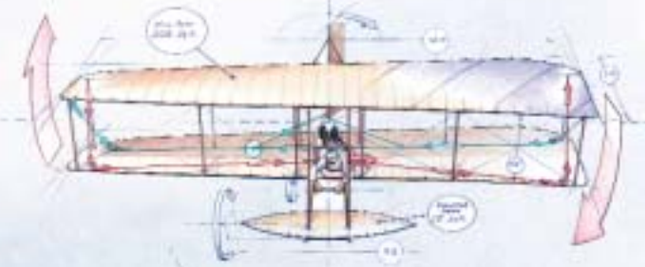
THE 1902 GLIDER

HOW THE PROBLEM OF CONTROL WAS SOLVED

CENTENNIAL OF FLIGHT
1903-2003



Three-Axis Control

By rotating the elevator control bar with his hands, the pilot moves the forward elevator to pitch the glider nose-up or nose-down. Here, the pilot has moved the hip cradle to his left, moving the control cables and warping the wings as indicated. The glider rolls to the left. The vertical rudder also moves left to counteract the increased drag created by the greater angle of attack on the right—that is, adverse yaw.

1901 Version 1

PROBLEM 1: Glider noses down
CAUSE: Center of gravity is forward of center of lift
SOLUTION: Pilot moves aft
PROBLEM 2: Uncontrollable in pitch, crashes
CAUSE: Ribs flex, changing airfoil shape
SOLUTION: Add middle spar and bracing so airfoil holds shape in modified version

1901 Version 2

PROBLEM: "Well-digging"—stall-spin introduced by operating wing warping for roll control
CAUSE: Adverse yaw-increased drag on wing with greater angle of attack, followed by stall on the same wing and spin in direction of stalled wing
SOLUTION: Add double vertical surfaces (fixed tail) at rear of next version

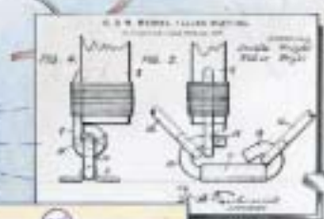
1902

PROBLEM: At low speeds and higher bank angles, glider slips toward low-wing side
CAUSE: Wind pressure on low-wing side of fixed tail increases adverse yaw and makes matters worse
SOLUTION: Change to single vertical rudder (movable) connected to wing-warping roll-control system to correct for adverse yaw

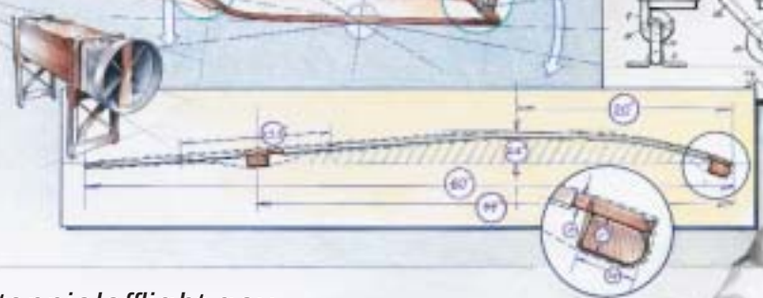
This final configuration contains all the essential elements of modern three-axis aircraft controls.

1901–02 Wind Tunnel

The 1900 and 1901 gliders were based on data obtained from Otto Lilienthal, which proved inadequate. The 1902 glider was based on the first accurate empirical data from tests in this wind tunnel. With it, the Wrights gathered data measuring lift and drag, as well as the effects of airfoil shape, wing shape, and aerodynamic forces at various angles of attack.



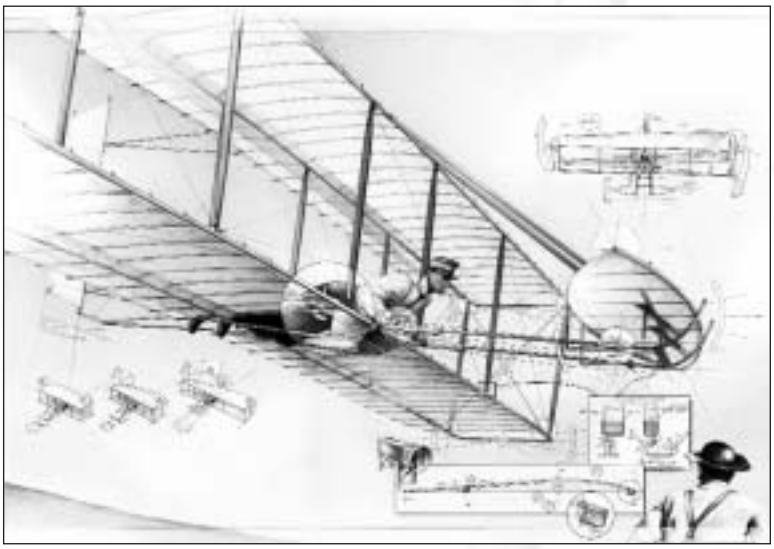
DETAIL: The Wrights connected bracing wires and uprights to wing struts with waxed linen cord and fittings custom-made of mild steel.



NASA
National Aeronautics and Space Administration

www.centennialofflight.gov

The 1902 Glider



The front of this poster describes the steps the Wrights took that led to the development of the 1902 glider. The Wright brothers first became seriously interested in solving the problem of human flight in 1899. After conducting extensive research, they concluded that the key to success lay in the pilot's ability to control the aircraft. They proceeded to design, build, and test a series of aircraft that began with a kite in 1899, followed by three gliders in 1900, 1901, and 1902. After a successful 1902 season, the Wrights were confident they had solved the problem of control. They were then able to focus their attention on determining the requirements for an engine and propellers that would sustain them in flight. On December 17, 1903, for the first time in history, an airplane took off, moved forward under its own power, and landed at a point as high as that from which it had started. Three more flights followed that day demonstrating, beyond any doubt, that their machine was capable of sustained flight under the complete control of the pilot.

To the Educator

In honor of the 100th anniversary of flight, the U.S. Congress established the U.S. Centennial of Flight Commission. The Commissioners and their partners are encouraging educators and students to learn about the Wright brothers' achievements and the contributions of others whose vision, persistence, and ingenuity have taken us from the first powered flight to the surface of the Moon and on to a permanent presence in space.

The links that are provided below will take you where you need to go to get started. NASA's "Re-Living the Wright Way" Web site, *http://wright.nasa.gov*, serves as the portal to the five Web-based experiences described on the following panels. Individual Web sites are also provided for each experience. The Topic Hotlists and the Multimedia Scrapbook will be particularly useful if you are introducing your students to the Internet. The Treasure Hunt, Subject Sampler, and WebQuest are designed for more experienced Internet users. Each Web-based experience includes a wide variety of topics, categorized by grade level, for you and your students to use as you explore the past, present, and future of aviation. This "Re-Living the Wright Way" site also hosts a multitude of aerospace-related educational resources. Also visit NASA's *Celebrating Flight* Web site, *http://spacelink.nasa.gov/celebratingflight,* for NASA investigations related to 100 years of flight—past, present, and future.

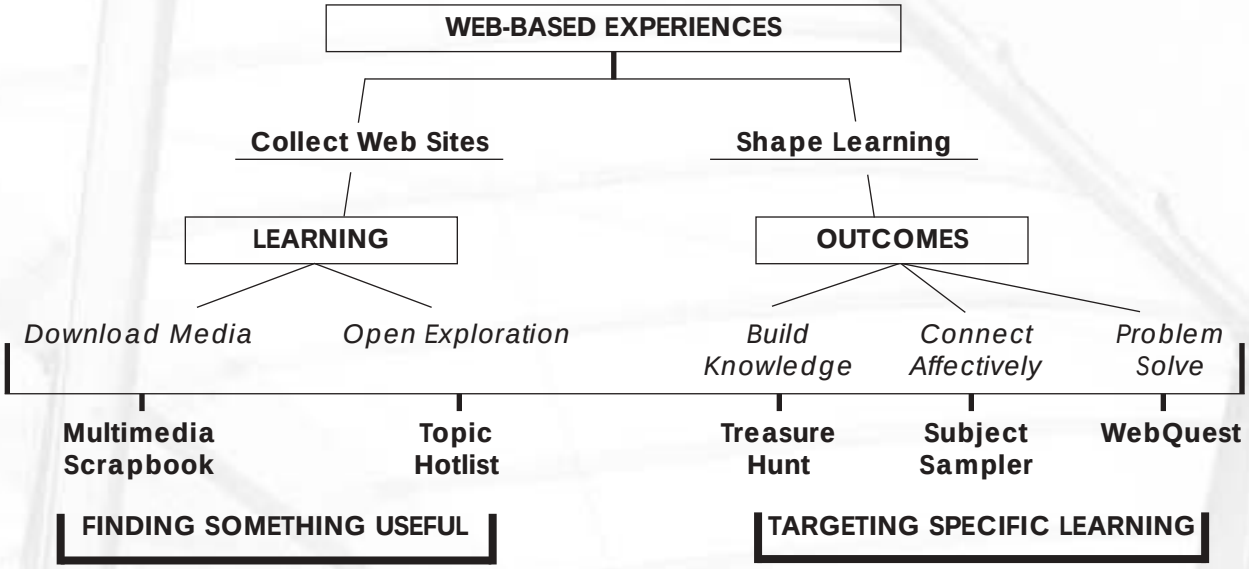
The U.S. Centennial of Flight Commission's Web site, *www.centennialofflight.gov*, has a vast array of resources related to the history of aviation and aerospace. Under "For Educators and Students," you will find posters, a downloadable bookmark, essays, and an "Educational Resource Matrix" with hundreds of aviation- and aerospace-related educational links. The "Sights and Sounds of Aviation" category of the site features pictures, films, and special collections. Many other exciting and interesting resources can be found throughout the site. A list of organizations that are working with the commission can be found at *www.centennialofflight.gov/partners*

You may wish to subscribe to NASA's Spacelink EXPRESS, an electronic mailing list for educators. By signing up for this service at *http://spacelink.nasa.gov/express*, you will receive notification about new NASA aerospace-related materials and opportunities as they become available. Additional NASA resources are provided throughout the back panels of this poster.

We hope that the 100th anniversary of powered flight and the related information on this poster will help you to inspire your students to learn from the past, imagine the future, and become the next generation of inventors, innovators, and dreamers!

Web-Based Experiences

Educators, use this framework to guide your choices in the type of web experiences to integrate into your classroom activities



Multimedia Scrapbook—Download Media

http://wright.nasa.gov/scrapbook

WHAT IT IS

A Multimedia Scrapbook focuses on providing links to a variety of NASA media and content types—photographs, maps, stories, facts, quotations, sound clips, videos, and virtual tours. A Scrapbook can be used to explore aspects of a topic that a user feels is important or interesting.

HOW TO USE

Download or copy and paste scrapbook items into a variety of formats—newsletter, desktop slide presentation, collage, HyperStudio stack, or Web page. The Multimedia Scrapbook offers an open, student-centered approach that encourages construction of meaning. An educator might use the Topic Hotlist and Scrapbook to promote the constructivist learning that can happen when students synthesize a large and contextually rich selection of data and experiences.

STARTER COLLECTION

Aerospace Multimedia Collection (Grades K–12)

A vast resource of aviation Web sites has been categorized by topics and information along with the types of media (photos, video, audio clips). The resources have been put in chronological order from the earliest dream of flying to the future of the aerospace industry. Suggested projects utilizing the information and resources are intended to serve as catalysts for educator ideas in the K–12 classroom.

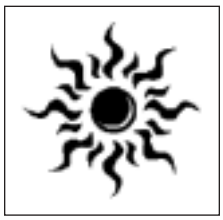
TOPIC HOTLIST—Open Exploration

wright.nasa.gov/topichotlist

WHAT IT IS

A Topic Hotlist provides an organized approach to sampling the wealth of NASA electronic and print resources. Each topic contains categories that serve as organizers for content. The resources listed under a topic's category likely differ in quality, currency, and type, but the learning strategy is the same—give the user a breadth of materials on the topic they find interesting or are studying.

HOW TO USE



A Topic Hotlist can be used to shape activities that utilize NASA resources and are related to learning. The natural way to begin integrating the Web for learning is by collecting sites that one finds most useful, interesting, and intriguing. What's missing is the exact learning to be achieved. That is left up to the educator. A Topic Hotlist is an easy strategy to employ. The educator simply adds the Web resources to an activity already prepared or being prepared.

STARTER COLLECTION

Wings and Things that Fly (Grades K–3)
Learn about "nature's flyers."

Aeronautics and Flight (Grades K–3)
Investigate the forces of flight and how airplanes fly. Discover the history of flight through interesting facts.

Famous Fliers (Grades K–3)
Learn about the men and women pioneers of aviation.

Paper Airplanes (Grades K–3)
Learn about paper airplane folding . . . at its best!

Wheels to Wings (Grades 4–6)
Investigate the Wright brothers and the process of invention from bicycles to biplanes.

Aerospace Careers Are for Everyone! (Grades 4–9)
Learn more about the opportunities and meet the people who help us reach into the sky and to the stars.

Toys that Fly (Grades 4–12)
Discover the flying toy that inspired the Wright brothers and how flying toys have changed since 1903.

Flight, Born of Dreams (Grades 7–12)
Read prominent ancient legends, balloon ascents, and early fixed-wing flight with historical references and the pioneers who dreamed and worked to give us wings.

Why Fly? (Grades 7–12)
Find out about the personal inspiration of pilots, astronauts, and others who wanted to experience the conquest of the sky and space.

The Next 100 Years of Flight (Grades 7–12)
Glimpse into plans for unusual aircraft and amazing technology that will change transportation and space travel in your future.

Forces of Flight (Grades 10–12)
Find out about the science of aeronautics with a special emphasis on Bernoulli's Principle.

Treasure Hunt—Build Knowledge

http://wright.nasa.gov/treasurehunt

WHAT IT IS

The basic strategy to the development of a Treasure Hunt is to find Web pages that hold information (text, graphic, sound, video, etc.) that is essential to understanding a given topic. After gathering these links, one key question for each Web site is posed.

HOW TO USE

A smartly designed Treasure Hunt can go far beyond finding unrelated nuggets of knowledge. By choosing questions that define the scope or parameters of the topic, students can be guided into more reflective thinking. Finally, by including a culminating "big question," students can synthesize what they have learned and shape it into a broader understanding of the big picture.

STARTER COLLECTION

Wind Beneath My Wings (Grades K–3)
Your mission is to investigate the fabulous four forces of flight to uncover the mystery of what lifts an airplane into the sky and why a heavy airplane can stay in the sky. Design, construct, and test a paper airplane.

The Wright Information (Grades 4–6)
Let's place the Wright brothers in historical context with investigative questions such as: When the Wright brothers first flew at Kitty Hawk, how many stars were on the U.S. flag? Research why they traveled from Ohio to North Carolina to do their experiments.

Famous Pilots Challenge (Grades 7–12)
This is an interactive learning tool to quiz students' knowledge of the "icons" of aerospace. The attributes and dreams of these courageous men and women may inspire others to pursue new heights in their own careers and lives.

Toys that Fly (Grades 7–12)
Frisbees, rubberband-powered gliders, and boomerangs can't compare with the size and power of even the smallest airplane. Nevertheless, they all have to fly through the same atmosphere. Are the forces that keep a 747 Jumbo jet flying at 30,000 feet the same as the forces on your Frisbee?

Higher, Faster, Farther, Part 1 (Grades 7–9)
Successful scientists and inventors always record their data carefully. Your guided hunt on the Internet will have you searching for information about their flights and then using the data to investigate the relationship between altitude and time.

Higher, Faster, Farther, Part 2 (Grades 10–12)
Successful scientists and inventors always record their data carefully. Your guided hunt on the Internet will have you searching for information about their flights and then using the data to investigate the relationship between speed and time.

NASA Student Competition Opportunities!
NASA Student Involvement Program (NSIP)—Science and Technology Journalism Competition (K–12) "Reflecting Upon the Adventures of Flight"
http://education.nasa.gov/nsip

Subject Sampler—Affective Thinking

wright.nasa.gov/subjectsampler

WHAT IT IS

Part of what makes the Internet so great is the quirky, passionate, real stuff that many people and organizations post. Subject Samplers tap into this vibrant vein in order to connect students to the chosen NASA topic.

HOW TO USE

Subject Sampler learners are presented with a small number of intriguing Web sites organized around a main topic. What makes this a particularly effective way to engage student buy-in is that you've chosen Web sites that offer something interesting to do, read, or see. Second, students are asked to respond to the Web-based activities from a personal perspective. Rather than uncover hard knowledge (as they do in a Treasure Hunt), students are asked about their perspectives on topics, comparisons to experiences they have had, and personal interpretations of data. Students see that their views are valued in this context.

STARTER COLLECTION

Wings and Things that Fly (Grades K–3)
Long before the Space Shuttle, even before Orville and Wilbur Wright ventured to Kitty Hawk, nature gave us the first flyers. What have we learned from "nature's flyers" and how has this influenced human flight? Discover the difference between true flight and glided flight, learn about flight patterns, and construct models of different animal wings, comparing them with the wings of an airplane. Then create a presentation that shows how one of "nature's flyers" might have influenced flight.

From Pilots to Passengers: The People Behind Flight (Grades 4–6)
When the Wright brothers first flew, only a few people were around to witness the event and to help. Not so today! Get to know the people behind flight from the pilots to the passengers!

A Place for Me in Aerospace (Grades 4–9)
Meet the people who work in the field of aerospace through Web chats, online interviews, and NASA Web sites. Pick out an aerospace career that fits you!

Evolution of Wings (Grades 7–12)
Journey through time as we investigate the search for flight from insects and birds to early human attempts to fly. What lessons have we learned from nature, and how are we translating that into innovative designs for flight around our own planet and the investigation of other worlds? Join the journey!

Poster Credits

The back of "The 1902 Glider—How the Problem of Control Was Solved" educational wallsheet was developed by NASA Headquarters Office of Education in cooperation with the Office of Aerospace Technology and the U.S. Centennial of Flight Commission by the following individuals: Bill Anderson, Shelley Canright, Debbie Gallaway, Marisa Harper, and Pam Mountjoy. The 2001–2002 Albert Einstein Distinguished Educator Fellows, representing four Federal agencies and Congressional offices, developed the Web tasks that are referenced on this poster. They include Peg Steffen, Cathy Barthelemy, Nick Cabot, Todd Clark, Katylee Hoover, Kathleen Burke House, Norma Howell, Kevin Manning, and Joseph McInerney.

The illustration on the front of the poster originally appeared as a supplement in the April/May 1998 issue of *AIR & SPACE Magazine*. The illustration was drawn by Bruce Morser and designed by Phil Jordan and Gretchen Maxwell in consultation with Rick Young.

WebQuest—Problem Solve

wright.nasa.gov/webquest

WHAT IT IS

A WebQuest is an inquiry activity that presents student groups with a challenging task, provides access to an abundance of usual online resources, and prompts higher-order thinking. The products of WebQuest are usually then put out "to the world" for some real feedback.

It's best to choose a topic in which aspects are under dispute or that at least offer a couple different perspectives. Current NASA events would work well. Also anything that requires evaluation or scientific hypothesizing will evoke a variety of interpretations.

HOW TO USE

Students benefit from being linked to a wide variety of Web resources so that they can explore and make sense of the issues involved in the challenge. Students begin by learning some common background knowledge, and then they divide into groups. Once divided into groups, each student or pair of students has a particular role, task, or perspective to master. They effectively become experts on one aspect of a topic. When the roles come together, students must synthesize their learning by completing a summarizing act, such as e-mailing or presenting their interpretation to NASA experts on the topic.

A NASA WebQuest might be used as a first activity to quickly immerse students in real learning before filling in the broader picture with a NASA Treasure Hunt or Subject Sampler.

STARTER COLLECTION

Famous Aviators (Grades K–3)
Take a Web trip through the centennial of flight with the famous aviators who flew those marvelous flying machines. Pick an aviator you'd most like to be and play the part at the Virtual Aviator's Convention.

Wind Tunnels (Grades 4–6)
Shakespeare called the atmosphere "airy nothing." He was right about many things, but wrong in this case! Air is real and can lift everything from the willowy 1903 Wright Flyer to today's largest jumbo jet. Explore online NASA wind tunnel data sets and answer questions about the four forces of flight.

Wing-Warping Controversy: The Great Debate (Grades 4–6)
The Wright patent was one of the most important ever issued by the United States, but some historians say it hindered the growth of aviation. Why? The key to Wright flight control was wing-warping; later inventors substituted ailerons, which are standard today. The Wrights felt their patent covered ailerons and sued all other airplane makers. Hold a "Great Debate" in your class to discuss the issue.

Wing-Warping Controversy: The Great Debate (Grades 7–12)
See above description.

From Wright Flyer to Mars Airplane (Grades 7–12)
This WebQuest activity highlights the physical and technological advancements made in the transition from flight in the Earth's atmosphere to flying a uniquely designed aircraft that is able to traverse an atmosphere of different composition and density on another planet. In the end, prepare a proposal for the design of a Mars airplane!

Forces of Flight (Grades 10–12)
Critically evaluate one's understanding of the forces that affect flying objects and then develop ways to explain why things fly to other people.

NASA Aerospace Technology Enterprise Education Projects on the Web

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

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

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

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

NASA CONNECT Video—Web Series (Grades 6–8)
Establish the connection between mathematics, science, and technology learned in school and used every day by NASA researchers (*http://connect.larc.nasa.gov*).

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

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

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

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

The Wright Way Web Site (Grades K–12)
Join NASA in celebrating the 100th anniversary of flight (*http://wright.nasa.gov*).

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

Mobile Aeronautics Education Laboratory (Grades K–12)
Learn how to establish an aeronautics learning lab in your community (*http://www.grc.nasa.gov/WWW/MAEL*).

Destination Tomorrow Video—Web Series (Grades 9–Adult)
NASA research—past, present, and future—is highlighted in a magazine-style format, with segments ranging in length from three to eight minutes (*http://destination.larc.nasa.gov*).

NASA RESOURCES FOR EDUCATORS

NASA 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 Network (ERCN). 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. The following is a list of the centers and the regions they serve:

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 Center
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/teacher.htm#educate

KY, NC, SC, VA, WV
Virginia Air & Space Center
Educator Resource Center for
NASA Langley Research Center
600 Settlers Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900, ext. 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
P.O. Box 273, M/S 4839
Edwards, CA 93523-0273
Phone: (661) 276-5009 or
(800) 521-3416, ext. 5009
http://www.dfrc.nasa.gov/trc/ERC/

VA 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 educators access to NASA educational materials in nearly every State. 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 Education Home Page serves as the education portal for information regarding educational programs and services offered by NASA for the American education community. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts, Field Center offices, and points of presence within each State. For further information, visit ***http://education.nasa.gov***

NASA Spacelink is one of NASA's electronic resources specifically developed for the educational 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 educational products can be found on Spacelink at ***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 three-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 program 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.

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.

EW–2002–08–136–HQ