FUTURE U.

Passenger Air Vehicle

Objectives

Students will be able to:

- **Compare** and **contrast** eVTOLs with other flying vehicles
- **Collaborate** and **create** a recommendation for how eVTOLs could benefit society
- **Develop** thoughtful questions that challenge their peers' recommendations

Overview

Students will join a team at Boeing who have been tasked with communicating the potential of eVTOLs (Electric Vertical Takeoff and Landing Vehicles) to state governments around the country. After learning about New Hampshire's recent legislation that allows flying cars, students will work in groups to research how eVTOLs and Boeing's PAV (Passenger Air Vehicle) compare to other flying vehicles. They will then collaborate to create a presentation for their state government that not only compares and contrasts eVTOLs with helicopters, airplanes, cars, and flying cars, but also highlights why eVTOLs may be beneficial to society and the environment. As students pretend to present to their state government, their peers will be challenged to pose questions from the opposite point of view.

This lesson focuses on the following

Engineering Design Process

- Defining the problem
- Designing solutions

21st-Century Skills

- Communication
- Collaboration
- Critical thinking
- Creativity

Timing

Two 60-minute class periods

Materials

Day 1

- Device with the ability to project, one for the instructor
- Devices with Internet access, at least enough for half the class
- Aviation Today article: one per student
- Handout 1: Vehicle Research, one per student

Day 2

- Completed handouts from Day 1, one per student
- Handout 2: Presentation Outline, one half-sheet per student

Have you ever wondered…

How are Electric Vertical Takeoff and Landing Vehicles (eVTOLs) unique from flying cars?
There are a few key differences between eVTOLs and flying cars. Flying cars are designed for personal use. They can drive on roads, like regular cars, as well as fly. Because they are designed more like airplanes, they need a runway to take off and land. Critics say that because flying cars are designed to both drive and fly, they have trouble doing either efficiently. This can be at least partially attributed to their weight.

eVTOLs, on the other hand, are designed for shared use and are not meant to be owned by individuals. They are not cars and will not drive on roads with other land vehicles. Rather, they will fly on air highways designed by the Federal Aviation Administration. Because eVTOLs are designed more like helicopters, they will not need a runway to take off or land. Unlike flying cars, which are more likely to rely on fuel to run, most eVTOLs will be electric, which may make them "quieter, cheaper, safer and more sustainable." [1]

Is there legislation surrounding eVTOLs in the United States?
Whereas the European Union Aviation Safety Agency (EASA) recently published its "Proposed Means of Compliance with the Special Condition VTOL," which begins to outline the certification process that eVTOLs will have to undergo in Europe, the United States is taking a different approach. Rather than publishing one document of regulations, the FAA will be assigning certification standards based on each particular aircraft and its intended use. A passenger taxi, for instance, is likely to have very different stipulations than an unmanned aircraft designed to operate in remote areas. The FAA is encouraging companies with eVTOL designs to contact them as early as possible so they can help guide the designers and work together on its certifiability from the very beginning.[2]

Make Connections

How does this connect to students?

The transport that will be available to students in five years, ten years, and more is uncharted territory.

From personal air vehicles to flying ambulances, hoverbikes, and all variations of flying cars…what once seemed futuristic may become students' reality.

While the ideas are varied, there are some shared themes among the innovations. Some of the most common themes in this ever-evolving technology are autonomy, electrification, and smart technology. eVTOLs, which students are learning about in this lesson, can fall in all three of these categories.

The future of transportation will affect the world at large—including careers, travel, and how people get around in their everyday lives. It is therefore important for students to be aware of these potential changes, trends, and innovations as vehicles, highways, skies, and urban areas shift and evolve.

How does this connect to careers?

Software Engineer: Software engineers develop software and systems for everything from games and business applications to drone and eVTOL operating systems. Once they have determined the software needs, they design, develop, and test their system according to the user's specifications.

Flight Test Engineer: Flight test engineers work with all kinds of aircraft. They determine what data needs to be collected during flight and they plan test flights to ensure they will collect the needed data. In addition to testing for different performance variables, Flight test engineers must also ensure that the aircraft meets Federal Aviation Administration (FAA) regulations.

Systems Engineer: Systems engineers work closely with engineers across many disciplines to design reliable and safe systems for all kinds of aircraft, including eVTOLs. These engineers must ensure that their systems are compliant with all regulatory requirements.

How does this connect to our world?

As means of transportation have evolved over the years, people and goods around the world have been able to travel farther and farther distances.

Now, the focus is not only on distance and speed but on how air travel can be used to efficiently and sustainably get people from Point A to Point B at any distance. Along these lines, companies around the world are investing in the research and development of flying taxis.

According to a senior industry analyst at Frost & Sullivan: "Air taxis are definitely the next phase of mobility. Urban centers across the globe are struggling to come to terms with the rising vehicle numbers and the resulting congestion, especially during peak traffic hours. When air taxis become widely commercialized, they will definitely ease the traffic burden on city roads. They will usher in a nimble form of intracity travel, transporting people on the shortest possible route between two locations."[3]

Congested cities like Tokyo, New York, Mumbai, Sao Paolo, Mexico City and more may be transformed if they can shift some of their transportation to the skies.

Sources

[1] "Will New Hampshire's Landmark 'Flying Car' Bill Lay the Groundwork for Air Taxis?" Aviation Today. aviationtoday.com/2020/08/04/will-new-hampshires-landmark-flying-car-bill-lay-groundwork-air-taxis/.

[2] "EASA and FAA eVTOL Standards: Two Approaches, One Objective". EVTOL.com. evtol.com/opinions/easa-faa-evtol-standards.

[3] "The flying taxi market may be ready for takeoff, changing the travel experience forever." CNBC. https://www.cnbc.com/2020/03/06/the-flying-taxi-market-is-ready-to-change-worldwide-travel.html.

Blueprint for Discovery

DAY 1

1. Begin the class session with a game of Three Truths and a Lie. Tell the class that you are going to read them four statements—three of which are true and one of which is a lie. They will have to decide which one is *not* true.

   Read through the following statements twice. The first time, encourage students to listen carefully. The second time, invite them to raise their hand when they believe the "lie" is read.

   - Statement #1: It is now legal to own and drive roadable aircraft (otherwise known as flying cars) in at least one state.
   - Statement #2: New Hampshire is the first state to allow flying cars.
   - Statement #3: Requirements for driving a roadable aircraft include having a regular driver's license and abiding by the Federal Aviation Administration's rules.
   - Statement #4: All roadable aircraft must take off and land from a suitable airstrip, not a public roadway.
   - Once students have cast their votes, share that it *is* true that New Hampshire recently passed a bill that makes it legal to own and drive flying cars! Toggle between some of the leading flying car brands (such as Samson Sky and Terrafugia) and explain that New Hampshire is currently the only state to allow such vehicles. In order to drive a flying car, you not only need to follow FAA standards, but you also need a valid pilot's license. You will also be required to take off and land from designated runways.
   - Therefore, Statement #3: *Requirements for driving a roadable aircraft include having a regular driver's license and abiding by the Federal Aviation Administration's rules is the false statement!* Everything else is true.

2. Move on and explain that you are visiting today to invite students onto a team at Boeing related to a similar topic area. Explain that Boeing has been working on an innovative vehicle called the Passenger Air Vehicle or PAV. While it has similarities to flying cars, it will also be very different. Boeing would like the students' help in spreading the word about these vehicles and their potential!

3. Pull up aurora.aero/pav-evtol-passenger-air-vehicle and introduce students to the PAV. Ask a student volunteer to read aloud all of the text above the webpage's video. Then scroll down to watch the video together. When the video is complete, call on another volunteer to read the text below the video.

4. Then write the term "eVTOL" on the board. Explain that, as the video stated, the PAV is an eVTOL—or an electric vertical takeoff and landing vehicle. Though many people are using the term eVTOL and flying cars interchangeably, explain that they are actually very different. Whereas New Hampshire passed legislation to allow flying cars, they did not pass legislation that allows eVTOLs like the PAV.

5. Pass out one copy of the *Aviation Today* article to each student. Ask students to turn to a nearby peer and read the article aloud together. Instruct them to stop reading after the four bullets that end with "realize their capabilities."

   As they read, pairs should look for details that explain some of the key difference between flying cars and eVTOLs like the PAV. Instruct them to annotate (highlight or underline) the text for these details.

6. Once about five minutes have passed, lead a quick discussion around the focus question. Be sure students understand that a couple of the biggest differences between eVTOLs and flying cars include:

   - eVTOLs will only fly; they will not drive on roads like regular cars. Flying cars will be able to do both.
   - eVTOLs are not designed for personal use. Flying cars are designed for personal use.

7. Now that students understand the main differences between these two types of vehicles, explain that they are ready to begin research that will prepare them to spread the word about eVTOLs. Explain more specifically that students will be preparing for a presentation to their state government that compares and contrasts eVTOLs with other flight vehicles *and* highlights their benefits. In order to prepare students for the activity:

   - *Distribute Handout 1: Vehicle Research* to each student. Explain that this handout is designed to help students organize their research and record their notes.
   - Review the vehicles listed on the left side of the handout, as well as the websites provided. Explain that these are the vehicles that students are required to research. They should begin their research by using the websites provided.
   - Tell the class that they likely will not be able to find all of the answers on these websites; these are just starting points. For some of their answers, students may use their background knowledge (e.g. most students can probably already describe that airplanes need a runway to take off and land). For other answers, they may complete additional Internet research.
   - Divide students into pairs and place pairs together to form groups of four. Encourage one pair to begin their research from the top of the chart and one pair to begin their research from the bottom of the chart. They will then reconvene at the end of the class session and share their notes with each other.
   - Answer student questions as needed. Then deduct about 10 minutes from the end of the class session and explain pairs will have this much time to complete as much research as they can.

8. When there are 10 minutes left in the class session, instruct pairs to join their group members and use the time remaining to share what they have learned. As pairs share, the other students in each group should take notes so their handout is complete by the end of the class session.

9. As class wraps up, either collect the students' work or instruct them to keep it in a safe place until the following class session.

DAY 2

1. Begin class by welcoming students back to Boeing's eVTOL team. Explain that today is an important day: Later today, students will be presenting to their state government. In order to convince the government to allow eVTOLs in their state, students will introduce eVTOLs and the PAV, explain *how* vehicles like the PAV should be used, and *why* their usage would be beneficial.

2. Distribute *Handout 2: Presentation Outline* (half sheet) to each student and review the presentation criteria. Further explain that:

- Students will work in their groups of four to prepare and present. Each student must speak during the presentation.
- Presentations should be concise and no more than two minutes long.
- As groups present, the rest of the class will pretend to be state government officials.
- Groups will have about 30 minutes to prepare and practice their presentations.

Once you have answered student questions as needed, encourage groups to begin.

3. When 25 minutes have passed, give a five-minute warning. Once 30 minutes have passed, bring the class back together.
4. Kick off the presentations by formally welcoming the class to the _____State Government's Committee Hearing on eVTOL Legislation. Thank students for joining as the government considers how to move forward with laws and regulations regarding electric vertical takeoff and landing vehicles designed for the public.

   Reiterate that, as groups present, the rest of the students will pretend to be members of their state government. As such, they should be prepared to ask tough questions that challenge whether eVTOLs should be allowed for public use.

   Explain that you will call on at least one group to ask a question at the end of each group's presentation, and everyone must be prepared.
5. Then select a group to kick off the eVTOL presentations. Remind presenters that presentations should be kept to two minutes in length. Remind audience members to remain silent throughout the presentation and listen carefully for points or arguments that they may like to question.
6. When the first presentation is complete, allow groups about 30 seconds to reconvene and brainstorm a question that challenges why eVTOLs should be allowed in their state. Randomly select at least one group to ask its question, and give the presenters a moment to respond. Then repeat steps 4 and 5 until every group has presented and every group has asked at least one question.
7. When the presentations are complete, take a minute to recap the different ways that groups suggested eVTOLs be integrated into society. Then ask students to recount the main benefits and considerations that the presentations shared.
8. Conclude by thanking the class for their hard work and convincing presentations. Explain that the government officials will take some time to review what they have heard today and arrive at a decision… but given the groups' presentations and the continuously evolving technology fueling eVTOLs, you believe the government is likely to move forward with legislation in their favor!

Extend

Students can apply their research as they consider additional ways that eVTOLs could be used to help society, regardless of their intended use. Students can identify a need; explain how an eVTOL could help meet this need; and either explain how the eVTOL's design makes this possible or explain how the eVTOL would have to be redesigned to better meet this need.

National Standards

Next Generation Science Standards

Human Impacts

- Disciplinary Core Idea:
    - ESS3.C: Human Impacts on Earth Systems: Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)

ITEEA Standards for Technological Literacy

Standard 1: Scope of Technology Inquiry. In order to comprehend the scope of technology, students in Grades 6-8 should learn that:

- F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.

Standard 4: The Cultural, Social, Economic, and Political Effects of Technology. In order to recognize the changes in society caused by the use of technology, students should learn that:

- G: Economic, political, and cultural issues are influenced by the development and use of technology.

Common Core State Standards for English Language Arts

- CCSS.ELA-LITERACY.CCRA.SL.4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Vehicle Research

	Is the vehicle autonomous and able to fly itself? (If this is not mentioned; assume no!)	**Carrying Capacity:** Up to how many passengers can this vehicle hold?	**Take-Off and Landing:** How does the vehicle do this?	**Flight details:** How high and how far can this vehicle fly?	**Environmental Effects or Benefits**	**Other key facts and distinguishing characteristics**
Boeing's PAV (eVTOL) Research: tinyurl.com/y6cg47gb tinyurl.com/ydbjrc5a tinyurl.com/y576jy6c						
Flying Cars Research: tinyurl.com/y692cz9g						
Helicopters Research: tinyurl.com/z2f22wg						
Airplanes Research: tinyurl.com/y5efndao tinyurl.com/y2j9zref						

Presentation Outline

Your presentation must include:

- Introduction:
    - Why are you here today? What would you like the state government to consider?
- The following points:
    - Background:
        - How is the Boeing PAV similar and different from other flying vehicles (airplanes, helicopters, flying cars, etc.)?
- Adoption:
    - In what way(s) should the government allow eVTOLs to be used?
    - How could the PAV benefit, or help, society?
    - How could the PAV benefit, or help, the environment?
    - Is there anything the state government should consider or think about *before* allowing the PAV in their state?
- Conclusion:
    - Brief closing argument that summarizes why the state government should consider allowing the PAV and other similar eVTOLs

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