Aircraft Safety Features

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)

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. Which are safer: cars or airplanes?
2. Which parts of an aircraft are designed with safety in mind?

LEARNING GOALS

Students Will Know

- Safety design features of modern general aviation, commercial, and military aircraft and UAS.
- How safety features prevent accidents and improve survivability.

Students Will Be Able To

- *State* a safety issue and *create* a proposal for a new aircraft safety device to solve for the issue. (DOK-L1, L4)
- *Categorize* safety design features of modern aircraft. (DOK-L2)

ASSESSMENT EVIDENCE

Warm-up
Students are asked to compare the relative safety of modern automobiles to modern aircraft.

Formative Assessment
Students will read a flight scenario that describes a series of mishaps. As the mishaps unfold, students will be asked to research what kind of aircraft safety feature would be employed to keep the pilots, passengers and aircraft safe.

Summative Assessment
Students will categorize various aircraft safety features and describe how they work and how they provide an added layer of safety.

LESSON PREPARATION

MATERIALS/RESOURCES

- Aircraft Safety Features Presentation
- Aircraft Safety Features Student Activity
- Aircraft Safety Features Teacher Notes

Propose A New Safety Innovation Activity (per team)

- Poster board
- Markers
- Post-it notes

LESSON SUMMARY

Lesson 1: Aircraft Structural Materials

Lesson 2: Aircraft Safety Features

Lesson 3: Unmanned Aircraft Materials

The lesson will begin with students brainstorming a list of safety features used on modern automobiles and modern aircraft. In small groups, students will then be asked to compare the relative safety of modern automobiles to modern aircraft.

During a class discussion, students will focus on safety features that have been incorporated into modern aircraft. Students will research additional items during a student activity where they read a flight scenario that describes a series of mishaps. As the mishaps unfold, students will be asked to research what kind of aircraft safety feature would be employed to keep the pilots, passengers and aircraft safe.

During the second session of this lesson, students will identify a safety issue and create a proposal for a new aircraft safety innovation that will solve for the issue. In the summative assessment, students will categorize various aircraft safety features and describe how they work and how they provide an added layer of safety.

BACKGROUND

Airbags, lane departure warnings, automatic braking, and many other features are constantly evolving in the automobile world. Crash test data and post-accident analysis help engineers identify areas for needed safety improvements and develop solutions. The aviation safety field works in a similar way.

Many factors influence the safety of modern civil and military aircraft. Some are related to design, others to the maintenance and operation of the aircraft. The factors and approaches employed vary with the type of aircraft. This lesson will focus on safety features built into the design of the aircraft. The features fall into four main categories: airframe, materials, information systems and equipment.

Airframe

According to Boeing, their aircraft are designed to withstand 150 percent of the greatest load that the aircraft might encounter. This helps ensure the airframe's integrity in the event of an emergency requiring fast and forceful maneuvering.

Some general aviation aircraft incorporate the equivalent of a "roll cage" around the cockpit area, which is stiff and strong to provide survival space and protection in case of impact.

The Boeing 787 Dreamliner is the first civilian airplane to use carbon composites to form wing spars. A wing spar is the main structural unit of the wing, running perpendicular to the fuselage.

Aluminum fuselages are built to handle changes caused by cabin pressurization—which inflates and deflates the body of an airliner as much as a quarter of an inch.

Flaps are located on the trailing edges of the wings. They are lowered during critical phases of flight (takeoff and landing) to increase lift. Flaps are used for extra lift on takeoff. They also provide extra lift on landing when the aircraft needs to slow down to land.

Earlier aircraft were controlled via heavy, complex mechanical linkages. This made flight a physically exhausting and often unsafe undertaking. Fly-by-wire technology—originally developed to help maneuver the Apollo lunar module—takes a pilot's actions in the cockpit and turns them into electrical signals, which computers then use to move the aircraft control surfaces and thereby fly the aircraft. The pilot no longer moves actuators connected to moving cables, for example. Instead, an electronic signal from movement of the yoke or stick tells the computer to command an actuator (such as an electric motor or hydraulic piston) adjustment. These same computers also monitor a pilot's actions, making sure their commands are within acceptable limits.

Materials

Fabrics and cushions in all aircraft are fire retardant and self-extinguishing, and they will not emit toxic smoke. Even the items you find in the seat back of airliners are tested to make sure they can't become lethal. The insulation in the cabin walls of airliners is also made of fire retardant materials.

Information Systems

As students learned in the ninth-grade curriculum, many aircraft have seen traditional analog (or round-dial) gauges replaced by electronic ones. "Glass cockpits" were introduced in the 1980s, altering how pilots fly. Before glass cockpits, individual dials and indicators were placed in the cockpit, forcing the pilot to study each readout and look at many different locations in the cockpit for the information they needed. With the introduction of glass cockpits, digital readouts of several indicators could be placed on one screen.

Some UAS have built-in obstacle avoidance. Optical sensors allow them to "see and avoid" potential obstacles. The onboard systems sense an obstacle and automatically route the drone around it if possible. In some cases, the UAS might slow down and hover in flight and wait for the pilot to redirect it.

Equipment

All airline seats meet tough standards for durability and head-impact protection. The modern airliner seat can withstand 16 times the force of gravity.

In the event of an emergency which requires passengers to evacuate, escape-path lighting helps passengers find their way to the exits in dark or smoky conditions. Evacuation slides will also deploy from each exit so that passengers can slide to the ground. Oftentimes, those slides double as life rafts in the event the airplane has to land in open water. Seat cushions also double as flotation devices.

In the unlikely event of an aircraft depressurization at altitude, the flight crew will perform a rapid descent to approximately 10,000 feet, where no supplemental oxygen is needed. However, oxygen masks will be used by the pilot and the passengers until a safe altitude is reached.

If a military pilot needs to get out of a fast-moving aircraft, they will pull the handle for an ejection seat. In most designs, the canopy will blow off the aircraft and the seat is propelled by an explosive charge or a rocket. The pilot remains in the seat as a parachute deploys to lower him or her to the ground.

Airframe parachutes are now incorporated on some general aviation airplanes. A whole-airframe parachute can set the entire aircraft down in an emergency; such as a midair collision, stall/spin, or engine failure over inhospitable terrain.

Airframe parachutes are activated by a handle in the cockpit. An activation cable leads to an igniter that fires a rocket motor to extract the parachute, which is usually in the rear of the aircraft. In seconds, the lines go taut, the canopy inflates, and the aircraft begins to decelerate. Once it stabilizes under the canopy, the airplane descends at a slightly nose-low attitude at about 15 to 28 feet per second.

LEARNING PLAN

ENGAGE

Teacher Material: Aircraft Safety Features Presentation

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

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

Warm-Up

Have students brainstorm a list of safety features used on modern automobiles and modern aircraft. Then, have them form groups of three to four and compare their responses. Based on their discussion, the group should answer the following questions and be prepared to share their answers with the class.

- Is it safer to travel by car or airplane?
- Why do you think this is true?
- Do you think most people would agree with you?

Slide 5: Share with students the likelihood of dying from certain events. According to the National Safety Council, there is a 1 in 114 chance of dying in a motor vehicle crash versus a 1 in 9,821 chance of dying in an air or space transport incident. Ask students why they think aviation is so safe?

EXPLORE

Teacher Material: Aircraft Safety Features Presentation

Slide 6: Aviation is one of the world's most important industries. With every air traffic accident, a segment of the public is more hesitant to fly, resulting in a loss of revenue to the airline industry. Global aviation's estimated economic impact is $2.96 billion and accounts for 8 percent of global GDP and 29 million jobs (direct and indirect). A decline in air travel due to safety concerns could result in millions of dollars of lost revenue across more industries than just aviation. Ignoring the direct cost of accidents, even a small reduction in air transport would have a large effect on the world's economy. It is essential that the public have confidence in the safety of air travel.

Early aircraft were viewed as dangerous machines flown by daredevils. Aviation industry leaders knew that air travel would not grow without safety reforms, and urged Congress to pass the Air Commerce Act in 1926, creating a forerunner of the FAA and establishing a precedent of the aviation industry working with the government to improve air safety (students should recall this information from second semester of Unit 2 in the ninth-grade curriculum).

Today's air transport industry has safety built into every part: from the design and manufacturing of aircraft, to daily operations, to crew training, no major decision is made without first considering the safety implications. That is why modern air travel is the safest form of transportation ever devised.

Slide 7: Many factors influence the safety of modern civil and military aircraft. Some are related to design, others to the maintenance and operation of the aircraft. The factors and approaches employed vary with the type of aircraft. This lesson will focus on safety features built into the design of the aircraft. The features fall into four main categories: airframe, materials, information systems and equipment.

The next few slides provide a broad overview of some of the safety features that have been incorporated into modern aircraft. Students will research additional items during a student activity.

Slide 8: According to Boeing, their aircraft are designed to withstand 150 percent of the greatest load that the aircraft might encounter. This helps ensure the airframe's integrity in the event of an emergency requiring fast and forceful maneuvering.

Show students a video of Boeing's 777 wing test. The wing finally broke at 154 percent of the designed limit load.

- "Boeing's 777 Wing Test" (Length 3:16) http://video.link/w/kUPd

Slide 9: Flaps are located on the trailing edges of wings. Flaps change the shape of the wing in flight, which allows pilots to optimize them for each phase: takeoff, climb, cruise, approach, and landing. They are lowered during critical phases of flight (takeoff and landing) to increase lift. Flaps add camber, and sometimes area, to the wing. That creates both more lift and drag. Flaps typically lower an airplane's stall speed, and allow airplanes to descend at steeper angles without gaining speed.

On some large aircraft, slats extend from the front of the wing to change its shape and lower its stall speed.

Slide 10: Fabrics and cushions in all aircraft are fire retardant and self-extinguishing, and they will not emit toxic smoke. Even the items you find in the seat backs of airliners are tested to make sure they can't become lethal. The insulation in the cabin walls of airliners is also made of fire retardant materials.

Slide 11: As students learned in the ninth-grade curriculum, many aircraft have seen traditional analog (or round-dial) gauges replaced by electronic ones. "Glass cockpits" were introduced in the 1980s, altering how pilots fly. Before glass cockpits, individual dials and indicators were placed in the cockpit, forcing the pilot to study each readout and look at many different locations in the cockpit for the information they needed. With the introduction of glass cockpits, digital readouts of several indicators could be placed on one screen.

Slide 12: Some UAS have built-in obstacle avoidance. Optical sensors allow them to "see and avoid" potential obstacles. The onboard systems sense an obstacle and automatically route the drone around it if possible. In some cases, the UAS might slow down and hover in flight and wait for the pilot to redirect it.

Show students a video that describes the technology used by a DJI Phantom 4 to "see and avoid" obstacles.

- Phantom 4 A Look Inside (Length 1:27) http://video.link/w/mUPd

Slide 13: Airframe parachutes are now incorporated on some general aviation airplanes. A whole-airframe parachute can set the aircraft down in an emergency such as a midair collision, stall/spin, or engine failure over inhospitable terrain. Airframe parachutes are activated by a handle in the cockpit. An activation cable leads to an igniter that fires a rocket motor to extract the parachute, which is usually in the rear of the aircraft. In seconds, the lines go taut, the canopy inflates, and the aircraft begins to decelerate. Once it stabilizes under the canopy, the airplane descends at a slightly nose-low attitude at about 15 to 28 feet per second.

Show students a video of how Cirrus Aircraft tested their ballistic airframe parachute. Tell students to take note of what goes into testing a new technology to ensure that it will be effective and safe.

- " Behind the Scenes: Cirrus Airframe Parachute System" (Length 3:14) http://video.link/w/IgPd

EXPLAIN

Teacher Materials: Aircraft Safety Features Presentation, Aircraft Safety Features Teacher Notes

Student Material: Aircraft Safety Features Student Activity

Slide 14: Conduct the **Formative Assessment.**

Formative Assessment

Divide students into small groups. Provide each group one of the three scenarios (airliner, private aircraft, or fighter jet) provided in **Aircraft Safety Features Student Activity**.

Each flight scenario describes a series of mishaps. As the mishaps unfold, students will be asked to stop and research what kind of aircraft safety feature would be employed to keep the pilots, passengers and aircraft safe.

This may be assigned as homework. If time allows, have groups that researched the same scenario, compare and correct their responses. Answers can be found in **Aircraft Safety Features Teacher Notes**. [DOK 2; use context cues, DOK 3; draw conclusions]

EXTEND

Teacher Material: Aircraft Safety Features Presentation

Slide 15-16: During the second session of this lesson, students will identify a safety issue and create a proposal for a new aircraft safety innovation that will solve for the issue.

Working in small groups, students will write a summary of their stated safety issue and describe their innovation. They should draw their innovation on a poster board and include key features. Their poster should also briefly describe the safety issue their new innovation will solve. The innovation has to be something the students haven't heard about before - it can't already exist.

Use a Gallery Walk for students to get feedback on their work. Hang the student innovations on the classroom walls and have students individually, or in groups, rotate around the room and provide feedback to the creators (ask questions, state what makes the innovation interesting, make suggestions, etc.). Students can write feedback on chart paper posted by each innovation, or they can use sticky notes to write their feedback.

An example of a safety innovation (with video) has been provided in the presentation.

- "Amazing Airplane Safety System!" (Length 1:19)
  http://video.link/w/BeQd

EVALUATE

Teacher Material: Aircraft Safety Features Presentation

Slide 17: Conduct the **Summative Assessment.**

Summative Assessment

On a piece of paper, students will copy down the list of aircraft safety features found on slide 16. They should categorize each safety feature as airframe, materials, information systems or equipment. They

should also provide a two to three sentence description of how the feature works and how it provides an added layer of safety. [DOK 3; draw conclusions, DOK 2; categorize, summarize]

Answers:

Fly-By-Wire Flight Controls
AIRFRAME
Takes a pilot's actions in the cockpit and turns them into electrical signals, which computers then use to move the aircraft control surfaces and thereby fly the aircraft. FBW is lighter, easier to maintain and allows for computer input. FBW also monitors a pilot's actions, making sure their commands are within acceptable limits.

Seatbelt Airbags

EQUIPMENT

Used to prevent injury to pilots and passengers from impact with glare shields, instrument panels and control yokes, as well as passengers from forward impact.

Emergency Locator Transmitter (ELT)

EQUIPMENT

Carried aboard most general aviation aircraft in the U.S.. In the event of an aircraft accident, these devices are designed to transmit a distress signal on 121.5, 243.0, and 406-megahertz frequencies. Helps search and rescue locate an aircraft and its occupants.

Traffic Collision Avoidance System (TCAS)

INFORMATION SYSTEMS

An aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. It monitors the airspace around an aircraft for other aircraft and warns pilots of their presence.

Summative Assessment Scoring Rubric

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

- Categorization of aircraft safety features
- Purpose of various safety features built into aircraft
- How various safety features prevent accidents and injury

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 and you have a drone at your disposal, allow students to test the return-to-home function as a way to easily visualize how automation can make flight easier and safer.

Show a video which provides a number of interesting statistics that speak to the safety of flying as a mode of transportation. Also provides some interesting information about the psychology of a fear of flying and why people tend to dismiss these statistics.

"25 Reasons Why Fear of Flying Is Plane Silly" (Length: 5:05) http://video.link/w/rePd

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **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
    - Disciplinary Core Ideas
        - 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.
- **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

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