National Aeronautics and Space Administration

STEM LEARNING:

Explore Flight: Supersonic Flight Recommendations

www.nasa.gov

BACKGROUND

The Federal Aviation Administration (FAA) sets regulations relating to United States airspace. Current rules prohibit commercial airplanes from flying at supersonic speeds over land because of the noise levels associated with sonic booms and the negative impacts to humans and animals. Despite this, supersonic travel is intriguing to airplane companies, because of the time it would save people on long flights. For example, a nonstop flight from Los Angels to New York City normally takes 5 hours. If planes were allowed to fly at supersonic speed, this time would decrease to 3 hours.

Figure 1. An artist's drawing of the X-59 flying over a landscape.

NASA's X-59 QueSST (Quiet Supersonic Technology) aircraft is the first step to changing existing regulations by demonstrating that an airplane can be designed to produce a quieter sonic "thump" instead of a disruptive sonic boom. Starting in 2023, the aircraft will fly over communities in the United States to measure sound levels and gather public perception data on the annoyance of the quieter thump. Once that data is collected, the FAA will be able to make a decision on whether or not to change existing rules and allow commercial companies to build planes that can fly at supersonic speeds over land.

CHALLENGE

The Federal Aviation Administration (FAA) makes rules about air travel in the United States, including speed and noise regulations. Airplane companies submit data about their planes to the FAA to make sure they are following the rules. As an FAA analyst, you have received raw data from several different aircraft that produce sonic booms. Your task is to analyze the data and help the FAA make decisions on how loud each plane's sonic boom will be and where it should be allowed to fly if the rules are changed.

In your groups, you will do the following activities:

1. You will analyze pressure wave data (using a graphing program) for the different types of aircraft
   a. To determine the relative loudness of the aircraft
2. Your group will rank the planes from quietest to loudest
   a. Using evidence from your graphical models to support your decision

Individually, you will:

1. Explain the evidence and reasoning for why you ranked the aircraft the way you did
   a. Using evidence from your graphs and your prior learning about sound
2. Make recommendations about where each plane should be allowed to fly
   a. Using evidence from land use data, your graphical models, and your prior learning about sound to support and explain the reasoning for your recommendations

WHAT IS BEING ASSESSED?

In this assessment, you will show that you can:

- Use graphing software to visualize and analyze the data from the five aircraft;
- Use mathematical and computation thinking to describe the amplitude and slope of air pressure data and how it relates to sound; and
- Create an argument, using evidence and reasoning to support your rankings and recommendations.

PART A: LEARN ABOUT THE HISTORY OF SUPERSONIC RESEARCH (INDIVIDUAL WORK)

1. Read (or review) "*Supersonic: The History of NASA's Sonic Boom Research.*"

2. Answer the questions below:

What did NASA research find out about how people reacted to sonic booms?

Describe how the graph of a typical supersonic airplane is different from a "low boom aircraft."

PART B: GRAPH AND ANALYZE THE PRESSURE DATA (GROUP WORK)

STEP 1: GRAPH THE PRESSURE DATA

1. Open the aircraft data file provided by your teacher.
2. Divide up the five aircraft so that each person is analyzing the data for one airplane.
3. For your airplane, select all of the data for time(s) and pressure (Pa).
4. Use your program's graphing tool to create a graph of the data.

STEP 2: ANALYZE THE DATA

1. Once all the data has been graphed, examine the graphs as a group and answer the questions below:

   Is the range of all of the axes the same (circle one): YES NO

   If the range is different, decide on a range for the Y axis and the X axis that will work for all four of the graphs. Write the range here:

   X axis range: From_____ To_____

   Y axis range: From_____ To_____

2. Change every graph's axes in the graphing program so that they are the same.
3. Make a quick sketch of all five graphs here. Don't forget a title for each graph and label your axes.

MAKE A CLAIM

Examine the five graphs in your group and answer these questions together.

Rank each aircraft from the predicted quietest to loudest:

_____ , _____ , _____ , _____ , _____

SUPPORT YOUR CLAIM

Why did you rank them this way?

Describe the specific features of the graph(s) that led your team to your decision.

PART C: SHARE YOUR RANKINGS WITH PEERS FOR FEEDBACK AND REVISE (GROUP WORK)

Discuss your ranking with the rest of the class

Write down anything you hear that might help you revise your own ranking or is a good example of evidence or reasoning in the space below.

REVISE YOUR GROUP RANKING BASED ON FEEDBACK FROM YOUR CLASS DISCUSSION

Final rank each aircraft from predicted quietest to loudest:

_____ , _____ , _____ , _____ , _____

PART D: EXPLAIN YOUR CLAIM WITH EVIDENCE AND REASONING (INDIVIDUAL WORK)

The public wants to know more about how the FAA uses data to set rules about aircraft noise. Explain how you ranked the airplanes from quietest to loudest. Be sure to talk about how the evidence you used to make your recommendations makes your argument strong (reasoning).

PART E: RECOMMENDATIONS FOR FUTURE REGULATIONS (INDIVIDUAL WORK)

Right now, the FAA's rules for where supersonic aircraft can fly are based on speed, not sound levels. If the FAA changes the way it sets the rules for supersonic travel, airplane companies will be able to fly some supersonic jets over land as long as they are below a certain sound level. As an FAA analyst, you've been asked to make recommendations about where each of the planes could fly if the rules are changed.

ADDITIONAL INFORMATION

Table 1. Current FAA regulations on sonic boom noise.

14 CFR § 91.817 - Civil aircraft sonic boom.
§ 91.817 Civil aircraft*sonic boom.
(a) No person may operate a civil aircraft in the United States at a true flight Mach number greater than 1 except in compliance with conditions and limitations in an authorization to exceed Mach 1 issued to the operator under appendix B of this part.
(b) In addition, no person may operate a civil aircraft for which the maximum operating limit speed MM0 exceeds a Mach number of 1, to or from an airport in the United States, unless -
(1) Information available to the flight crew includes flight limitations that ensure that flights entering or leaving the United States will not cause a sonic boom to reach the surface within the United States; and
(2) The operator complies with the flight limitations prescribed in paragraph (b)(1) of this section or complies with conditions and limitations in an authorization to exceed Mach 1 issued under appendix B of this part.
* *Note: Military jets are not "civil aircraft" and therefore aren't covered by these rules, but they mostly follow FAA rules while in U.S. Airspace. There are, however, designated zones in the U.S. where military jets are allowed to travel at supersonic speeds mostly for training missions. These designated zones are usually over non-populated areas, such as the one just north of Los Angeles in the Southern California desert. Military jets have also flown over land at supersonic speeds during national emergencies or during national security incidents.*

ADDITIONAL INFORMATION CONTINUED

Table 2. U.S. Department of Agriculture (USDA) major land use types in the United States.

Land Use Type	Description	Density of Human Houses	Density of Man-Made Structures
Pasture/Rangeland	Grasslands, shrublands, woodlands, wetlands, and deserts that are grazed by domestic livestock, such as cows or sheep, or wild animals.	Low	Low
Forest	Areas of land that are dominated by trees	Low	Low
Cropland	Areas of land that are used to grow crops for humans or animals such as corn, soybeans, and wheat	Low	Low
Special Use			
Natural Areas	National parks, state parks, wildlife areas	Low	Low
Public Infrastructure	Highways, railroads, military bases, airports and a few others	Low	High
Miscellaneous	Cemeteries, golf courses, marshes, deserts, and other areas of "low economic value."	Low	Low
Urban	Areas of land that are dominated by human settlement such as cities, towns, or suburbs	High	High

MAKE A CLAIM ABOUT WHERE EACH AIRCRAFT SHOULD FLY

Fill in the table below with your recommendations. Make a check in each box where you think that aircraft should be able to fly.

	Pasture	Forest	Cropland	Natural Areas	Public Infrastructure	Misc.	Urban
Military Jet	☐	☐	☐	☐	☐	☐	☐
Business Jet	☐	☐	☐	☐	☐	☐	☐
Small Supersonic Airliner	☐	☐	☐	☐	☐	☐	☐
Large Supersonic Airliner	☐	☐	☐	☐	☐	☐	☐

SUPPORT YOUR CLAIM WITH EVIDENCE AND REASONING

Explain how you made your recommendations. Be sure to talk about how the evidence you used to make your recommendations makes your argument strong (reasoning).

National Aeronautics and Space Administration

Headquarters
300 E. Street, SW
Washington, DC 20546

www.nasa.gov

NP-2019-10-2778-HQ