FUTURE U.

Topic Series: Flight Path

Objectives

Students will be able to:

- **Apply** testing protocols and strategies to their plane designs
- **Analyze** the results of their tests in order to optimize their planes for minimal drag

Episode 3

Testing & Analysis—What's working? What needs to change?

Timing

45–60 minutes

Materials

- Students' airplane prototypes from Activity 2
- Flight Testing video, to project
- Testing Process handout, one per student
- One of the following for each group (of four students):
    - Testing and Analysis handout
    - Additional Flight Testing handout
    - Ruler or tape measure
    - Timer

National Standards

Next Generation Science Standards

Engineering Design

- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

ITEEA Standards for Technological Literacy

Standard 9: Engineering Design

In order to comprehend engineering design, students should learn that:

- H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Engage

- Instruct students to find their group members from the first two activities and take out their 3D airplane prototypes.
- Tell the class that, as you hinted last time, today students will be testing their prototypes. And—like the rest of the plane manufacturing process—there are many steps involved in the testing phase!
- Write the following groups across the board:
    - *Passengers*
    - *Federal Aviation Administration*
      Tip: As you write this, remind students that the FAA regulates and enforces all rules and safety guidelines for aircrafts in the United States.
    - *Environmental Scientists*
    - *Aerospace Engineers*
- Then, group by group, ask the class to brainstorm what each one might be especially focused on or interested in when it comes to testing aircraft. In other words: What might be of particular concern to airline passengers? What might the FAA most focus on, etc.?

Investigate & View

- Explain that each of the concerns that the students just stated will likely be tested and then tested again. Commercial aircraft must go through so many tests before they are certified to fly that it can take years! And the number of tests is counted every time.
- Distribute one Testing Process handout to students and read the directions provided.
- Reiterate that the handout flowchart is a basic overview of the testing cycle. As students listen to what is involved in each phase of the testing process, encourage them to take notes in the corresponding boxes.
- Then play the Flight Testing video. It may be helpful to pause at a couple points to give students a chance to jot ideas.
- When the video ends, take a moment to discuss what students have recorded in each testing phase: preparation, execution, and analysis/reporting.
- Before moving on, be sure students understand that the testing cycle is not over once the analysis and reporting occurs. Changes can and should be made to the design if it seems like the plane's performance could be improved. The process often loops all the way back to design and manufacturing until everyone is satisfied with all parts of the aircraft and its performance.

Apply

- Distribute one Testing and Analysis handout and one Additional Flight Testing handout to each group. Groups will also need a ruler or tape measure and a timer. Explain that students should carefully read the steps provided as they make their way through the testing process.
- Before they begin, take a moment to remind students that their primary goal is to create a plane design that minimizes drag as much as possible. Ask students to remind you what *drag* is, as well as how drag may affect their test flights. Be sure students understand that prototypes with less drag will likely be able

to stay in the air for longer, fly more quickly, and travel a longer distance before they reach the ground than those with more drag.

- Then show students where they can perform their flight testing and encourage groups to begin!

  Tip: An area like a hallway, lobby, cafeteria, or gymnasium may work best, but it's also possible for flight testing to occur in the classroom or outdoors.

- When the session is nearly complete, bring the class back together to analyze their results. Share and discuss:
  - Which group's plane was able to fly the fastest?
  - Which group's plane was able to fly the farthest?
- Once the class has determined which planes performed best and seemed to have the least drag, compare and contrast these plane designs with the others. Ask:
  - What similarities do you observe among the highest performing planes?
  - Which factors seemed to have the biggest impact on drag?
  - Which factors did not seem to affect drag?
- Conclude the session by asking teams to use the results of their testing to select *one* of their planes to progress to next session's manufacturing phase!

Manufacturing Checklist

Directions: The process of testing aircraft generally occurs in three phases. Each phase contains many important parts. As you watch the Flight Testing video, use the flow chart below to jot notes to help you remember what happens during each phase of the process.

Preparation

Execution

Analysis & Reporting

Testing and Analysis

Directions: Label your 3D plane prototypes as "#1" and "#2". Then follow the steps below to test both planes.

Step 1: Establish which team member will be responsible for "piloting" your planes. This "pilot" should practice throwing one plane several times—concentrating on throwing it the same way each time. Once the pilot throws it consistently (so it lands in approximately the same spot) more than three times in a row, the pilot is ready for the test flights!

Step 2: Your group will now test the flight of each airplane two different times. Each time, you will fill out all sections in the chart below. In order to do this:

- Assign one group member to observe the plane as soon as it leaves the pilot's hand. This person should draw a line to illustrate its flight path in the chart below.
- Assign another group member to time how long the plane is in the air.
- Then once the plane lands, assign a third group member to measure how far the plane traveled. You will be able to use the distance traveled and the length of the flight to calculate its speed.

Plane #1, Test Flight 1 Flight Path Illustration: Additional Observations: _____ _____ _____ _____	**Distance Traveled:** _____cm **Length of flight:** ____seconds **Speed:** ____cm/second
Plane #1, Test Flight 2 Flight Path Illustration: Additional Observations: _____ _____ _____ _____	**Distance Traveled:** _____cm **Length of flight:** ____seconds **Speed:** ____cm/second

Testing and Analysis

Plane #2, Test Flight 1 Flight Path Illustration: Additional Observations: _____ _____ _____ _____	**Distance Traveled:** _____cm **Length of flight:** ____seconds **Speed:** ____cm/second
Plane #2, Test Flight 2 Flight Path Illustration: Additional Observations: _____ _____ _____ _____	**Distance Traveled:** _____cm **Length of flight:** ____seconds **Speed:** ____cm/second

Step 3: Consider how far, fast, and straight your planes were able to fly. These can all be indicators of drag. Based on these factors, which plane seemed to experience less drag?

Why may this have been the case?

Tip: Look back on the prior activities about drag if you need a refresher!

Step 4: Then circle back to the design phase. Considering how your planes performed, what could you change about your plane design to decrease drag and increase performance? Edit your designs and then begin the testing phase again.

Use the Additional Flight Testing handout to track each of your tests. Remember to include the plane number *and* the flight number!

Additional Flight Testing

Plane #______, Test Flight ______ Flight Path Illustration: Additional Observations: ____ ____ ____ ____	**Distance Traveled:** ______cm **Length of flight:** ____seconds **Speed:** ____cm/second
Plane #______, Test Flight ______ Flight Path Illustration: Additional Observations: ____ ____ ____ ____	**Distance Traveled:** ______cm **Length of flight:** ____seconds **Speed:** ____cm/second
Plane #______, Test Flight ______ Flight Path Illustration: Additional Observations: ____ ____ ____ ____	**Distance Traveled:** ______cm **Length of flight:** ____seconds **Speed:** ____cm/second