5 p.m.	5–6 p.m.
6–7 p.m.	7–8 p.m.	8–9 p.m.
9–10 p.m.	10–11 p.m.	11–12 p.m.
12–1 a.m.	1–2 a.m.	2–3 a.m.

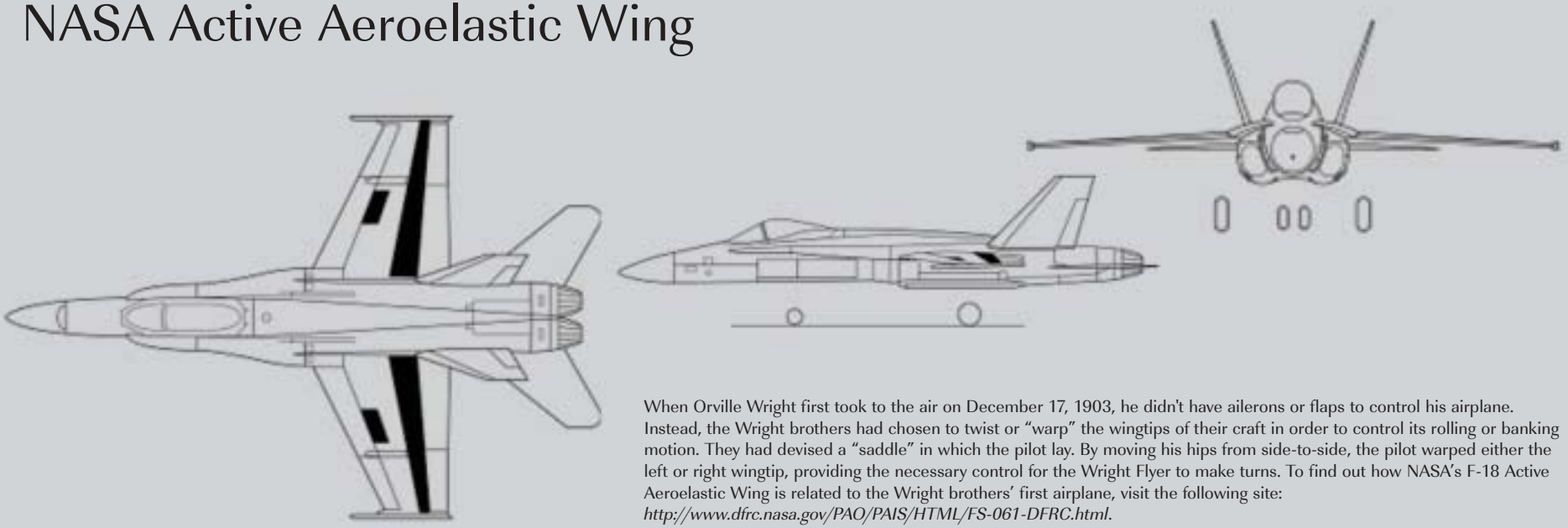
How to Access Information on NASA's Education Program, Materials, and Services (EP-2002-07-345-HQ)
This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink.

EW-2002-08-133-HQ
Please take a moment to evaluate this product at

http://ehb2.gsfc.nasa.gov/edcats/educational_wallsheet

Your evaluation and suggestions are vital to continually improving NASA educational materials. Thank you.

NASA Active Aeroelastic Wing



When Orville Wright first took to the air on December 17, 1903, he didn't have ailerons or flaps to control his airplane. Instead, the Wright brothers had chosen to twist or "warp" the wingtips of their craft in order to control its rolling or banking motion. They had devised a "saddle" in which the pilot lay. By moving his hips from side-to-side, the pilot warped either the left or right wingtip, providing the necessary control for the Wright Flyer to make turns. To find out how NASA's F-18 Active Aeroelastic Wing is related to the Wright brothers' first airplane, visit the following site: *http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-061-DFRC.html*.

Educational Resource Sites

National Education Standards

National Science Education Standards
http://books.nap.edu/books/0309053269/html/index.html

Principles and Standards for School Mathematics
http://standards.nctm.org/

The National Geography Standards
http://www.ncge.org/publications/tutorial/standards/

Standards for Technological Literacy from the International Technology Education Association
http://www.iteawww.org/TAA/TAA.html

The National Educational Technology Standards
http://cnets.iste.org/index.html

Related Sites

U.S. Centennial of Flight Commission
http://www.centennialofflight.gov

NASA's Celebrating Flight Web Site—Investigations celebrating 100 years of flight: past, present and future!
http://spacelink.nasa.gov/celebratingflight

NASA Science Files
http://sciencefiles.larc.nasa.gov

NASA CONNECT Series
http://connect.larc.nasa.gov/

NASA QUEST "WEBCASTS," Interactive Events for Students
http://quest.arc.nasa.gov

NASA Educational Workshops for Teachers
http://education.nasa.gov/new or
http://www.nsta.org/new

Aerodynamics Problem Sets for High School Mathematics Courses
http://www.grc.nasa.gov/WWW/K-12/BGA/BGAindex.html

Destination Tomorrow—A series of 30-minute programs that focus on NASA research—past, present, and future. Intended audience is grades 9–16 and adult.
http://destination.larc.nasa.gov/index_net.html

Re-Living the Wright Way—Information and links about how the Wright brothers used the process of invention to pave the way for powered flight.
http://wright.nasa.gov/

NASAexplores—An online resource with express lessons for grades K–12.
http://www.nasaexplores.com/lessons/02-012/index.html

Links to many aerospace activities, resources, online opportunities and careers.
http://www.aero-space.nasa.gov/edu