4-H NATIONAL YOUTH SCIENCE DAY

DRONE DISCOVERY

Youth Guide

I pledge my **HEAD** to clearer thinking,

my **HEART** to greater loyalty,

my **HANDS** to larger service,

and my **HEALTH** to better living,

for my club, my community, my country

and my world.

Welcome to the Drone Discovery!

Introduction

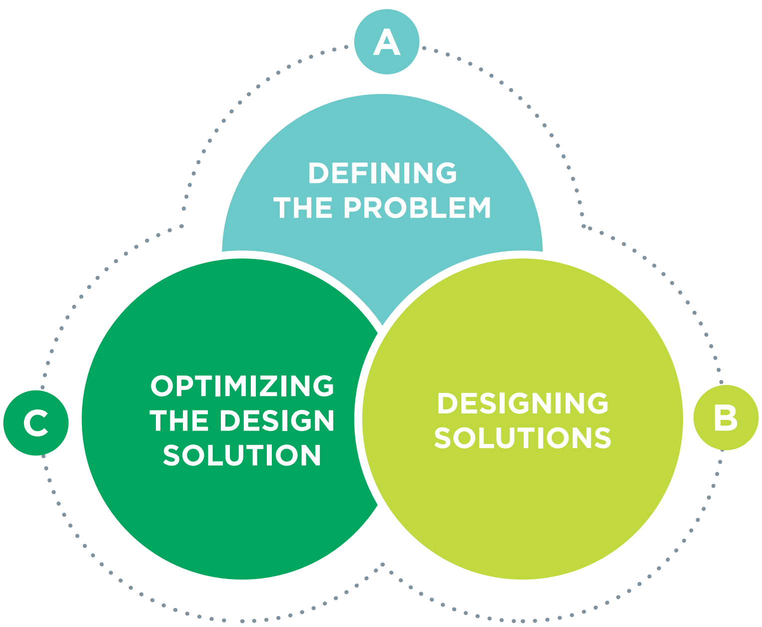
In October 2016, you will become part of the biggest youth science event in the nation: 4-H National Youth Science Day (NYSD). With the help of thousands of volunteers and educators from the country's 110 land-grant universities, you and millions of other youth will become 4-H engineers for the day and engage in the ninth annual NYSD.

During this year's challenge, you will explore how drone engineering and remote sensing can be used to solve real world problems, such as helping a community develop climate change resiliency and energy sustainability.

Mission Drone Discovery

To succeed in this challenge, you'll need to think like an engineer as you design, build and test drones. There are many different kinds of engineers and different ways to approach a challenge. What kind of engineer do you think you'll need to be in order to master drone technology?

The engineering design process has three basic steps: define, design and optimize.



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 systematically tested and refined, and the final design is improved by trading off less important features for those that are more important.

Your Drone Discovery challenge is to work through the engineering design process with your team of engineers to build two different kinds of drones: a Foam Drone and a Code Drone.

Let's get started!

What are drones?

What do you know about drones? Draw a picture of what you think a drone is and what it can be used for.

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

TAKE OFF

Choose Your Drone Adventure

ACTIVITY 1

It's time to decide how your drone will be used. Work with your engineering team to choose your own adventure. First, determine if your team will tackle an Agriculture or a Business challenge. Circle one option in each category for the challenge your team chooses and fill in a friend's name.

Circle one option in each category:

	AGRICULTURE CHALLENGE	BUSINESS CHALLENGE
Community Setting	• Corn field • Residential suburb • Forest • Community garden	• Well-traveled town road • Home • Rooftops • Ocean
Issue/Challenge	• Issue/ Challenge • Corn plants are being crowded out by weeds • A forest fire • Damaged and dying trees • A missing dog	• Potholes • Getting orders to people as accurately and as soon as possible • Tracking solar energy use • Shipping freight across the ocean
Drone Action	• Water the location • Listen to a sound • Take a video • Water the field	• Make a delivery • Take a video • Use sonar • Listen to a sound
Group Action	• Observes invasive plants • Observes insect damage • Listens to a sound recording • Locates the missing dog	• Successfully delivers a package • Observes the number and size of solar panels in the community • Counts the number of potholes • Maps ocean currents
Take Action	• 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)	• 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): ____________________ ____________________

"Choose Your Drone Adventure"

Insert your choices from the table on page 1 into the story below.

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 __________________ . Your team __________________ .
(Drone Action) (Group Action)

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

Reflection Space

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

____

____

____

____

____

____

How do you think a drone will help here?

____

____

____

____

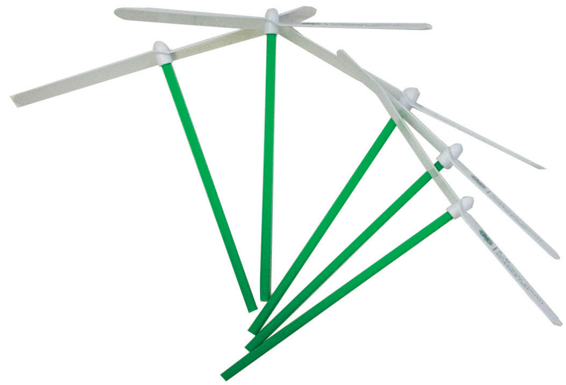
Let's find out!

Things that Fly

ACTIVITY 2

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

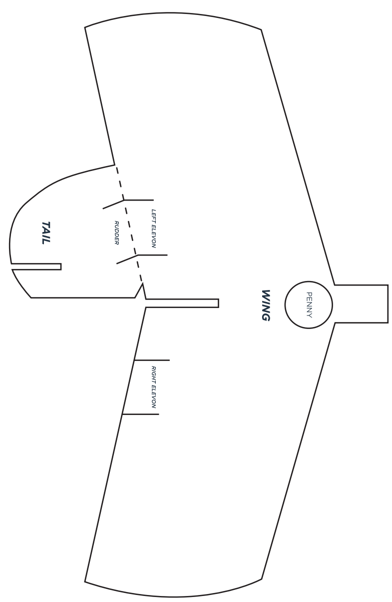
Fly a Propcopter

Let's start exploring flight with a rotary wing aircraft. Assemble your propcopter. How can you control its flight pattern?

Design and Fly a FPG-9 Glider

ACTIVITY 3

- Now that you have explored rotary wing aircraft, let's explore fixed-wing aircraft.
- Your facilitator will provide you with the FPG-9 blueprint to build your own glider.
- Can you control the flight of this glider?
- Try adjusting the elevons on the wings and the rudder on the tail to change the direction of the glider's flight.
- What way do the elevons move the glider? How does the rudder change the glider's flight?



Optimize Your Solution

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

Conclusions

What is one similarity and one difference between flying a rotary-wing aircraft and a fixed-wing aircraft?

Engineering Tasks

- 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 your spatial thinking skills.

Talk About It

- How would changing what the plane is made of change its flight pattern?
- How would changing the wings make a difference?

FOAM DRONE

Who's Doing What?

Work with your engineering team to make sure everyone on your team has a role for this challenge. 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 a 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: With your engineering team, build a model drone that can help solve the challenge you created in the "Choose Your Drone Adventure" scenario.

Constraints: Your Foam Drone must include a platform and sensor that can collect information from a target.

Success: What does success look like for your scenario? What must happen for your design to be a success? What trade-offs do you need to make?

Engineering Tasks

- Understand that remote sensing is learning from a distance.
- Design a remote sensing system model to tackle your challenge.
- Communicate what you learned.

Remember your Choose Your Drone Adventure? For your scenario, identify each element of your drone design:

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

Design a Solution

Build Your Drone Prototype

Experiment with the glider and the sensor separately.

Can you control the flight of your platform when the sensor is not attached? Consider how these variables change the flight pattern:

- Launch force
- Launch direction

Practice using the sensor. Record a test video and play it back on the computer.

Next, put your platform and sensor together to construct a model drone system. Work with your team to design a camera/plane arrangement to collect data about your target. Discuss the advantages and disadvantages of each arrangement.

DRAW A PICTURE OF YOUR MODEL DRONE HERE.

Test Remote Sensing

ACTIVITY 2

Now let's test your model drone system!

Fly your model drone system over the target, collecting video as it flies. Remember to start the camera before you fly your glider and stop recording after the flight ends.

Review your video and download the video file to your computer. Navigate to the video file and open it in a video player application.

Assess the video quality. What adjustments do you want to make to the glider/camera arrangement?

How do the flight pattern and speed affect the data collected by the sensor? How can you collect the most useful information?

Assess Your Video

- Was the camera on?
- Was the camera right side up?
- Was the target captured in the video?
- Did you collect the data needed?
- Do you like the video you collected?

Optimize Your Solution

Experiment with the drone's flight path and sensor placement to capture the best video.

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

Try several different drone designs. What differences do the changes make?

Draw a picture of your redesigned drone.

Conclusions

How would you describe remote sensing? How do you think a remote sensing system could be applied in your community?

Foam Flight Film Festival

ACTIVITY 3

Communicate Your Results

Present your team's final videos to the whole group (or your favorite video if you recorded more than one). Describe your design process before showing your video. Take a bow!

If you have the opportunity to watch other teams' videos, be an attentive audience member. Ask questions about their engineering design decisions.

What would be different if you used a toy quadcopter in this activity instead of the foam glider?

If you fly a hobby drone, be sure to check out Before You Fly (next page) for important flight safety information.

Connect with other people interested in flying hobby drones by visiting the Academy of Model Aeronautics at **www.modelaircraft.org/clubsearch.aspx**

Notes

Before You Fly

Thinking about getting 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 pounds.
- 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

Who's Doing What?

Work with your group to make sure that everyone on your engineering team has a role for this challenge. If you 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 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.	

Code Copters IRL (In Real Life)

ACTIVITY 1

Define the Engineering Problem

Challenge: With your engineering team, build a model drone that can help solve the problem or improve the community issue/challenge you created in the Pre-Flight Check. Create a program to guide a drone through all parts of a landscape following the most efficient pathway possible. Your facilitator will take on the role of the drone.

Constraints: **Your drone only understands nine commands.** Repeat these commands as many times as needed—in any order your team determines necessary—to accomplish your task.

Success: What does success look like for your scenario? What must happen for your design to be a success? What trade-offs might you have to make?

Design a Solution

Flight Pattern Design: Where your drone will fly. See opposite page.

Optimize Your Solution

When you decide on your code, read it to your facilitator and see how well your program works. Revise and retry your codes until your design is a success.

Conclusion

- Were there certain codes that were more efficient than others?
- What are the advantages of using a coordinate system?
- After doing this activity, what challenges do you think programmers face in the real world of drones?

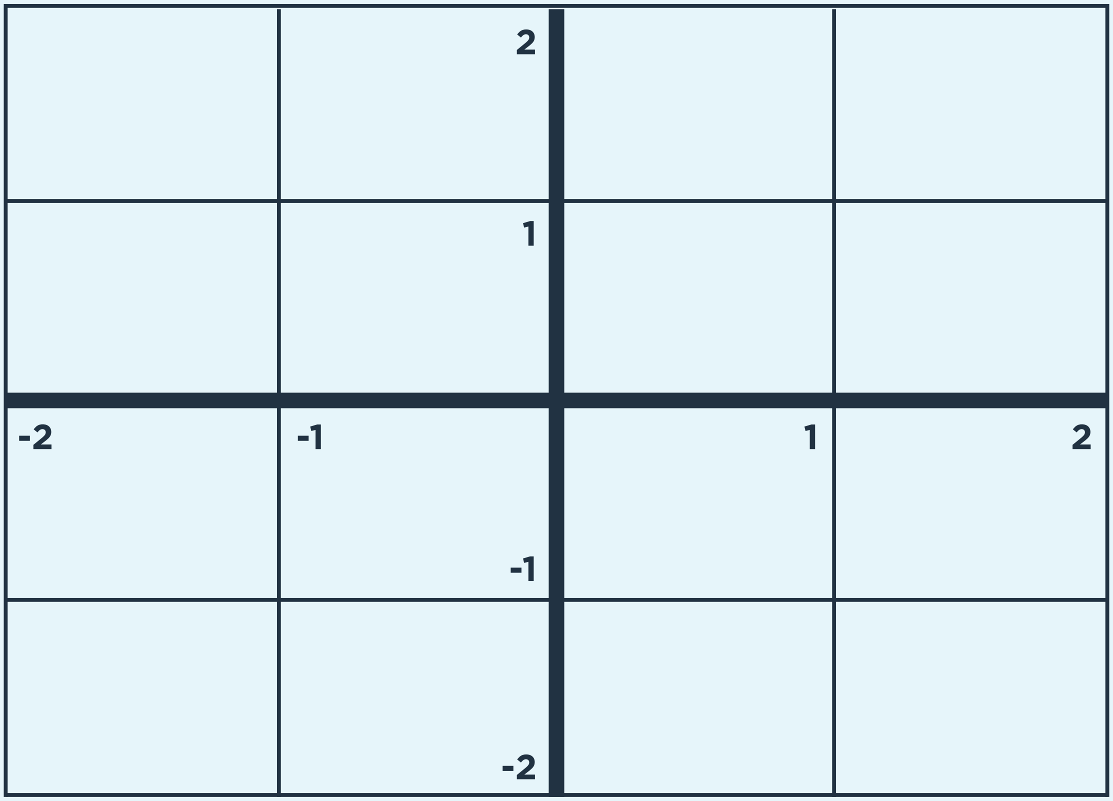
Engineering Tasks

- Develop strategies to gather, evaluate, and communicate information in an effective way.
- Explore remote sensing principles through basic coding.
- Communicate and summarize information both within Scratch via broadcasting code and between students in group discussion.
- Strengthen your spatial thinking skills.

Did You Know?

How do drones relate to coding? With all of the exciting new technology available, it's easy to think that computers and robots are getting smarter, but in reality, computers are only as smart as their programmers! It's the job of the programmer to convert instructions into a language that a drone will understand. This is the challenge of the programmer, and the challenge you are about to take on.

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



Command Choices

COMMANDS MAY BE USED MORE THAN ONCE AND IN ANY ORDER.

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: __________

Your Code:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

Code Copters

ACTIVITY 2

Now let's translate your code into the Scratch programming language.

Define the Engineering Problem

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

Challenge: With your engineering team, build a model drone that can help solve the problem or improve the community situation you created in the "Choose Your Drone Adventure" activity.

Constraints: Your model must collect information from a target.

Success: What does success look like for your scenario? What must happen for your design to be a success? What trade-offs might you have to make?

Design a Solution

Setting up your Scratch Account

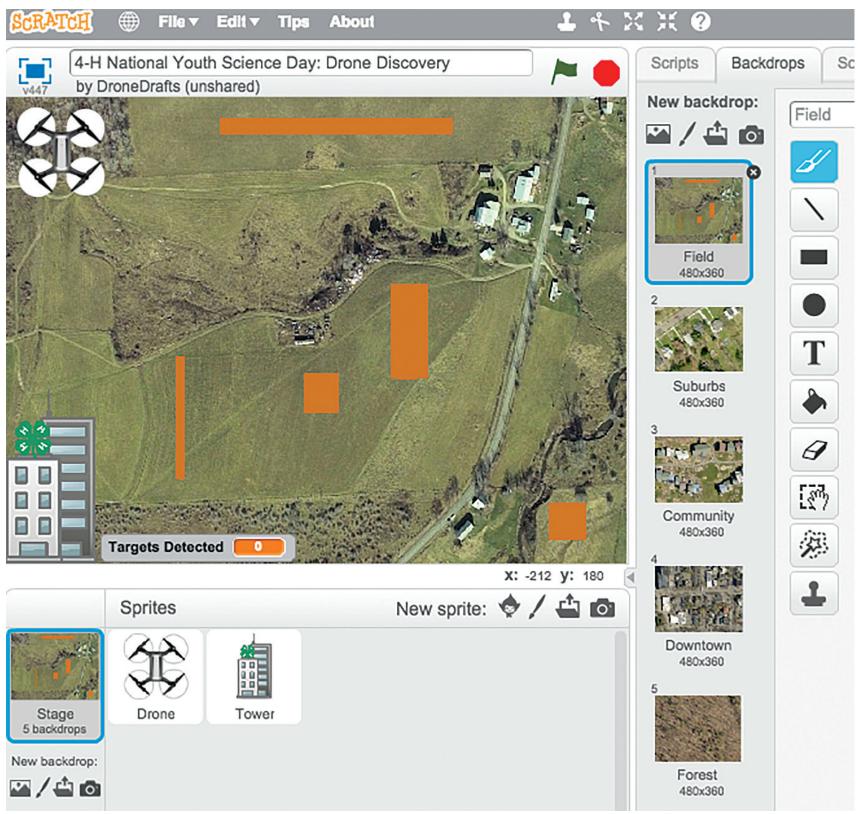
- Get permission from your adult leader to go online.
- Go to www.scratch.mit.edu and create a username and login for your 4-H group.
- On the "Explore" page, search for the National Youth Science Day Drone Discovery template.
- Locate the public template that can be used to "remix" or create a new Code Copter simulation.

Sprite

A Drone is called a 'Sprite' in Scratch.

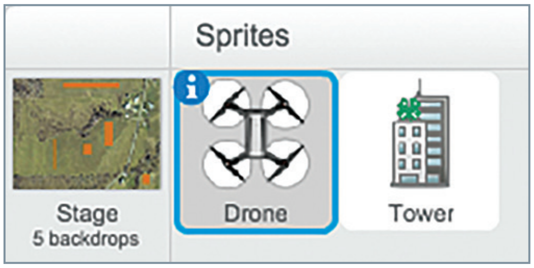
Choose Your Landscape

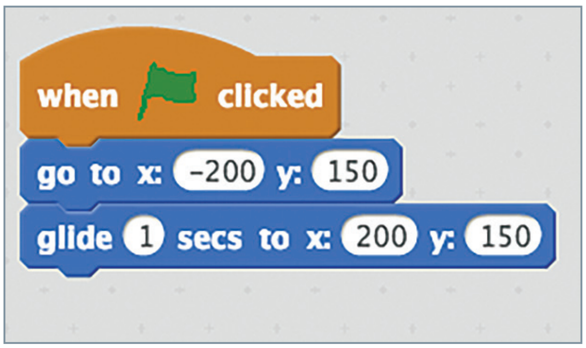
Is your drone surveying a cornfield for infected crops or looking out for potholes in the suburbs? Choose the appropriate landscape from the "backdrops" tab for your drone's mission.



Write Your Code

Make sure the "drone" Sprite is highlighted. Next, click and drag each command into the workspace and attach them to each other like puzzle pieces! Follow the code you created in "Code Copters IRL".





Optimize Your Solution

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

Conclusion

What were the differences between programming on the computer, and programming your facilitator?

What was the most efficient strategy your team developed to move the drone? Were certain commands more efficient than others?

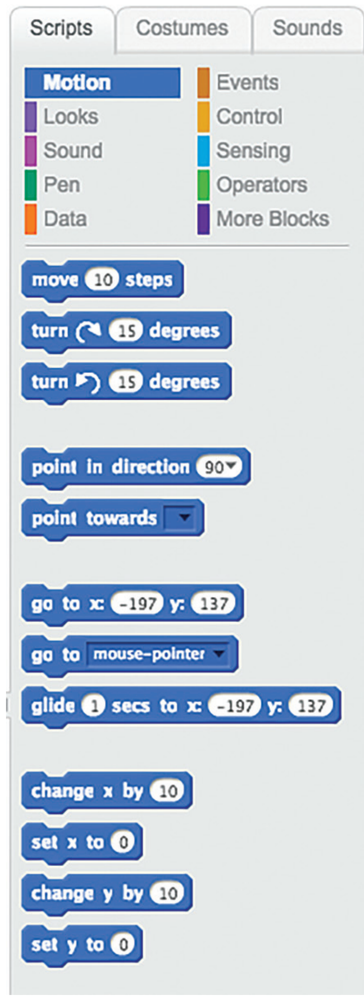
Coding a drone in Scratch is a fun simulation. What are some things you'd have to consider if you were programming a drone in real life?

What else do you think you can program your drone to do?

Did You Know?

Scratch works on an invisible grid.

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



Having Trouble?

For a step-by-step walk through and additional Scratch challenges, visit the National Youth Science Day website!

www.4-H.org/NYSD

LANDING: TAKE ACTION

After you've completed the Drone Discovery with your group, use what you learned to take action by exploring careers, participating in a citizen science project, or getting involved in your community.

Career Exploration

As drones continue to be used in new and exciting ways, there are more and more career opportunities to learn about and explore. Research the possibilities! Work with your group leader to talk with local professionals about their careers and the next generation of engineering opportunities.

Citizen Science

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

Civic Engagement

Voice your views on emerging policies or explore how drones are used in community projects. Because drone technology and it's uses are changing so rapidly, drone use policies and regulations are also changing rapidly. 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**. You can also play a role in "mapping" 4-H history. All you need to do is enter the geographical location in your 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.

Did You Know?

Check out the NYSD website for details and how to take action!.

www.4-H.org/NYSD

Glossary Terms

Code - A collection of commands in a specific, usable order.

Command - A specific instruction given to a computer application to perform a task.

Coordinate Grid - A plane that is formed by the intersection of a horizontal number line (the x-axis) and a vertical number line (the y-axis).

Drone - Unmanned or remotely piloted aircraft.

Engineer - A person who designs and builds complex products, machines, systems, or structures.

Engineering - The art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants.

Fixed-wing aircraft - An aircraft capable of flight using stationary wings that generate lift caused by the vehicle's forward airspeed and the shape of the wings. Fixed-wing aircraft are distinct from rotary-wing aircraft that have wings mounted on a spinning shaft.

Flight dynamics - Directions of movement an aircraft makes during flight. These forces can be used to control a flight. Each movement is oriented around one axis of the aircraft. Dynamic forces are yaw, pitch and roll.

Forces of flight – Four main forces that determine a controlled and balanced flight: drag, lift, thrust and gravity.

IRL – In Real LIfe.

Platform – The vehicle on which a sensor (camera) is placed in order to form remote sensing.

Prototype – A model from which other forms are developed.

Quadcopter – A multi-rotor vehicle with four arms, each with a motor and propeller.

Remote sensing – Collecting information about an object or location without making physical contact with the object.

Rotary wing aircraft – An aircraft that uses a long airfoil blade that rotates to provide lift.

RPA – Remotely Piloted Aircraft.

RPS - Remotely Piloted Systems.

Sensor – The device which is used to collect data/information through remote sensing.

Spatial thinking – Imagining the location of objects, their shapes, their relationship to each other, and the paths they take as they move.

Sprite - A sprite represents (or replaces) a drone in the scratch computer simulation program.

Target - The object of interest in remote sensing; the object for which data is collected.

UAS – Unmanned Aircraft Systems.

UAV – Unmanned Aerial Vehicles.

Flight Log

DRONE DISCOVERY

Cornell University Cooperative Extension

USDA United States Department of Agriculture | National Institute of Food and Agriculture

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4-H GROWS HERE

In 4-H, we believe in the power of young people. We see that every child has valuable strengths and real influence to improve the world around us. We are America's largest youth development organization—empowering nearly six million young people across the U.S. with the skills to lead for a lifetime.

Learn more online at: **www.4-H.org** | **#4HNYSD**