Next Generation Air Transportation System

Session Time: One, 50-minute session

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Appreciate the rich, global history of aviation/aerospace and the historical factors that necessitated rapid industry development and expansion. (EU1)

Aspire to the highest level of technical proficiency as it relates to flight operations and engineering processes. (EU5)

Develop an uncompromising safety mindset, understanding that growth and development in the aviation/aerospace industry must always be accompanied by responsible safety initiatives. (EU6)

ESSENTIAL QUESTIONS

1. What are the major limitations of the current national air transportation system?
2. What risks do we face if we do not improve the national air transportation system?
3. Is it possible to greatly increase the capacity and efficiency of the national air transportation system while also maintaining current safety standards?

LEARNING GOALS

Students Will Know

- Why the national air traffic control system is being modernized
- The new system for managing air traffic that is replacing radar and radio technology
- Benefits of modernizing the air traffic control system

Students Will Be Able To

- *Summarize* how innovation and technology help solve airspace capacity limitations and increase safety. (DOK-L2)
- *Synthesize* the need for airspace modernization. (DOK-L4)

ASSESSMENT EVIDENCE

Warm-up
Students will participate in a class discussion after watching a video that provides a 24-hour view of air traffic. Students will consider when and where “rush hours” occur and the challenges that might exist in attempting to increase airspace capacity over the United States.

Formative Assessment
Students will create a public service announcement that asks them to describe the benefits of the Next Generation Air Transportation System (NextGen).

Summative Assessment

Students will imagine that they work for an interest group that lobbies Congress to provide funding for NextGen. They will write a letter to describe the problem and the need to address the problem with urgency. Students will explain how this impacts their aviation-related careers.

LESSON PREPARATION

MATERIALS/RESOURCES

- Next Generation Air Transportation System Presentation
- Next Generation Air Transportation System Student Activity
- Next Generation Air Transportation System Teacher Notes

LESSON SUMMARY

Lesson 1 – Next Generation Air Transportation System
Lesson 2 – Integrating Drones

The lesson will begin by having students watch a video that gives a 24-hour view of air traffic. Students will consider when "rush hours" occur and challenges that might exist in attempting to increase airspace capacity over the United States.

Through a presentation, students will learn the factors that underlie the necessity of modernizing the national airspace system and how the current system of guiding air traffic is outdated. They also will learn about the satellite/GPS-based technology that is the backbone of NextGen. As a formative assessment, students will create a public service announcement that asks them to describe the benefits of NextGen.

For an extension activity, students will view a video and complete a video guide that will prompt them to think about the consequences of the move to NextGen.

Finally, students will imagine that they work for an interest group that lobbies Congress to provide funding for NextGen. They will write a letter to describe the problem and the need to address the problem with urgency. Students will explain how this impacts their aviation-related careers.

BACKGROUND

In a little more than one century, aviation has transformed the planet. Nearly everyone is affected by it in one way or another. This includes access to affordable and quick transportation, the ability to travel to places that otherwise would be nearly inaccessible, and goods that are now available globally and not just locally.

As reliance on aviation increases, there is also more air traffic. Existing airports and the airspace above must be able to accommodate new aircraft types, more aircraft, and the specific needs of each.

Students were first introduced to the current air traffic control system in Unit 5. They learned that tracking aircraft is not all that precise with the technology being used today, which relies primarily on radar – a technology that first impacted aviation during World War II.

Radar is a detection system that uses radio waves to determine the range, angle, or velocity of objects. A radar system consists of a transmitter producing electromagnetic waves, a transmitting antenna, a receiving antenna, and a receiver and processor to determine properties of the object(s). Radio waves from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed. Transponders, located on most aircraft, detect incoming radar signals and broadcast an amplified, encoded radio signal in the direction of the detected radar wave. The transponder signal provides an air traffic controller with the aircraft's flight number, altitude, airspeed, and destination. There is a delay in the time it takes for the radio signal to return to the receiver. In addition, the air traffic controller's picture on the radar scope updates only as fast as the radar antenna can spin around. This also causes a

delay and leads to less accurate information about the location of the aircraft. These limitations are why the FAA requires a significant margin of error be maintained between aircraft. This in turn means fewer airplanes can move through a given amount of airspace, leading to delays. The delays become extensive when occurrences like weather or temporary flight restrictions (TFRs) arise. (A TFR restricts certain aircraft from operating within a defined area in order to protect persons or property in the air or on the ground. The FAA issues TFRs when the president travels, for instance, or around a forest fire so that firefighting airplanes do not have to be concerned about colliding with other aircraft.)

Scientists and engineers have been working to modernize the air traffic control system for years. A new airspace system called the Next Generation Air Transportation System (dubbed NextGen) will convert the current radar-based air traffic system to a satellite-based one using the global positioning system (GPS). Using a satellite-based system will provide air traffic controllers with exact locations of aircraft in real time, allowing for more precise detection of aircraft in the air, keeping the increasingly congested airspace safer, and allowing aircraft to fly closer together. This technology will be used to shorten flight routes, save time and fuel, reduce traffic delays, increase airspace capacity, and permit controllers to monitor and manage aircraft with greater safety margins. It also will be crucial as newer aircraft, such as drones, are integrated into the airspace. Data exchange eventually will replace radio communications. This means pilots will receive air traffic control clearances and instructions via something like a text message rather than voice communications over a radio.

Automatic Dependent Surveillance-Broadcast (ADS-B) is the GPS-equipped hardware that will be installed on aircraft in order to give air traffic controllers more precise aircraft positions. Nearly all aircraft will be required to have ADS-B equipment installed by 2020. ADS-B equipment transmits high-fidelity GPS data to ATC facilities. ADS-B equipped aircraft also will be able to communicate with each other, anticipate potential collisions, and adjust flight paths as necessary to avoid conflicts.

MISCONCEPTIONS

Because GPS has become so widely adopted, some students may believe that it is currently used as the primary technology to track aircraft in the national airspace system when radar technology developed during World War II is still the primary method of controlling and separating airplanes.

DIFFERENTIATION

During the **ENGAGE** and **EXPLORE** components of the lesson, utilize strategies to assist students in processing the information, such as doing Think-Pair-Share and by probing basic answers of students performing below grade level.

LEARNING PLAN

ENGAGE

Teacher Material: Next Generation Air Transportation System Presentation

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

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

Warm-up

Ask students to recall the lesson from Unit 7 about air traffic control as a career. This lesson will focus on the development of technology designed to assist air traffic controllers in their work.

Before students watch the video, ask them to consider the following questions:

- When and where do airplane “rush hours” occur?
- What challenges exist to expanding airspace capacity in the future?

Show students the video and then discuss the two questions above.

- A Day in the Life of Air Traffic Over the United States (Length 2:57) http://video.link/w/NXOe

Questions

When and where do airplane “rush hours” occur?

Traffic starts on the East Coast in the early morning and builds as the day progresses, progressively moving toward the West Coast. The video shows the most congestion around major cities where airlines have hubs (like New York City, Los Angeles, and Memphis). Aircraft peaks with about 5,000 aircraft in the skies at the same time.

What challenges exist to expanding airspace capacity in the future?

Weather can cause major delays. So does restricted airspace, like special military areas. Densely populated areas (like the East Coast) provide challenges, too.

EXPLORE

Teacher Material: Next Generation Air Transportation System Presentation

Slide 5: Help students understand the factors that underlie the necessity for modernizing the national airspace system. As the global economy and population expand, reliance on aviation will increase. The goals of modernization include using new technologies and procedures to increase the safety, efficiency, capacity, access, flexibility, predictability, and resilience of the national airspace system while reducing the environmental impacts of flying. Students will recall from previous lessons that tracking aircraft is not all that precise with the technology being used today, which relies primarily on radar – a technology that was developed during World War II.

Slides 6-7: Boeing estimates that in the next 20 years, the global fleet of aircraft will double to 48,540 airplanes, causing the national airspace to be saturated with twice the traffic. A U.S. Department of Transportation 30-year outlook report published in 2016, “Beyond Traffic: Trends and Choices 2045,” estimated flight delays and congestion cost the U.S. economy more than $20 billion each year. In addition, the report predicts the total number of people flying on U.S. airlines will increase by 50 percent over the next two decades. If capacity is to keep pace with increased demand for services, changes are needed in the way services are provided.

Slide 8: Ask students using a Think-Pair-Share format what specific types of air traffic they predict will increase over the coming years.

Questions

What specific types of air traffic do you think will increase over the coming years?

Answers might include:

- *More passengers will mean more airliners in the sky.*
- *More goods traveling around the globe will mean more cargo aircraft in the sky.*
- *Millions of drones will be entering the skies. (Inform students that the integration of drones in the airspace will be covered in the next lesson.)*

EXPLAIN

Teacher Material: Next Generation Air Transportation System Presentation

Slides 9-10: During a class discussion, explain to students how the current system of guiding air traffic is outdated. Locating airplanes in the sky is not all that precise today. The current air traffic control system relies primarily on radar – a very old technology that first made an impact on aviation during World War II. After the war, civil aviation began to use radar for aircraft guidance and surveillance.

A radar system consists of a transmitter producing electromagnetic waves, a transmitting antenna, a receiving antenna, and a receiver and processor to determine properties of the object(s). Radio waves from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed. Transponders, located on most aircraft, detect incoming radar signals and broadcast an amplified, encoded radio signal in the direction of the detected radar wave. The transponder signal provides an air traffic controller with the aircraft's flight number, altitude, airspeed, and destination. There is a delay in the time it takes for the radio signal to return to the receiver. In addition, the air traffic controller's picture on the radar scope updates only as fast as the radar antenna can spin around. This also causes a delay and leads to less accurate information about the location of the aircraft. These limitations are why the FAA requires a significant margin of error be maintained between aircraft. This in turn means fewer airplanes can move through a given amount of airspace, leading to delays.

Slide 11: The Next Generation Air Transportation System (dubbed NextGen) is the FAA-led modernization of the U.S. national airspace system. Scientists and engineers have been working to modernize the air traffic control system for years. NextGen will convert the current radar-based air traffic system to a satellite-based one using GPS. Using a satellite-based system will provide air traffic controllers with exact locations of aircraft in real time, allowing for more precise detection of aircraft in the air, keeping the increasingly congested airspace safer, and allowing aircraft to fly closer together.

Slide 12: Data exchange eventually will replace radio communications. This means pilots will receive air traffic control clearances and instructions via something like a text message rather than voice communications over a radio. Air traffic controllers are able to send clearances with route information to pilots instead of providing the instructions over the radio. Pilots review the clearances and accept them by simply pushing a button, which then loads the route into the aircraft's flight computer.

According to the FAA, more than 4,000 aircraft are already equipped with the equipment needed to receive data clearances. Data communications are expected to save operators more than $10 billion over 30 years due to reduced taxiing time on airport grounds and fuel consumption on the ground and in the air.

Slide 13: Automatic Dependent Surveillance-Broadcast (ADS-B) is the GPS-equipped hardware that will be installed on aircraft in order to give air traffic controllers more precise aircraft positions. Nearly all aircraft will be required to have ADS-B equipment installed by 2020. ADS-B equipment transmits high-fidelity GPS data to air traffic control facilities. ADS-B equipped aircraft also will be able to communicate with each other, anticipate potential collisions, and adjust flight paths as necessary to avoid conflicts.

Slide 14: Describe the three main benefits of NextGen: increased safety, increased airspace capacity, and lessened aviation impact on the environment.

Teaching Tips

If time allows, extend the conversation by having students discuss, define, and propose solutions to overcome potential problems they see in NextGen.

Possible shortfalls include drone integration, in-flight emergencies, slow integration of NextGen, and commercial space traffic. Student proposals will vary.

Slide 15: Conduct the **Formative Assessment**.

Formative Assessment

In groups of two or three, have students create a public service announcement that highlights the benefits of NextGen. Student work should include a script no longer than 30 seconds in length. As an extension, students may present this project in other types of media (e.g., video). Allow groups to share their work with the class. Take no more than 10 minutes for this assessment.

[DOK 4: *create*; DOK 2: *show*]

EXTEND

Teacher Materials: Next Generation Air Transportation System Presentation, Next Generation Air Transportation System Teacher Notes
Student Material: Next Generation Air Transportation System Student Activity

Slide 16: Students will watch the video "NextGen Flight 101" and answer the questions on a video guide provided in the **Next Generation Air Transportation System Student Activity**. The guide will help emphasize the benefits of NextGen. Answers to the video guide can be found in **Next Generation Air Transportation System Teacher Notes**.

- "NextGen Flight 101" (Length 6:35)
  http://video.link/w/iAPd

EVALUATE

Teacher Material: Next Generation Air Transportation System Presentation

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

Summative Assessment

Have students imagine that they work for an interest group that lobbies Congress to provide funding for NextGen. They should write a letter to describe the problem and the need to address the problem with urgency. Students should explain how this impacts their future aviation-related careers. Students must work individually and may use their notes.

[DOK L4: *synthesize*]

Summative Assessment Scoring Rubric

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

- An understanding of why the national airspace system needs to be modernized
- Knowledge of the system that is being replaced and the technology that is being deployed to modernize air traffic control
- An understanding of the benefits for modernizing the air traffic control system

Student work shows overall 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

Students can do additional online research to determine how much cost savings NextGen will bring (i.e., savings to airlines in reduced delays and fuel saved) and the quantitative impact it will have on the environment (i.e., reduced emissions and noise).

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-dimensional Learning

- **HS-ETS1-1** – Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
    - 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
        - Systems and System Models

        - Influence of Science, Engineering, and Technology on Society and the Natural World
- **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
        - Influence of Science, Engineering, and Technology on Society and the Natural World
- **HS-ETS1-4** – Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
    - Science and Engineering Practices
        - Using Mathematics and Computational Thinking
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - Systems and System Models

COMMON CORE STATE STANDARDS

- **RL.9-10.2** – Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.
- **RL.9-10.4** – Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
- **RST.9-10.1** – Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **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.9-10.2** – Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- **WHST.9-10.4** – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- **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.faa.gov/news/fact_sheets/news_story.cfm?newsId=21514
https://www.faa.gov/nextgen/what_is_nextgen/
https://www.transportation.gov/policy-initiatives/beyond-traffic-2045-final-report
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