Aircraft Roles and Missions

Session Time: Two, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

The intended purpose and use of an aircraft drives aircraft design considerations and construction techniques, materials, and components. (EU1)

ESSENTIAL QUESTIONS

1. Why are different aircraft types needed for different roles and missions?
2. Is flexibility a desired characteristic in aircraft design?
3. How can aircraft work together on the same mission?

LEARNING GOALS

Students Will Know

- How the role of an aircraft can change depending on the mission
- That diverse aircraft can play complementary roles in a single mission

Students Will Be Able To

- *Explain* how a single aircraft type can serve multiple purposes. (DOK-L2)
- *Analyze* a single mission to determine how multiple aircraft types can complement one another. (DOK-L3)

ASSESSMENT EVIDENCE

Warm-up
In a Think-Pair-Share activity, students will recall what they've learned about each major segment of aviation. Working with a partner, they will name missions and roles within each segment.

Formative Assessment
Students work in groups to research a modern aircraft within an assigned category. The focus of their research will be on how the aircraft's design supports its mission and role.

Summative Assessment
Students will analyze a single mission (e.g., flighting a large forest fire) and determine the different types of aircraft that play complementary roles in order to accomplish the mission.

LESSON PREPARATION

MATERIALS/RESOURCES

- Aircraft Roles and Missions Presentation
- Aircraft Roles and Missions Student Activity 1
- Aircraft Roles and Missions Student Activity 2
- Aircraft Roles and Missions Teaching Aid
- Aircraft Roles and Missions Teacher Notes 1
- Aircraft Roles and Missions Teacher Notes 2

LESSON SUMMARY

Lesson 1: Aircraft Roles and Missions

The lesson will begin with a review of the three major segments of aviation: commercial, military, and general aviation. Students were first introduced to these segments in the ninth-grade curriculum, so they should come to this lesson able to describe the three segments. In this lesson, students will build on their previous knowledge by considering how the role and mission of an aircraft informs its design.

During the next part of the lesson, students will review several aircraft and consider their intended role and mission based on their design and configuration. After this discussion, students will work in groups to research a modern aircraft within an assigned category. The focus of their research will be on how the aircraft's design supports its mission and role.

Video shows students how the same aircraft can perform different missions by varying its landing gear configuration. They will consider how design variations can impact an aircraft's role and mission.

Finally, students will analyze a single mission (e.g., fighting a large forest fire) and determine the different types of aircraft that play complementary roles in order to accomplish the mission.

BACKGROUND

The students who participated in the ninth-grade curriculum will already be familiar with the three major segments of aviation; however, they may not have a sense of how different aircraft work together to accomplish the same mission. Students may know or guess what role common aircraft play in a mission, but not less popular aircraft.

The three major segments of aviation are commercial, military, and general aviation. Commercial aviation consists of scheduled (daily, posted flights) and non-scheduled (custom planned to meet customer's needs) flights that carry passengers and cargo for compensation. Military aviation is used to defend the nation and its interests, and consists of the aircraft that enable or conduct aerial warfare. General aviation consists of all civilian aircraft operations other than scheduled airline operations and military aviation. As the largest segment of the U.S. aircraft fleet, general aviation aircraft include everything from large jets, to single-seat airplanes, to unmanned aircraft systems (UAS).

For more background information about these three major categories, please see **Aircraft Roles and Missions Teacher Aid**.

Each segment of aviation utilizes more than one type of aircraft and carries out multiple missions. By carefully examining the design and features of an aircraft, students can make logical deductions about how the design is related to its function. Similarly, critical thinking about specific missions, such as fighting wildfires, can help students understand that different aircraft designs can complement one another to complete the mission.

This lesson will enable students to differentiate between various aircraft and determine what purpose they serve. This will also help broaden the student's perspective regarding what aviation-related careers exist and where the student would best fit in.

DIFFERENTIATION

For the research-based formative assessment in the **EXPLAIN** section of this lesson, provide a detailed rubric that describes what excellent work looks like to help students understand what is expected of them. While other groups present their own research, encourage students in the audience to evaluate their peers' presentations using the same rubric. If time allows, have students share their evaluations with the presenters, asking them to consider how they could use the feedback to improve their delivery. Teachers can involve students in creating rubrics to increase their understanding and participation.

LEARNING PLAN

ENGAGE

Teacher Materials: Aircraft Roles and Missions Presentation, Aircraft Roles and Missions Teaching Aid

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4: Conduct the **Warm-Up.**

Warm-Up

Have students perform a Think-Pair-Share. Students work independently to recall what they know about the three segments of aviation: commercial, military, and general aviation. Then, working with a partner, have them write down at least two specific examples of roles or missions for each segment. Ask students to be prepared to share their answers with the class.

Teachers may want to consult the **Aircraft Roles and Missions Teacher Notes 1** for more background information on these three segments of aviation.

Possible responses:

Commercial - scheduled and non-scheduled passenger flights for hire, carrying cargo for hire

Military - fighters keeping enemy aircraft out of the sky, reconnaissance aircraft finding out where the enemy is and what they are doing, transport and tanker aircraft moving supplies and troops

General aviation - law enforcement, flight training, corporate travel, crop dusting, aerial photography

[DOK-L2; *categorize*]

EXPLORE

Teacher Materials: Aircraft Roles and Missions Presentation, Aircraft Roles and Missions Teacher Notes 1
Student Material: Aircraft Roles and Missions Student Activity 1

Slide 5: Each segment of aviation utilizes more than one type of aircraft and carries out multiple missions. By carefully examining the design and features of an aircraft, students can make logical deductions about how the design is related to its function. Similarly, critical thinking about specific missions, such as fighting wildfires, can help students understand that different aircraft can complement one another to complete the mission.

This lesson will enable students to differentiate among various aircraft and determine what purpose they serve. Using the following slides, students will make inferences about an aircraft's mission or role based on the aircraft's design and configuration.

Slide 6: The military has many different roles and missions it must accomplish through the use of an extensive and varied fleet of aircraft. Begin by showing students the image of the Air Force F-117A Nighthawk stealth fighter aircraft. This aircraft was used by the United States Air Force during military campaigns, such as the Persian Gulf War in 1991. Based on the photos and the listed features, ask students what they think this aircraft's mission was and what characteristics provide clues. If students struggle with connecting design to mission with this aircraft, point out the sharp angles of the wings and body.

Slide 7: The sharp angles of the wings and body are one of the design elements that made this a stealth aircraft, which means it is difficult to detect on radar. Having stealth capabilities allowed the aircraft to operate undetected behind enemy lines, a capability uniquely applicable for military operations. Other design features of the aircraft that contributed to its "stealthiness" were the bomb bays because keeping the munitions inside of the aircraft reduced the radar cross section. The exhaust of the F-117 was different than a conventional exhaust system and was designed to mix as much cool air as possible with the hot exhaust gases in order to reduce the heat signature and detectability of the aircraft.

The bomb bays indicate that this aircraft was used to drop munitions, and the advanced targeting and tracking capabilities should lead students to understand that the munitions dropped from this aircraft were delivered precisely on targets.

The students should come to the conclusion that this aircraft was used to drop munitions on targets behind enemy lines. Its smaller size and stealth capabilities are what differentiate this aircraft from a traditional attack aircraft. Attack aircraft are designed to deal with the complications of low altitude anti-aircraft threat. The F-117 dealt with these threats by remaining invisible and being able to move quickly in and out of enemy airspace.

Slides 8-9: The U-2 Dragon Lady is a high-altitude intelligence gathering and reconnaissance airplane. The long, thin wings give the U-2 glider-like characteristics and the ability to stay aloft for hours at a time. U-2 aircraft can fly at an altitude of approximately 70,000 feet, allowing them to spy on enemies without being detected or intercepted. Cameras and sensors allow the crew to gather intelligence as they are flying over points of interest.

The F-16 is a highly maneuverable and fast fighter aircraft. The F-16 was designed to establish and maintain air superiority. Students should identify the multiple missiles on the wings and fuselage. The F-16 is small and light, giving it amazing performance characteristics. The F-16 has a thrust-to-weight ratio exceeding 1:1, allowing for incredible climbs and fast acceleration. The maneuverability of the F-16 helps it fulfill its mission of establishing and maintaining air superiority. The aircraft can carry a variety of air-to-ground missiles, rockets and bombs. The cannon also allows it to perform close-range air-to-air combat and strafing.

These two aircraft can play complementary roles in achieving the same mission: the U-2 provides valuable information on targets that the F-16 can strike.

Slide 10: Show students the image of the MQ-9 Reaper to introduce the idea of unmanned aircraft. Unmanned aircraft are quickly acquiring the ability to perform many of the roles manned aircraft have in the past. Because there is no human onboard, the aircraft can be designed and operated differently. The space and support systems that required for a human pilot are no longer needed. Oxygen systems, seats, parachutes, and other equipment can be left out of the design, and the operations are not limited by human factors such as eating, sleeping, and using the restroom.

On this particular aircraft, the students should identify the sensors, as well as the weapons hardpoints, allowing them to conclude that this aircraft can be used to fulfill multiple roles of surveillance and attack. These capabilities, paired with the performance of the aircraft, allow the aircraft to be in place over long durations, ready to strike at a moment's notice. This significantly reduces the risk to human life compared to the alternative of having manned fighters or attack aircraft loitering in the skies.

Slide 11: This slide shows three different variants of a Boeing 747. This is an example of a common commercial aircraft that has been modified to fill several missions.

Ask students guiding questions to help them critically analyze the kinds of missions made possible through different configurations of the same airplane. Ask students how the aircraft design supports these different missions.

Passenger variant - The passenger configuration of a 747 allows for the transportation of hundreds of passengers at once over long distances. Its distinctive hump along the forward part of the aircraft allows for a second deck and more room for additional seats. Many airlines used the upper deck for premium seating. Its wide body allows for as many as 10 seats in a single row.

Cargo variant - The fuselage of the 747 is as tall as a six-story building and can hold massive amounts of cargo. The cargo variant of the 747 has a hinged nose which can open to allow the aircraft to be loaded with shipping containers, crates, and other items like tanks, cars and even cattle! The design of this aircraft is meant to allow for long flights with a lot of cargo.

Firefighting variant- A tanker variant of the 747 was developed for firefighting. The cargo area was converted to hold 19,600 gallons of retardant or water.

Show students a time-lapse video of cattle being loaded onto a 747 in Fargo, ND. These cows flew to Kazakhstan.

- Flying Cows Boeing 747-400 (Length 1:32)
  http://video.link/w/DEXd

Slide 12: The E-4B is yet another special application of the 747. This aircraft has been specially designed to act as a mobile command post for the U.S. government in case of emergency. The aircraft is shielded from electromagnetic pulses (EMP), and also has thermal and nuclear shielding. While the aircraft may have state-of-the-art technology, the cockpits are still equipped with analog instruments, as they are less susceptible to an EMP. This is one of the small ways this aircraft has been thought out and designed to fit a very specific role and mission. As well as being fully equipped with state-of-the-art communications equipment, the aircraft is also designed to stay aloft for more than one week at a time in case of emergency, relying on mid-air refueling.

Slide 13: Now that students have seen how a specific type of aircraft can complete a specific type of mission, show students that a specific aircraft can also complete different types of missions, especially when certain features of the aircraft are modified.

Show students the following videos demonstrating how the Twin Otter uses different landing gear configurations to take off and land in various environments. Just by changing the type of landing gear, the students can see how the airplane accomplishes various missions.

- "Loganair Twin Otter take off at Barra" (Length 2:21)
  http://video.link/w/7hQd
- "Twin Otter Seaplane Landing" (Length 1:50)
  http://video.link/w/8hQd
- "Twin Otter Landing Frozen Lake with Wheel-skis" (Length 1:23)
  http://video.link/w/9hQd

Slide 14: Based on what they've learned, have students consider how one aircraft can fulfill multiple roles; allow them to share their ideas. Students should understand that with different landing gear configurations, the same aircraft can fulfill different and diverse missions.

Questions

Discuss with students the different design elements and ask them the following questions:

- Why do you think these design considerations were made? How do these design considerations help the airplane function in unique environments?
  These changes in design allow the same aircraft to fulfill multiple roles and missions. Depending on where and how the aircraft is being used, it might need different landing gear.

- What missions could be accomplished with the various landing gear configurations?
  On floats, groceries can be delivered to a remote village in Alaska or help with a water rescue. On skis, the aircraft can deliver supplies to a mountain town if roads become inaccessible.

Slide 15: Provide students copies of **Aircraft Roles and Missions Student Activity 1**. During this activity, they will identify to which segment the aircraft belongs: commercial, military, or general aviation. They will also identify the role each aircraft plays and explain how they can determine that based on the aircraft's design. Lastly, they will determine how the role or mission of the aircraft could change given variations in the aircraft's internal or external configuration. Encourage students to use Internet research to help determine their answers and discover additional missions and roles for these aircraft.

Suggested answers to this activity are included in **Aircraft Roles and Missions Teacher Notes 1**. Review answers as a class, either by calling on individual students to share or by having students quickly vote on the types/roles of the pictured aircraft.

EXPLAIN

Teacher Material: Aircraft Roles and Missions Presentation

Slide 16: Complete the **Formative Assessment.**

Formative Assessment

Split students into groups of 2 to 3 and assign each group a different segment of aviation: commercial, military, and general aviation. Each group will choose an impressive modern aircraft within their assigned category and research the following:

- Aircraft design, noting its features and function
- Types of missions their aircraft is used for
- How the aircraft's design supports these different types of missions

Students should choose to research aircraft not yet covered in the lesson. The research portion should take the remainder of the first session. During the beginning of the second session of the lesson, have students present their chosen aircraft to the rest of the class. They should include a description of the design and how it impacts the aircraft's mission. You may ask students to take notes on each other's presentations, and submit their notes to the presenters. Each group will review the notes from the rest of the class to learn how they can improve their presentation.

[DOK-L2; *infer*]

EXTEND

Teacher Material: Aircraft Roles and Missions Presentation

Slide 17: After the presentations, show students a video about the capability of a Pilatus PC-12 to carry-out various special missions. Have students complete a brief discussion about the connection between an aircraft's design and its function. After the video, ask students to describe how this airplane was configured.

- Special Mission Aircraft Pilatus PC-12 NG Spectre (Length 1:51)
  http://video.link/w/d4Wd

Ask students how this aircraft was configured specifically to perform the different missions. Students should conclude that the different missions of this airplane depend less on the external design and more on the internal configuration. Explain, if necessary, that this airplane is a popular choice for passenger transport and medical transport.

EVALUATE

Teacher Materials: Aircraft Roles and Missions Presentation, Aircraft Roles and Missions Teacher Notes 2
Student Material: Aircraft Roles and Missions Student Activity 2

Slide 18: Conduct the **Summative Assessment.**

Summative Assessment

Divide students into small groups. Assign each group one of the two scenarios included in **Aircraft Roles and Missions Student Activity 2.** Have students conduct Internet research and identify aircraft that are capable of accomplishing the specific tasks outlined for the assigned mission. There may be more than one aircraft that is capable of completing each of the specific tasks. Students should indicate the characteristics the aircraft has, or what configuration it needs, to accomplish these tasks.

Collect student work and grade using the Summative Assessment Scoring Rubric.

[DOK-L3; *compare/contrast*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Student work shows an understanding of characteristics of an aircraft that enable it to successfully accomplish the tasks associated with a mission
- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking, including analysis or synthesis of lesson objectives

Points	Performance Levels
9–10	Consistently demonstrates criteria
7–8	Usually demonstrates criteria
5–6	Sometimes demonstrates criteria
0–4	Rarely to never demonstrates criteria

GOING FURTHER

Show students the following video explaining how drones were used at the 2018 Winter Olympics and lead them in a discussion about other ways an aircraft's mission influences its design, and vice versa. For example, in the video of the Winter Olympics light show, hundreds of small drones move in coordinated flight patterns to create aerial light shows. Drones are perfect for such a task because they are small and unmanned, so a large number of them can be used in a small area. Drones are currently a poor choice for transporting cargo or people because they are too small to carry a significant payload. Reinforce the lesson concepts by challenging students to brainstorm, either solo or with a partner, another example of a unique feature of an aircraft that makes it suitable for a particular mission—and unsuitable for other missions.

- "High-tech Drones Steal the Show at the Winter Olympics" (Length 3:44)
  http://video.link/w/BkQd

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-ETS1-2** - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
  - Science and Engineering Practices
    - Asking Questions and Defining Problems
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.A: Defining and Delimiting Engineering Problems
  - Crosscutting Concepts
    - None
- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
  - Science and Engineering Practices
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.B: Developing Possible Solutions
  - Crosscutting Concepts
    - None

COMMON CORE STATE STANDARDS

- **MP.2**: Reason abstractly and quantitatively
- **MP.3**: Construct viable arguments and critique the reasoning of others.
- **MP.7**: Look for and make use of structure.

- **RI.9-10.1**: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- **RI.9-10.2**: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- **RI.9-10.4**: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **W.9-10.4**: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **W.9-10.6**: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **W.9-10.7**: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **W.9-10.8**: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **W.9-10.9**: Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/pilot_handbook.pdf http://www.sciencechannel.com/inscider/5-cutting-edge-military-technologies/
http://fireaviation.com