Civil Air Patrol's ACE Program

FPG-9 Glider
Grade 5 Academic Lesson #4

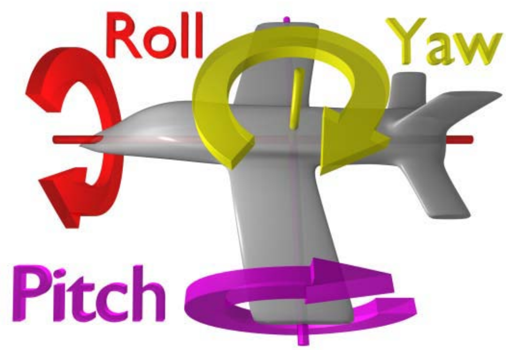
Topics: flight, cause and effect, observation (science)

Lesson Reference: Jack Reynolds
Courtesy of the Academy of Model Aeronautics (AMA) at
http://www.modelaircraft.org/education/fpg-9.aspx (It includes a video on building and flying the FPG-9.) The video explanation, may also be found at https://www.youtube.com/watch?v=pNtew_VzzWg.

Length of Lesson: 40-50 minutes

Objectives:
- Students will build a glider.
- Students will experiment with "launch" technique, elevons, and rudders to determine how to best fly the glider.

National Science Standards:
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science
  - Position and motion of objects
- Content Standard E: Science and Technology
  - Abilities of technological design
- Unifying Concepts and Processes
  - Form and function



Background Information: (by Jack Reynolds, AMA Volunteer)
Play has been defined as the work of children and, as such, toys are the tools of their work. If play is the work of children, the "art of fine play," (fun with a purpose) is the work of teachers. Orville and Wilbur Wright first learned about flight when their father brought home a toy helicopter for their amusement Orville recalled that they played with it for hours, eventually designing and modifying the original many times.

The FPG-9 derives its name from its origins, the venerable and ubiquitous foam picnic plate. The Foam Plate Glider is created from a 9-inch diameter plate, available in most grocery and convenience stores. It can be used for an engaging and safe exploratory activity to excite students and deepen their understanding about science and the physics of flight. The activity introduces concepts about how aircraft use control surfaces to climb, turn and maintain stable flight.

Most students can better understand how things work when they are given a toy and the time to learn about its characteristics. This simple plane will help your students understand how control surfaces affect flight. For example, they can discover for themselves that a plane will loop and turn, depending upon the position of the *elevons and rudder. Classroom work with these planes is a natural invitation for students to experiment and make observations. This discovery activity challenges students to solve problems as they devise their own experiments.

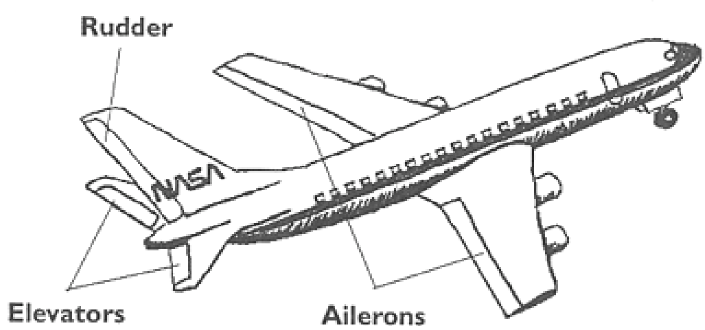
It will take approximately five minutes for students to assemble this aircraft. Once the planes are assembled, allow the students to play and experiment with their new creation for about ten minutes. After students have developed skill in "teaching the plane how to fly," they will need approximately twenty minutes to complete the FPG-9 worksheet. Make sure that your students understand that they must launch their planes with the same amount of force and at the same angle for each step in the activity.

As Orville once said, "I can remember when Wilbur and I could hardly wait for morning to come to get at something that interested us. That's happiness!"

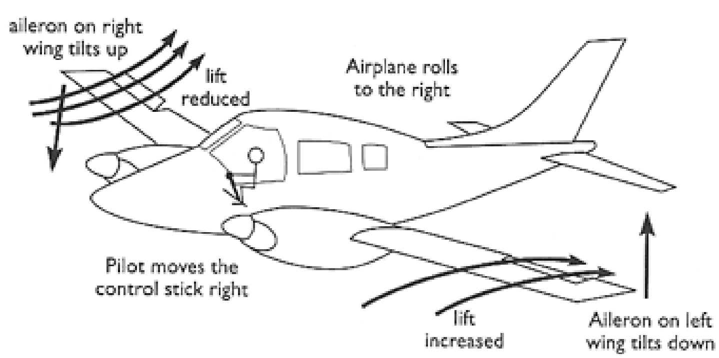
** The FPG-9 uses "elevons" to control both pitch up and down and roll to the left or right. In a conventional airplane, elevators control pitch and ailerons control roll.*

The background information that follows is from NASA Quest at
http://quest.arc.nasa.gov/aero/planetary/atmospheric/control.html.

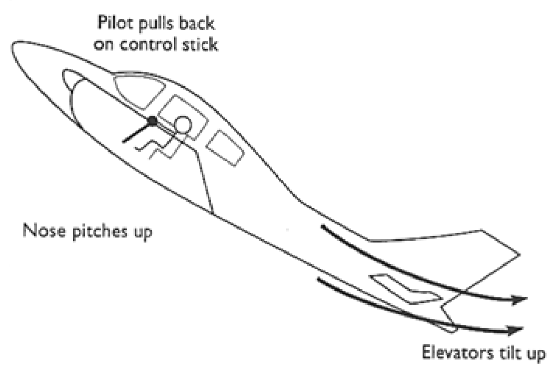
An airplane has three control surfaces: ailerons, elevators and a rudder. These control surfaces affect the motions of an airplane by changing the way the air flows around it.



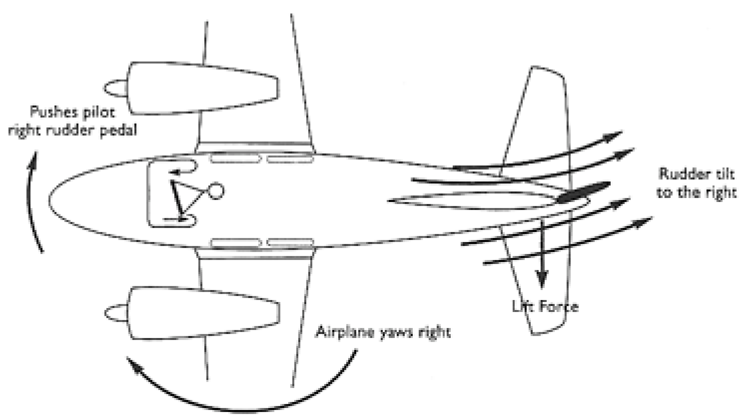
The ailerons are flap-like structures on the trailing edge of the wings -one on each side. When the pilot moves the control stick to the right, the right aileron will tilt up and the left aileron will tilt down. This will cause the airplane to roll to the right. When the pilot moves the control stick to the left, the left aileron tilts up, the right aileron tilts down and the airplane rolls to the left. This happens because as the aileron tilts downward (effectively increasing camber) more lift is created and the wing rises. As it tilts upward, less lift will be created and the wing will lower. If the wing of one side of the airplane rises and the other descends, the airplane will roll towards the side with the decrease in lift.



The elevators are also flap-like structures that are mounted on each side of the horizontal stabilizer. As an airplane flies in its proper orientation and level to the horizon the pilot uses the elevator to control the pitch of the nose. That means the elevator controls the nose's motion of up and down. When the pilot pushes the control stick forward, the elevators tilt downward -this is called pitching down. When the pilot pulls the control stick back, the elevators tilt upward, the tail goes down and the fuselage pitches nose-up. When the elevator tilts downward more lift is created (like the ailerons) and the tail rises. When the elevator tilts upward, less lift is created and the tail descends.



The rudder is located on the vertical fin. The rudder controls the motion of yaw. Yaw causes the airplane's nose to move sideways to the left or right. The two rudder pedals are located at the pilot's feet. When the pilot pushes on the right rudder pedal, the rudder tilts to the right and the airplane yaws nose-right. When the pilot pushes on the left rudder pedal, the rudder tilts to the left and the airplane yaws nose-left. Again this is due to lift. However, the direction of this lift force is different than the lift force that causes the airplane to ascend. When the rudder tilts to the right, more lift is created on the right, which lifts or pushes the vertical stabilizer to the left. This, in turn, causes the airplane to yaw nose-right. The opposite motion occurs when the rudder tilts to the left.



The thinner the atmosphere the slower the reaction of the airplane to its control surfaces. Airplanes flying at fast speeds in the lower atmosphere react more quickly to a change in the control surfaces than airplanes flying at extremely high altitudes at the same speed. That's because there are fewer air molecules to disturb. This becomes even more important when flying airplanes on planets with atmospheres that are less dense than Earth's atmosphere.

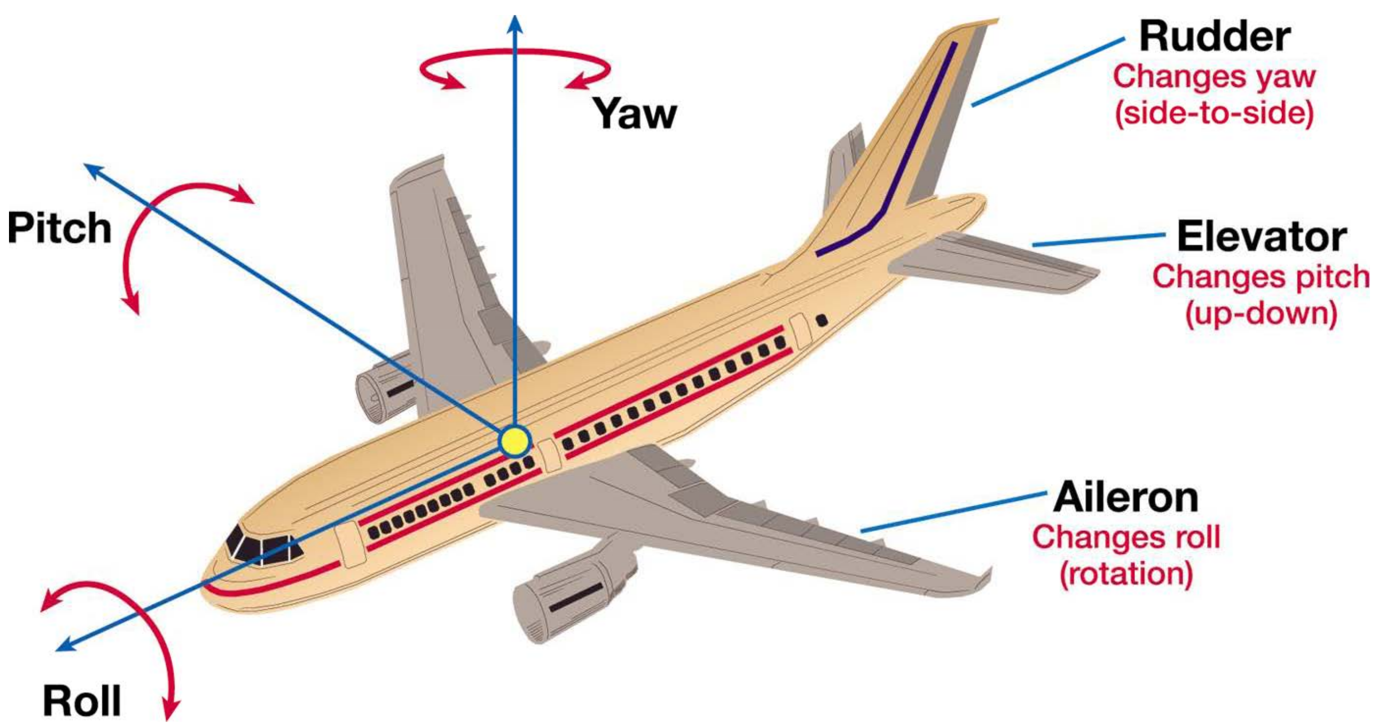
(Info and picture below from http://www.melodyshaw.com/files/SpaceDayToolkit.pdf.) Pilots use

different terms to describe the particular ways an aircraft moves forward:

Pitch: Aircraft nose moves up or down
Roll: One wing of aircraft tips up while the other tips down
Yaw: Nose of airplane moves left or right while remaining level with the ground

Pilots use several control surfaces (movable sections on the aircraft's surface) to better direct an aircraft's movement. These include:

Elevator: Section on horizontal part of tail that controls pitch
Aileron: Section at rear edge of wing near tip that controls roll
Rudder: Section attached to vertical part of tail that controls yaw



Materials per student:

- FPG-9 pattern (or 10" pattern, copy included)
- 9" foam plate (or 10")
- scissors
- masking tape
- Copies of an FPG-9 data sheet (2 different worksheets are included)
- pen
- penny

NOTE: Since a paper pattern is hard for students to trace around, the instructor may want to cut out a foam plate master template for the students to use to trace around. This lesson, however, provides instructions for students using a paper pattern. Adjust as necessary.

Watch a video of this lesson at http://www.modelaircraft.org/education/fpg-9.aspx or http://www.youtube.com/watch?v=pNtew_VzzWg.

If you wish to substitute the Geobat lesson for this one, you may do so.

Lesson Presentation:

1. Ask a student to define glider. (Students who participated in this program last year should know.) Confirm that a glider is a type of aircraft that has no power source, like an engine, to help it move forward and prevent it from falling to the ground due to Earth's gravity.
2. Tell students that they will build an FPG-9 glider today. Tell students that as they build the glider, they can also be thinking about what "FPG-9" may mean.
3. Provide students with the FPG-9 paper pattern.

4. Have students cut out the pattern. Tell them **NOT** to cut along the dotted line on the paper pattern. **Only cut along the bolded lines.**
5. Have students place the paper pattern in the center of the foam plate ensuring that the tail of the pattern stays inside of the curved portion of the plate bottom. (*The tail must remain on the plate's flat bottom*.) It's fine if the tab on the front of the pattern is on the curved portion. The ends of the wings should spill over the curved edge of the plate.
6. Tell students to trace around the pattern with an ink pen. Remind them to mark the scissor slits A and B! When marking slits A and B, the students only need to make one line. These will create the elevons and rudder.

7. (optional) Show the students the online video that shows how to make the glider.
8. Have the students cut out the FPG-9 they just traced by following the pen lines. Tell them to cut along the dotted line to separate the tail from the wing of the FPG-9. It works better if you make all of your cuts from the outside of the plate towards the center of the plate. Do not try to turn your scissors to cut sharp corners. When cutting out the slots, make them only as wide as the thickness of the foam plate. If the slots are cut too wide the pieces of the plane will not fit together snuggly.

9. The wing and the tail each have slits drawn on them. Have the students make a cut along each of these lines as drawn.

10. To attach the tail to the wing, slide **Slot 1** into **Slot 2**. Use two small (2") pieces of tape to secure the bottom of the tail to the bottom of the wing. Ensure the tail is perpendicular to the wing before adding the tape.

11. In order to make the plane fly successfully, the students must attach a penny on top of the wing right behind the square tab. Fold the tab back over the penny and tape it down to secure the coin.

12. Discuss and demonstrate "roll," "pitch," and "yaw." (See background information. Consider showing a transparency of page 64. Students may recall this from a fourth-grade paper airplane ACE lesson if it was a lesson the fourth-grade ACE teacher selected to teach.)

13. Bend the elevons on the wing upward. This will provide for a flatter glide. If the students want the plane to turn they can adjust the rudder on the vertical fin.

14. Tell students that their FPG-9 is complete and ready to fly. Have students *gently* toss the plane directly in front of them upon your signal.

15. Once students have the glider flying reasonably straight ahead and gliding well, have them try throwing it hard with the nose of the glider pointed 30° above the horizon. The FPG-9 should perform a big loop and have enough speed for a glide of 20 – 25 feet after the loop.

16. Distribute an FPG-9 data sheet. Allow students to get a partner, form a small group, or work individually to complete the data sheet.

17. Either collect the activity sheets to grade or allow students to keep their work, but gather together to discuss and summarize the lesson.

Summarization:
Ask students to share some of their findings from their activity sheet and discuss. Ask if anyone knows what "FPG-9" means. Confirm that it stands for "Foam Plate Glider." The "9" represents the diameter of the foam plate, 9". (You may have used the 10" plate, in which case it would be the "FPG-10" glider.)

Character Connection: Remind students that one cannot enhance his or her skills without trying new things. Practice does help us get better at that which we try. Sometimes we just need to make little adjustments here and there. Sometimes, we have to make some big changes. Sometimes, we watch what others have done and learn from their successes and failures. Ultimately, the choice is ours to learn and improve our lives. Saying no to drugs and yes to good decisions will help them glide smoothly along the journey of life. Encourage students to look for ways they can make small or big changes, like changing the surface controls on their glider, in order to "fly" better and reach their goals.

Assessment:

- teacher observation
- completed FGP-9
- FPG-9 data sheet

Additional ideas to enrich and extend the primary lesson (optional):

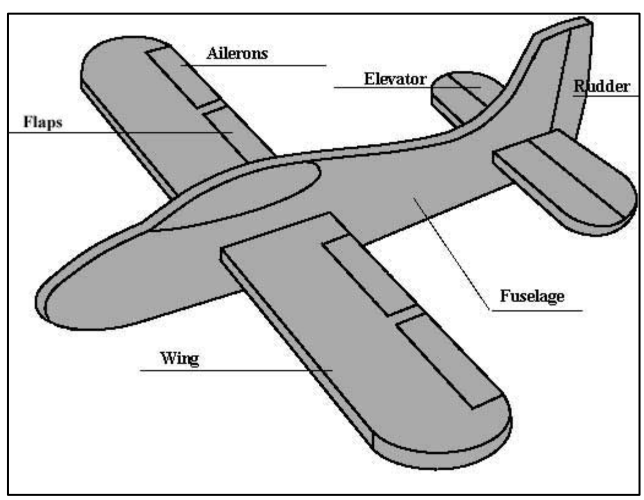
- Have students experiment with Geobat. (pattern included at the end of this lesson plan) To learn more about Geobat or to see a video about it, visit http://www.aerobataviation.com/.

- Allow students to have a glider contest. The goal for the contest(s) may be longest distance, most air time, or landing at/hitting a designated target.

- The Ultra-Efficient Engine Technology (UEET) website has a Kid's Site that provides a scavenger hunt where students can learn more about aeronautics and the careers involved in this field. Go to https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/scavenger.html to obtain a pdf of the student scavenger hunt questions. The students will then use http://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/to complete the scavenger hunt.

  UEET Scavenger Hunt ANSWER KEY

  1. science; flight
  2. Answers will vary. Students may choose any careers under the following general headings: scientists, engineers or technicians.
  3. Answers will vary. Students may choose classes such as: Algebra, Biology, Calculus, Chemistry, Computer Applications/Programming, English, Fine Arts/Humanities, Foreign Language, Geometry, Physics, Social Studies, or Trigonometry.
  4. 1. Lift 2. Drag 3. Weight (or gravity) 4. Thrust
  5. Between 27 and 30 (about 28.5)
  6. Space Shuttle or X-15.
  7. Wings
  8. Fuselage
  9. Wings
  10. Moves the plane to the side and helps it turn during flight.
  11. 1. Fan 2. Compressor 3. Combuster 4. Turbine 5. Nozzle
  12. Combuster
  13. 12 horse power gas powered engine
  14. Turbofan
  15. Montgolfier
  16. Otto Lilienthal
  17. Orville



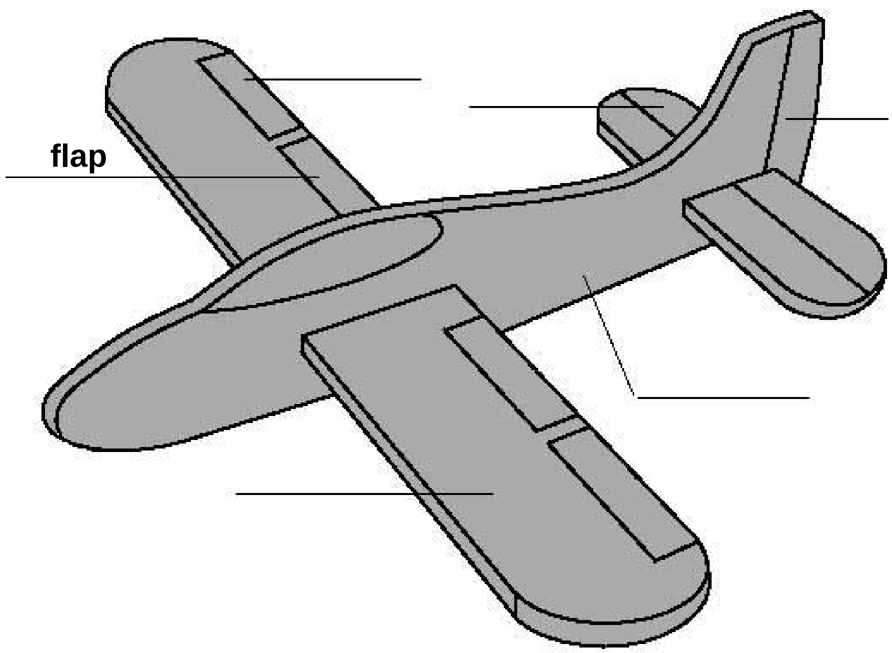
- Have students complete the **"Name That Plane Part" worksheet**. The plane to the right shows the correct labeling.
  The other answers are:
  1. fuselage 2. aileron 3. elevator
  4. rudder 5. flap 6. wing

Name That Plane Part (Extension)

Student Name_______________________________________

Use the words below to label the parts of the plane and complete the sentences below. One is done for you.

rudder **fuselage** **aileron**
flap **wing** **elevator**



1. The main body of the airplane is the___________________________.
2. The control surface that makes the airplane "roll" is the__________________.
3. The control surface that creates "pitch" up or down is the_________________.
4. The control surface that creates "yaw" is the___________________.
5. The part that slows the plane down and is especially used during take-offs and landings is the__________________.
6. The part that balances the plane and generates the force of lift is the

   ________________.

FPG-9 GLIDER DATA SHEET

Name(s) ____________________________________

Part A: With the rudder straight, record your observations for the following elevon positions:

1. Both elevons straight (not bent up or down):

2. Both elevons up:

3. Both elevons down:

4. Left elevon up; right elevon down:

5. Right elevon up; left elevon down:

Part B: Record your observations using the following elevon and rudder positions:

6. Both elevons straight (not bent up or down); rudder turned left:

7. Both elevons straight (not bent up or down); rudder turned to right

8. Right elevon up; left elevon down; rudder turned to the right

Part C: List two other surface control positions and record the flight results:

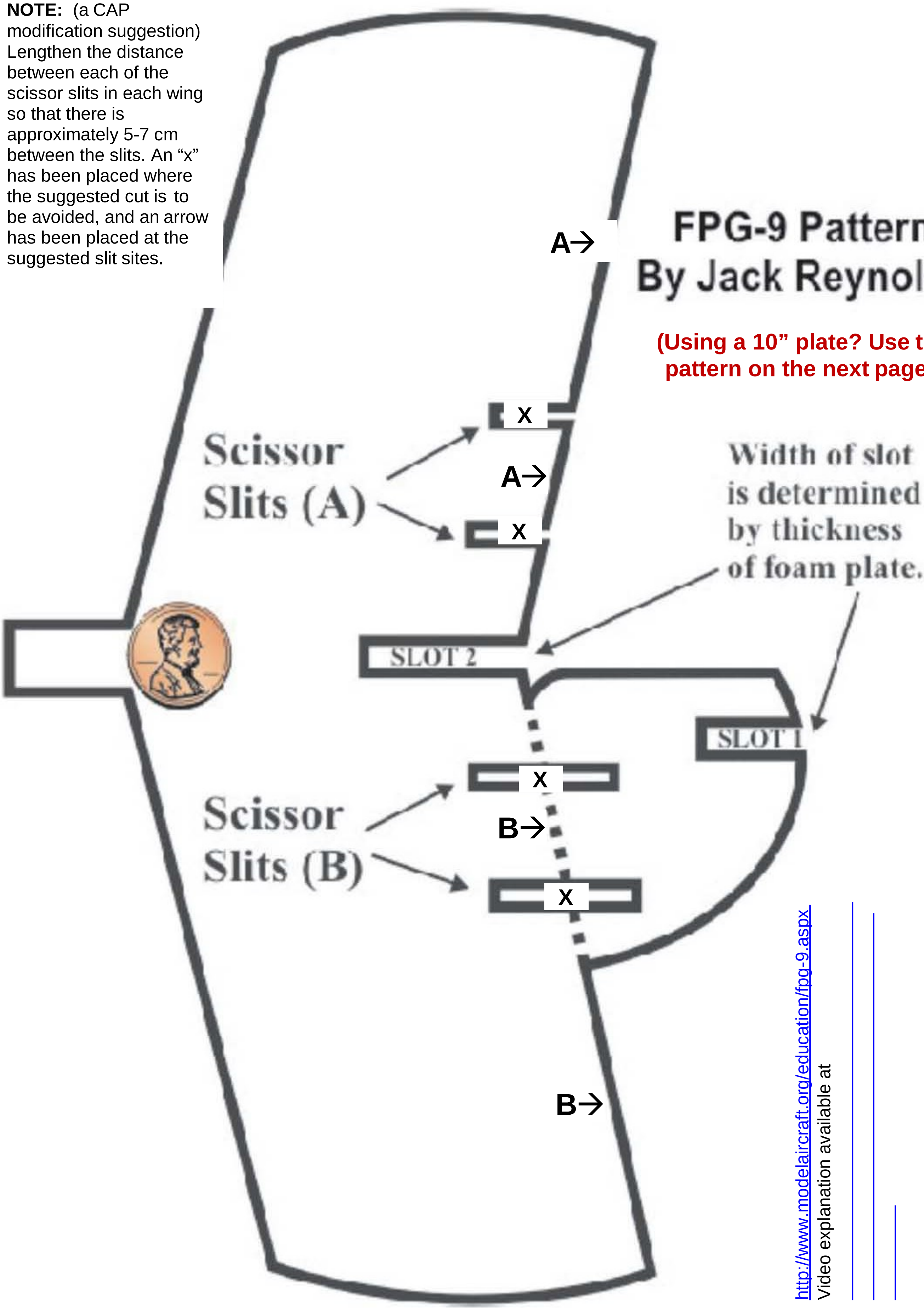
9.

10.

NOTE: (a CAP modification suggestion) Lengthen the distance between each of the scissor slits in each wing so that there is approximately 5-7 cm between the slits. An "x" has been placed where the suggested cut is to be avoided, and an arrow has been placed at the suggested slit sites.

FPG-9 Pattern
By Jack Reynolds

(Using a 10" plate? Use the pattern on the next page.)



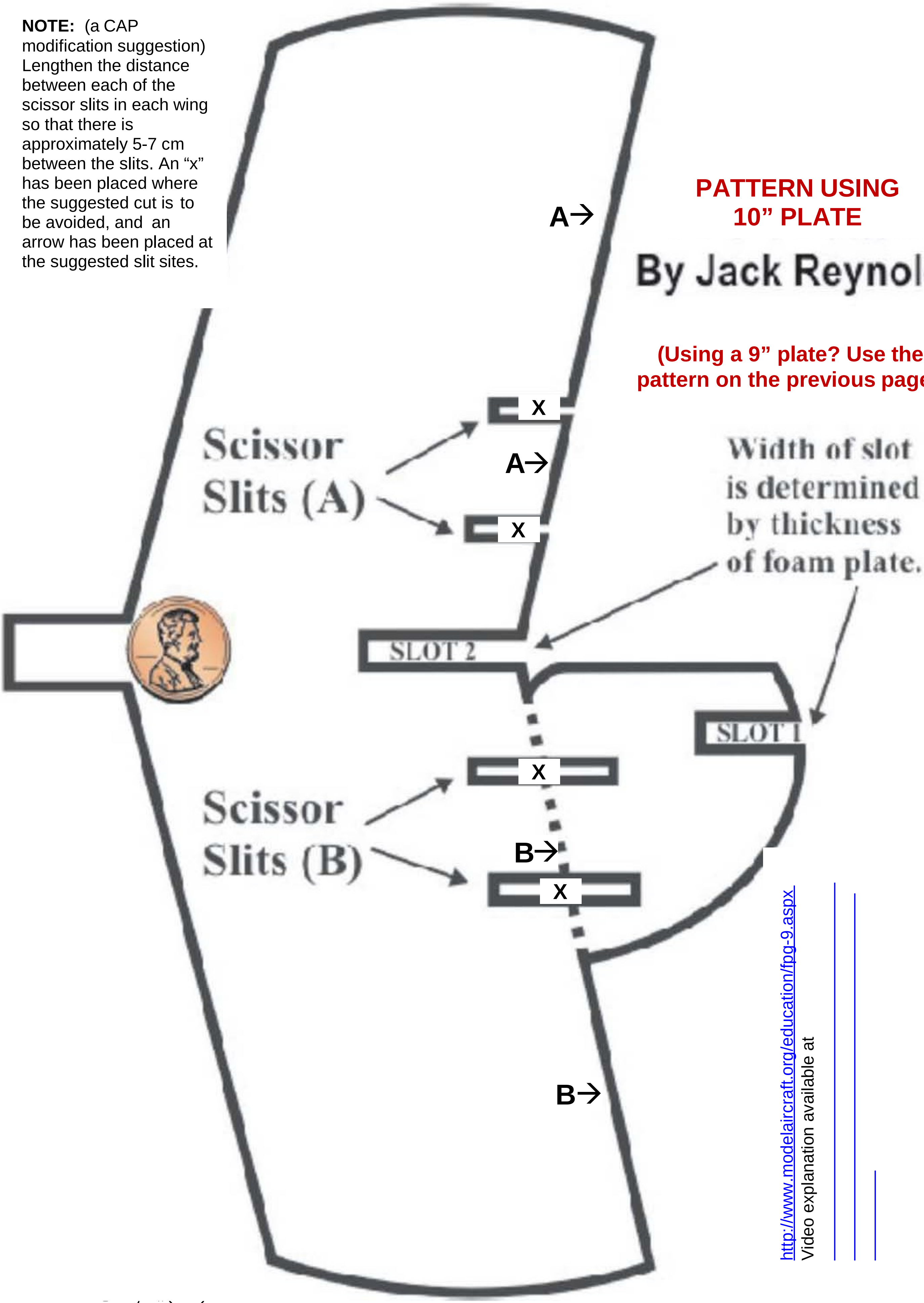
Video explanation available at http://www.modelaircraft.org/education/fpg-9.aspx

NOTE: (a CAP modification suggestion) Lengthen the distance between each of the scissor slits in each wing so that there is approximately 5-7 cm between the slits. An “x” has been placed where the suggested cut is to be avoided, and an arrow has been placed at the suggested slit sites.

PATTERN USING 10” PLATE

By Jack Reynolds

(Using a 9” plate? Use the pattern on the previous page.)



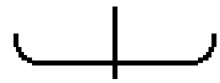
Video explanation available at http://www.modelaircraft.org/education/fpg-9.aspx

FPG-9 Control Activity Data Sheet
by Jack Reynolds

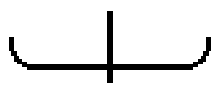
http://www.modelaircraft.org/education/fpg-9.aspx

Name____

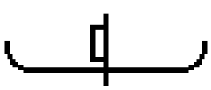
Directions: Answer the questions below. Draw pictures to aid each response. You should draw the plane from a rearview perspective, as though the plane is flying away from you and in to the paper. Remember to launch your plane with the same amount of force and at the same angle for each step in this activity.



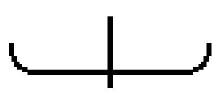
1. How would you position both elevons so the plane will loop? Draw the elevons on the picture below: (You are looking at the back of the plane.)



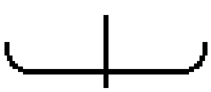
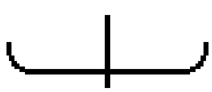
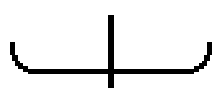
2. What happens when the elevons are neutral (they are even with the wing) and the rudder is moved to the left? (You are looking at the back of the plane.)



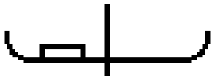
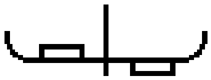
3. Place the rudder in a neutral position for the following experiment: How would you arrange **both** elevons to get your plane to fly to the left? Draw the position of the plane's elevons.



4. How can you get your plane to fly to the right? There are at least 3 possible answers. Draw a picture of the back of each plane and show the position of its control surfaces. Feel free to use combinations of the rudder and the elevons.

Collect data for these two different elevon configurations:

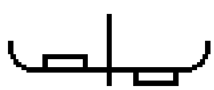
Elevon Configuration	**Flight Time (Seconds)**				**Average Flight Time (Seconds)**
	Trial 1	Trial 2	Trial 3	Trial 4	
A) 					
B) 					

5. Which configuration (A or B) is better at keeping the nose of the plane in the air? Which plane flew longer? Why did it fly longer?

6. Which configuration (A or B) has more drag? Why? What do you think drag is?

7. Refer to the following picture to answer this question: Which wing has higher pressure under it when the plane is flying? Circle your answer below:

*The **left wing** has higher pressure under it.*



*The **right wing** has higher pressure under it.*

Geobat

(enrichment/extension activity)

The idea of circular aircraft, better known today as UFO's (unidentified flying objects) or flying saucers, has been around for a long time. Swedish inventor Emanuel Swedenborg is known for the earliest design of a "flying saucer" as his idea was documented in an article entitled "Sketch of a Machine for Flying in the Air" in 1716. Since then, many people have continued to dream and work on developing a circular flying machine. During World War II, it is reported that the German scientists developed and built some circular flying aircraft. Even the U.S. military has developed and flown circular aircraft, but details about the designs, flights, and performance are vague. Today, aerospace enthusiasts still work on designs, such as Paul Moller, who is working to make a "flying saucer" a "car" of the future.

Geobat is one of several current flying saucer designs. It was designed by an artist, Jack Jones. He derived the name Geobat from its geometric design (geo) and a bat he remembered from childhood (bat). Geobat may look futuristic, but in reality, it is a flying machine. One distinct difference in its design compared to other flying saucer designs is that part of its center area has been removed. This helps reduce unnecessary weight.

Currently, Geobat can be made as a flying remote control aircraft, and the military is experimenting with its possible uses and effectiveness as a military aircraft. Could it someday be used to carry passengers, like a jet liner? Could it be used to explore other planets? Are "flying saucers" already being used by beings from other solar systems?

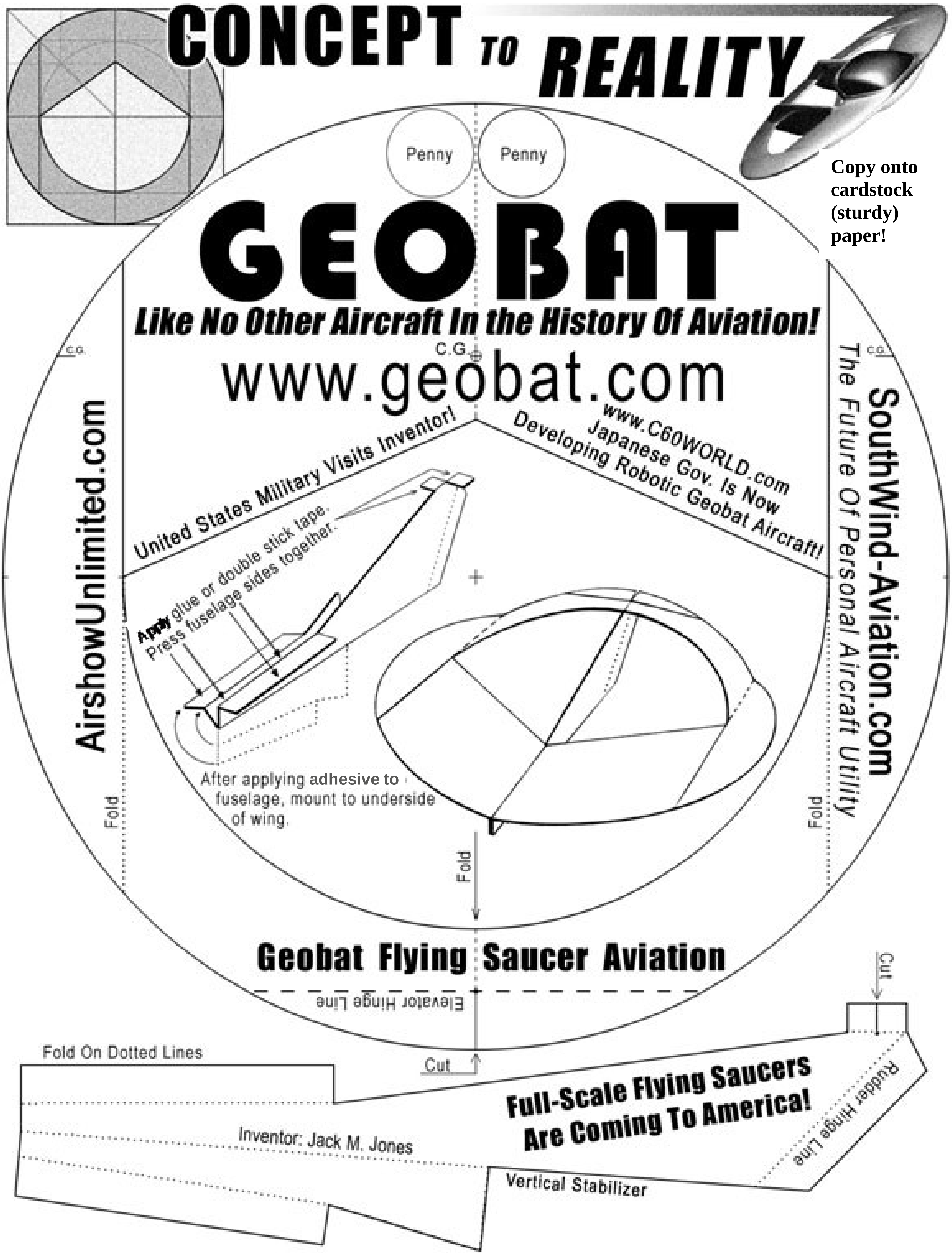
Materials:

- Geobat pattern (on previous page) for each student printed on CARDSTOCK
- scissors - scotch tape - 2 pennies per student

Instructions:

Consider watching a 5-minute video available at http://www.aerobataviation.com Distribute the Geobat pattern and guide students through the process of cutting out the pattern and assembling the fuselage to the disc according to the directions printed in the cut-out portion of the disc (as illustrated in the pictures above). Tape can be used to attach the fuselage and the pennies to the disc.

Character Connection: Robert Goddard was an early rocket scientist in the early 1900's. In 1929, he became the first person to launch a rocket using liquid fuel. He was ridiculed because of his belief and expression of the idea that traveling to places beyond Earth, such as the moon, was possible. This was not a popular or realistic idea in his time. He said, "Every vision is a joke until the first man accomplishes it; once realized, it becomes commonplace." Ask students what they think this means. Ensure that students understand that ideas perceived as being unrealistic don't mean that the idea is impossible. People tend to make fun of something or discount someone's idea until someone actually accomplishes it, and once people get used to the new invention, it becomes normal. Remind students that dreaming and trying to invent new things is a great adventure. Always pursue your dreams!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Apply glue or double stick tape. Press fuselage sides together.
After applying adhesive to fuselage, mount to underside of wing.
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Fold
Fold
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Elevator Hinge Line
Cut
Cut
Fold On Dotted Lines
Full-Scale Flying Saucers Are Coming To America!
Inventor: Jack M. Jones
Rudder Hinge Line
Vertical Stabilizer