National Aeronautics and Space Administration

STEM ACTIVITY:
Prioritize Your Flight

Grades 9–12

www.nasa.gov

PRIORITIZE YOUR FLIGHT

SUMMARY

In this activity, students will learn about NASA's research in aviation and the work that is being done to create a sustainable future in flight for us all. Students will look at a list of considerations for the ideal flight, from wing design to the number of seats on board. While working in groups, students will rank their preferences from most important to least important and defend their choices to the rest of the student groups.

Grade Level: 9-12

Materials Needed:
- Student Handout (1 per group)
- Writing Utensil
- Scissors

Time required: 45–60 minutes

OBJECTIVES

Students will:
- Analyze and determine features of an aircraft that will create the least number of environmental impacts while maintaining comfort for passengers.
- Defend their choices with valid arguments.

SAFETY NOTE

Scissors and craft knives have sharp edges and points. Students should handle tools with sharp edges with care.

BACKGROUND

Overview

Aviation is a constantly changing industry that impacts all parts of our society even if you don't realize it. The ability to quickly move people and materials between locations using planes is unmatched. The industry has long been an essential part of our global economy and provides millions of jobs including but not limited to pilot, ground pilot, civil engineer, mechanic, and computer engineer.
As the price of fossil fuel fluctuates so does the price of packages or cargo being delivered between local or international destinations. Companies pass on/charge these expenses to their customers, increasing the price people pay for goods. Fuel increases may also impact tourism and a family's decision on whether they will have a family vacation.

In response to the dynamic price of oil, airliners have developed fascinating/creative methods to save money on fuel costs by reducing weight on their daily flights. A lighter aircraft lowers fuel consumption and minimizes carbon emissions on the environment. Even though many of these changes seem very small, they make a huge impact.

Common ways airlines have saved money by reducing fuel consumption:

- Lighter Magazines: One airline saved 170,000 gallons of fuel a year, or $290,000 in annual fuel costs by printing in-flight magazines on lighter paper. The airline operates over 4,500 flights per day, therefore the weight reductions on their daily flights reduced their fuel costs.
- Plastic Straws: By going straw-less another airliner reduced its impact on the environment through its initiative to reduce the amount of plastic used onboard its planes. The airliner flies over 6,700 flights per day. Eliminating straws on their flights reduced transporting as much as 70,000 pounds of plastic per year. Ditching the straws also saves oceans from this waste.
- Thinner Seats: Although removing seat cushioning may sound demeaning to the passenger experience, it can be just as accommodating. Removing some of the extra cushioning from the airline seats has saved space and weight for several airlines.
- Lighter Drinking Carts: An airline can have thousands of flights a day and bulky items aboard a flight means more fuel consumption. Many airlines have taken initiative to lighten cargo by lightening their drink carts.
- Slice and Dice: As outrageous as it sounds, the way a lime is sliced makes a huge impact on fuel consumption. Slicing limes into 16 pieces instead of 10 reduces the number of limes aircraft transport for in-flight concessions by almost half.
- Lighter Utensils: Some airlines have created a new line of utensils that are 11% lighter than the previous products used which has saved airlines thousands of gallons in fuel costs.

The air transportation industry has instituted creative ways to save on fuel costs and minimize its impact on the environment, but how is NASA making aircraft more sustainable using new, green technologies?

Sustainable Aviation

NASA is on a mission to protect the planet while continuing our growth in aeronautics technology. One of NASA's priorities is minimizing the impact that passenger planes have on the environment. NASA and industry partners are expanding research for sustainable aviation by developing and testing new green technologies for next-generation aircraft to accomplish aviation's goal of net-zero emissions by 2060. These future aircraft will be quieter, safer, and longer range, while offering cleaner air. Airlines will also be able to offer cheaper flights due to lower weight which equals less fuel consumption.

Hybrid–Electric Propulsion

NASA is leading the evolution to the maturity of hybrid–electric propulsion for aircraft—a game-changing development that will reset how aviation is powered. Hybrid–electric propulsion is an exciting development area that uses either fuel-fed engines, electrically driven fans, or a combination of both systems to propel the aircraft during various phases of flight. Think of a flying hybrid car. Although electric power is more sustainable than gas, larger aircraft require more thrust to get into the air and for landing, and at this point can only be generated with gas turbine engines.

Transonic Truss-Braced Wing

NASA is ground testing a promising revolutionary transonic truss-braced wing (TTBW) configuration that will achieve much higher levels of aerodynamic efficiency than possible with today's aircraft. Adding trusses to the wings helps support the wings, allowing them to be longer and thinner than conventional wings. This helps reduce drag, meaning that the plane burns less fuel while flying. Historically, swept-back wings increase the stability of the plane. They also reduce turbulence when flying at different speeds and can be made thin to reduce friction from airflow over the wings. https://youtu.be/Wqh_ihyKpQY

Figure 1: Transonic truss-braced wings can help reduce fuel consumption by up to 10 percent. (NASA)

Smart Vortex Generator

For several years, NASA's aeronautical innovators have been working to create "smart" vortex generators activated with shape-memory alloys. Testing of this new technology began on the ecoDemonstrator in late 2022. If this works well, the vortex generators can then be used widely in aviation. Vortex generators are small, fin-like components on an airplane's exterior to help improve aerodynamic performance by guiding airflow around it. This improved airflow can help an airplane be quieter and more fuel efficient. Current vortex generators are fixed in place and do not move. Therefore, the effect they have remains the same in every condition an airplane flies in. If vortex generators could change shape, however, an airplane's performance could be tailored to a variety of flight conditions. These next-generation vortex generators will be able to change shape at different altitudes, temperatures, and speeds to improve an airplane's performance and help it adapt better in flight, which will reduce fuel consumption.

Advanced Composites Manufacturing Technologies

Engineers are also developing advanced composite materials and advanced engine technologies based on breakthrough NASA innovations. Many external airplane components are constructed of metal alloys, although composites made of materials such as carbon fiber and a variety of fiberglass resins are becoming more popular as technology improves. NASA's new techniques for large-scale manufacturing of composite materials will revolutionize the future of aviation!

Figure 2 Magnetic Ribbon: New magnetic materials enable vehicle electrification by operating at higher frequencies and temperatures with low power loss.

INSTRUCTIONS

People have many choices in the products they buy. People choose products for different reasons. Consumers make choices based on price, quality, available features, brand preference, and many other factors. What factors affect the choices of available products or luxuries available in flight? Who chooses what features are included in planning the ideal flight on an aircraft?

Each group will:
Cut apart the pictures and lay them face up on the table.

As a group, choose the top 16 features you would use in the planning of your ideal flight. Place them on the Design Chart from most important to the least important, where 1=most Important and 16=least Important.

Write out the list of items below.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

Repeat this activity from the perspective of a NASA engineer.
Because NASA is working towards reducing energy and emissions, it is important to understand why certain features or characteristics of an aircraft exist in their current form. For this round, when your group places the cards in order, make sure you prioritize the goal of reducing energy and emission since you are a NASA engineer.

Thinking about this from an engineer's point of view there are other factors to consider: materials, cost, customer comfort, etc. Discuss with your team what features you might consider when planning the ideal flight as an engineer. (In the extension, below, you can continue to explore from other points of view. You may even want to give each group a different point of view to do the activity from if you have multiple groups).
Place the pictures on the Design Chart from most important to least, where 1=most Important and 16=least Important.

When your group has come to Its final decision, on the Ranking Chart, list your top 16 features and why that option is important. Be sure to reference the Pro and Cons sheet to defend your reasoning.

Discuss the questions as a group and record your answer.

What items (consider all cards) would need to be sacrificed to improve fuel efficiency? Why? To improve passenger experience? Why?

Compare your list from round 1 to your list from round 2. Note the differences between your lists and provide possible reasons for them.

Provide a brief summary of your experience using different perspectives to prioritize your ideal flight. Include details such as how did your focus change from the passenger to the NASA engineer? Which role required more strategic thinking vs impulsivity? Which priority list was easier to create? Why? How do you think the different perspectives work together to create flights as we know them today?

DIFFERENTIATION AND GOING FURTHER

Reduce the number of feature choices given to the students,
Reduce the number of feature choices that need to be prioritized.

Extension

Have students create feature cards based on their own research and Ideas.

Have groups exchange the new feature cards and complete the activity using the new feature cards.

Break students into teams, where each team has a different priority (one team is made of engineers, another is made of paying customers, another is made of an environmental organization, and another is a marketing team). Each group will pick different items according to their priority and a larger discussion can take place about why priorities would be different.

Research Aeronautics careers now and upcoming careers to support the future of Aeronautics.

STANDARDS

Next Generation Science Standards

Disciplinary Core Ideas

- HS-LS2-7 Ecosystems
- HS-ESS3-4 Earth and Human Activity

Crosscutting Concepts

- H Influence of Science, Engineering, and Technology on Society and the Natural World

Science and Engineering Practices

- HS-ETS1-1 Engineering Design
- HS-ETS1-2 Engineering Design
- HS-ETS1-3 Engineering Design

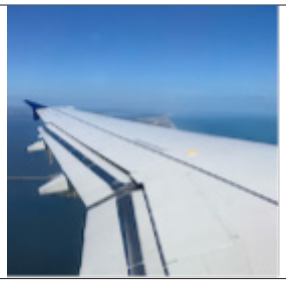
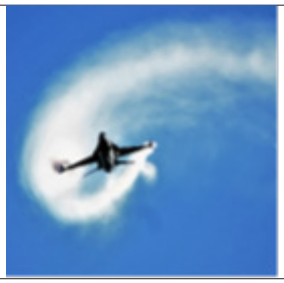
Design Chart

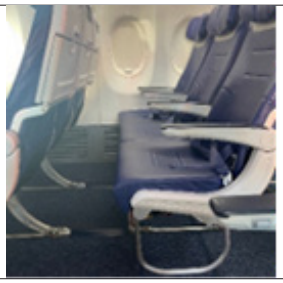
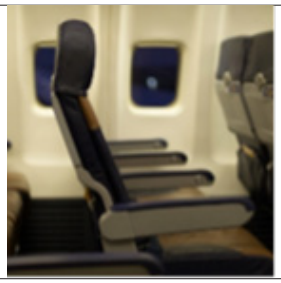
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

Ranking Chart

Item	Reason for the rank/potential purpose for selection: Why is this item important?
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	

Airplane Features

			
Screen in Seatback	Snacks	Intercom	Wing Design
			
Lighter Aircraft Structure	More Fuel Efficient	Charging Station	Overhead Lighting
			
Alternative Fuel	Less Emissions	Seat Arrangement	Number of People
			
Drink Cart	Less Noise Pollution	Air Vent	Reading Light

			
Hot Water Systems	**Cost of Overhead Luggage**	**Coffee**	**In-Flight Meals**
			
Bathrooms	**Cost of Ticket**	**Leg Room**	**Reclining Seats**
			
Cost of Checked Bags			

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