Air Traffic Management

NASA Office of STEM Engagement Next Gen STEM

EDUCATOR NOTES

Learning Objectives

Students will:

- Analyze new challenges posed by increased air traffic in the future
- Evaluate and refine a technological solution to increased air traffic around an airport to minimize the impact on the surrounding environment

Investigation Overview

In this activity, students will use a programming language to create an interactive simulation of a drone navigating through a crowded airspace while delivering passengers or products to their destination. The simulation engages students in computational thinking, problem solving, and real-world application of mathematics.

NASA CONTEXT

We are embarking in a new era of aviation and our future has never looked brighter. As air taxis and delivery and emergency response drones begin to crowd the air space around our airports and cities, so does the hazards and risks associated with heavier air traffic. This increase in aircraft over our cities will require new research tools, innovative technologies, and operational methods. A major aspect of handling this increase in air traffic is safety, and that is the goal of NASA's **System-Wide Safety (SWS)** project.

SWS assesses how the aerospace industry, and aircraft modernization, impacts the safety in and around our airspace by using the latest technology to address possible risks. The future of aviation will include using digital platforms, so NASA is developing innovative solutions that are already aligned with these platforms. By ensuring that aviation safety is a priority during this digital transformation, the SWS project seeks to ensure future aviation is even safer than it is today. The SWS project is part of

HIGH SCHOOL

Grades 9-12

Suggested Pacing

60 to 120 minutes

Materials

- Computer or tablet with internet access (or download all content to run locally)
- Download file containing: Drone Sprites, Stages, and Geofenced Area Sprites
- Programming language of your choice (Note: *Snap!* and *Scratch* can be downloaded to run locally) This activity gives instructions using *Scratch*
  - Free *Scratch* account at: **http://scratch.mit.edu**
  - Free *Snap!* Account at: **https://snap.berkeley.edu**

National STEM Standards

- **HS-ESS3-4 Earth and Human Activity**
  Evaluate or refine a technological solution to reduce impacts of human activity on natural systems.
- **HS-ETS1-1 Engineering Design**
  Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions accounting for societal needs and wants.
  HS-ETS1-2 Engineering Design
  Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- **HS-ETS1-4 Engineering Design**
  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.

the Airspace Operations and Safety Program within NASA's **Aeronautics Research Mission Directorate**. SWS is focused on exploring, discovering, and understanding the impact on safety from future advancements in aviation and any associated risks. Through SWS's research involving emerging, unpiloted aircraft and urban operations, the project will also benefit the non-flying public by helping to reduce risk to people, property, and infrastructure on the ground.

In this activity, students will role play as an aircraft dispatcher of the future. They will be creating a crowded airspace over an urban or suburban digital environment and will be challenged to navigate the airspace to various waypoints and destinations, all while avoiding collisions with other aircraft. Students will be provided with digital files of various aircraft to choose from. One of the vehicles is an air taxi. Air taxis are zero-emission aircraft using electric power to take off, cruise, and land, providing an appealing option for commercial industry interested in more sustainable transportation. The air taxi will provide cross-town trips, like the ride-share services we use today, but in the sky! The passenger will board the flight at a convenient location, and the flight will depart without delay. They take off and land vertically like helicopters. The landing zones for these aircraft are called vertiports. NASA is researching how adding new aviation capabilities will affect communities. This includes physical areas of focus — including adding vertiports to existing airports and building charging stations — as well as digital areas of focus — how aircraft will communicate with one another and with air traffic control.

Students will also be using other aircraft such as drones and quadcopters. NASA is conducting research into ways for drones of all types and sizes to safely move through the sky, using "invisible highways."
Drones can be used to deliver goods to a consumer's home, such as medical prescriptions, small packages, and large cargo deliveries. Drones can also help aid in disaster relief, assist in firefighting missions, and provide supplies to hard-to-reach areas. To learn more about the vehicles of our future, visit NASA's **Urban Air Mobility (UAM)** website.

Best of luck to your students as they navigate the challenges that our future of aviation poses to our communities and Earth as a whole!

Advanced Air Mobility, with its many vehicle concepts and potential uses in both local and intraregional applications, is shown in this illustration. NASA/Lillian Gipson/Kyle Jenkins

Investigation Preparation

- Download the files provided with this activity for students to access in their programming environment
  - If local internet is not available, you can download both *Snap!* and *Scratch* to run locally
- This activity can be done individually by students, or you can pair them together, based on the educator's discretion
- If students complete the task with time remaining, you can assign them additional higher-level requirements to keep them challenged, located in the *Elaborate* section. Additionally, they can develop their own requirements and change their code to meet the new requirements.
- The *Additional Resources* section at the end of this activity also contains other NASA products for more practice with block-based programming, which are especially helpful for beginner programmers

Introduce the Investigation

For this activity, students will upload one of the two stages provided for their program. On the stage, students will choose a start/end point for the drone, place a vertiport sprite at that location, and choose where it will fly to complete its mission. The drone must return to the vertiport once it has completed its mission. Next, students will add various aircraft to fly onto and off the stage. The aircraft should be continually moving and entering and exiting the screen in a loop. Just as in the future, there will be "invisible highways" in the sky, planes will be flying in a prescribed flight path, and drones will need to avoid colliding with various aircraft. Students should add at least four aircraft to the stage. To create the drone's flight path, add as many waypoints as needed to avoid the other aircraft flying along their "invisible highways." The drone will fly from the start point to the first waypoint, then to the second, and so on. One of the waypoints should be the drop-off area. The drone will end its flight back at the vertiport without running into any of the other aircraft. If the drone flies into another aircraft, the drone should immediately stop flying and the program should end.

Criteria	Constraints
Choose one of the two stages provided	The drone cannot fly into any other aircraft
Use at least two waypoints	
Use at least four aircraft to create air traffic	
Choose one of the two drones provided	
The drone must make a complete round trip	

Facilitate the Investigation

ENGAGE

Consider introducing students to NASA's work with air-traffic management and the future of flight with the following resources:

- Video — Future of Flight (3:42) **www.youtube.com/watch?v=PhYwuMzR5ds**
- Website — Sky for All **nari.arc.nasa.gov/skyforall/**
- Video — Sky for All in the Mid-21st Century Future (1:55) **www.youtube.com/watch?v=TftvDXKaG-s**
- Video — UAM (Urban Air Mobility) Let's open the Skies (1:30) **www.youtube.com watch?v=FmBbVJ4TkO4&list=PLiuUQ9asub3R10rlZ8h8vHWLYaQAGRh8S&index=6**

EXPLORE

Provide the following instructions to students:

- Upload one of the two provided stages
- Choose one drone sprite from the two provided and upload it into the program
- Choose what area(s) will serve as take-off point(s) (i.e., vertiport(s)) and the destination(s), and use the provided sprites to mark those areas on the stage after uploading them into the program
  - Students may decide to have several destinations, depending on the mission they have decided to perform
- Choose appropriate sizes for the sprites
  - The drone will not be to scale with the background, so students will need to scale it to the appropriate size
- Upload at least four more aircraft sprites

    - Write programs for each aircraft to fly in and out of the stage in a repetitive manner
    - Students may choose various latitudes and longitudes for the entering/exiting of each aircraft
- Write a script so the drone moves from waypoint to waypoint to complete their mission and return to the start/end point without colliding with the other aircraft
- Pause at the drop-off location and alert the user that the drone has completed its mission

EXPLAIN

- Students will write or describe their own scenario for the simulation and present their scenario to another student or to the entire class.
    - Examples: a drone is delivering medication to a hospital, a drone is delivering a game controller to a friend in the neighborhood, a drone is helping locate flood victims
- Add manual controls so the user can control the drone's movement and prevent collisions with the other aircraft
- Add a button the user can click for directions and further understand the scenario for the simulation
- Research the "Sky for All" website (**nari.arc.nasa.gov/skyforall/**) and create a presentation about their simulation, including their background research about the future of air travel

ELABORATE

You can extend this activity in many ways for students who quickly grasp the concept:

- Add a splash screen at the start of the program giving the basic instructions
- Create a new sprite for the drone using *Scratch's* paint tool or other software
- Add sound effects (there are sound effects built into *Scratch*, or students can record their own)
- Create a new background (i.e., stage) using mapping software (this could include the area around where the student lives)
- The program determines and records whether the drone delivered the communication message to the correct delivery location (i.e., did it touch the delivery location sprite during the drop-off?)
- Add multiple delivery locations or delivery vehicles
- Use a different coding program, such as Python, to create a flight plan simulation

EVALUATE

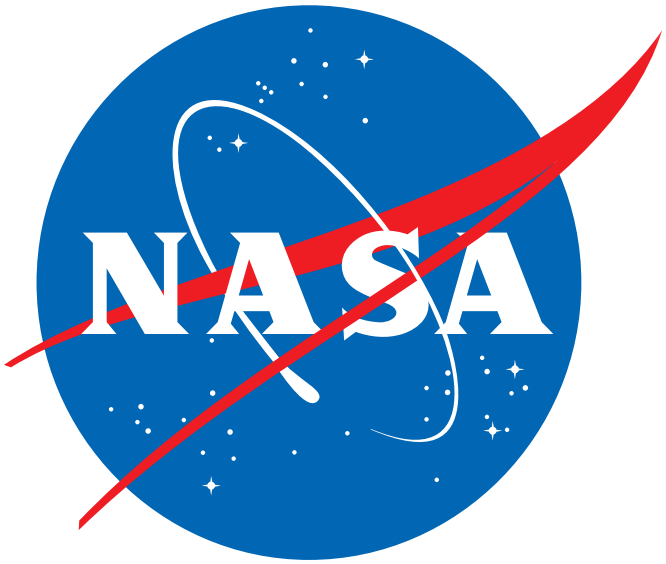
Instruct students to trade their coding simulation with other students and have them assess each other's code by answering the following questions:

- Does the program meet all the assigned requirements?
- Does the drone do what it is supposed to do with no errors (i.e., navigate the airspace to complete its mission without running into other aircraft)?
- Have all errors or bugs been eliminated throughout the code?
- Did the student go beyond the basics and explore the addition of creative or more in-depth scripts?

Additional Resources

For beginning coders, the following resources provide step-by-step instructions:

- Attack of the Drones:
    - **www.nasa.gov/stem-content/attack-of-the-drones/**
    - NASA's Aeronautics Research Mission Directorate developed this tutorial-style activity to guide students through the creation of a side-scrolling game which highlights some of the aspects of AAM (Advanced Air Mobility)
- Explore Mars with *Scratch*:
    - **www.jpl.nasa.gov/edu/teach/activity/explore-mars-with-scratch/**
    - NASA's Jet Propulsion Laboratory in Southern California designed this activity, which takes a student through the steps of creating a simple game of controlling a rover on Mars
- Crew Orbital Docking Simulation:
    - **www.nasa.gov/stem-ed-resources/crew-orbital-docking-simulation-coding-sim.html**
    - Designed as part of the Commercial Crew Program, this NASA activity challenges students to create a simulation of a commercial spacecraft docking with the International Space Station
- **Code.org** for beginner tips/tricks on coding basics



For more, join our community of educators, NASA CONNECTS!

https://stemgateway.nasa.gov/connects/s

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