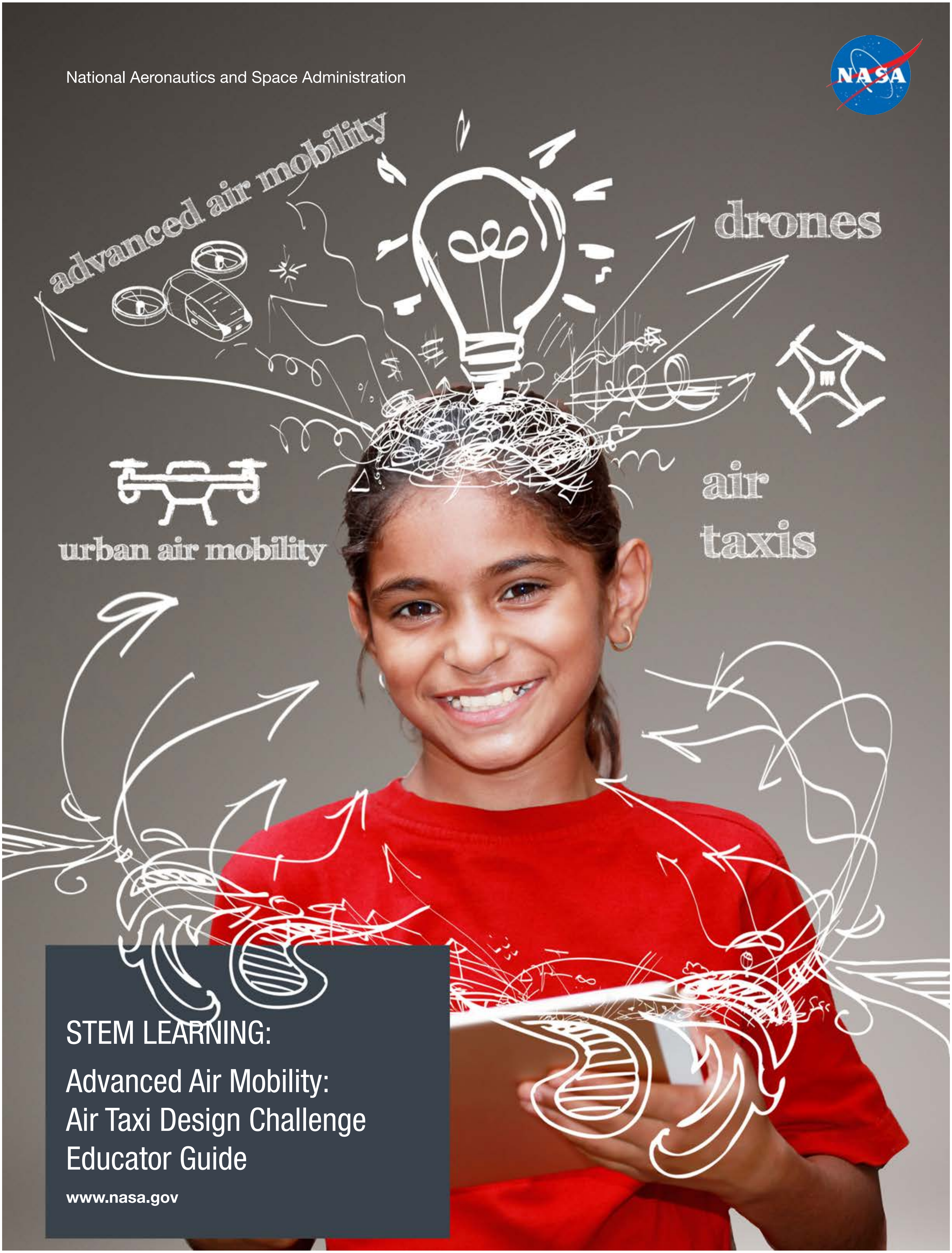
National Aeronautics and Space Administration



STEM LEARNING:

Advanced Air Mobility: Air Taxi Design Challenge Educator Guide

www.nasa.gov

OVERVIEW

In this lesson, students use what they know about the science behind quadcopters to participate in a challenge to design and build a model of an air taxi. They will be asked to evaluate their final design and the designs of their classmates, and then present their final design to the class.

Objectives

Students will be able to:

- Evaluate the effectiveness of an air taxi based on a list of design considerations
- Work in teams using the engineering design process to design and build a model of a flying air taxi
- Propose a final design and support their proposal with reasoning

Student Prerequisite Knowledge

Before beginning this lesson, students should be familiar with:

- The science behind quadcopters (NASA's Aeronautics Research Mission Directorate has a lesson about this as part of the Advanced Air Mobility (AAM) STEM Module)
- The engineering design process

Standards

Next Generation Science Standards

Disciplinary Core Ideas

- NGSS.MS.PS2.A Motion and stability: forces and interactions
  - Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Cross Cutting Concepts

- Patterns

Science and Engineering Practices

- Developing and using models
- Constructing explanations and designing solutions
- Obtaining, evaluating, and communicating information

Materials

Each group requires the following materials (that can be modified as needed):

- Tape
- Cardstock/cardboard
- Scissors
- Glue
- Paper
- Paper clips
- Craft sticks
- Foil
- Student handout(s)

Preparation

- [ ] Print one student guide for each student
- [ ] Gather all materials and place in a central location (or you can give each group a specific amount of each material)

Grouping Students

This activity can be completed either as a team or individually, depending on time and preference. Grouping strategies during the design challenge can be used to efficiently break up student tasks, help promote student engagement, and appeal to a variety of learning styles and student strengths. To maximize student input within groups, it is recommended that students individually develop and create a sketch of a design before getting into groups. Here are some recommended group roles for this activity:

- **Project manager**—keeps the team on task, asks clarifying questions of the teacher, and assists in all group tasks.
- **Drafter/sketch artist**—makes technical drawings of the proposed, built, and final designs and assists in all group tasks.
- **Technical writer**—records how the design meets the requirements and assists in all group tasks.
- **Engineer**—collects materials, coordinates the building of the model, consults earlier assignments/activities as needed to inform the design process, and assists in all group tasks.
- **Spokesperson**—shares the group's design with the class (explaining how it meets the requirements and justifying the group's design choice) and assists in all group tasks.

Teacher Background

A country's airspace is defined as the portion of the atmosphere controlled by that country. To ensure the safety of aircraft traveling through United States airspace, a nationwide air traffic control system has been put in place. NASA played a major role in developing and implementing this system and remains active in helping the transition to a new modernized air traffic control system. For decades, the United States has used a radar-based system but is currently transitioning to a satellite-based system that will make air travel safer and more efficient.

Figure 1. Air traffic in the future will include higher quantities of smaller vehicles than today's air traffic.
Credit: NASA, Lillian Gipson

Apart from takeoff and landing, the planes and helicopters flying in the airspace usually fly at high altitudes. They are usually powered by petroleum based fuels and travel long distances. Now, however, a new generation of aircraft has begun to arrive. These new aircraft are smaller, fly lower than traditional aircraft, are electrically powered, and cover relatively short distances. They range in size from small quadcopter style drones up to vertical takeoff and landing (VTOL) vehicles capable of carrying people. Because of the nature of these aircraft, our air traffic control system cannot effectively control them. They are too small and they fly at low altitudes in both urban and rural areas. These factors impede the ability to track the aircraft using radar signals.

According to recent NASA-commissioned market studies, by 2030 there will be as many as 500 million flights per year for package delivery services and 750 million flights per year for air taxi/metro services. AAM is the air traffic management system that helps ensure this new airspace is safe and efficient.

Air taxis are small, battery powered VTOL aircraft that transport between two to five passengers at a time. They can transport passengers within a city, around urban areas, or between the two. When operating in urban areas, landing and taking off from a street is not realistic. Instead, locations for these aircraft to fly to and from will need to be established. One concept is a series of vertiports, locations where aircraft can land and take off vertically, located throughout the city. These can be standalone buildings or built on rooftops of existing buildings.

Safety, environmental impact, noise level, and consumer confidence are all critical for air taxis to become a viable mode of transportation. NASA and its partners continue to work on developing and improving air taxis in all of these areas.

TEACHER DIRECTIONS

1. Use a warm-up or other method to engage students in discussion about AAM. Refrain from showing students videos or pictures depicting conceptual designs for air taxis, as this could impact student designs. The student guide's “Background” section is intentionally vague to prevent bias to students' design decisions.

2. Introduce the students to the concept of battery-powered air taxis capable of carrying up to five passengers.

3. 3.Lead the class in a brainstorming session to establish the requirements for an air taxi (safety, environmental impact, noise, urban and rural accessibility, etc.). Synthesize ideas to develop a list of requirements each design must meet. It is important to include passenger capacity and power source as requirements. Limit the final list to these two and up to five more requirements, so as not to overwhelm students. Questions to help you facilitate these questions are included on the next page. These questions are not the only possible requirements that students might want to address.

4. Have students work independently, using pages 1 and 2 of the student guide, to conceptualize an air taxi that meets the requirements.

5. Place students into groups.

6. Each team member should share their design with the group. Once all members of a group have shared, the team should work together to develop a design. It can have components from all or some of the group members' individual designs.

7. Give groups about 20 minutes to design and sketch their air taxi, ensuring it meets each of the requirements.

8. Since these designs and the final models will not be operationally testable, pair up groups and have them share with each other. Encourage groups to question each other so any design weaknesses can be determined and addressed.

9. Give students about 20 minutes to redesign as necessary. Each group should then sketch, explain, and build a model of their final design.

10. Give each group 3 minutes to have their spokesperson share their design with the class.

11. After each group has shared their design, have students individually answer the reflection questions found in the student guide.

12. If time permits, show the students examples of air taxi designs that are being considered or produced. An internet search will provide examples. Have the students see how these designs compare with the ones they designed.

IDEAS FOR AIR TAXI REQUIREMENTS

- Passenger capacity—Is it a single passenger air taxi or can it carry more?
- Power source—Gas burning combustion engines create a great deal of pollution and there are likely to be many air taxis. Which alternative power source is the way to go?
- How will it land and takeoff? Keep in mind that in a city, there aren't runways, so it needs to land and takeoff vertically (like a helicopter).
- How large will it be? This is related to passenger capacity, but it's important to think about overall size, especially given the crowded nature of urban environments.
- Speed and range—How far does it need to travel? How fast can it go to get there? Would the system to allow vertical landing and takeoff be able to move it fast enough?
- Safety requirements—What happens if it loses power while flying? How can it avoid obstacles and other vehicles? How can passengers get on and off safely if there are rotating propellers?
- Noise level—How can the noise it creates be controlled?
- Location—Is it urban, rural, or will it fly in both locations? What weather or terrain obstacles would the location present?

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EP-2020-04-520-HQ