Air Traffic Control

Session Time: Two, 50-minute session(s)

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Coordinating ATC expectations and pilot intentions is a key element of aviation safety.

In airspace covered by radar, ATC and pilots have multiple ways to ensure aircraft move safely through the sky.

ESSENTIAL QUESTIONS

1. How does ATC keep all of the aircraft in its area safe?

LEARNING GOALS

Students Will Know

- Types of equipment ATC uses for traffic separation and advisories
- Types of equipment pilots use for traffic separation and advisories
- Terminology specific to radar beacon use
- Types of services ATC offers pilots

Students Will Be Able To

- *Compare* the capabilities of primary radar, radar beacon systems, and automatic dependent surveillance-broadcast (ADS-B) systems. [DOK-L3]
- *Summarize* the services ATC is able to provide pilots. [DOK-L2]

ASSESSMENT EVIDENCE

Warm-up
Students review the FAA pamphlet *Runway Safety Best Practices Brochure* and complete a self-assessment, then discuss how ATC can track aircraft that are in the air, far away, or obscured by clouds.

Formative Assessment
Students individually answer questions about radar, transponders, and ADS-B provided to them on a student activity worksheet.

Summative Assessment
Students individually answer questions on all major topics presented in this lesson. Questions are provided on a student activity worksheet.

LESSON PREPARATION

MATERIALS/RESOURCES

- Air Traffic Control Presentation
- Air Traffic Control Student Activity 1
- Air Traffic Control Student Activity 2
- Air Traffic Control Student Activity 3
- Air Traffic Control Student Activity 4
- Air Traffic Control Teacher Notes 1
- Air Traffic Control Teacher Notes 2
- Air Traffic Control Teacher Notes 3
- Air Traffic Control Teacher Notes 4
- Runway Safety Best Practices Brochure

Marco Polo: Student Activity 1 (per group)

- Narrow-focus flashlight or laser pointer
- Meter stick
- 20 strands of yarn (24"/strand)
- 1 roll of strong tape
- 36" 36" piece of cardboard, cut into the shape of a mountain

Responding to Traffic Calls: Student Activity 3 (per team)

- Bright colored chalk or tape
- 3 sheets of cardboard or blank paper, 8 " 11"

LESSON SUMMARY

Lesson 1: Introduction to Airports and Airport Data
Lesson 2: Airport Markings and Signs
Lesson 3: Airport Lighting
Lesson 4: Traffic Patterns
Lesson 5: Communications
Lesson 6: Air Traffic Control (ATC)
Lesson 7: Pilot Communications and the Airport Environment
Lesson 8: Airport Safety and Pilot Considerations

Session One of the lesson begins with a warm-up that reviews the previous lesson. Students read page 7 of the *Runway Safety Best Practices Brochure,* and then answer related questions. They then consider how air traffic controllers (ATC) are able to keep track of aircraft that they can't see (for example, airplanes flying miles away or obscured by mountains).

The lesson then moves to an activity that demonstrates the abilities and limitations of radar using a laser pointer and various "props" to simulate limitations to radar, such as rain and mountains. During the next part of the lesson, students are introduced to radar and how it functions in more detail, including explanations of how radio waves get sent out and return signals that enable controllers to "see" aircraft and distance on their screens. Transponders are explained as the technology that allows more enhanced radar screen "blips," while also enabling controllers to see aircraft altitude. The various buttons and knobs on the transponder are explained, as are the standard transponder codes.

ADS-B technology is explained as the next generation of aircraft location and identification technology, creating (for the first time) a way for pilots to see other aircraft traffic on cockpit screens and without ATC involvement. Fundamental ATC communications are then introduced, with an emphasis on VFR flight, allowing students to gain a solid understanding of ATC's methods of calling out traffic and providing aircraft separation.

Session Two begins with a formative assessment of knowledge retention, then moves to an activity in which students and the teacher take turns playing the role of pilots and ATC. ATC provides clearances and traffic call-outs to the “aircraft,” and students respond accordingly. Emphasis is on aircraft “ground track” as opposed to “heading” as ATC calls out clock direction to the pilots. Students then answer sample FAA Private Pilot Knowledge Exam questions relating to ATC services. Finally, a summative assessment is conducted to evaluate student knowledge of the material presented in this lesson.

BACKGROUND

When Wilbur and Orville Wright first took to the skies, there wasn’t much need for air traffic control; they were the only plane in the sky. That exclusivity didn’t last long. In just a few years, thousands of airplanes were buzzing over towns and across farmland throughout America and Europe. Aircraft collisions, some fatal, began to appear in the newspapers, and many pilots complained about how easy it was to get lost when flying between points. It became clear to all that some form of ground-based control was needed to enhance safety and efficiency of flight. In 1929, the first “air traffic controller,” Archie League, was hired by the city of St. Louis, MO, to use various flags to signal to airplanes to “go” or “hold.” The idea caught on, and quickly spread nationwide. In just a year or two, flags were replaced by onboard radios used for communication and to aid in navigation between airports. By the 1930s, air traffic control was a fact of life for aviators flying long distances or between cities. The era of ATC was here.

The British made widespread use of radar during World War II to warn them against incoming German bombers and fighters; this relatively new technology soon became a universal tool of ATC. Primitive transponders were developed to aid British radar operators in distinguishing “friendly” aircraft from “hostiles.” This first radar could only display location information, but soon altitude detection capabilities were added. Before long this radar was used in civilian aviation to keep pilots apprised, by radio, of nearby air traffic and to ensure adequate separation. This radar also detected weather systems, so controllers could direct pilots around the worst weather for better safety.

Today’s ATC still utilizes radar, but newer, satellite-based technologies have emerged that greatly improve the utility of radar-like services to pilots. Through ADS-B (Automatic Dependent Surveillance – Broadcast) technology, pilots can now see other aircraft in their vicinity, displayed on cockpit screens, without the need for ATC to call out traffic advisories. Since ADS-B is satellite based, it is much less affected by weather and other disturbances. ADS-B promises to be a tremendous asset to ATC, providing controllers better, more reliable information about flights under their control, and improving safety.

Both radar and ADS-B make it possible for controllers to provide “flight following” services to pilots. By seeing aircraft on their radar screens, controllers can advise pilots of other aircraft in their proximity. Pilots then search the skies in the direction of the call-out and maneuver their aircraft to minimize the risk of conflict.

MISCONCEPTIONS

One common misconception comes from the name itself: air traffic control. Controllers do not actually control aircraft; this is done by the pilots. ATC provides information for pilots to use in decision-making; in some cases, it directs pilots to fly specific courses and altitudes. In the end, however, it is the pilot-in-command who is responsible for the conduct of every flight and who controls the aircraft from engine start to shutdown.

Another misconception is that ATC can see all aircraft at all times. This is not the case. Several kinds of aircraft will not appear on an air traffic controller’s radar screen, including aircraft flying low to the ground, aircraft located too far from a radar antenna, and aircraft whose aerodynamic profile was designed to evade radar detection (for example, stealth military aircraft).

DIFFERENTIATION

To help students retain information presented during the EXPLAIN section of the lesson plan, create a Quizlet deck of flashcards (https://quizlet.com/) to define the following vocabulary words: range, azimuth, tilt, radio wave, antenna, phenomena, attenuation, interrogator, transponder, radarscope, squawk, ident, mayday, ADS-B, avionics, vectoring. You may suggest that students review these flashcards at the end of session 1 so that they may feel more confident as they complete the Formative Assessment at the beginning of session 2.

LEARNING PLAN

ENGAGE

Teacher Material: Air Traffic Control Presentation
Student Material: Runway Safety Best Practices Brochure

SESSION 1

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

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

Warm-Up

Instruct students to review the previous lesson by reading page 7 of the following FAA pamphlet:

- *Runway Safety Best Practices Brochure*

This page discusses proper taxiing procedures as they relate to communicating with ATC. Once students have read the material, ask the questions found on page 8 of the pamphlet (Scenarios A–D). Students may answer the questions orally in class, as a group, or individually, as time permits. Emphasize that taxiing aircraft are monitored by a controller who can look out the window and see them; the controller doesn't require any special equipment to keep track of taxiing aircraft.

Then ask this question: "How do controllers keep track of aircraft they CAN'T see, such as those flying miles away?" Lead a classroom discussion, allowing students to speculate about how ATC works with aircraft too far away to see visually, or aircraft obscured by clouds or mountains.

[DOK-L3; *explain, strategize*]

EXPLORE

Teacher Materials: Air Traffic Control Presentation, Air Traffic Control Teacher Notes 1
Student Material: Air Traffic Control Student Activity 1

Slide 5: Radar is the basic technology that enables air traffic controllers to "see" aircraft that are far away or hidden by clouds. In its most basic form, radar sends out microwave signals from an antenna that sweeps through 360° circles. These microwaves bounce off objects in their path (e.g., airplanes) and are returned to the antenna for processing. Processed radar "returns" appear on ATC radar screens as blips. Each blip is a separate aircraft. The location of the blips on the screen indicate the direction and distance of the aircraft from the radar antenna.

The distance, or "range", a radar signal will travel and the altitude it will reach is largely determined by the dish antenna's "tilt." The higher the angle that the antenna is set, the farther and higher the radar microwaves will travel.

Slide 6: Because radar signals are microwaves, they pass through the atmosphere as they emanate outward from the antenna. Disturbances in the atmosphere can interfere with these waves, making them less accurate and precise. Rain and snow are examples of disturbances that can have a significant effect on the range and accuracy of radar. Similarly, mountains or other obstacles that lie between the radar antenna and the aircraft can block radar's ability to see the aircraft, creating zones of poor or no radar coverage.

Slide 7: Distribute **Air Traffic Control Student Activity 1**, which asks students to compare the childhood game of flashlight tag—running around in the dark trying to spot friends with a flashlight—to the process by which ATC looks for airplanes in the sky. ATC's radar is like the flashlight; when it bounces off an airplane (or sometimes other objects like rain or birds), an air traffic controller's radarscope "lights up" a spot, or blip, so the controller can "see" the location of the aircraft. Some obstacles, however, can impede radar's ability to reach the aircraft.

To complete the activity, divide students into groups of 6 and distribute the materials and the worksheet for the activity to each group. When they have completed the activity, have students answer the questions, either alone or within their groups. Answers to the questions are provided in **Air Traffic Control Teacher Notes 1**.

Slide 8: Play the video, "How Do We Monitor all the Planes in the Sky?", and then ask the question that follows. The discussion of transponders is good preparatory information for later in the lesson.

- "How Do We Monitor all the Planes in the Sky?" (Length 3.28)
  https://video.link/w/GxFt

For teachers who are unable to access Safe YouTube links, the video can also be found here: https://www.youtube.cohttps://video.link/w/GxFtm/embed/TLHjVSlXQng?start=0&end=208

Questions

Can you think of any other ways that radar would be useful besides aviation and air traffic control?

Answers may vary: self-driving cars, mobility for blind people, ships avoiding rocks and small islands, submarines, drones, etc.

NOTE: This second video, "Radar as Fast as Possible," is an additional video with the benefit of a brief animation of radar energy bouncing off of an airplane. Near the end, a quick mention of how aircraft evade radar by flying low emphasizes how terrain blocks radar which was an element of **Air Traffic Control Student Activity 1**.

- "Radar as Fast as Possible by Tech Quickie" (Length 3:01)
  https://video.link/w/C2Ft

For teachers who are unable to access Safe YouTube links, the video can also be found here: https://www.youtube.com/embed/A3uIXt1V7YY?start=0&end=181

EXPLAIN

Teacher Materials: Air Traffic Control Presentation, Air Traffic Control Teacher Notes 2
Student Material: Air Traffic Control Student Activity 2

Slide 9: Radar systems are made of a variety of parts, each of which has a specific function.

- The radar *transmitter* sends microwave signals out through an *antenna,* often shaped like a dish. Radar antennas used for aviation are usually pointed just slightly upward to get maximum range at the altitudes airplanes fly and avoid returns from terrain or other ground-based objects.
- When these microwaves bounce off an object, such as an aircraft, the microwaves are sent back to the antenna where they are collected and sent to the system's *receiver* for processing.

- A computer turns the received microwaves into an electronic signal that can be used by a *radarscope.* The radarscope presents the bounced microwaves to the air traffic controller in the form of blips on the screen.
- Each blip is an aircraft, and the presentation depicts the aircraft's position and distance relative to the radar antenna, but not altitude. To depict altitude, the system needs another component, discussed below.

Slide 10: As shown in **Air Traffic Control Student Activity 1**, radar may be compared to the childhood game Marco Polo, in which one swimmer (Marco) attempts to locate other swimmers in a pool. The transmitter sends out the "Marco!" by blasting microwaves out into the air. Aircraft get hit with these microwaves, which bounce back to the radar antenna and receiver, sort of like answering "Polo!" The radar system can determine what direction the return is coming from based on the position of the rotating antenna when the return is received. Distance is calculated easily since the speed (rate) of the microwave signal is known as is the time it takes to reach the target and return. Simple math tells the computer that distance = rate x time.

Slide 11: Knowing the direction and distance of an aircraft is important, but flying is a three-dimensional activity. What about altitude? Unfortunately, radar cannot determine an aircraft's altitude, so an additional device is needed: the transponder.

The transponder is a special radio communication device that mainly provides ATC with two pieces of information: the aircraft's altitude and a four-digit code to help identify specific aircraft. Incoming radar signals "interrogate" the transponder, which responds automatically (the transponder does not use voice communication) by returning a four-digit code that appears next to the aircraft's blip on ATC's radarscope. Transponders with "Mode C" capability also show the aircraft's altitude next to an aircraft's radar blip. ATC can add the aircraft's destination to the data next to the blip if desired, resulting in even more useful information for controllers. The text near a radar blip is called the data block.

Questions

Where are the transponder antennas?

The aircraft has a small antenna on the bottom of the fuselage (body of the aircraft), and the ATC transponder antenna is a bar-shaped antenna that sits atop the dish-shaped primary radar antenna. They rotate together.

Slide 12: Buttons and knobs on the transponder enable the pilot to control its function. At the beginning of each flight, pilots operating in controlled airspace will set the transponder to transmit a 4-digit "squawk" code that identifies that specific aircraft on the radarscope. Without this code all the blips on the scope would look the same, and it would be difficult to identify which blip is which aircraft. The pilot inputs this code into the transponder using the buttons or knobs dedicated to this function. No two aircraft on the radarscope that are being handled by ATC will have the same code, making it easy for controllers to tell aircraft apart. Using this 4-digit system, the transponder is capable of displaying 4,096 unique codes.

Other buttons and knobs on the transponder include:

- On/Off: This turns the transponder on and off.
- Standby: This enables the transponder to be on and warmed without responding to interrogations.
- Altitude: Most transponders today are "Mode C" capable, which means they will transmit altitude information to the controllers automatically. This control is normally on, but in cases where pilots do not wish to transmit altitude, or when the altitude reporting function is faulty, this altitude function is turned off.

- Ident: This causes the blip of the radarscope for this aircraft to glow brighter for a few seconds, making it easier for the controller to pick out a particular aircraft.
- Other optional buttons may be present on some transponders that extend the functionality of the device. For instance, some transponders include a timer and stopwatch function. In those cases, special buttons and knobs are included to control those parameters.

Slide 13: In controlled airspace, transponder codes are often assigned by ATC to aid them in identifying aircraft. The controller will advise the pilot to "Squawk 4212" (or some other 4-digit code), and the pilot will respond by entering the code into the transponder. Sometimes, however, the pilot will initiate a code by entering it into the transponder without receiving an instruction to do so from ATC. Certain unique codes broadcast information to ATC without the need for radio communications.

For example, when operating VFR without the need for flight following, pilots will enter 1200 into their transponder. This identifies their aircraft as a VFR flight, but does not point it out to controllers as a specific aircraft. A controller may see multiple aircraft squawking 1200 on the radarscope at the same time, and will recognize those flights as VFR operations not requesting traffic advisories or other services.

If an aircraft gets hijacked, pilots are trained to enter 7500 into their transponder. This tells ATC that the airplane has been commandeered illegally and sets a law enforcement process in motion.

If an aircraft's radios fail, or communications between the aircraft and ATC have been otherwise lost, pilots enter 7600 into the transponder to advise ATC that they are no longer receiving transmissions. ATC uses this information when directing other traffic around the aircraft squawking 7600, and reverts to light signals when the aircraft is in the traffic pattern.

7700 is the code entered when there is an in-flight emergency. Any event that could jeopardize the safety of the flight may trigger the pilot to enter 7700.

Lastly, military aircraft that are on a mission to intercept another aircraft will squawk 7777, reminding ATC that their aircraft has been tasked to locate and direct another aircraft to either land or to follow them to an airport.

Slide 14: Starting January 1, 2020, aircraft flying in airspace that currently requires transponders (i.e. Class A, B, C, and all airspace above 10,000 feet MSL) will be required to have a new kind of transponder capable of providing even better location information to ATC and other aircraft. This new technology, called Automatic Dependent Surveillance – Broadcast (abbreviated ADS-B), will change the way pilots receive traffic and weather information while in flight, and will greatly enhance ATC's ability to control traffic, especially in congested airspace.

The high-precision GPS data from ADS-B provides greater safety, efficiency, and capacity to the national airspace system, while giving pilots onboard collision-avoidance information known as TIS-B (Traffic Information System – Broadcast) and weather information through FIS-B (Flight Information Services – Broadcast).

Slides 15-16: The ADS-B system relies on several components. An ADS-B transponder in the aircraft both sends and receives signals related to other air traffic and, depending on the system, receives data related to weather. GPS satellites provide extremely accurate aircraft location and altitude information to the system, and onboard GPS equipment sends that data to a network of over 700 ground stations (antennas) across the US. The ground stations then provide aircraft location information to ATC, which displays aircraft location, altitude, and other critical information about each flight on the electronic display at the controller's position. The controller may then vector (direct or guide) aircraft around conflicting traffic; that is, instruct aircraft to turn, climb or descend to prevent conflict. With ADS-B, pilots can also receive traffic information directly from other aircraft, without the need for ATC, greatly aiding in collision avoidance and situational awareness. Many ADS-B installations enable the receipt of FIS-B graphics and data, allowing the pilot to see weather in the vicinity as well as traffic. All of this is possible without traditional radar facilities since accurate position information is provided based on GPS data about every aircraft.

Slide 17: Some may think that the development of ADS-B technology makes ATC unnecessary, but you already know that operating to, from, and through an area with an operating control tower requires two-way radio communication. What about once you have flown beyond a towered airport's airspace? Is it necessary to talk to ATC?

VFR pilots can take advantage of ATC radar services by calling radar facilities, such as control towers and air route traffic control centers (ARTCCs). These controllers assign a discrete transponder code to the pilot, identify the aircraft on their radar display, and then provide separation and sequencing of aircraft, traffic and weather advisories, as well as vectors to help pilots find destinations or avoid other aircraft, obstacles, or weather. VFR flight following can make it easier for controllers to assist pilots who are in distress.

IMPORTANT: Talking to ATC while flying VFR is helpful, but pilots MUST remember that they are the ones responsible for seeing and avoiding other aircraft, obstacles, and weather.

Slide 18: Controllers are not in the airplane with pilots and cannot say, "Hey, watch out for that airplane over there!" Therefore, there must be a system by which controllers can identify the location of traffic that may cause a conflict and communicate that conflict to the pilot using simple, standardized language which the pilot can quickly understand. Enter the analog clock system.

Controllers identify the direction of traffic using the clock as a reference. Imagine an airplane in flight is an analog clock (a clock with "hands" and the numbers 1 through 12 arranged in a circle): 12 o'clock is straight in front (looking forward out the windshield), 3 o'clock is off the right wingtip, 6 o'clock is directly behind the plane, and 9 o'clock is off the left wingtip. When ATC sees traffic that may conflict with a flight, the controller will call the pilot and advise the location of that traffic referencing the clock system. For example, a controller might call a pilot and say something like, "Cirrus 24Y, traffic 3 o'clock 2 miles eastbound is a Bonanza at 3,000." What that means is that the possible conflicting traffic is off the right wingtip, 2 nautical miles away, flying toward the east at 3,000 feet. The system takes some getting used to, but even student pilots quickly catch on and can soon spot traffic quickly and accurately using the analog clock system.

Teaching Tips

As a quick in-class exercise, have a volunteer student/pilot stand in the center of a circle of students and respond to teacher's/controller's traffic call-outs. Have the volunteer call out the name of the student in the location that the teacher call-out indicates. For example, teacher /controller might say "Traffic 6 o'clock." The volunteer would then look straight behind him/herself and call out the name of the student at that location. Give the volunteer 4-5 call-outs, then rotate volunteers so that several students get the chance to be a "pilot."

For reinforcement, you may wish to show this video from AOPA's Air Safety Institute:

- "Jason Schappert on Traffic Advisories - Let Us Know" (Length 3:04)
  https://video.link/w/uj7u

  For teachers who are unable to access Safe YouTube links, the video can also be found here:
  https://www.youtube.com/watch?v=NWYZqXOvwTM

SESSION 2

Slide 19: Complete the **Formative Assessment**.

Formative Assessment

Provide students with **Air Traffic Control Student Activity 2** worksheet: How Much Do You Know About ATC? Instruct them to answer the questions, working alone. Answers are provided in **Air Traffic Control Teacher Notes 2**.

[DOK-L2; *explain*, DOK-L1; *recall*]

EXTEND

Teacher Materials: Air Traffic Control Presentation, Air Traffic Control Teacher Notes 3
Student Material: Air Traffic Control Student Activity 3

Slide 20: While the traffic callout system using analog clock references seems pretty simple, there are some nuances that can complicate it a little. For example, since the controller cannot see what direction the airplane is actually pointing, but rather only sees that aircraft's track over the ground, the clock directions may not be exactly accurate. Let' s say you're flying airplane "A" in the top right of this slide. If you received a call from ATC that there was "traffic 12 o' clock, 2 miles," you would look straight ahead. Since you are flying into a direct headwind in this scenario, there is no crab angle, so the clock callout is pretty simple; look straight ahead, find the aircraft, and maneuver to avoid it if necessary.

Slide 21: But now let's say you're flying aircraft "B." To maintain your desired track (due north), you would have to turn the airplane slightly to the left to counteract the force of the wind pushing you to the right. Recall that this is called "crabbing" and is done all the time by pilots wishing to fly a desired track when the wind is blowing. Now, imagine that ATC calls you and says, "Traffic 3 o'clock, four miles." Where would you look? If you looked straight out the right window, you would not see the target traffic, because it is actually slightly behind the right wing, probably more like the 4 o'clock position. Why? Because the crab angle cannot be seen by ATC. The controller thinks you're pointed due north when, in fact, you're pointed slightly to the northwest. To spot your target airplane, you would have to compensate for this crab angle and look slightly behind that right wing. In practice, pilots take the callout direction from ATC as a general guide and look around the entire area where traffic is called.

Slide 22: One more time. Look at the scenario pictured in the top right of this slide. What might ATC say to the pilot of aircraft "A" to alert the pilot to aircraft "B?" Where would the pilot of aircraft "A" actually look out the cockpit window?

Since the track of aircraft "A" is due east, and aircraft "B" is in line with that track, ATC would say that there was traffic at 12 o'clock. Because of the crab angle aircraft "A" is flying, the pilot would have to look out the window in a 1 o'clock or 2 o'clock direction to see aircraft "B."

Slide 23: Complete **Air Traffic Control Student Activity 3**. Divide the class into two teams ("traffic" and "pilot") and distribute the activity worksheets. Mark the activity area with designated airports, using chalk or tape. The teacher may begin by playing the part of ATC and give clearances for the pilots to fly from San Francisco, Chicago, and Houston. Along the way, you give traffic advisories, identifying target traffic by the name of the target student. Student "pilots" respond by looking in the right direction and acknowledging the advisory by saying, "looking," or "[target student name] in sight."

You may begin with a no-wind situation, but add a challenge by stating that the wind is blowing from a particular direction. See if students crab appropriately then instruct pilots to continue crabbing along their route of flight and respond appropriately to traffic calls. Remind them that responding to calls while crabbing requires that they look in a slightly different location than ATC indicates, taking into consideration the wind and the direction in which they crab to compensate. When the activity is complete, instruct students to answer questions, either individually or as teams. If time permits, initiate class discussion of the **Going Further** question.

EVALUATE

Teacher Materials: Air Traffic Control Presentation, Air Traffic Control Teacher Notes 4
Student Material: Air Traffic Control Student Activity 4

Slides 24-35: Sample FAA Knowledge Exam Questions

Slide 36: Conduct the **Summative Assessment**.

Summative Assessment

Distribute **Air Traffic Control Student Activity 4**, "It's a Wrap! Confirm Your Knowledge." Instruct students to work alone to answer the questions on the learning material presented throughout this lesson. Answers to questions are provided in **Air Traffic Control Teacher Notes 4**.

[DOK-L2: *explain*, DOK-L1: *recall*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Postings show evidence of one or more of the following:
    - Knowledge of flight paths and basic instruments
    - Provides details about the factors that affect flight path
    - Provides explanation of actions pilots can take to account for wind and other factors while flying
- Contributions show understanding of course of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	Provides complete answers the questions with full understanding of the lesson objectives demonstrated.
7-8	Provides answers to the questions; minor gaps in understanding of lesson objectives is evident.
5-6	Provides answers to most questions; many gaps in understanding of lesson objectives is evident.
0-4	Student work is incomplete; there is a lack of understanding of the lesson objectives.

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
        - Constructing Explanations and Designing Solutions
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions

- Crosscutting Concepts
    - None

COMMON CORE STATE STANDARDS

- **RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - 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 11-12 texts and topics*.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

FAA AIRMAN CERTIFICATION STANDARDS

PRIVATE PILOT

I. Preflight Preparation

Task B. Airworthiness Requirements

- Knowledge - The applicant demonstrates understanding of:
    - **PA.I.B.K1** General airworthiness requirements and compliance for airplanes, including
        - **PA.I.B.K1a** Certificate location and expiration dates
    - **PA.I.B.K3** Equipment requirements for day and night VFR flight
- Risk Management - The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
    - **PA.I.B.R1** Inoperative equipment discovered prior to flight.
- Skills - The applicant demonstrates the ability to:
    - **PA.I.B.S1** Locate and describe airplane airworthiness and registration information
    - **PA.I.B.S2** Determine the airplane is airworthy in a scenario given by the evaluator.
    - **PA.I.B.S3** Apply appropriate procedures for operating with inoperative equipment in a scenario given by the evaluator.

III. Airport and Seaplane Base Operations

Task A. Communications, Light Signals, and Runway Lighting Systems

- Knowledge - The applicant demonstrates understanding of:

- **PA.III.A.K2** Proper radio communication procedures and ATC phraseology.
- **PA.III.A.K4** Appropriate use of transponders.
- **PA.III.A.K5** Lost communication procedures.
- **PA.III.A.K6** Equipment issues that could cause loss of communication.
- **PA.III.A.K7** Radar assistance.

- Risk Management - The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
  - **PA.III.A.R1** Poor communication.
- Skills - The applicant demonstrates the ability to:
  - **PA.III.A.S1** Select appropriate frequencies.
  - **PA.III.A.S2** Transmit using phraseology and procedures as specified in the AIM.
  - **PA.III.A.S3** Acknowledge radio communications and comply with instructions.

REFERENCES

https://www.faa.gov/air_traffic/technology/asr-11/

https://www.faa.gov/nextgen/programs/adsb/

https://www.faa.gov/nextgen/equipadsb/capabilities/ins_outs/

https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-114A_CHG_1.pdf

FAA Advanced Avionics Handbook

FAA Airplane Flying Handbook

FAA Aeronautical Information Manual