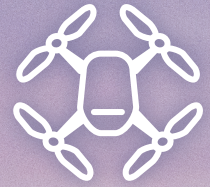


LOWER TANANA ATHABASCAN



LEARNING THROUGH
CULTURAL
CONNECTIONS

DRONES

Drones in Alaska Student Guide



<https://sites.google.com/alaska.edu/drones>

Yots'enodzida

Drone "bumblebee in the sky"

image courtesy of ACUASI

Alaska has many exciting opportunities for drone research. ACUASI at the University of Alaska Fairbanks is one of several official drone test site locations across the country.



What is a drone?

Drones are aircraft that fly without a **k'och'enat't'wghenh** (pilot) inside. Drones come in many shapes and sizes. Some are small enough to fit in the palm of your hand, while others are big enough to carry people. Drones are remote-controlled and some are highly advanced robots that can move and make decisions.

Drones have many uses. They can carry cameras and other tools to study Earth from above. They are easier and often cheaper to fly than a manned airplane. They can reach places that are difficult or dangerous for people to reach on foot or in a vehicle. Drones have many uses in Alaska. How might a drone be used in your community?

“ When [the drone] works, they can check where it's safe to travel throughout the winter. They can check different creeks [to see] if it's open over these ridges that they're passing. They can use it for a lot [of purposes]. It's just, you know, eyes in the air. ”

Martha Turner
Nulato, Alaska

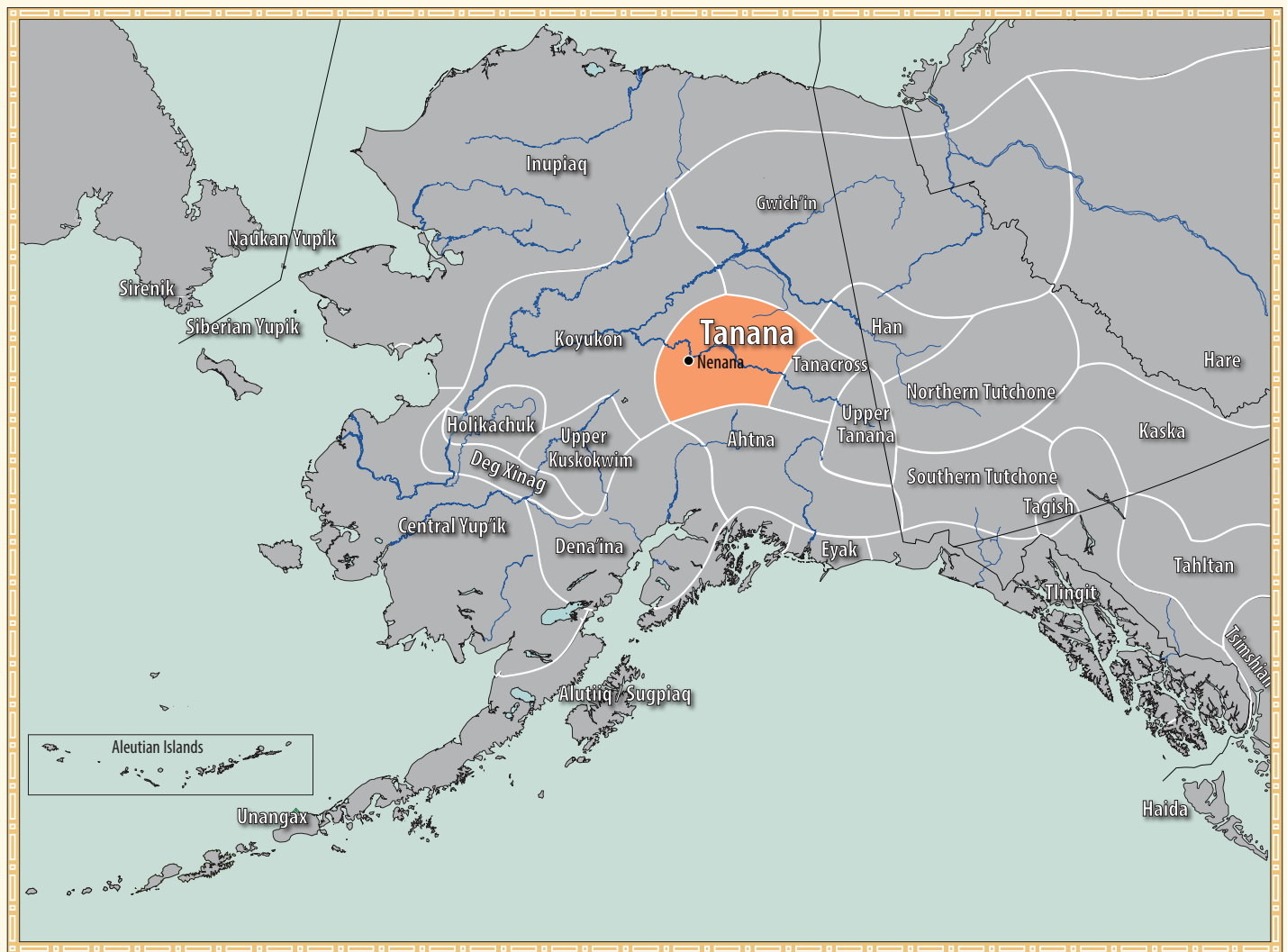


Activity 1

Drone Vocabulary

Alaska Native Values for Curriculum: Honor Your Elders, See Connections, Know Who You Are

Would you like to learn Alaska Native language terms related to drones? Work with classmates or your teacher to practice the vocabulary words in this booklet. Use the cards provided in the drone kit, or print them at <https://sites.google.com/alaska.edu/drones/>.



Krauss, Michael, Gary Holton, Jim Kerr, and Colin T. West. 2011. Indigenous Peoples and Languages of Alaska. Fairbanks and Anchorage: Alaska Native Language Center and UAA Institute of Social and Economic Research. Online: <https://www.uaa.edu/anla/collections/map/>.

Practice these vocabulary words and listen online by visiting <https://sites.google.com/alaska.edu/drones/>.

Nenana dialect: Lower Tanana Athabaskan	English term or phrase
yots'enodzida	drone "bumblebee in the sky"
tsuya	birds of summer
Not'wkh.	It's flying.
Nonghit'wk.	It's landed.
ch'eyona'	eagle
dotron'	raven
ełtr'eyh	wind
k'och'enatł'wghenh	pilot
Khwnił'anh.	See it.
K'okhideneyh.	They're working.

“That’s so important, to be able to have [the children who are members of Native corporations] and our children speak in our native languages... You can’t have language without culture, and you can’t have culture without language. It’s got to go together.

Chief Bill Smith
Valdez, Alaska



Dotron' nił'anh khw

View of a Bird

photo by MJ Preston



How is a bird's view of the world different from a person's view?

A **dotron'** (raven) flying overhead sees the world differently than you can see it from the ground. That is because a **dotron'** has an aerial view – a view from above. Have you ever climbed a tall hill or looked out the window of an airplane as it flies? How does being up high change what you can see? You might notice that when you are on the ground, you can see tree trunks and the walls of buildings. When you have an aerial view, you see tree tops and the roofs of buildings. You can also see a larger area from above than you can from the ground.

“There's a Native [saying]... the English version of it is 'Show me your pack so I can fill it with meat,' and when you're watching the raven flying up when you are out moose hunting... you say that in the Native tongue, and when the raven is flying by and it flips its wings down – where that wing is pointing down – that's where you go for the moose. He's showing you where the moose is because when you're done skinning the moose, there's tidbits left for the raven to eat.”

*Don Charlie
Nenana, Alaska*





image courtesy of ACUASI

This aerial image taken from a **yots'enodzida** (drone) shows a road, trees and other plants from high above. Can you see the shadows of the trees?

image by Daniel Walker, UAF/GI



Ch'eyona' (eagle) is another important figure in Alaska Native cultures and stories. Eagles rely on their bird's eye view to hunt prey.

There are many advantages to a bird's eye view.

A **dotron'** (raven), is a well-known bird in Alaska. **Dotron'** is an important figure in the spiritual stories of many Alaska Native cultures. In the stories, **Dotron'** often uses his aerial view to help him. Do you know any **Dotron'** stories? How might **Dotron'** use his ability to see from above to his advantage?

Like **Dotron'** and any other flying bird, a **yots'enodzida** also has an aerial view of the world. Drones allow people to see the world from above, without having to climb to a high height or ride in an airplane. If you could fly a **yots'enodzida** anywhere you wanted, where would you go? What would you like to see from above?

Activity 2

Bird's Eye View

Alaska Native Values for Curriculum: Know Who You Are, Honor Your Elders, See Connections

Have you ever listened to a storyteller share a story about **Dotron'** (Raven)? Try it! As the Elder shares the story with you, think about the way **Dotron'** used aerial and ground-based perspectives to achieve his goal. Then think about how you could use an aerial perspective to achieve a goal.

Materials:

- "How Raven Stole the Sun" by Maria Williams
- "Kushtaka: The One Who Sits and Waits" by Chief Bill Smith
- "Raven and the Sun" by Mary Esmailka (Koyukon)
- "Raven Falls in Love with Goose" by Matthew Titus
- Tea and refreshments
- Cups
- Paper
- Colored pencils



illustration by Hannah Foss, UAF/GI

Procedure:

1. Invite an Elder to your classroom to share a story about **Dotron'**. Welcome the Elder and give them a comfortable place to sit. Serve them tea or coffee and listen closely as they share the story with you.
2. Think about the story you just heard. At what point in the story did **Dotron'** have an aerial view? At what point did he have a view from the ground? How were these different perspectives useful? How did **Dotron'** use both perspectives to accomplish his goal?
3. Draw a picture of what **Dotron'** saw in the story.
4. Share your drawing with the Elder and your classmates. Discuss: Did **Dotron'** have an aerial view or was he on the ground? What advantages does **Dotron'** have by being able to see from the sky?
5. Now draw a picture from the perspective of another character from the story. Share with a partner. Discuss how your second drawing is different from your first. How do the two characters see the same setting differently?
6. As a class, discuss with your guest how birds are similar to and different from drones. **Dotron'** used an aerial perspective when he was trying to achieve his goal. How might you use an aerial perspective to achieve a goal?
7. Thank the Elder for sharing the story with you. You can make a thank you card, make them some artwork, or help them with something to show your appreciation.

“I'm Tlingit and my father used to often times tell this wonderful story "How Raven Stole the Sun," which I've heard multiple times. It's a story that is shared by multiple tribes with different variations but I'm sharing the variation as told to me by my father.

Maria Williams
Author



image by Daniel Walker, UAF/GI

Chief Bill Smith shows a drum he made that illustrates an Eyak story of how Raven stole the sun, moon and stars.

Yots'enodzida

Bumblebee in the Sky

photo courtesy of ACUASI



This camera drone is being used to inspect the bridge. Before drones were used for this, a person had to make the dangerous climb onto the underside of the bridge to perform the inspection.

What kinds of data can a **yots'enodzida** collect?

High definition camera drones use many types of cameras. Large drones can carry high quality cameras and many other instruments. High quality drone cameras take detailed images at long range. The **k'och'enat't'wghenh** (pilot), scientists, and many others use these detailed photos to study waters, lands, wildlife or structures that may be hard to reach. This is easier than using a satellite or an airplane because drones can be flown lower and more precisely.

“ I used a drone to get coordinates for a plot for someone's house... We get nice aerial footage of our construction and look for plots or aerial views of where the building could go or where we could have a new building site without having to walk there or cut everything down. We can see right overhead.

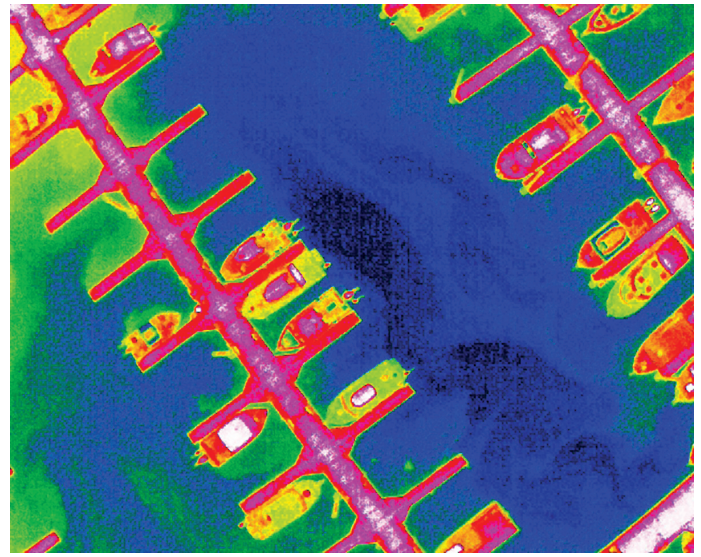
Steve Roberts
Nulato, Alaska



Infrared (IR) technology can show how warm an object is compared to other objects in the image. This type of data can be used to identify objects that are hot or cold. In the image below, warm or hot objects appear in shades of red or white. Cooler objects appear green to blue. What color would your classroom appear? How about yourself?

IR is used to spot warmth in an image from the sky. The harbor used it below to note how the boat harbor was laid out. IR images can be used to study wildlife or locate missing people. The body heat from an animal or human stands out brightly compared to the outdoors. Firefighters also use IR to identify wildfire hotspots below the ground.

images courtesy City of Valdez UAS Team



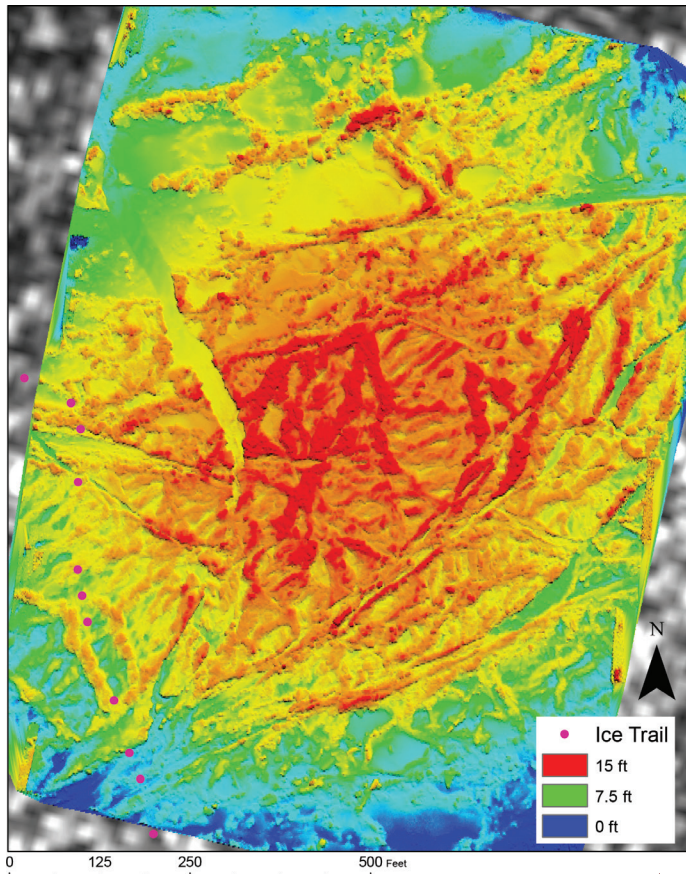
These two images show boats in the harbor in Valdez, Alaska. Which items in the image are warmest? Which are coolest? How do you know?



They would save us a lot of money on search and rescue if we could have drones to find people – infrared drones.

Van Madros
Nulato, Alaska





This is a topographic map of the sea ice near Utqiagvik. The map was created using a LiDAR instrument on a **yots'enodzida**, not an infrared camera. The colors in this image do not show heat. The red indicates tall ridges on the ice, while the green shows lower areas. If you needed to find a path across the ice, how could this image help you?

Eyal Sait and Oliver Dammann, UAFGI, Craig George, Dept of Wildlife Management, image courtesy of ACUASI

LiDAR (Light Detection And Ranging) is used to measure different distances to the Earth. LiDAR collects data by using a laser. First, the laser is pointed at an object. A sensor then measures how fast the laser reflects back. This can measure the distance between the drone and that object. The data can be used to make detailed 3D models of the ground, vegetation or buildings below the **yots'enodzida**.

“ I think it's also really cool to think about how drones can collect data, like LiDAR...that is another awesome tool that you can actually just map the ground surface. You can determine what type of vegetation is out there. You can also see animal trails. So that's really helpful when thinking about where animals are at. Where are they feeding? Where are they going? Drones have a lot of applications for natural resources management.

Eva Dawn Burk
Nenana, Alaska

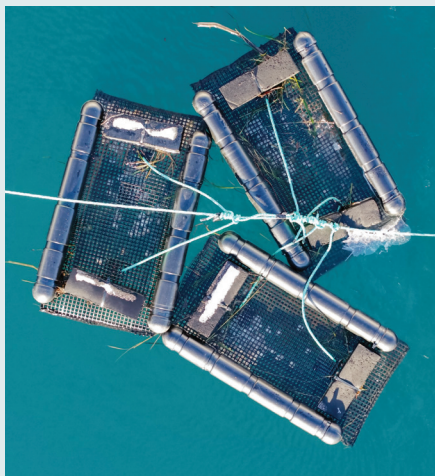


image courtesy Valdez Native Tribe

“ We've got a farm out here – an oyster farm – and we've been doing the surveillance through drones, which has been really innovative. [Before], I've always done it by boat – go out there and check – but here they can just let [the drone] take off right from the parking lot, fly ten minutes over there and they're over the farm.

John Boone,
Valdez, Alaska



Activity 3

Drone's Eye View

Alaska Native Values for Curriculum: Know Who You Are, See Connections

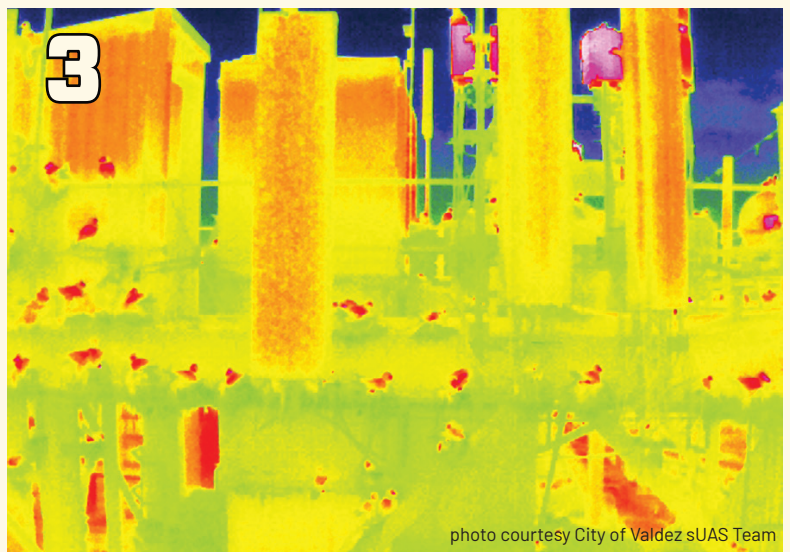
What types of data might you collect with a **yots'enodzida**? Why? Analyze drone images to explore how drones help people answer questions and see from new perspectives.

Procedure:

1. Brainstorm: What types of information can a drone collect?
 - a. become trapped beneath the ice in large bubbles like those shown here.
2. Watch the Drones in Alaska video available at <https://sites.google.com/alaska.edu/drones>. Think, Pair, Share: What did you learn from the video about how drones can be used in Alaska communities?
 - a. Where is the sun shining from?
 - b. Which side of the image contains the lake?
 - c. How many methane bubbles can you see?
 - d. How is the perspective from the drone different than what we would see from the ground?
3. Work with a group of 3. Look at image 1.
 - a. Find the group of animals in the center of the photo. Can you tell what they are?
 - b. How many can you see on the beach?
 - c. What type of information might the drone pilot who took this photo be collecting?
4. Find image 2. It shows a forest and a lake in Alaska. The big black circles are methane bubbles in the lake. Methane is a gas that can form as organic matter decays under the lake. During winter, when ice covers the lake, the methane can
 - a. This image shows birds sitting on an electrical transformer. Can you spot the birds? How?
 - b. How many birds do you see in the image?
5. Look at image 3 with your class. This is an infrared image (IR). The red and white in the image represents heat. The green and blue represent cooler objects.

Discuss:

- Could the tools used to create these photos be used to collect data in your community?
- What type of local challenges or needs could they help with?



Lis noghelbet. It is Spinning.

images by Daniel Walker and J.R. Ancheta, UAF/GI



How do drones and plants travel through the air in similar ways?

Some plants rely on twirling to scatter their seeds. Others float through the air. The shape of the seed affects how it moves through the air, just as the shape of a **yots'enodzida** (drone) affects how it moves through the air.

A spruce seed and a drone rotor have a shape that allows them to twirl through the air.

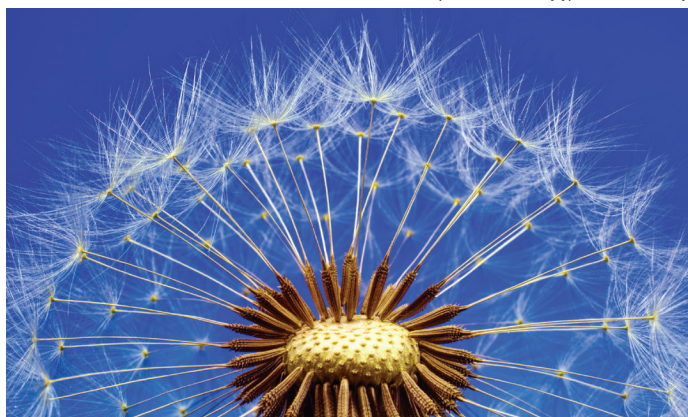
Ts'eba/Spruce

Spruce seeds grow inside of a spruce cone and then fall out as the cone dries. Each seed is attached to an oval-shaped wing. The shape of the blade or wing causes the seed to spin through the air as it falls. This spinning motion keeps the seed airborne for longer, enabling it to travel greater distances than the seed would travel without the wing. A spruce seed looks a lot like one blade of a drone rotor. Like the seed, the rotors on drones also spin to keep the drone aloft.

Ch'etth'ena' t'on' tr'eł'ani/Dandelion

A **ch'etth'ena' t'on' tr'eł'ani** (dandelion) also uses air to disperse with a different seed structure. A **ch'etth'ena' t'on' tr'eł'ani** produces very light seeds with sail-like hairs that enable them to be carried by the **ełtr'eyh** (wind). The seeds are wider at the top and narrower at the bottom. This allows them to stay aloft and be carried on air currents. Drones have a similar shape with rotors spread wide at the top and a smaller body at the bottom.

photo courtesy jplenio | Pixabay



How does a **yots'enodzida** fly?

Air has mass and takes up space. A **yots'enodzida** must push air out of its way to move. Gravity is the natural force that causes things to fall toward Earth. Drones use spinning rotors to overcome gravity and lift off the ground.

Have you ever blown on a pinwheel? The force of air from your breath will cause the pinwheel to spin. The harder (faster) the force of the air, the faster the blades spin. Reversing this action, we can spin the pinwheel (like a fan) and make the pinwheel blow the air away. The faster we spin the blades, the more force (lift) we can generate to keep our drone flying. The way drones interact with air and gravity can also be affected by weather. A **k'och'enatł'wghenh** or pilot must be aware of the weather when flying a drone.

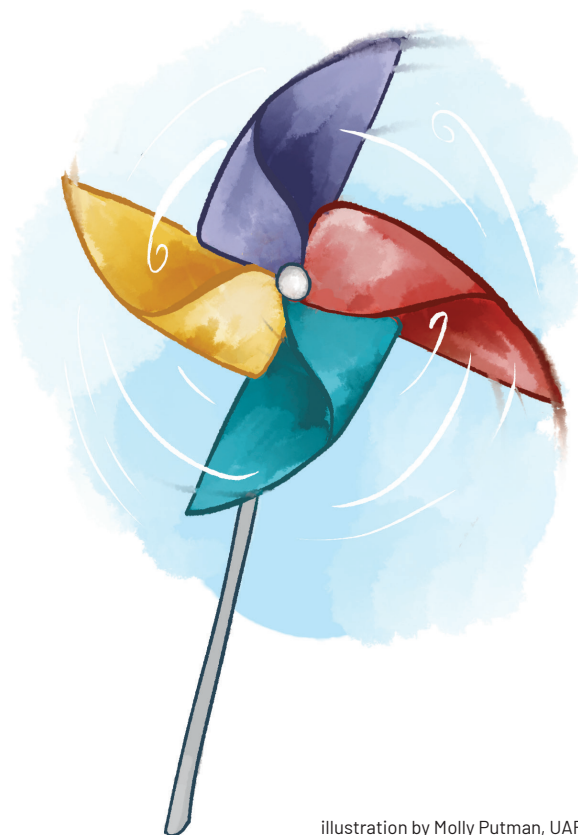


illustration by Molly Putman, UAF/GI

“ Dandelions use air to transport seeds. What kid hasn't blown on a dandelion and watched the seeds float around as they make their wish? ”

Bernice Krinke
Valdez, Alaska



photo by Eric Tidwell | NPS



ts'eba
spruce tree

photo by W. Carter | wikimedia



ch'etth'ena' t'on' tr'eł'ani
fireweed

photo by Marco Silva | Unsplash



ch'etth'ena' t'on' tr'eł'ani
dandelion

photo by Kargona | Dreamstime.com



t'egheth
cottonwood tree

Activity 4

How Does a Drone Fly?

Alaska Native Values for Curriculum: Show Respect to Others, See Connections, Honor Your Elders, Know Who You Are

In this activity, you will build a whirligig that uses the same type of twirling motion a spruce seed and a drone rotor use. When you drop your whirligig, the air provides resistance that slows it down. As you build your whirligig, think about what you read on how the whirligig “flies.” By experimenting with the weight, shape and position of the blades, you change how fast and how much air is pushed out of the way.

Materials:

- Scissors
- Tape
- Colored pencils
- Paper clips
- Hula hoop
- Whirligig template
- Stopwatch (optional)

Procedure:

1. Use scissors to cut out your whirligig from the template.
2. Cut along dotted lines and fold on solid lines. Attach a paperclip to the tail of your whirligig.
3. Work with a partner. Place a hula hoop on the floor as a target for your whirligig.
4. Lift your whirligig above your head and drop, aiming for the target on the floor. As your whirligig twirls to the ground, announce, “**Lis noghelbet.**” (It is spinning).

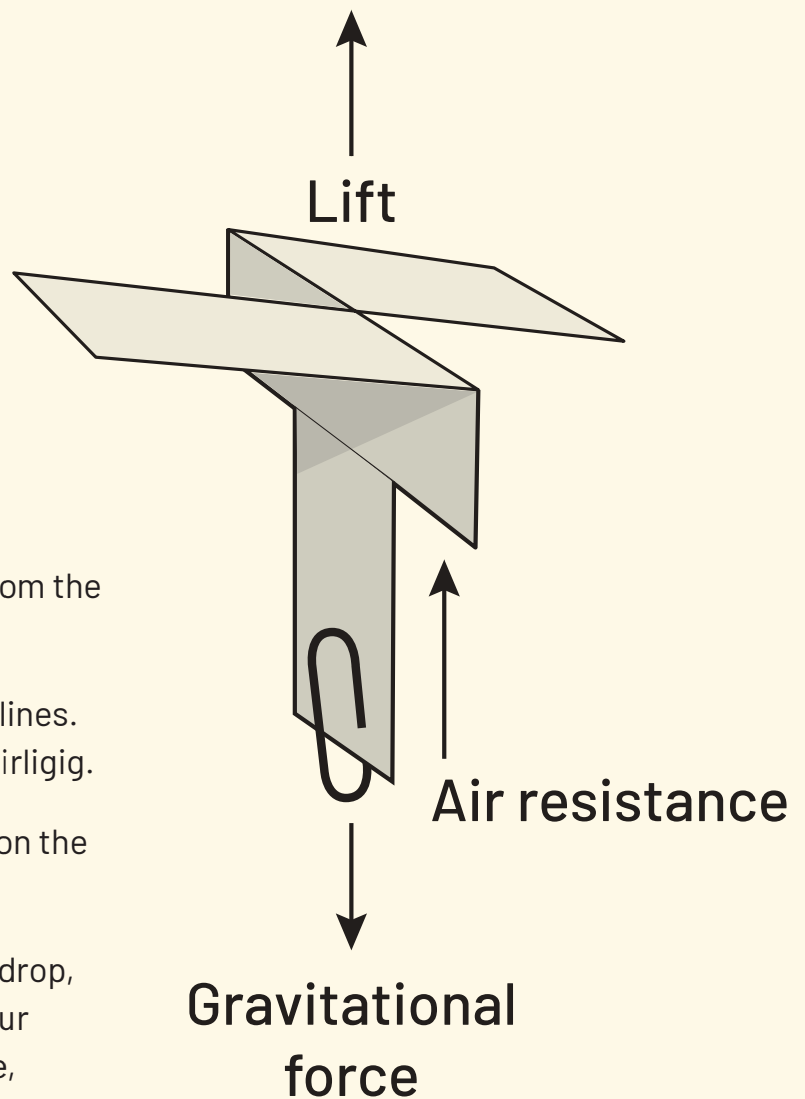


illustration by Katherine Holmgren, UAF/GI

5. Record your observations. Where did your whirligig land? What direction did it fall? Can you count the number of rotations your whirligig makes as it descends to the floor?
6. Drop your whirligig 3 more times. Remember to say, "**Lis noghelbet**," each time you drop it. How might you redesign your whirligig to change the way it flies?

Discuss:

- What did you notice about the way the whirligig flies?
- Did the whirligigs turn in a certain direction? Why?
- How might you make the whirligig rotate in the opposite direction?
- Why might one student's whirligig fly straight down while another moves side to side?
- Do all of the whirligigs remain in the air for the same length of time? Why or why not?

photo courtesy of ACUASI



Not'wkh. It's flying.

images courtesy of alexas_fotos | pixabay and Fir0002 | Flagstaffotos



How do things that fly change position in the air?

Birds are found in all types of environments, and species come in all sizes and shapes with wings that are adapted for their survival needs. A **dotron'** (raven) has flight feathers and muscles in its wings which are light and strong. These help to lift the bird's weight off the ground. Each **dotron'** also has contour feathers that give it a smooth shape. A **dotron'** can change direction in mid-air by twisting its tail or changing the position of its wings. Increasing or decreasing its speed can also change the bird's position in the air. Airplanes mimic the shape of birds and use many of the same strategies to change position in the air.

“ Most drones have four propellers...It's a lot of precision controls... Technology has finally gotten to a point where you can tell each [drone] motor to do exactly what you want and it does some really cool tricks. I remember seeing a drone do the flips!

Karsten Sierra
Fairbanks, Alaska



Look at the birds shown below. Have you seen these birds where you live? How do these different birds move differently through the air?

image by Daniel Walker, UAF/GI



bats
gull

image courtesy of Zaimful | pixabay



khwkh
Canada goose

image by Daniel Walker, UAF/GI



ch'eyona'
eagle

image courtesy of connie_sf | pixabay

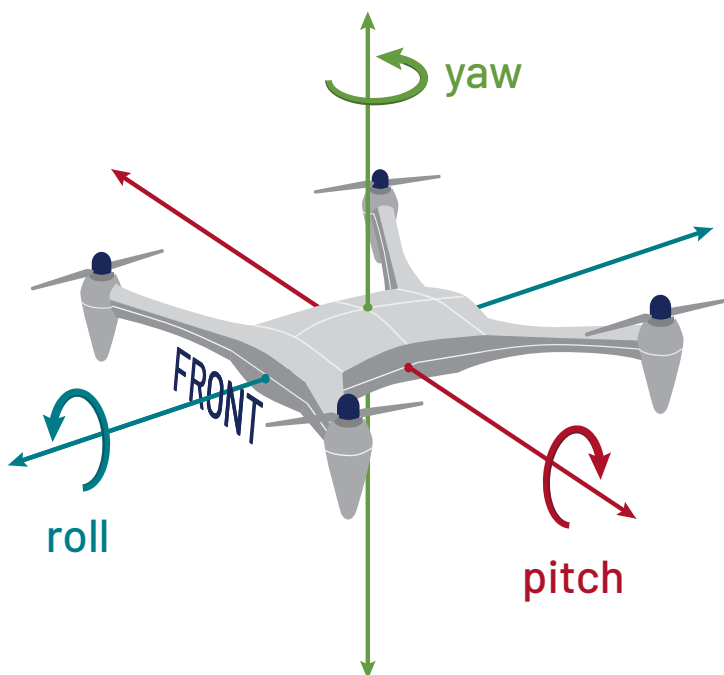


dotron'
raven

What type of movements can a **yots'enodzida** (drone) make?

Drones are able to move in several directions through the air. The **yots'enodzida** is controlled from the ground by the **k'och'enałt'wghenh** (pilot). Movements the **yots'enodzida** makes are based on which directions the **k'och'enałt'wghenh** moves the throttles.

The movements a **yots'enodzida** can make reposition it in the air by changing the pitch, yaw, roll and lift of the **yots'enodzida**. Changing pitch causes the nose and tail of the **yots'enodzida** to move up and down. Yaw moves the nose from side to side. Roll is a circular movement (clockwise or counterclockwise) of the body as the **yots'enodzida** moves forward. Lift is vertical movement of the **yots'enodzida** body up and down.



How do you safely fly a **yots'enodzida**?

It is very important to ensure a safe flying environment before piloting your **yots'enodzida**. Below are 6 general safety guidelines to follow as a drone **k'och'enałt'wghenh** (pilot).

6 Safety Guidelines

1. Maintain a "line of sight."
2. Don't fly over people.
3. Learn and follow local drone rules.
4. If you want to fly outdoors, get clearance from the FAA and local authorities, and pass the TRUST exam.
5. Don't fly in the dark or under bad weather conditions.
6. Stay below 400 feet altitude.



A UAF drone pilot demonstrates safe flying practices while flying a drone above Nulato, AK.

drone illustration by Katherine Holmgren, UAF/GI, photo by Mariah McNamara, UAF/GI

Activity 5

Pitch, Yaw, Roll, Lift

Alaska Native Values for Curriculum: Show Respect to Others, See Connections, Have Patience

Drones change pitch, yaw, roll and lift as they travel through the air. It is important for the **k'och'enat't'wghenh** (pilot) to know and understand each direction a drone can fly while piloting a drone. Imagine you are a **yots'enodzida** (drone). In this activity, you will practice moving your body to demonstrate pitch, yaw, roll and lift!

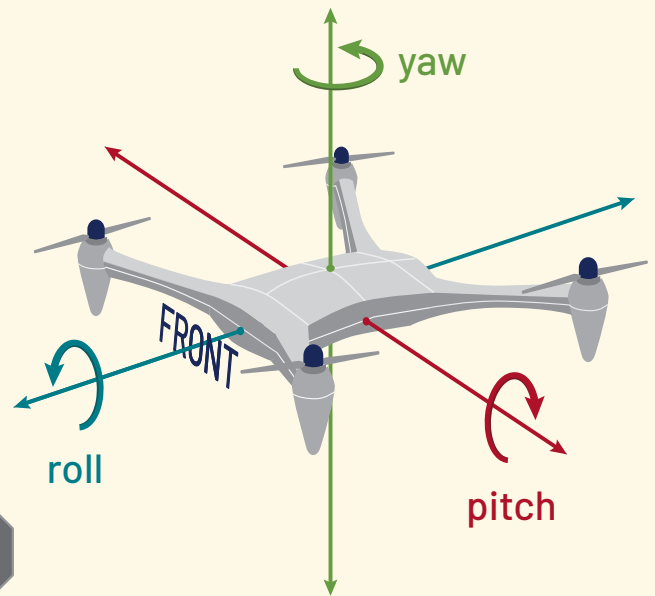
Materials:

- Drone Safety Video
- Pitch Yaw Roll Animation

Procedure:

1. Watch Pitch, Yaw, Roll Animation. Pay careful attention to how the controller causes the **yots'enodzida** to move.
2. Follow along with your body, moving as the drone moves. Describe each movement type and what direction they help a **yots'enodzida** move in space.
3. In an open space, play a modeling game. Use your body to represent the **yots'enodzida**. Spread your arms to represent the wings that hold the rotors. Your nose will be the front of the drone. When your teacher calls out: pitch, yaw, or roll, take these actions:
 - a. Pitch (drone has nose up or tail up): fold forward and bend backward at the waist. Move in these directions back and forth.
 - b. Yaw (drone nose moves side to side): Hold arms straight out to the left and right. Plant your feet and turn at the waist to the left and right.
 - c. Roll (drone nose moves in a circular motion as it moves forward): Hold arms straight out to the left and right. At your waist, tilt your body to the left and then tilt your body to the right.
 - d. Lift (drone moves up or down vertically): Squat down and then stand back up.

4. Watch the Drone Safety Video.
5. Review the **Safety Guidelines** on page 21 of this student guide with a partner then discuss why each rule is important for flying. Make a list of other safety tips that you learned from the Drone Safety Video. Why are these tips important?



drone illustration by Katie Bendall, UAF/GI
remote illustration by Molly Putman, UAF/GI
phone illustration by aozora21 | vecteezy.com

K'okhideneyh. They're Working.

image courtesy of ACUASI







A professional drone team works together to fly a **yots'enodzida**.

Who makes up a drone team?

Are you ready to fly a **yots'enodzida** (drone)? There are many different roles and responsibilities that are involved with a successful **yots'enodzida** flight. A **k'och'enałt'wghenh** (pilot) is responsible for operating the **yots'enodzida** while it is in the air. The **k'och'enałt'wghenh** needs to watch the controller and keep the **yots'enodzida** in sight. A spotter can help the **k'och'enałt'wghenh** notice incoming obstacles or look for hazards that may appear. Drones can have technical issues as well. A

technician specializes in taking care of the **yots'enodzida** and making sure all parts are in working condition. Scientists use many tools and devices to gather the data they need from a flight. A data analyst interprets the many types of data collected by drone instruments. In the table below, take a look at the four roles listed in a **yots'enodzida** flight team. Which role are you most interested in? Would you like to try them all?

Drone Flight Team

Team Member	Duties
Technician 	Charge phone and batteries. Check the drone before use. Install the battery. Change the propellers if needed. Attach phone to controller. Place the drone on the pad. Change batteries during challenges. Organize the battery charger to keep enough batteries charged at all times.
K'och'enat't'wghenh 	Start the drone and the recording. Manage the drone controller. Sit or stand in one place. Fly the drone. Follow the drone via the live broadcast camera only.
Spotter 	Co-pilot the drone. Monitor the drone to ensure that the drone is not in danger of hitting another object. Communicate with the k'och'enat't'wghenh to let them know if there are risks or obstacles near the drone.
Data Analyst 	Assist the team during the flight and observe the progress of the flight. At the end of each exercise, retrieve the video from the phone. Save a copy. View the video recording. Discuss future improvements with the team.

graphics by Molly Putman, UAF/GI



There needs to be a level of respect in capturing [data], but also respecting the equipment and safety. I think for people flying – going over checklists, looking at the equipment and being calm [are important].

Adam Demientieff
Fairbanks, Alaska



Activity 6

Flying the Yots'enodzida (Drone)

Alaska Native Values for Curriculum: Show Respect to Others, Share what you have, See Connections

Have you ever flown a **yots'enodzida**? Would you like to? What type of things might you see or do with a **yots'enodzida**? As a team, practice your **yots'enodzida** flight skills and work through the challenges together.

Materials:

- Drone
- Propellers
- Batteries and charger
- Phone (or tablet), controller, and charging cord
- Clipboard
- Hula hoops
- Computer
- Challenge cards and lanyards
- Tape

Drone Tips:

- Tie back long hair to avoid catching it in any drone parts.
- Roll up loose sleeves.

Procedure:

1. Review the safe flying practices you read about and watched in the Drone Safety Video.
2. Break into groups of four. Discuss the four team roles and how to keep all team members safe.
3. In your group decide who would like to test out each role and give each person the matching role card. There are many opportunities to work as a team. Everyone will be able to try out more than one role.
4. Your group will need one drone, one smartphone, extra battery packs, a charging deck, a clipboard and charging cords. Bring your materials and Student Challenge cards to the gymnasium.
5. Follow the instructions on each flight challenge card to complete the challenge.



A drone pilot and a Nulato student work together to fly a **yots'enodzida**.

“ I can think of so many ways to start a business just with a drone. You can see that people are starting to replace a lot of things with drones, so teach it to younger kids and teach them that drones are the future — just like we used to say the internet was the future. Drones are going to be useful in so many ways that I can't even think of because kids are so brilliant these days and they'll come up with so many reasons [to use drones.] ”

Hope Roberts
Valdez, Alaska



Please note:

The Athabascan terminology in this student guide is from the Tanana dialect spoken in the Nenana area. Check with local speakers to find out if some of the terms in your community are different.

Basi' (Thank you):

Special thanks to the Nulato Tribal Council, the Nenana Native Association, and the Valdez Native Tribe. Teams from each community guided development of this publication, including:

- Nulato Koyukon Athabascan community members Martha Turner and Maurice McGinty;
- Nenana Tanana Athabascan community members Don Charlie, Victor Lord and Eva Burk; and
- Valdez Native Tribe community members Hope Roberts, Sheila Jordan and Anna Bateman.

Basi' to these teams and the many additional local knowledge bearers, educators, and scientists who contributed their expertise, interviews, data and pictures to this project. The information provided in this publication is for educational purposes only and not for commercial use.

Credits:

This publication was produced at the University of Alaska Fairbanks Geophysical Institute as part of the Drone Research Opportunities for Native Elementary Students (DRONES) project under the oversight of Principal Investigator Lynda McGilvary and Co-Principal Investigators Charlene Stern (UAF), Cathy Cahill (UAF) and Dayna Jean DeFeo (Univ. of Alaska Anchorage).

Authors: Mariah McNamara, Lori Schoening, Marine Vanlandeghem Gillespie, Martha Turner, Maurice McGinty, Don Charlie, Victor Lord, Eva Burk, Hope Roberts, Sheila Jordan, Anna Bateman

Tanana Athabascan Consultant: Siri Tuttle

Design, Graphics and Layout: Vicki Daniels, Katherine Bendall, Molly Putman, Hannah Foss

Science Editor: Andrew Wentworth, Mike Hatfield

English Editor: Kelly Eagan

Education Researcher: Dayna Jean DeFeo

This material is based upon work supported by the National Science Foundation under Grant Nos. 1850561 & 1850556. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. UA is an affirmative action/equal opportunity employer, educational institution and provider and prohibits illegal discrimination against any individual: www.alaska.edu/nondiscrimination/. ©2024, Geophysical Institute, University of Alaska Fairbanks. Cover image by JR Ancheta and Daniel Walker, UAF/GI.



UNIVERSITY of ALASKA ANCHORAGE