



4-H
NATIONAL
YOUTH
SCIENCE DAY

DRONE



DISCOVERY

Facilitator Guide



I pledge my **H** **AD** to clearer thinking,

my **HE** **RT** to greater loyalty,

my **H** **NDS** to larger service,

and my **HE** **LTH** to better living,

for my club, my community, my country

and my world. 



Welcome to the Drone Discovery!



Introduction

4-H National Youth Science Day (NYSD) is an exciting, interactive learning experience that engages youth in science, technology, engineering and math (STEM). It is the premier national rallying event for year-round 4-H STEM programming, bringing together volunteers, young people and educators from the nation's 110 land-grant colleges and universities to simultaneously complete the National Science Challenge.

This year's challenge, Drone Discovery, explores the engineering design and flight principles of drones. The activities demonstrate how drones and remote sensing can be used to solve real-world problems. The Drone Discovery challenges, if completed at the same time, are designed to take approximately two hours and are appropriate for students from grade 4 and above. Additional activities provide suggestions to extend learning about drones to real-world applications.

Your Role as Facilitator

The goal of 4-H National Youth Science Day is to introduce young people to and spark their interest in STEM opportunities. Your role as facilitator is vital. As you guide the participants through the engineering design process, you will have the opportunity to mentor young people through active learning experiences. Thank you for inspiring youth to learn and grow!

Using This Guide

The Facilitator Guide includes content from the Youth Guide, as well as additional information to assist you in facilitating the Drone Discovery. Throughout the guide, you will find:



Did You Know?

Additional information for participants.



Talk About It

Questions you can use to facilitate group discovery and inquiry.



Leader Notes

Additional background information and tips for facilitating the challenge.



Youth Guide

When you see this symbol, direct youth to their Flight Log to record their work.



NATIONAL YOUTH SCIENCE DAY: DRONE DISCOVERY

The premier national rallying event for year-round 4-H STEM programming



The Challenge

The Drone Discovery Challenge is modular to enable you to design activities that work best for your group. Drone Discovery can be held in a variety of locations, indoors or out. Below are the various Drone Discovery activities.



TAKE OFF

25 Minutes

Youth create a scenario to use their drones. They learn what drones are and explore flight dynamics and principles.

or



TAKE OFF (Short)

5 Minutes

Youth create a scenario to use their drones. They then do the "What are Drones?" reflection to explore what drones are and how they can be used.



FOAM DRONE

60 Minutes

Youth learn about remote sensing by designing and using a model drone. They share the data their drones collect at a video film festival.



CODE COPTERS

40 Minutes

Use the "Code Copters" activity to explore coding concepts. Then youth complete the activity by creating, coding, and "flying" a simulated drone using Scratch programming language.

or



CODE COPTERS (IRL)

30 Minutes

Do the "Code Copters IRL (In Real Life)" activity for a low-tech way to explore coding.



LANDING: TAKE ACTION

5 Minutes

Youth use what they have learned to take action through citizen science, career exploration or civic engagement.

Planning Your Challenge Event

There are a variety of ways to lead a group through the Drone Discovery (see below for some examples). Choose the one that works best for your group or design your own! Remember to start your challenge with a welcome and the 4-H Pledge.

EXPERIENCE THE FULL CHALLENGE

TAKE OFF



25 Minutes

FOAM DRONE



60 Minutes

CODE COPTERS



40 Minutes

LANDING: TAKE ACTION



5 Minutes

SHORT & SWEET

TAKE OFF (SHORT)



5 Minutes

FOAM DRONE



60 Minutes

or

CODE COPTERS



40 Minutes

LANDING: TAKE ACTION



5 Minutes

LOW-TECH

TAKE OFF



25 Minutes

FOAM DRONE



60 Minutes

CODE COPTERS (IRL)



10 Minutes

LANDING: TAKE ACTION



5 Minutes

The Challenge in Two Parts

You might find it helpful to ask a group to start their NYSD experience with pre-work before you arrive to facilitate, for example when working with an afterschool program or classroom. In this case, send the group the “Take Off” activity to complete before you arrive. Then continue with the remaining Challenge activities.

Working with Younger Audiences

With a few adaptations, any of these activities could be developmentally appropriate for a younger audience. Keep in mind that younger youth learn better with more active, shorter experiences. Take Off is especially well suited to a younger audience.

Why Drones?

Drones are tools for remote sensing or learning from a distance. ‘Drone’ is the common name for an Unmanned Aerial Vehicle (UAV). UAVs are comprised of a system of tools that work together. The four main parts of the system are the platform, sensor, target and ground control station. The platform is the aircraft, such as a fixed wing plane or quadcopter. Remote sensors, such as cameras, collect information about a target. The target is what is being observed, such as landscape features or wildlife populations. The ground control station is where the person remotely operates the drone.

Drones are particularly useful for jobs that are dull, dirty or dangerous, such as inspecting cell towers and roofs. They have been used to monitor flare stacks for natural gas, to fly over flooded rivers and analyze storm damage, or in military situations to keep soldiers out of harm’s way. Drones also give us more degrees of freedom, as they can travel almost anywhere as often as needed, including under bridges or over crops in a field. They have been used to map ocean currents, cross-country power lines and pipelines, and can be used for anything from pollution monitoring to pizza delivery, agriculture to humanitarian aid, and forecasting the weather to firefighting.

People are discovering new ways to use drones every day. The technology is developing rapidly; engineers can now build drones of all sizes that can fly longer distances and are equipped with increasingly precise sensors. No one knows yet the full range of what can be accomplished with drone technology.

The Drone Discovery gives the participants a chance to create their own scenarios that simulate using drones to improve their communities. The simulations give youth the opportunity to discover practical engineering design solutions to real world problems.

What’s in a name?

Drone, UAV, UAS, RPV, RPA, RPS? All of these are names for flying, sensing vehicles that are piloted remotely. All of these vehicles are very similar. The name you choose depends on how you intend to use it.

- UAV: Unmanned Aerial Vehicle
- UAS: Unmanned Aerial System
- RPA: Remotely Piloted Aircraft
- RPS: Remotely Piloted System



Youth Guide (p. 3)

In “What are Drones”, ask the youth to reflect on what they think drones are and what they can do.

Explore STEM in the Drone Discovery

4-H STEM programs provide young people with opportunities to have fun learning about and using science, technology, engineering and math to envision themselves as future scientists and engineers, and to use what they learn to contribute to their communities.

Have Fun with the Drone Discovery!

Take time to play as you fly things, make movies and create computer simulations of real-world applications for drones. Allow time for the youth to design, reflect and redesign. When they run into problems, ask questions to help them come to their own solutions. Suggest ways they can help each other or explore other resources to solve the Drone Discovery challenge. Celebrate initial successes, avoid comparing them to each other, and play along! Your enthusiasm can be contagious!

Explore STEM Concepts

Explore the concepts of flight dynamics, engineering design, the principles of flight, remote sensing and computer coding in the Drone Discovery.

Explore Flight Dynamics: Take Off and Foam Drone

Flight dynamics is the study of performance, stability and control of vehicles flying through the air. It's also a great way to explore math concepts through the applications of the Cartesian coordinate system, using x, y and z axes.

- **Roll:** Rotation around the front-to-back axis
- **Pitch:** Rotation around the side-to-side axis
- **Yaw:** Rotation around the vertical axis

The route an aircraft moves through is called a flight path, which is controlled by flight dynamics. A flight pattern is a standard path the aircraft follows to complete a task. Drones can be programmed to fly in specific flight patterns like a lawn mower pattern, or to fly to a specific point.

Explore Forces of Flight: Take Off and Foam Drone

Flying an aircraft is a balancing act between the four forces involved in flight. These forces are:

- **Lift:** The force that is opposite to gravity, or the upward force created by airflow as it passes over and under a wing
- **Gravity:** The force that is the opposite of lift and causes an object to be pulled downward
- **Thrust:** The force that moves an object through the air, i.e., the opposite of drag
- **Drag:** The force that limits the speed of an object, i.e., the opposite of thrust

Explore Remote Sensing: Foam Drone and Code Copters

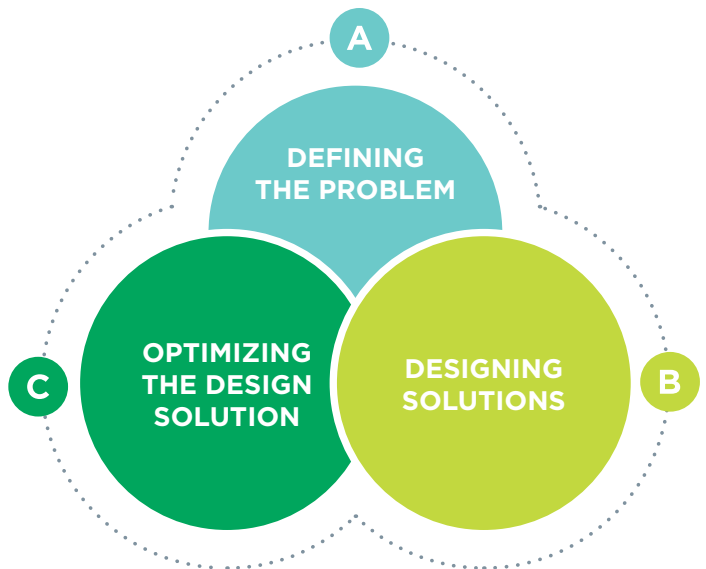
Remote sensing is learning from a distance, which is often done using aircraft or satellites. Remote sensors can either be passive or active. Passive sensors collect information that is naturally available, such as the light captured in video and pictures. Active sensors project their own energy, such as a laser beam or sound waves, and then measure what is reflected.

Explore Computer Coding: Code Copters

Computer coding is telling a computer what you want it to do. Unlike humans, computers only recognize specific phrases and do not have the ability to interpret instructions. In order to tell a drone what to do, we have to speak in their language—computer code.

Practice Being an Engineer

Give the participants the opportunity to think and act like an engineer. These activities help them define a problem, design a solution, and then optimize a solution in a cyclical process.



A **Defining engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits.

B **Designing solutions to engineering problems** begins with generating a number of possible solutions, then evaluating those solutions to see which ones best meet the criteria and constraints of the problem.

C **Optimizing the design solution** involves a process in which solutions are systemically tested and refined, and the final design is improved by trading off less important features for those that are more important.

The Drone Discovery activities help young people strengthen their spatial thinking, which concerns the location, shape and movement of objects in relation to each other. Spatial thinking also involves observing and mentally manipulating shapes and movement. Spatial thinking is important for solving any engineering problem. Spatial thinkers are likely to have more interest in STEM and are more likely to demonstrate STEM abilities. We can help young people develop their spatial thinking skills by practicing activities that incorporate spatial language, maps, gestures and analogies.

Take Action

After you've completed the Drone Discovery with your group, help them use what they learned to take action by exploring careers, participating in a citizen science project, or getting involved in their community. Check out the "Landing: Take Action" suggestions for more information.

Youth Guide
In "Mission Drone Discovery," in the Youth Guide (p.3), ask the youth to reflect on what they think engineers do.



TAKE OFF

Choose Your Drone Adventure

ACTIVITY 1



Leader Notes

Help the participants choose a scenario for an Agriculture or Business Challenge, after which they can work through that scenario column to choose one answer in each category: community setting, issue, drone action, group action, and take action.


If you are going to create one scenario for several engineering teams at once, consider making a large poster or projecting the choices on a screen so that everyone can see the choices and read the stories together.

Circle one option in each category:

	AGRICULTURE CHALLENGE	BUSINESS CHALLENGE
Community Setting	<ul style="list-style-type: none"> • Corn field • Residential suburb • Forest • Community garden 	<ul style="list-style-type: none"> • Well-traveled town road • Home • Rooftops • Ocean
Issue/Challenge	<ul style="list-style-type: none"> • Issue/ Challenge • Corn plants are being crowded out by weeds • A forest fire • Damaged and dying trees • A missing dog 	<ul style="list-style-type: none"> • Potholes • Getting orders to people as accurately and as soon as possible • Tracking solar energy use • Shipping freight across the ocean
Drone Action	<ul style="list-style-type: none"> • Water the location • Listen to a sound • Take a video • Water the field 	<ul style="list-style-type: none"> • Make a delivery • Take a video • Use sonar • Listen to a sound
Group Action	<ul style="list-style-type: none"> • Observes invasive plants • Observes insect damage • Listens to a sound recording • Locates the missing dog 	<ul style="list-style-type: none"> • Successfully delivers package • Observes the number and size of solar panels in the community • Counts the number of potholes • Maps ocean currents
Take Action	<ul style="list-style-type: none"> • Exploring careers related to drones • Trying a citizen science project • Trying a community action project • Celebrating with your group • Sharing your #4HNYSD story on social media (with adult permission) 	<ul style="list-style-type: none"> • Exploring careers related to drones • Trying a citizen science project • Trying a community action project • Celebrating with your group • Sharing your #4HNYSD story on social media (with adult permission)

Friend's Name (fill in the blank): _____

Insert your choices from the table on the previous page into the story below.




Youth Guide
The youth can choose scenario options and write their story in their Flight Log.

Your _____ is facing a challenge: _____. You and your engineering team
(Community Setting) (Issue/Challenge)

decide to find out more. _____ says, "I think drones can help with this!"
(Friend's Name)

They suggest using a drone to _____.
(Drone Action)

Your team _____.
(Group Action)




Leader Notes
Work with the group to make changes to their scenario if needed. For example, listening to a sound may not be helpful when looking for invasive plants. Switch up the story so it works for the team.

Success! Your engineering team decides to celebrate by _____.
(Take Action)

Reflection Space

Ask the youth: What do you think about your scenario story? Does it seem possible? What changes could you make for it to be more realistic?

How do you think a drone will help here? What does success look like in this scenario?



Youth Guide
The students can record their answers to these reflection questions in their Flight Log.

Things that Fly

Objectives

- Learn about the platform part of a drone system
- Design flying devices to explore the forces of flight (drag, lift, thrust and gravity) and flight dynamics (yaw, pitch and roll)
- Strengthen spatial thinking skills

Materials

- Propcopters (plastic helicopter)—blade and hollow tube
- 9" foam plate
- Scissors
- Clear tape
- FPG-9 pattern
- Ink pen
- Penny

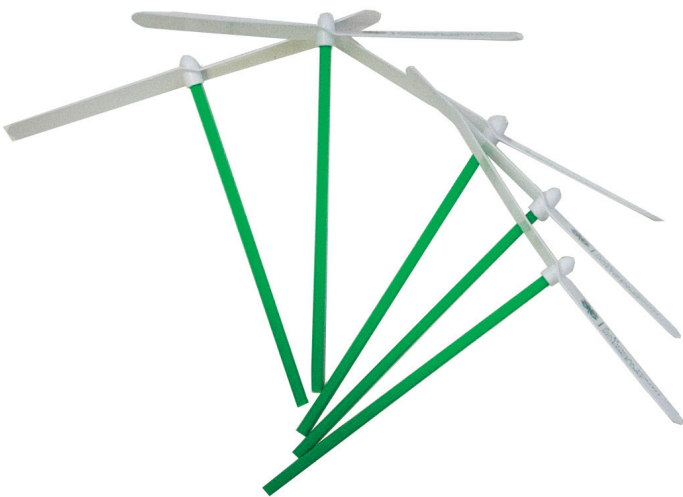
Define the Engineering Problem

- What do you know about how things fly? What kinds of vehicles fly?
- Can you build something that will fly? How can you control its flight pattern and speed? Write down some of your ideas or draw a picture to describe what you know.

Design a Solution

Propcopter Pilot

Start exploring flight with a rotary wing aircraft. Have the youth assemble their Propcopter Pilot. Ask the team how they can control its flight pattern.



Leader Notes

Ask the team to share their reflections about flight and drones. Point out keywords and concepts they mention related to the forces of flight, flight dynamics, and remote sensing. Add to their understanding by describing what remote sensing is and the four main parts of a drone.



Youth Guide

Youth can record their answers to these reflection questions in their Flight Log.



Leader Notes

Use the Propeller Pilot experience to help youth investigate the principles and dynamics of flight. Gather their questions about flight. It's a great icebreaker!

Challenge youth participants to try to control the flight pattern of their Propcopters.

Ask these questions:

- How do you make it fly?
- Can you control the direction it goes? The distance?
- What part or parts of the Propcopter direct the flight path?

Introduce the forces of flight and flight dynamics. Tell the youth they will try to control these forces more precisely in the next activity by designing and flying a FPG-9 Glider.

Design and Fly a FPG-9 Glider

Now that you have explored rotary wing aircraft with the Propcopter, it's time to explore fixed-wing aircraft.

Construct the glider

- Ask the youth how they can control the flight of this glider.
- Suggest adjusting the elevons on the wings and the rudder on the tail to change the direction of the glider's flight.
- Ask which way the elevons move the glider? The rudder?

Optimize Your Solution

If you have time, try to fly your glider in a big loop.

Conclusions

In general, drones have either rotary or fixed-wing aircraft platforms. Rotary-wing aircraft are better for precision flying when it is important to stay in one place, such as when precise camera positioning is required. Fixed-wing aircraft, on the other hand, can carry heavier loads for longer distances and use less power.

Talk with the teams about the pros and cons of using each aircraft platform for different tasks.



Youth Guide

Youth can record their answers to these reflection questions in their Flight Log.

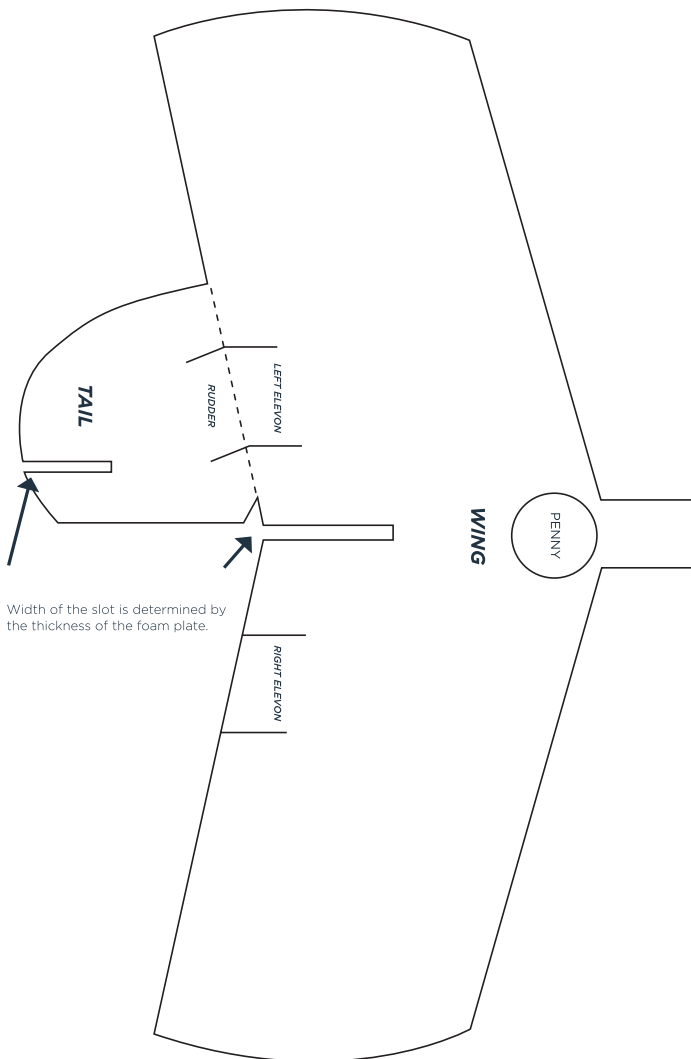


Leader Notes

- Since a paper pattern can be hard for young people to trace, you may want to cut out a foam plate master template.
- Make sure the tail is cut out of the flat part of the plate, not the curved edge.
- It's ok if the tab on the front of the pattern is on the curved edge.
- It works better if you make all of your cuts from the outside of the plate towards the center of the plate.
- Do not try to turn your scissors to cut sharp corners.
- When cutting out the slots, make them only as wide as the thickness of the foam plate.
- If the slots are cut too wide, the pieces of the plane will not fit together snugly.
- To fly in a loop, throw it hard with the nose of the glider pointed 30° above the horizon.
- The FPG-9 should perform a big loop and have enough speed for a glide of 20 – 25 feet after the loop.

Visit www.amaflightschool.org/diy/fpg-9-foam-glider for more information, instructions, and videos of the FPG-9 in action.

FPG-9 Glider Pattern is located in Appendix A.



How to construct the FPG-9 Glider

1. Make paper copies of the FPG-9 Glider Pattern.
2. Cut out the FPG-9 Glider pattern along the bolded lines. Do NOT cut the dotted lines.
3. Place the paper pattern in the center of the plate and trace around it. Make sure to mark all of the lines.
 - Make sure the tail of the pattern stays flat on the bottom of the plate.
 - The ends of the wings should spill over the curved edge of the plate.
4. Trace around the bolded edge of the pattern with an ink pen.
5. Mark where the scissor slits go on the wings.
6. Cut out the FPG-9 from the foam plate by following the pen lines you just traced. This time, cut along the dotted line. This piece becomes the tail of the glider.
7. Be sure to cut along the slits drawn on the wing and the tail. These slits form the elevons and the rudder.
8. Attach the tail to the wing by sliding the slots together. Make sure the tail is perpendicular to the wing.
9. Tape the tail securely to the wing.
10. The paper pattern shows a circle on the wing marked "Penny". Attach a penny here on top of the wing.
11. Fold the tab back over the penny and tape it down to secure the penny in place.
12. Bend the left and right elevons on the wing upward.
13. Gently toss your plane into the air to make it fly.

More Information

Check out the Academy of Model Aeronautics for more detailed directions and a video:

www.modelaircraft.org/education/fpg-9.aspx



FOAM DRONE

Objectives

- Understand that remote sensing is learning from a distance
- Design a remote sensing system model to answer a specific question
- Strengthen spatial thinking skills
- Develop strategies to gather, evaluate and communicate information in an effective way

Materials

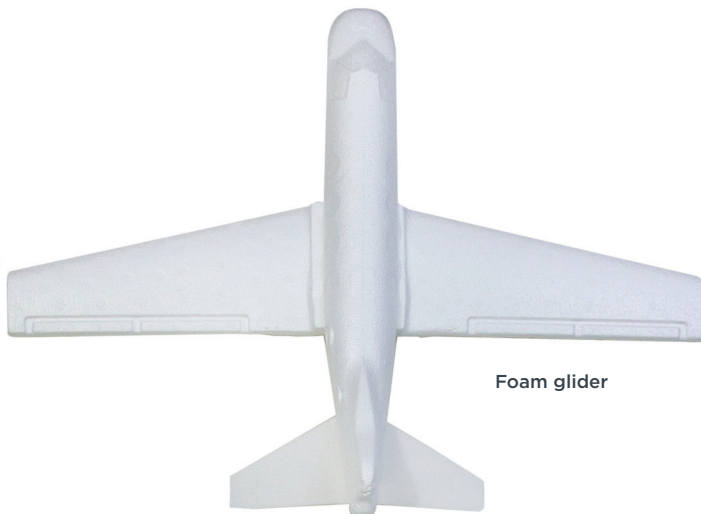
- Foam glider
- Keychain camera
- Micro SD card
- USB cable
- Access to a computer or tablet with a USB port or a micro SD reader for video playback (internet not required)
- Self-adhesive hook and loop dots
- Tape (duct, cellophane, etc.)
- Target (poster or your own set-up)



Leader Notes

In this remote sensing model, the foam glider is the platform and the keychain camera is the sensor.

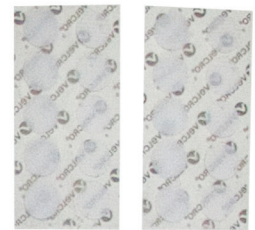
Set up your target using found materials in your area. For example, lay a bunch of pencils out on the ground. You might even want to go outside to an area that resembles the target in the scenario your group created.



Foam glider



Keychain camera and USB cable



Self-adhesive hook and loop dots

Team Roles

Make sure everyone on the team has a role. Here are some suggested roles:

ROLE	PERSON
Project Manager: Coordinates work for the team. Makes sure everyone has a part and can contribute. Keeps work on task within a limited time frame and moves the project forward.	
Lead Engineer: Leads the building process. Takes the lead in assembling the aircraft.	
Flight Engineer: Responsible for the aircraft's engines during flight. Repairs the plane and makes sure the aircraft keeps flying throughout the challenge.	
Sensor Engineer: Responsible for using and maintaining the drone's sensors. Operates the camera and attempts to capture the best video possible. Works with the Flight Engineer to determine the location and orientation of the sensor (camera).	
Product Owner: The voice of the customer or the community the engineering team is working with.	
Design Engineer: Responsible for graphic design. Leads the decoration/detailing of the aircraft.	
Documentarian: Keeps records of the design process.	
Marketing Specialist: Takes pictures and posts about progress in order to communicate about STEM to the public.	
Data Manager: Transfers video data from the camera to the computer for analysis/viewing.	
Other: Describe other roles your engineering team needs and assign them here.	

Design a Foam Drone

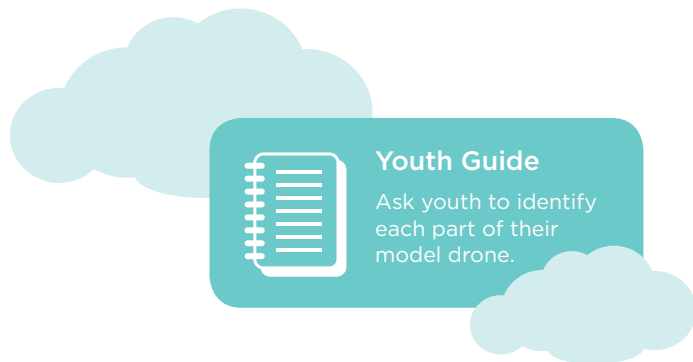
ACTIVITY 1

Define the Engineering Problem

Challenge: Each engineering team will build a model drone to help solve the problem or improve the community situation created in the "Choose Your Drone Adventure" activity.

Constraints: The model drone must include a platform and sensor that can collect information from a target.

Success: What does success look like for each scenario? What must happen for the design to be a success? What trade-offs might need to be made?



Help the youth connect their model drone to the real-world application of their challenge scenario. Ask them to identify how each part of their model drone corresponds to a real drone system:

	SCENARIO (What your model represents in the real world)	MODEL (What you will actually use)
PLATFORM		
SENSOR		
TARGET		

Design a Solution

ACTIVITY 2

Building a Drone Prototype

Ask the teams to experiment with the glider and sensor separately.

Ask how the flight can be controlled when the sensor is not attached.

Ask the teams to think about how these variables change a flight pattern:

- Launch force
- Launch direction

Have teams practice using the sensor. Ask them to record a test video and play it back on the computer.

Have the teams put the platform and sensor together to construct a model drone system. Design a camera/plane arrangement to collect data about the target. Discuss the advantages and disadvantages of each arrangement.

- Ask what happened when they flew their model drone.
- Ask youth to draw a picture of their model drone.



Leader Notes

Give youth hook and eye dots and different kinds of tape. Let them choose which method works best for connecting the camera to the glider.

People often place the camera on the glider upside down, so be ready to help with this. When they review the video and see everything upside down, ask them why they think that happened and how they could fix it.



Leader Notes

VERY IMPORTANT!

Charge the camera before starting this activity by connecting to a computer.

- Learn to operate the camera, especially the on/off button and video camera button. Make sure the SD card is in the camera before flying the drone. See instructions in Appendix B.
- Set up the target area before starting to capture video. You could place a target picture inside a hula hoop, chalk circle or whatever makes sense for your setting.
- Choose a target scenario that is most interesting for your group, or you can set up your own.
- Have the youth work in teams of five or more for this part of the challenge.
- There are many aircraft (glider)/camera arrangements. Here are some examples:
 - Bottom mounted
 - Nose mounted
 - Tail mounted
 - Wing mounted
- You can download the video from the camera to the computer in two ways:
 - Connect the camera to the computer using a USB cable.
 - Remove the micro SD card from the camera, place it into the adaptor and insert it into the SD card drive.

Test Remote Sensing

ACTIVITY 3

Have the engineering teams test their model drone systems.

Teams should fly their model drones over the target, collecting video as they fly. They should start the camera before they fly and stop recording after the flight ends.

Download the video files to a computer, navigate to the video file and open it in a video player application.

Assess the video quality:

- Was the camera on?
- Was the camera right side up?
- Was the target captured in the video?
- Did the model drone collect the needed data?
- Do you like the video you collected?
- What adjustments need to be made to the glider/camera arrangement?

How does flight pattern and speed affect the data collected by the drone's sensor?

How can the most useful information be collected?



Leader Notes

You may want to suggest to the engineering team that they set themselves up in a circle or box shape around the target, then fly the model drone to each other.

You could also introduce the concept of coordinate systems here. The youth standing in a square could act like points on the coordinate system as they fly the plane to each other. They will explore this system more in Code Copters.

Optimize Your Solution

Repeat the glider design and remote sensing activities, experimenting and adjusting to capture good images.

Ask the teams:

- What changes can you make to better control the flight of your drone?
- What changes can you make to collect more accurate information about your target?

Remind the teams that optimizing the design is a critical part of the engineering process. Ask them to try several different drone designs and assess what differences the changes made.

Conclusion

Remember that remote sensing is learning from a distance. Have the teams refer back to the scenario they created for some community applications for agriculture or business. Ask the teams to explore how remote sensing might be useful in their community.



Youth Guide

Youth can record their answers to these reflection questions in their Flight Log.



Leader Notes

As youth look to redesign their aircraft to better control their flight, you could suggest that they cut elevons and a rudder into the foam glider.

Help them reflect on the speed of the glider as it flies and how speed affects the amount of information they can collect about the target. (These gliders fly too fast to get detailed information about the target.) This would be a great point to talk about with the group regarding the advantages of rotating wing drones (like quadcopters) when looking for details of a target, as rotating wing aircraft can hover in one place.

Foam Flight Film Festival

ACTIVITY 3

Communicate Your Results: Film Festival

Have each team present their video to the whole group (or their favorite video if they recorded more than one).

Have each team describe their design process, show their video, and take a bow!

If you have the opportunity to watch other teams' videos, encourage everyone to be an attentive audience member and ask questions about the presentations.

Presentation Notes

- Describe your scenario, system, and design process.
- Why did you choose your design?
- What did you learn about the target from your sensor?
- What challenges and successes did you have?

Pick up Steam

If the video part of this activity sparks interest, try out a free video editing option from:

- Windows Movie Maker
- YouTube

Note: Encourage each team to present only the best part of their video. If you are limited for time, suggest they show the most informative five seconds of their video.

Keep Learning More

Check out “Before You Fly” for important safety recommendations and rules. You can also connect with other people interested in flying hobby drones by visiting the Academy of Model Aeronautics at www.modelaircraft.org/clubsearch.aspx.

Before You Fly

Thinking about getting a drone or already have a hobby drone? Make sure you fly responsibly.

In the U.S., the Federal Aviation Administration (FAA) regulates all aircraft operations, including drones. The FAA's main concern is safety in national airspace, including people piloting remote or other aircraft, and people and property on the ground. Because there are new and emerging personal and commercial uses for drones, these regulations change often. Be sure to check federal and local laws for operating drones *before* you fly!

HERE ARE SOME THINGS TO KEEP IN MIND:

- The FAA requires all owners of small unmanned aircraft or drones, weighing between 0.55 and 55 pounds, to be registered.
- Fly below 400 feet and remain clear of surrounding obstacles.
- Keep the aircraft in your line of sight at all times.
- Remain well clear of and do not interfere with manned aircraft operations.
- Don't fly within five miles of an airport unless you contact the airport and control tower before flying.
- Don't fly near people or stadiums.
- Don't fly an aircraft that weighs more than 55 lbs.
- If you're flying a small drone inside, consider flying it inside a screen tent to limit the airspace.

Learn More

- Know Before You Fly: www.knowbeforeyoufly.org
- Federal Aviation Administration: www.faa.gov/uas/model_aircraft
- Academy of Model Aeronautics: www.modelaircraft.org



CODE COPTERS

There are two ways to facilitate Code Copters. You can choose to focus just on Code Copters IRL (Code Copters In Real Life) where you won't need access to computers, or you can lead the youth through the full activity including both IRL and Scratch coding.

Objectives

- Explore remote sensing principles through basic coding
- Practice writing and using specific code
- Use a coordinate system to program a drone flight pattern
- Communicate and summarize information both within Scratch via broadcasting code and between those involved in the team discussions
- Strengthen spatial thinking skills

Materials

- Code Copters IRL: Masking tape, command cards (Appendix C)
- Code Copters: Computer with internet access (one per youth or pair of youth)

Team Roles

Make sure everyone on each team has a role for this challenge. If they have already completed the Foam Flight Film Festival, consider switching roles. Here are some suggested roles:

ROLE	PERSON
Flight Plan Engineer: Thinks about the best strategy to move the drone around the landscape. Are different patterns and paths better than others? Discuss with your team and draw your blueprint!	
Programmer: Takes the pathway your Flight Plan Engineer has developed and creates a series of instructions to make your drone move along the grid in the pattern you designed. Remember, your codes must be very precise!	
Prototype Engineer: Takes the codes your team has written and reads them to your drone. Takes notes on what went wrong and reports back to the group. Redesigns and retests until you have completed your engineering challenge.	
Marketing Specialist: Takes pictures and posts about the activity to communicate about your project to the public.	
Other: Describe other roles your team needs and assign them here.	



Leader Notes

How do drones relate to coding?

With all of our exciting new technology, it's easy to think that our computers and robots are getting smarter. In reality, however, computers are only as smart as their programmers! Unlike humans, drones only recognize specific phrases and do not have the ability to interpret instructions like we do.

Think about this scenario: If you wanted an orange for a snack, you could easily ask a person to peel it for you. However, if you wanted a robot to peel it for you, you would have to tell them to walk to the fridge, open the door, find the orange, pick it up, make a dent, pull backwards, etc.

In order to tell a drone what to do, we have to speak in their language. It is the job of the programmer to convert instructions into a language that the drone will understand. This is the challenge of the programmer, and the challenge you are about to take on!

Code Copters IRL (In Real Life)

ACTIVITY 1

As facilitator, you are the drone. Please follow “commands” on where to move given to you by the youth.

Define the Engineering Problem

Challenge: The teams will create a program to guide a drone through all parts of a landscape following the most efficient pathway possible.

Constraints: The drone only understands nine commands. Repeat these commands as many times as necessary, and in any order, to accomplish the task.

Success: What does success look like for each scenario? What must happen for the design to be a success? What trade-offs might need to be made?



Did You Know?

Commands are the individual phrases that the drone will understand. The combination of these commands in a useable order is called **Code**.

Design a Solution



Leader Notes

Create a 4x4 grid on the ground with masking tape, or use the grid here in the guide. Mark the center point (0,0). This will be the landscape you move through as you follow your group's code.

In the Youth Guide there is space for teams to make flying patterns and write their code. You may also use the “Command Cards” available in Appendix C.

As the teams make their plans, review their commands and make sure they know how their drones will respond to each command! Check the reference guide on the following page for more detail.

Flight Pattern Design

Where your drone will fly

		2		
		1		
-2	-1		1	2
		-1		
		-2		

Command Choices

When I say “ _____ ”

Move _____ steps

Turn clockwise _____ degrees

Turn counter clockwise _____ degrees

Point in direction _____

Go to X: _____, Y: _____

Glide to X: _____, Y: _____

Change X by: _____

Change Y by: _____

LEADER’S RESPONSE TO CODES:

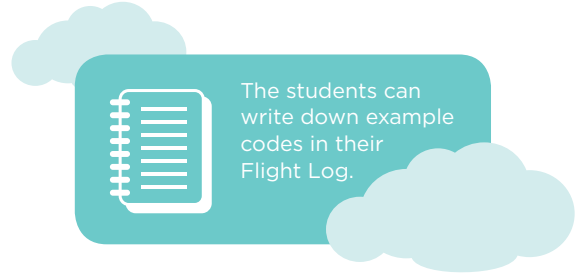
When I say “ _____ ”	You cannot follow ANY instructions until the youth have given you this code. Otherwise, the drone does not know WHEN to begin following the code.
Move _____ steps	You will walk the number of steps they tell you, however, unless they tell you a direction first, you can walk wherever you want. “Move” is too vague. Walk off the grid to make the point clear!
Turn clockwise ____ degrees	Turn to your right. 90 degrees is a quarter turn, 180 a half turn, 270 is three quarters of a turn.
Turn counter clockwise ____ degrees	Same as above, except to the left.
Point in direction _____	Turn the direction they tell you.
Go to X: _____, Y: _____	JUMP to the coordinates they give you. “Go” to the drone means disappearing from one location and reappearing in the next, skipping the space in between. (Note: To cover the whole landscape, it is better to use “glide” or to change values in small increments.)
Glide to X: _____, Y: _____	You can walk to the coordinates they give you. In this case, you will have surveyed everything along the path.
Change x by _____	‘Change x by’ means you will take a step along the x axis. Changing x by a POSITIVE number will move you to the RIGHT. Changing x by a NEGATIVE number will move you to the LEFT.
Change y by _____	‘Change y by’ means you will take a step along the y axis. Changing y by a POSITIVE number will move you FORWARD. Changing y by a NEGATIVE number will move you BACKWARD.
Set x to _____	Again, JUMP to the x-value you are given.
Set y to _____	JUMP to the y-value you are given.
Repeat _____ times	Repeat any number of codes the youth give you.

Optimize Your Solution

When the teams have decided on their code, they will read it to you for you to act out the commands. Encourage them to revise and retry their codes until their design is a success.

Conclusion

The 'move' command alone does not tell the drone WHERE to move. The coordinate system (x- and y-values) eliminates this problem by giving the subject a point to move to that is not related to a previous location or direction. Encourage the teams to experiment with different flight patterns and codes!



Code Copters

ACTIVITY 2

Define the Engineering Problem

Transfer the code design into a Scratch program and watch the drone fly!

Challenge: Each engineering team will build a model drone to help solve the problem or improve the community situation created in the "Choose Your Adventure" activity.

Constraints: The model drone must include a platform and sensor that can collect information from a target.

Success: What does success look like for each scenario? What must happen for the design to be a success? What trade-offs might need to be made?

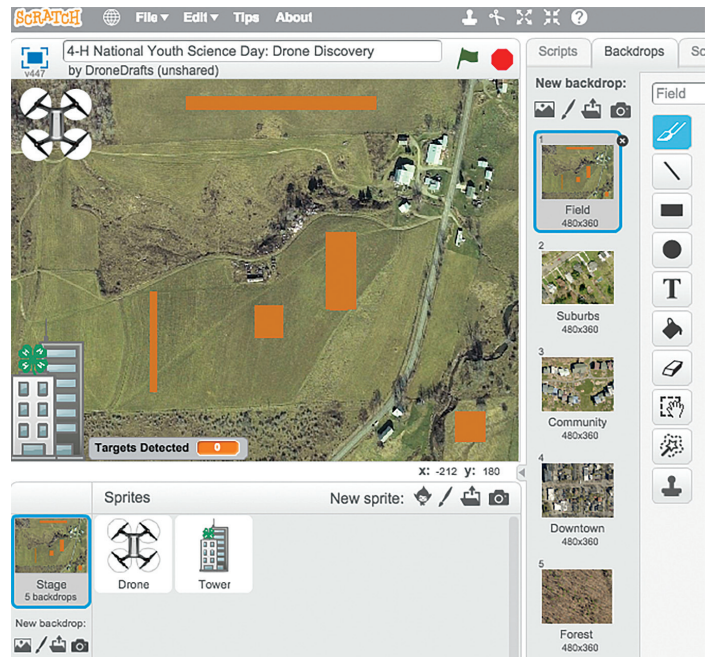
Design a Solution

Setting up your Scratch Account:

- Go to <https://scratch.mit.edu/projects/116115355/> and create a username and login for your 4-H group. Or you can search "NYS" from the Scratch homepage.
- Click on the "See Inside" button on the upper right-hand corner of the page.
- Visit www.4-h.org/NYSVideos for the video tutorial on how to use Scratch.

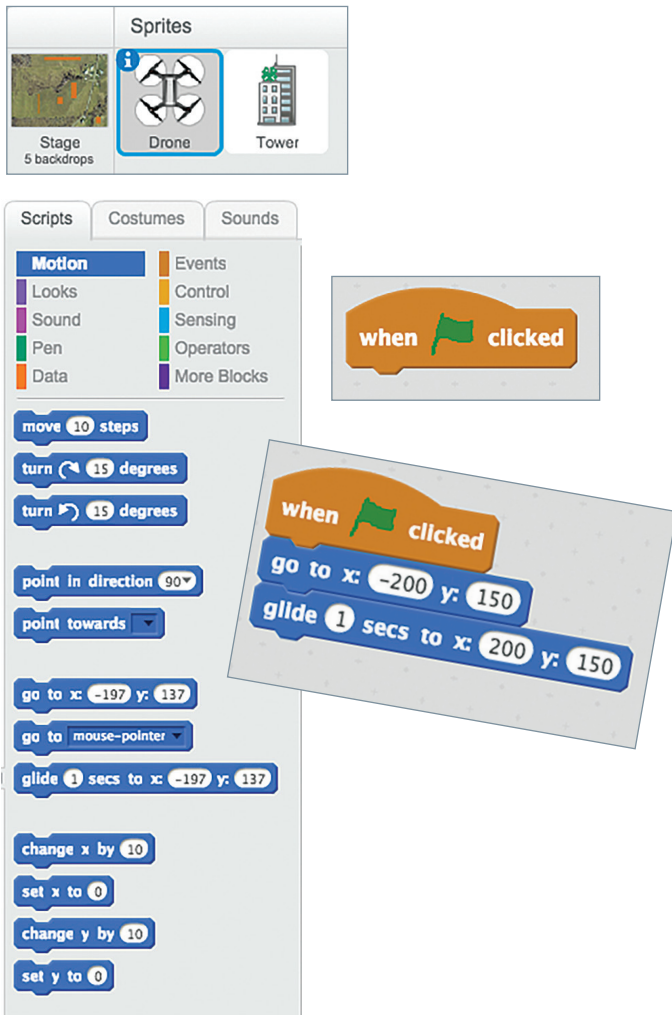
Choose Your Landscape

Ask the teams: Is your drone surveying a cornfield for infected crops? Is it looking out for potholes in the suburbs? Choose the appropriate landscape from the "backdrops" tab for your drone's mission.



Write Your Code

Make sure the “drone” sprite is highlighted. Next, click and drag each code into the workspace and attach them to each other like puzzle pieces. With a few modifications, the commands created in Code Copters IRL should directly correspond to the commands in Scratch.



Did You Know?

Even though it is invisible, Scratch works on a coordinate system, just like when your teams programmed you across the floor grid.

Instead of a small 4x4 grid, the screen ranges from -240 (left) to 240 (right) on the x-axis, and -180 (bottom) to 180 (top) on the y-axis.

Experiment instructing the drone to move to different coordinates to become familiar with the new space.

Tip

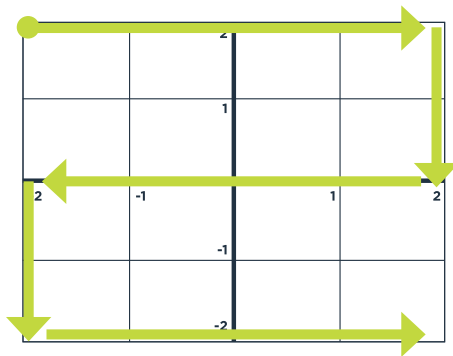
Test your code often by clicking the flag, then go back and make changes as necessary. Trial and error is essential to any design process!

Having Trouble? Want More?

For a step-by-step walk-through and additional Scratch challenges, visit the National Youth Science Day website at www.4-H.org/NYSD.

Code Copter Example Solutions

These are only possibilities!



IRL Student Commands:

When I say "Start"
 Go to x: -2, y: 2 (Its important to tell the drone where to start)
 Glide to x: 2, y: 2
 Change y by -2
 Glide to x: -2, y: 0
 Change y by -2
 Glide to x: 2, y: -2

```

when clicked
go to x: -200 y: 150
glide 1 secs to x: 200 y: 150
change y by -100
glide 1 secs to x: -200 y: 50
change y by -100
glide 1 secs to x: 200 y: -50
change y by -100
glide 1 secs to x: -200 y: -150
    
```

IRL Student Commands:

When I say "Start"
 Go to x: -2, y: 2
 Point in direction 90 degrees
 Move 4 steps
 Rotate clockwise 90 degrees
 Move 2 steps
 Rotate clockwise 90 degrees
 Move 4 steps
 Rotate counter clockwise 90 degrees
 Move 2 steps
 Rotate counter clockwise 90 degrees
 Move 4 steps

```

when clicked
go to x: -200 y: 150
point in direction 90
wait 1 secs
move 400 steps
wait 1 secs
turn 90 degrees
move 120 steps
wait 1 secs
turn 90 degrees
move 400 steps
wait 1 secs
turn 90 degrees
move 120 steps
wait 1 secs
turn 90 degrees
move 400 steps
    
```

NOTE: In this case, it is necessary to add the "wait" command in Scratch after each movement. Otherwise, the drone will instantly jump to its final location without visually showing the path it took.

Conclusion

Unlike a person, a computer doesn't have the problem-solving or critical thinking skills to tell you why a program isn't working. Code Copters IRL gives young people a chance to practice using a smaller, visible coordinate grid to figure out their codes. Then Scratch challenges them to use those skills (and trial and error) to get the correct coordinates on a larger, invisible grid.

The most efficient patterns are those that allow the drone to survey the landscape without repeating space, and with minimal commands. The commands that involve the coordinate system are typically more efficient.

Coding a drone on Scratch is a fun simulation. To apply this in real life, we'd have to think about what the drone is looking for (its target), if there are obstacles in the landscape (mountains, trees, buildings), and what the best method of collecting data would be (photos, video, radar, sound).



Youth Guide

Youth can record their answers to these reflection questions in their Flight Log.



LANDING: TAKE ACTION

After you've completed the Drone Discovery Challenge with your group, help them use what they learned to take action by exploring careers, participating in a citizen science project, or getting involved in their community. Visit www.4-H.org/NYSD for more information and resources.

Career Exploration

As drones are used in new and exciting ways, more and more career opportunities are opening up. Consider inviting local professionals to share their career stories with your group.

Citizen Science

Help the youth use what they learned to contribute to citizen science projects. Citizen science is the engagement of public participants in real-world scientific collaborations: asking questions, collecting data, and/or interpreting results. Now that they've strengthened their aerial mapping and remote data collection skills, how about using those skills to make observations that help scientists answer big questions about our world? YardMap (www.yardmap.org) or Fossil Finder (www.fossilfinder.org) are two great citizen science projects that allow students to use mapping skills or interpret data collected by drones. You can also visit SciStarter (www.scistarter.com) to choose your own project and learn more.

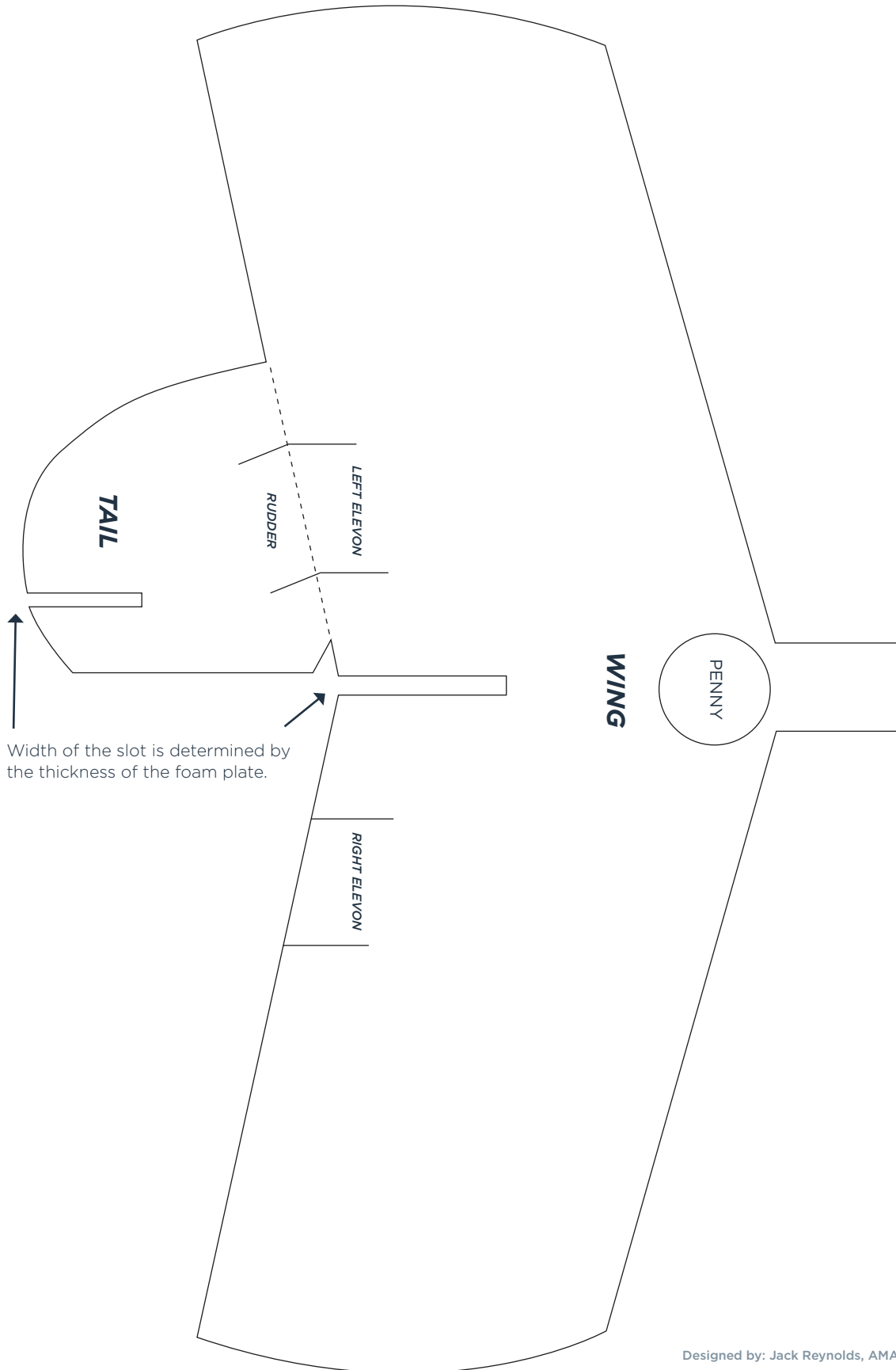
Civic Engagement

Help young people voice their views on emerging policies or explore how drones are used in community projects. At the beginning of 2016, the Federal Aviation Administration suggested new regulations around the use of drones, including limitations, operator responsibilities and aircraft requirements. Review and reflect on these regulations: www.faa.gov/uas/nprm. Youth can also play a role in "mapping" 4-H history. All they need to do is enter the geographical location in their community or state where an important 4-H historical event occurred. It can be in the form of written 4-H history, a digital interview, or even location imagery obtained from a drone flyover. Go to www.4-hhistorypreservation.com/History_Map to nominate the location of the point of interest or 4-H history.

Acknowledgments

The New York State 4-H Challenge Development Team extends its sincere appreciation to the Cornell Cooperative Extension (CCE) staff, volunteers and youth who contributed their time, ideas and STEM expertise to the development of the Drone Discovery. Thanks go to the CCE Broome County team for creating a video of the Drone Discovery challenges in action, with a special thanks to Tyler Poole for editing the video. A particular word of thanks goes to the East Middle School 4-H Tech Wizards mentors and mentees, and to the 4-H Cornell Career Explorations "Finding Your Favorite Places" youth participants, who helped test pilot test the activities. We are grateful to the NYS 4-H Geospatial Science June In-Service participants for trying out the activities, and to Adam Bredesen for creating a drone and building sprite graphics for the Scratch activities, and providing coding support for Code Copters. A special thanks to Charles Mondello from Pictometry for suggesting key chain cameras best suited to our drone models and to Bobby Sudekum for inspiring the idea of a foam glider and camera as a drone model. Thank you to Lori Radcliff-Woods for taking pictures of the Film Flight Festival in action and to CCE Rensselaer County for "Wendell's Flight".

Appendix A: FPG-9 Glider Pattern



Designed by: Jack Reynolds, AMA

Appendix B: Keychain Camera 808 Operation Instructions



Keychain Camera components:

1. Keychain Camera for taking video with audio and still photos
2. USB adaptor
3. Micro SD card

Keychain Camera operation: ***The camera must be charged before use***

1. Press the **OFF/ON** button until the Indicator Light comes on.
2. To record a video (including audio), press and hold the **VIDEO/CAMERA** button until the indicator light flashes three times. To stop recording, press the **VIDEO/CAMERA** button briefly.
3. For still photos, press and release the **VIDEO/CAMERA** button once.

To download videos and photos from the Keychain Camera:

1. Attach the USB adapter to the Keychain Camera.
2. Plug the USB adapter into a computer.
3. On your computer, navigate to the SD card or external storage drive. Open the video or image folder. Open the file to view.
4. You can also save the file to your computer for later viewing and editing.

Appendix C: Code Copter IRL Command Cards

When I say _____	When I say _____	When I say _____
Turn Clockwise _____ Degrees	Turn Clockwise _____ Degrees	Turn Clockwise _____ Degrees
Turn Counter Clockwise _____ Degrees	Turn Counter Clockwise _____ Degrees	Turn Counter Clockwise _____ Degrees
Point in direction _____ Degrees	Point in direction _____ Degrees	Go to X:_____ Y:_____
Go to X:_____ Y:_____	Glide to X:_____ Y:_____	Glide to X:_____ Y:_____
Change X by: _____	Change X by: _____	Change Y by: _____
Change Y by: _____	Move _____ Steps	Move _____ Steps

DRONE DISCOVERY



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