Unmanned Aircraft Materials

Session Time: One, 50-minute session

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

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

Innovations in aviation are driven by the desire to make aircraft safer, more capable, and more efficient. (EU3)

A deep understanding of how an aircraft operates enables a pilot to fly the aircraft to its maximum capabilities in both normal and abnormal situations. (EU5)

ESSENTIAL QUESTIONS

1. What are the best UAS made of?

2. Which UAS construction material is superior to all others?

LEARNING GOALS

Students Will Know

- Similarities and differences in the construction of unmanned aircraft and traditional aircraft
- Types of materials used in the construction of popular unmanned aircraft
- Considerations made when determining what materials to use in the construction of unmanned aircraft

Students Will Be Able To

- *Compare* the construction materials used in unmanned and manned aircraft. (DOK-L2)
- *Analyze* which materials should be used to build a drone based on the drone's purpose. (DOK-L4)

ASSESSMENT EVIDENCE

Warm-up
Students are asked to discuss what materials they think would be most appropriate in the construction of drones and why.

Formative Assessment
Students will evaluate three different types of drones and their primary missions. Students will list characteristics each drone needs for the mission and then list material(s) best suited to the drone type and justify their choices.

Summative Assessment
Students will summarize this section by writing several paragraphs discussing the considerations that engineers must make when choosing materials for both manned and unmanned aircraft.

LESSON PREPARATION

MATERIALS/RESOURCES

- Unmanned Aircraft Materials Presentation
- Unmanned Aircraft Materials Student Activity
- Unmanned Aircraft Materials Teacher Notes

LESSON SUMMARY

Lesson 1: Aircraft Structural Materials

Lesson 2: Aircraft Safety Features

Lesson 3: Unmanned Aircraft Materials

The lesson begins with a general discussion about which materials students would choose to build a drone, and why they would choose those materials. Students are then introduced to three popular UAS: the Parrot Disco, the DJI Mavic Pro, and the Northrop Grumman Global Hawk. Students watch brief videos of each drone in action and learn about some of their specific features and the materials used to build them.

Next, students are introduced to three important attributes of materials used in the construction of unmanned aircraft. For each attribute, students will learn its trade-offs. Several popular materials used to build drones are introduced during a class discussion. They are asked to consider the advantages of each material and the types of applications for which each would be best suited.

During a student activity, students will evaluate three different types of drones and their primary missions. Individually, students will list the characteristics the drone needs to complete the mission and then list material(s) best suited to the drone type and justify their choices.

Finally, students will summarize this section by writing several paragraphs discussing the considerations engineers must make when choosing materials for both manned and unmanned aircraft.

BACKGROUND

Materials used to construct devices are selected with the intended purpose of the device in mind. For example, hybrid vehicles are often constructed of lighter-weight materials than other automobiles in order to allow for maximum battery performance and fuel efficiency. However, cost and production time also influence material choice (e.g. once plastic became available, it replaced glass as the material of choice for soft drink and milk bottles). The Parrot Disco is made of styrofoam because it is lightweight and easy to form into a wing shape. The foam is easy to repair, and it serves as a suitable flight control surface for the drone. Quadcopters, on the other hand, are often made of molded plastic. While this plastic is easy to reproduce, it is not easy to repair. Therefore, crashing this type of drone would almost certainly require replacement of damaged components.

LEARNING PLAN

ENGAGE

Teacher Material: Unmanned Aircraft Materials Presentation

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

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

Warm-Up

Engage students in a class discussion by asking the following questions. [DOK 3; draw conclusions, hypothesize]

- If you were going to build a drone, what kinds of materials do you think would be best suited for its construction?

Anything light and easy to repair or replace. Plastic, foam, wood, and composites are all light. Composites are not easy to repair, however.

- Why would you choose these materials?

Lighter materials increase payload capability and flight endurance. If they are easy to repair, it makes it possible to patch up the drone after inadvertent impacts and get it back in the air.

- Would these materials be suitable for a traditional aircraft?

In order to ensure pilot and passenger safety, strong and reliable materials are necessary for aircraft designed for manned flight.

EXPLORE

Student Material: Unmanned Aircraft Materials Presentation

Slide 5: Show students a video of the Parrot Disco Drone in action. Ask them to note what kind(s) of material(s) it is made of. The Disco is mainly constructed from a flexible foam material and is designed to fly like an airplane.

- "Parrot Disco FPV" (Length 1:10)
  http://video.link/w/nhPd

Slide 6: Show students a video of the DJI Mavic Pro in action. Ask them to note what kind(s) of material(s) it is made of. The Mavic Pro is a traditional rotor drone. Its body is made of reinforced polymer (plastic) and the rotors are made of composite. It also has some aluminum components on the hull.

- "DJI Mavic - Fun of Flying" (Length 2:06)
  http://video.link/w/iUPd

Slide 7: Finally, show students a video of a Northrop Grumman Global Hawk in flight. Ask them to note what kind(s) of material(s) it is made of. The Global Hawk is a large fixed-wing UAS and it has many traditional aircraft components. It has a takeoff weight of over 32,000 pounds, so it is made of very strong materials. The fuselage is made of aluminum and the wings are composite.

- "NATO AGS Global Hawk Flight" (Length 00:41) http://video.link/w/hUPd

EXPLAIN

Teacher Materials: Unmanned Aircraft Materials Presentation, Unmanned Aircraft Materials Teacher Notes

Student Material: Unmanned Aircraft Materials Student Activity

Slides 8-10: Explain three important attributes of materials used in the building of unmanned aircraft. For each attribute, students will learn its trade-off. For example, in many cases a very lightweight material (foam) will not be very strong or able to carry a heavy load.

Slide 11: Like traditional manned aircraft, there are many different types of materials used to create the frame, wings, rotors, and other components on UAS.

Explain to students that as UAS get more complex, the materials used for their construction must be able to withstand greater forces, carry more weight and be more durable.

Foam is used on many recreational, inexpensive drones. It is lightweight and stiff. It can be molded and worked with easily. In minor crashes, the foam will flex, and the structure will remain intact. When more forceful impacts break the foam, it is relatively easy to glue back together.

Plastic is considered a good compromise between weight and impact resistance, although it can be difficult to glue and repair. It can be shaped and molded with precise and smooth curves. 3D printers can also make many shapes from plastic in a cost-effective way. Plastic is generally low-cost, which makes it easier and cheaper to replace parts rather than repair them.

Composite is tough and lightweight, which means the UAS will fly better and consume less energy. Some composites impede radio signals, which must be kept in mind when installing electronic components (like an antenna) on a drone.

Aluminum is relatively light, but not as light as composite. It is easy to access but can be difficult to repair (requires welding or fasters). It can also dent relatively easily upon impact.

Slide 12: Conduct the **Formative Assessment.**

Formative Assessment

Students will evaluate three different types of drones and their primary missions. Provide copies of **Unmanned Aircraft Materials Student Activity**. Individually, students will list the characteristics each drone needs for the mission and then list material(s) best suited to the drone type and justify their choices.

Allow students up to 10 minutes to answer these questions, and then have them share their responses with the class. Possible answers are provide in **Unmanned Aircraft Materials Teacher Notes**. [DOK 2; categorize; summarize, DOK 3; draw conclusions]

EXTEND

Teacher Material: Unmanned Aircraft Materials Presentation

Slide 13: Thinking back to what students learned in the first lesson of this section (Aircraft Structural Materials), ask students what kinds of materials are used in the construction of both manned and unmanned aircraft.

Questions

What kinds of materials are used in the construction of both manned and unmanned aircraft?

Other than the need to accommodate people in manned aircraft, large unmanned aircraft have many of the same requirements as far as strength and durability, and can therefore be constructed of the same materials.

Aluminium and composites are common materials found in the construction of UAS and traditional manned aircraft. They provide the strength and durability necessary for both types of aircraft, and can be assembled using established techniques.

Plastics, used as a structural material in small, unmanned drones, aren't much used in the airframe structures of traditional aircraft, but can be found in places such as avionics panels, safety equipment and cabin amenities.

Foam is not generally used in the airframes of manned aircraft, but it is appropriate for many small and medium sized drones.Manned and unmanned aircraft that have more serious and complex missions (like carrying passengers or performing military surveillance) will likely use materials that are are able to withstand more wear and tear. The materials to build these kinds of aircraft will likely be more expensive and their construction will be more involved.

Why do these similarities exist? What must the materials in both manned and unmanned aircraft provide?

Similar materials can be used in the construction of either manned or unmanned aircraft when they are of similar size and perform similar missions. Regardless of the mission, operators want to be able to use the aircraft over and over again. Materials for both manned and unmanned aircraft are chosen for their reliability and durability. However, designers must weigh reliability and durability against other factors like weight and ease of repair. Whether manned or unmanned, engineers must always weigh the pros and cons of materials used in aircraft construction against the aircraft' s use.

EVALUATE

Slide 11: Conduct the **Summative Assessment.**

Summative Assessment

To summarize this section, ask students to write several paragraphs discussing the considerations that engineers must make when choosing materials for both manned and unmanned aircraft. The discussion should include the kinds of materials used and the reasons for using them. Students should also discuss when and how safety is factored into the design and materials selection process of aircraft development.

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Group work shows evidence of one or more of the following:

An understanding of unmanned and manned aircraft materials

The considerations and tradeoffs that engineers must make as materials are chosen during the aircraft design process

How safety plays into the choice of materials used

- Student work shows overall understanding of the concepts covered in the lesson

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

If time allows, provide additional information about the structural features of drones. The following website has quite a bit of information on the basic shape of a variety of drones as well as additional details about the different types of plastic, foam, and wood that are often used in drone construction.

https://www.robotshop.com/blog/en/how-to-make-a-drone-uav-lesson-8-airplanes-19230

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
        - ETS1.B: Developing Possible Solutions
    - 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
        - Asking Questions and Defining Problems
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas

        - ETS1.A: Defining and Delimiting Engineering Problems
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - None

COMMON CORE STATE STANDARDS

- **RST.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.
- **RST.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.
- **WHST.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.
- **WHST.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.
- **WHST.9-10.9** - Draw evidence from informational texts to support analysis, reflection, and research.

REFERENCES

https://www.robotshop.com/blog/en/how-to-make-a-drone-uav-lesson-8-airplanes-19230

https://en.wikipedia.org/wiki/Northrop_Grumman_RQ-4_Global_Hawk#/media/File:Northrop_Grumman_RQ-4_Global_Hawk.jpg