# X-Glider Educational Brief

National Aeronautics and
Space Administration

| Educational Product | |
|---|---|
| Educators & Students | Grades K-4 |

EB-1999-03-002-DFRC

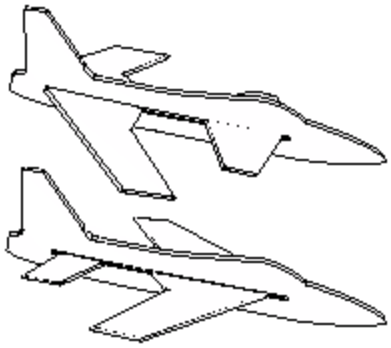
# Educational Brief

## X-Gliders: Exploring Flight Research with Experimental Gliders

**Objectives**

The students will:
Build a glider.
Learn how to change the flight characteristics of a glider.
Conduct an experiment to answer a question.

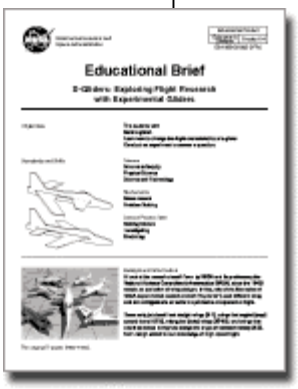
**Standards and Skills**



**Science**
Science as Inquiry
Physical Science
Science and Technology

**Mathematics**
Measurement
Problem Solving

**Science Process Skills**
Making Models
Investigating
Predicting



The original X-planes (1947-1952).

**Background Information**
A look at the research aircraft flown by NASA and its predecessor, the National Advisory Committee for Aeronautics (NACA), since the 1940's reveals an evolution of wing designs. In fact, each of the first series of NACA experimental research aircraft ("X-planes") used different wing and tail configurations to tackle the problems of supersonic flight.

These early jet aircraft had straight wings (X-1), wings that angled (swept) toward the tail (X-2), triangular (delta) wings (XF-92), and wings that could be moved in flight to change the angle of backward sweep (X-5). Each design added to our knowledge of high-speed flight.

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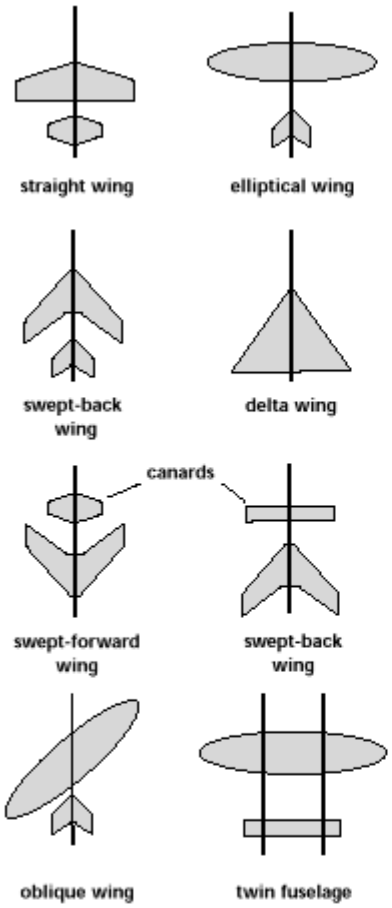
AD-1(1979-1982)

X-29 (1984-1992)




More recently, aircraft designs have incorporated wings that sweep forward (X-29), and even wings that sweep forward and backward at the same time (AD-1 oblique wing aircraft). The X-29 and X-31 also made use of small wing-like control surfaces called canards which are located ahead of the main wings. The X-36, which was flown during the late 1990's, used canards and swept-back wings but had no vertical tail. (For additional background information see the *Aircraft as Research Tools* page at the end of this Educational Brief.)

The templates supplied with this activity allow educators and students to build and experiment with all of these basic wing/tail/canard configurations. Eight different plastic foam "X-gliders" can be built using these templates (see illustrations, left), but the total number of variations is only limited by the imagination of the "designer."

Materials for building airplanes must be lightweight, strong, and readily available. These qualities make plastic foam a good material for the construction of flying models. Introduce the X-Glider Activity by discussing with the students some reasons for using plastic foam in the construction of a model glider. Most real airplanes are made from another lightweight, strong, and readily available material called aluminum.

**X-Glider Materials**

Plastic foam food tray, about 28 cm X 23 cm (Size 12)
Cellophane tape
Paper clips
Binder clips
Ball point pen
Plastic knife or scissors
Toothpicks
Goggles (eye protection)
Emery boards or sandpaper



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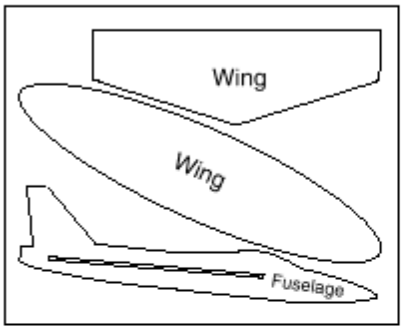
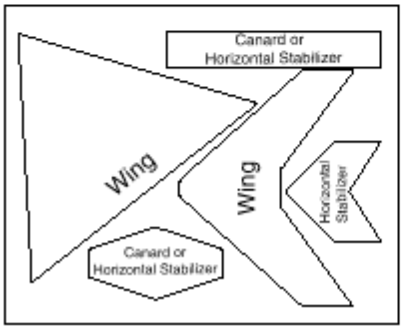
## Activity

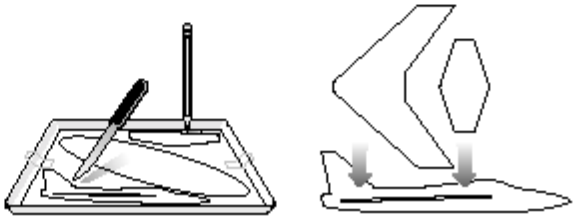
**template 1 key**



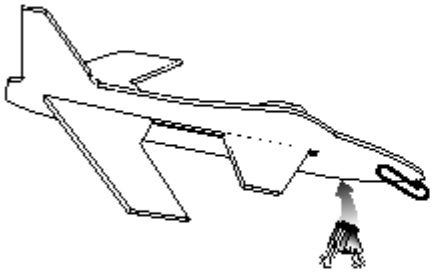

**template 2 key**




1. Provide the student with a word list for parts of the glider: *fuselage, wing, rudder, horizontal stabilizer, canard* (see template keys).
2. Distribute plastic foam trays and copies of each X-glider template.
3. Ask the student to write the name of each airplane part on the template.
4. Tape the glider template to the food tray.
5. Cut out the airplane parts using the templates. Plastic foam can be cut using scissors, a razor knife, or a serrated plastic knife. It can also be cut using a sharp pencil or round toothpick to punch a series of holes approximately 2mm apart around the outside edge of the part. The part can then be pushed out from the tray. Educators of K-2 students may want to cut out the glider parts ahead of time.
6. If there are any rough edges around a part, they can be smoothed using sandpaper or an emery board.
7. Carefully cut a slot in the fuselage. Slide other parts into it to finish the glider (refer to the X-glider silhouettes for the basic designs; another fuselage is needed to make the "twin fuselage" glider).



## Extensions



1. An airplane's weight must be properly balanced for it to fly safely. The same "weight and balance" principles apply to models. The students can determine the proper weight and balance by attaching a paper clip or binder clip to the fuselage. Students should vary the position of the clip with each flight until the glider flies the greatest distance in a straight line. Additional clips might be needed to improve the glider's flight performance.
2. Weight and balance is also determined by the position of the wings, canards, and other surfaces along the fuselage. Have the students move the wings, stabilizers, and canards to different positions in the fuselage to determine the settings that make the glider fly best.
3. Have students measure and record the distance of each flight, and compare the results with each change in the glider's weight and balance.



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# Aircraft as Research Tools

Aeronautical research usually begins with computers, wind tunnels, and flight simulators, but eventually the theories must fly. This is when flight research begins, and aircraft are the primary tools of the trade.

Flight research involves doing precision maneuvers in either a specially built experimental aircraft or an existing production airplane that has been modified. For example, the AD-1 was a unique airplane made only for flight research, while the NASA F-18 High Alpha Reaseach Vehicle (HARV) was a standard fighter aircraft that was transformed into a one-of-a-kind aircraft as it was fitted with new propulsion systems, flight controls, and scientific equipment. All research aircraft are able to perform scientific experiments because of the onboard instruments that record data about its systems, aerodynamics, and the outside environment.

NASA pilots work closely with engineers to conduct a meticulous flight program that gradually probes an aircraft's capabilities: edging toward the speed, altitude, and structural limits that will define the final performance of an aircraft or concept. This procedure furnishes answers that will verify, extend, and perhaps correct the inputs from computer studies, wind tunnel tests, and simulation. It is the last step in the development process and leads the way for designs that can be put into production. It also delivers the final word on a most crucial question: How well does it fly?

The X-5 for instance, showed that an aircraft can be flown with variable-sweep wings, a concept that was later used in the many airplanes, such as the F-111, F-14, and B-1. However, the X-3 demonstrated that while some of the concepts in its design were successful (short wings), the combination of short wings, small tail, and long fuselage did not fly well; aircraft designers took note, and avoided the X-3's problems on subsequent short-winged aircraft.

Experimental research aircraft are tools of exploration, incorporating the newest ideas in every aspect of aerospace flight, so for this reason they come in many shapes and sizes. Some have short wings, delta wings, swept wings, movable wings, and no wings. They fly with jet engines, rocket engines, piston engines, solar-electric engines, and even no engines. Some research planes are too small to carry a pilot, while others are as big as airliners. And no matter how radical they seem at first, they contribute to what is eventually considered conventional.

The first experimental planes designed exclusively for research were the XS-1 and the D-558-1. They were made in 1946 to enable scientists and pilots to study flight near the speed of sound. Custom-made airplanes were the only means to accomplish this research because supersonic wind tunnels at the time were not accurate enough, and no other airplanes had flown that fast. The supersonic era began when the XS-1 broke the "sound barrier" in 1947.

In the 1950's the famous "X-Planes" continued to take people to higher altitudes and greater speeds. They were the first aircraft to fly Mach 2 and Mach 3, and the studies done with them influenced the designs of all supersonic planes.

In the early 1960's, the X-15 rocket plane became the first aircraft to fly into space. It was one of many aeronautics projects that supported NASA's Apollo Lunar Landing Program, but the X-15 was so advanced that it also benefited the Space Shuttle nearly 15 years later.

Since the 1970's, NASA flight research has become more comprehensive, with flights involving everything from Space Shuttles to ultralights. NASA now flies not only the fastest airplanes, but some of the slowest. Flying machines continue to evolve with new wing designs, propulsion systems, and flight controls. As always, a look at today's experimental research aircraft is a preview of the future.

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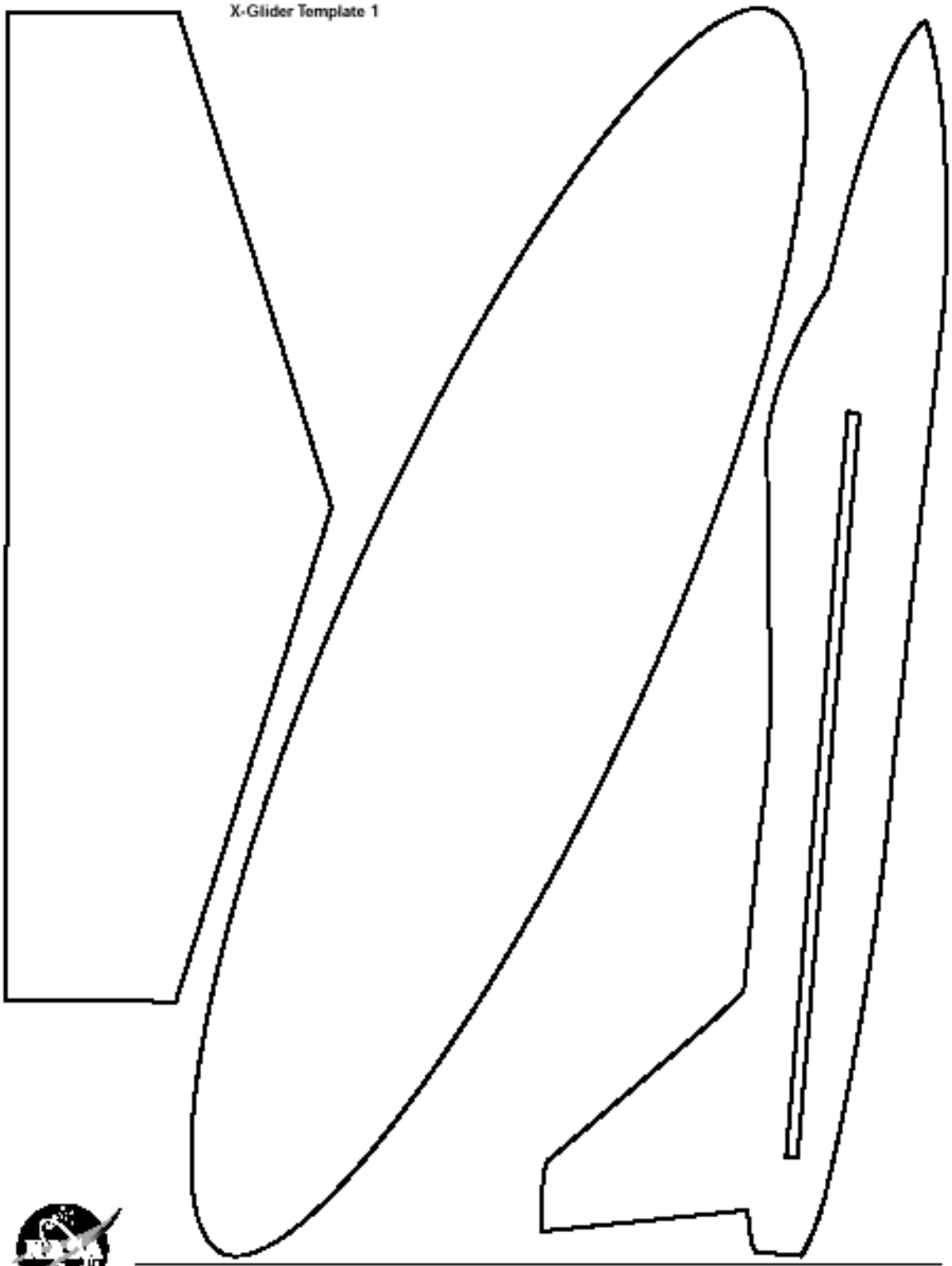
X-Glider Template 1





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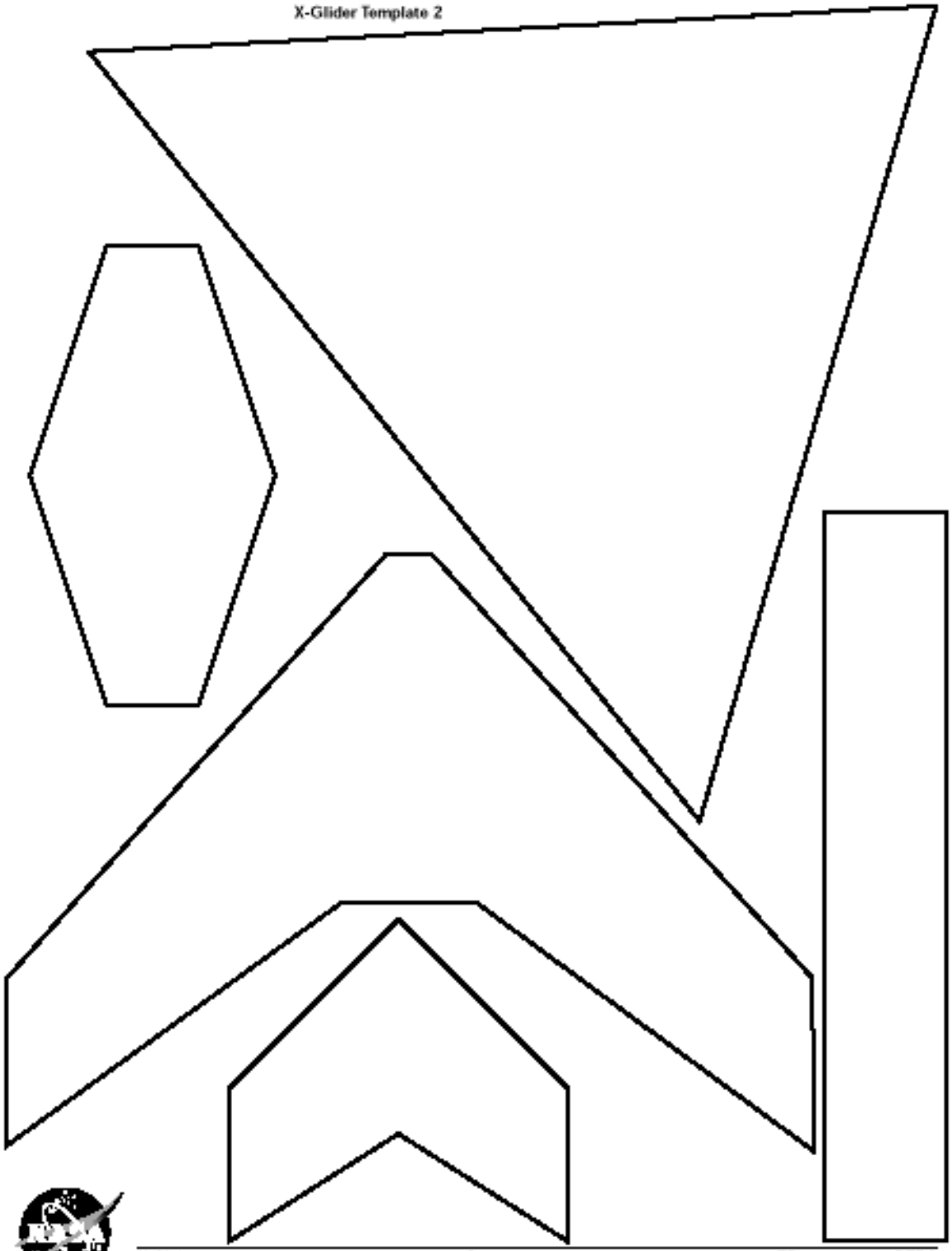
X-Glider Template 2





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