SOARING SAILPLANES

BUILDING THE AIR FORCE ACADEMY'S HISTORIC TG-4A GLIDER / SAILPLANE

OBJECTIVE – Students will be able to build a flying foam replica of the Air Force Academy's TG-4A glider and gain more information on the glider training and the U.S. Air Force Academy.

U.S. Air Force Academy TG-4A Glider – USAF Academy Glider Training Operation

NATIONAL STANDARDS –

Next Generation Science Standards (www.nextgenscience.org):

Disciplinary Core Idea Progressions

Physical Science Progression

- HS PS2.A: Forces and Motion

Crosscutting Concepts

- Systems and system models
- Energy and matter
- Structure and function

Science and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
6. Constructing explanations (for science) and designing solutions (for engineering)

VOCABULARY – Often, the words "glider" and "sailplane" are used in the same context. A glider is an aircraft that is usually towed aloft and then released to glide back to Earth. During World War II, gliders, filled with soldiers and equipment, were towed to a combat zone and released. The gliders descended to a landing where the soldiers then entered the battle. A sailplane is also towed aloft; however, when it is released, it uses the energy of the environment to continue flying. Sailplane pilots will seek rising columns of air, called thermals, to provide lift and subsequently gain altitude. A skillful sailplane pilot can use the lifting forces within the environment to stay aloft for one or more hours.

BACKGROUND –
(https://www.usafa.af.mil/AboutUs/FlightOperations/USAFAcademyAircraftIdentification.aspx)

About the historic TG-4A: The TG-4A is a conventional two-place tandem, basic training glider/ sailplane, manufactured by the Schweizer Aircraft Corporation, Elmira, New York. Its construction is all metal with fabric covering the fuselage and tail surfaces. It has a one-piece canopy for increased visibility. The wings are tapered in the outboard section and air brakes are incorporated. The model TG-4A is the same as the civilian SGS 2-33 version, except for the rudder. The TG-4A's rudder is taller and incorporates a balance weight in the upper forward end, which overhangs the top of the vertical stabilizer, or fin. The dimensions are: length—25'9"; Span—51'; Height—9' 3-1/2"; Wing area—219.48 square feet; Aspect ratio—11.85:1. The maximum gross weight is 1,040 pounds and the glide ratio is 23:1 (glide ratio of 23:1 means the glider will glide 23 times as far forward as it will fall downward. Glide ratio is forward motion to downward motion or ground distance covered to altitude lost).

The glider has dual flight controls. The flight control surfaces are actuated by control sticks and rudder pedals through a push rod and cable system. Aileron and elevator control is accomplished through push rods connected to both control sticks. Rudder control is accomplished through cables attached to both sets of rudder pedals.

Spoilers, or "air brakes," are installed primarily for glide-path control. They can also be used for rapid descents, maintaining airspeed within limits, and to recover from large slack-line situations while in tow. The air brakes are actuated through push rods, by handles located on the left side of both cockpits.

There is a red tow release knob located in the center at the bottom of the front instrument panel. There is another release knob located in the rear cockpit on the left side of the top front seat bracket.

All TG-4A aircraft are equipped with an airspeed indicator, altimeter, vertical velocity indicator, variometer (to measure ft. per minute changes) and a magnetic compass mounted on the front instrument panel.

About the current sailplanes: The Academy sailplane fleet consists of TG-15s, and TG-16s. The soaring mission also uses Piper Super Cub tow planes. These tow planes fly standardized departure and arrival routings, altered only as required to maintain safe deconfliction with other aircraft operating in the area or when weather conditions warrant deviations in the interest of safety. Soaring operations take place almost exclusively over USAF Academy property, remaining west of I-25 and periodically extending over the neighborhoods immediately to the south of the Academy.

(USAFA Soaring Program video: https://youtu.be/XF2lZeOP_Fk)

About the US Air Force Academy: The USAFA is located in Colorado Springs, Colorado. The mission statement is: "inspire and develop outstanding young men and women to become Air Force officers with knowledge, character, and discipline; motivated to lead the world's greatest aerospace force in service to the nation." The USAFA is recognized as one of the nation's finest four-year institutions of higher learning.

The Air Force Academy is both a military organization and a university. Much of the Academy is set up like most other Air Force bases, particularly the 10th Air Base Wing, but the Superintendent, Commandant, Dean of Faculty, and Cadet Wing are set up in a manner resembling a civilian university.

The Superintendent is the Academy's commanding officer and is responsible for the Academy's regimen of military training, academics, athletic, and character development programs. The Commandant oversees the 4,400-member cadet wing and more than 300 Air Force and civilian support personnel. The Commandant is also responsible for cadet military training and Airmanship education, supervising cadet life activities, and providing support to facilities and logistics. The Dean of Faculty commands a 700-person mission element and oversees annual course design and instruction of more than 500 courses, crossing 32 academic disciplines, and directs the operation of five support staff agencies and faculty resources involving more than $250 million.

The 10th Air Base Wing comprises more than 3,000 military, civilian, and contract personnel who conduct all base-level support activities, including law enforcement and force protection, civil engineering, communications, logistics, military and civilian personnel, financial management services, and the clinic, for a military community of about 25,000 people.

MATERIALS

1. Two foam meat trays per student (Preferably yellow as the real historic plane is yellow)
2. Hot glue gun/glue sticks
3. Utility knife or box cutter
4. Wooden coffee stirrers
5. One penny per student (for nose weight)
6. Wax paper
7. Optional: #80-100 sandpaper

MANAGEMENT TIP:– It is a good idea to use a piece of flat cardboard under the foam cutting procedure. This keeps the table from being cut and it allows the builder to make a clean cut all the way through the foam. You can buy utility knives or box cutters at a hardware store. These are very sharp and strong but make the job of cutting the foam much easier than with scissors. Please use caution and make sure that if students are doing the cutting, there is ample adult supervision. Also, be careful with the hot glue gun as the tips and even the glue can cause burns.

PROCEDURE -

1. Make a copy of the template. It can be enlarged or diminished in size depending upon your meat tray.

2. Put the template down on the outside surface of the foam tray.

3. Use a utility knife to cut out the glider's parts.

4. Optional- Using #80-100 sandpaper, sand the edges of the glider's wing and tail pieces so that they look like elongated tear drops. (Refer to the "Bernoulli's Basics" for correct wing shape.)

5. Position the horizontal stabilizer to the rear of the fuselage. Make sure that it is perpendicular to the fuselage. Run a bead of hot glue along the back end of the fuselage and mount the horizontal stabilizer onto the glue, centering it.

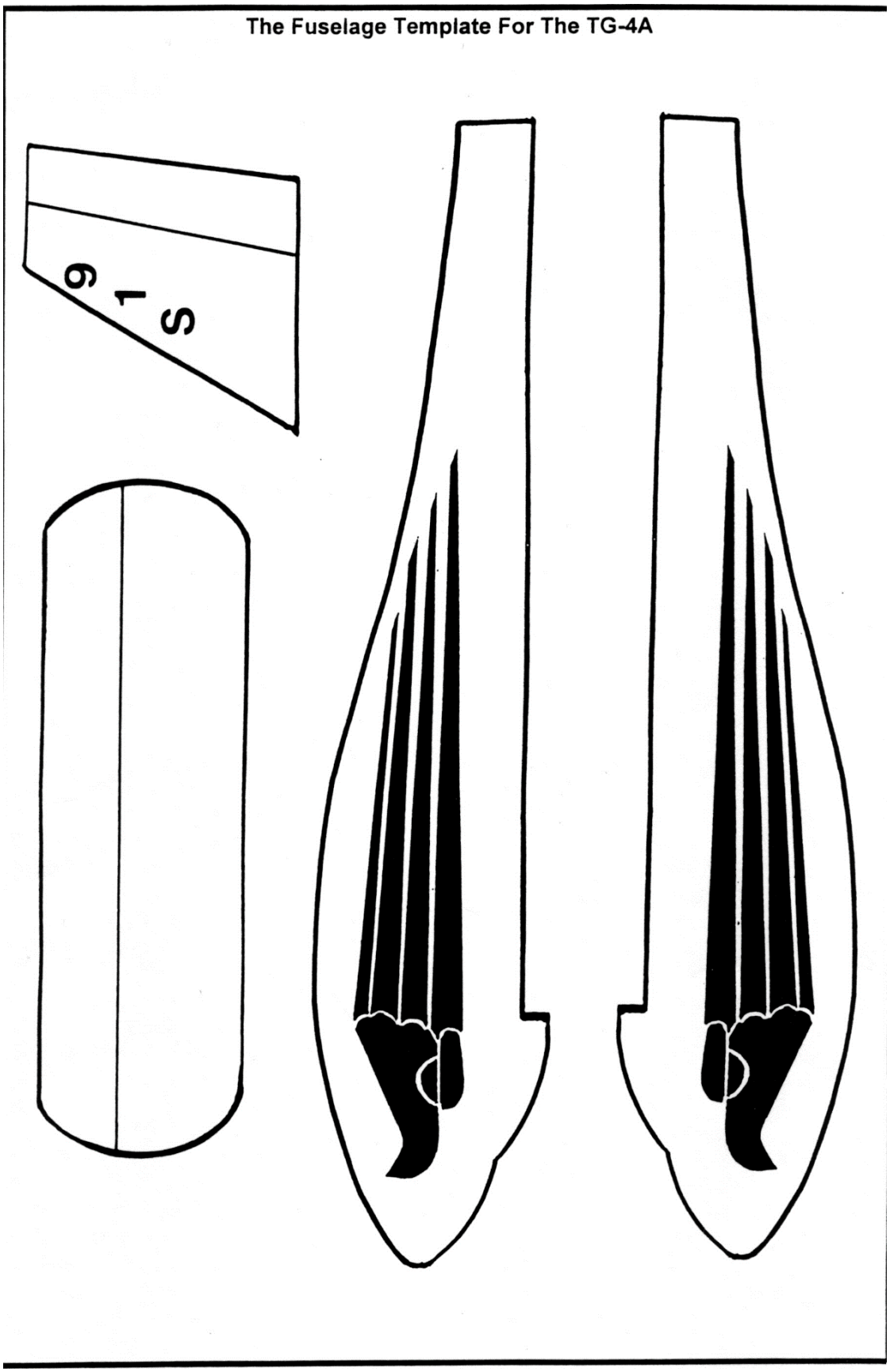
6. Mount the vertical stabilizer onto the horizontal stabilizer using hot glue. Make sure that the vertical stabilizer is perpendicular to the horizontal stabilizer.

7. The wing "halves" are glued together at their roots. It is a good idea to put a piece of wax paper under the wings so the wings won't be glued to the table. When set, glue the wing to the fuselage so that the leading edge of the wing will fit into the notch just behind the cockpit.

8. The wings are placed in position and held there until the glue sets.

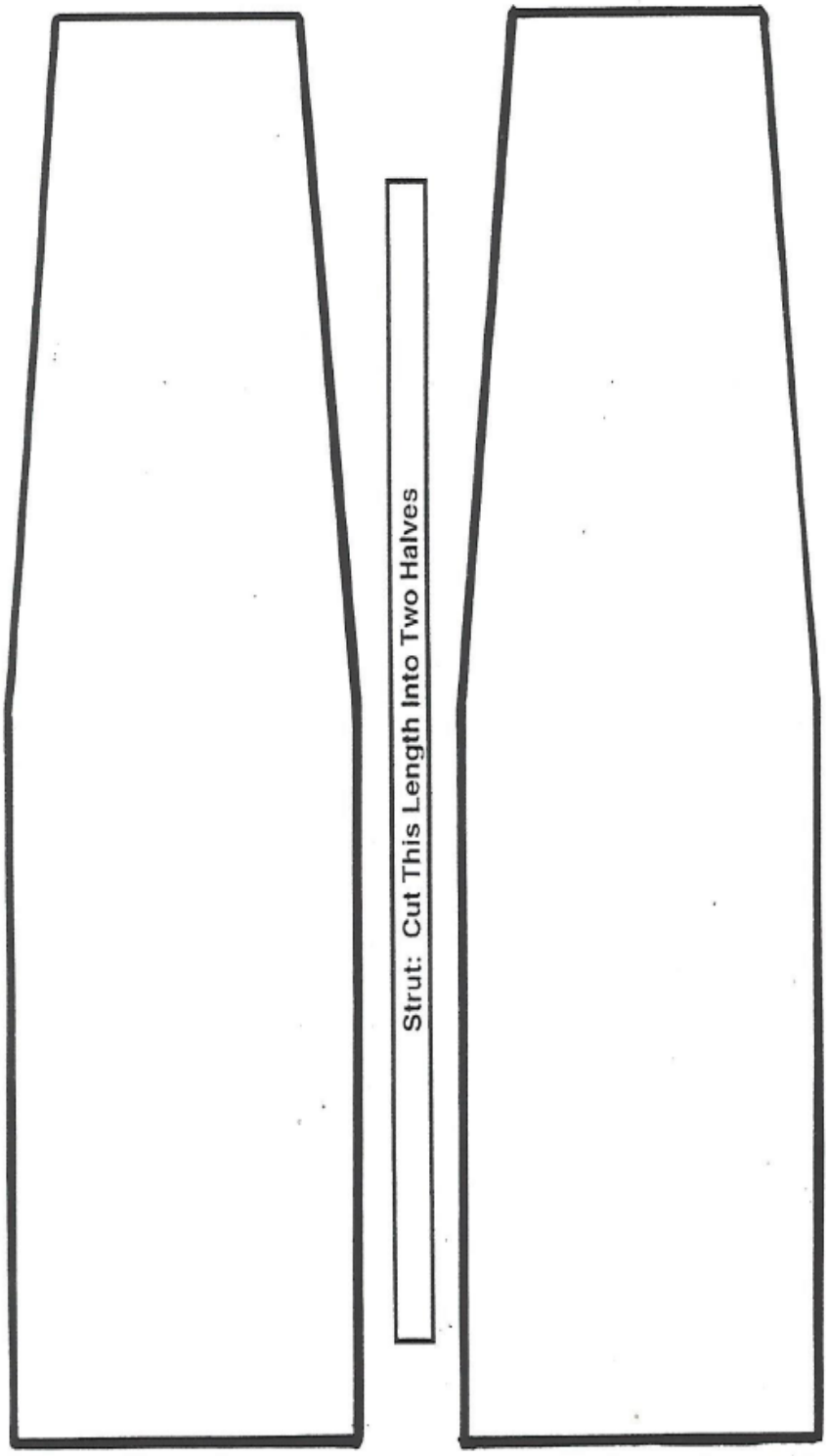
9. Once the wings set, you may install the small wing struts. Coffee stirring sticks work well for these.

10. Find an old penny and hot glue it to the front of the fuselage. This will give you the right amount of weight to make the model glider fly.



This is one of two templates. The second template is on the next page. It is recommended that the builder enlarge these templates by 110% on a copy machine. Only one fuselage is necessary; however, the builder can make two sides and bond them together with white glue. Marking pens can be used to add the graphics.

THE WINGS TEMPLATE FOR THE TG-4A



EXTENSIONS –

NASA Glenn Research Center: Let It Glide Challenge (https://www.nasa.gov/glenn-edcs-let-it-glide)

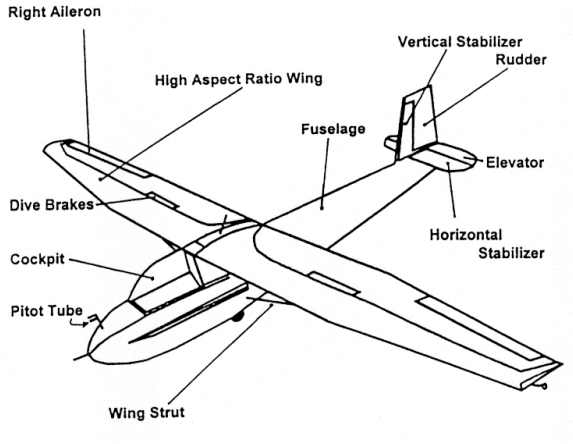
- Using the Engineering Design Process, students will develop and build a shoe box glider, and then improve it in terms of aircraft and wing materials, shapes, and structure, to produce the greatest glide slope (the ratio of the distance traveled to decrease in altitude) possible.

- Introduce the activity using the NASA Let It Glide Challenge Video (https://www.youtube.com/watch?v=ium3IS41Xqc)

LEARNING THE LANGUAGE OF GLIDERS:

TG-4A Glider Vocabulary

A glider has similar components to that of a conventional airplane. Students should know the parts of their glider after completion of the activity. Instruct the students to label the parts on their model.



1. Have students find the left aileron, the right elevator, etc.

2. Fuselage – Have the students put a 5-digit number on the side starting with the letter "N" (because "N" is the international prefix for the USA.) This will be their registration. An example would be "N55361." They could also use a letter of the alphabet to substitute for the last number. An example would be "N5536A."

3. Facilitate a discussion with the following questions: (Answers are in italics.)

- What is another name for the dive brakes? *spoilers*
- Where does the pilot sit? *cockpit*
- What is a pitot tube for? (requires outside investigation) *Static tube system, which is used to measure forward speed. (A differential pressure gauge.)*
- What is the rudder used for, and what is it attached to? *The rudder is hinged to the trailing edge of the fin (a small vertical wing fixed to the fuselage). It is used to overcome and balance yaw (sideways swing of glider).*
- What is an elevator used for? *The elevator pitches the nose of the glider up or down. It is the primary means of controlling the speed of the glider.*
- Have students investigate what "high aspect ratio" means and how it applies to gliders. *Aspect ratio of a wing is the wingspan squared divided by the area of the wing. Gliders have a high aspect ratio because they have long and skinny wings since they aren't concerned with speed and maneuverability as much as efficiency.*
- Look at the picture of the actual TG-4A at the beginning of this activity. Why is there a wheel on the wing? *To keep the wing from scraping along the ground.*
- Why do wings have struts? *A strut is a brace to support wings, usually attached from the fuselage to the wing.*
- What does it mean to "use the energy of the environment to maintain lift?" *The key to keeping the glider in the air longer is to get help from the air. There are three types of rising air used by glider pilots. The three types are thermals, ridge lift, and wave lift.*

4. Learn more about gliders and the types of rising air at http://www.howstuffworks.com/glider.htm