SCIENCE 3D

SHARKS!

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **STEM Project**, students will use the engineering design process to define criteria and constraints for putting cameras on shark bodies as well as on drones (to count sharks from the air). Then, they will diagnose places where engineered systems have failed in shark studies and suggest improvements to existing designs.

To study sharks and other marine animals, scientists often use technology. They depend on engineers to make the machines and technologies they need. Alyssa, Yannis, and Mike used many different technologies to study blacktip and hammerhead sharks. One problem with using new technologies, especially in harsh conditions, is that new designs don't always work. When they fail, engineers must determine what went wrong, design a solution to fix the problem, and test the new design.

Activity 1: Defining the Engineering Criteria and Constraints

Have students work in small groups to complete the lists of criteria and constraints for putting cameras on animals and collecting data from the air. Once students have developed their lists, have them report back to the entire class. They should update their own lists to reflect the class list. Depending on the amount of time you want to devote to the lesson, you can have different groups work on just drones or just underwater cameras.

The team used video cameras in the air attached to an unpiloted aerial vehicle called a "drone." These cameras are controlled from the boat using signals between the controller and the drone! They need enough battery power to be able to fly long periods of time and far distances and still make it back to the boat for collection. Also, to collect data the team needs to know where the drone was when it recorded the video.

The team also attached video cameras with computers to the sharks. They recorded data on temperature and speed. These cameras turn on automatically several hours after the shark is released. The team then finds the cameras once they float to the surface 24 hours or more later.

These systems don't work every time! To determine what might cause them to succeed or fail, we need to think about the criteria and constraints. **Criteria** are the things a system needs to do. A **constraint** is something that limits the system.

1. Systems on sharks

a. Define the engineering problem that the team needs to solve to get underwater video from sharks.

The team needs to figure out how to build a camera system that does not leak.

The team needs to make sure the camera system won't detach from the shark's body.

b. Think about all the things the camera system needs to do. What are all the challenges it will face? Below, list the criteria and the constraints for the underwater shark camera design. Be sure to consider every step from putting the camera on the shark to retrieving it!

Criteria:

Possible answers include:

- must record enough video to see foraging
- must be attached to an animal and stay attached until it is time to release
- must be able to be retrieved
- must be able to float
- must have a tracking device to find it after it floats to the surface

Constraints:

Possible answers include:

- cannot be too large for animal
- cannot be too heavy to deploy on animals
- cannot be too expensive
- cannot consume too much power
- cannot leak or sink

2. Systems in the air

a. Define the engineering problem that the team needs to solve to get video from the drone.

b. Below, list the criteria and constraints for the aerial camera design. Think about needing to fly a drone over open water and get it back!

Criteria:

Possible answers include:

- must be able to fly for a long time
- must be able to be retrieved from a boat
- must be able to be controlled from the boat
- must know the altitude
- must be able to record/transmit video
- must be able to know location

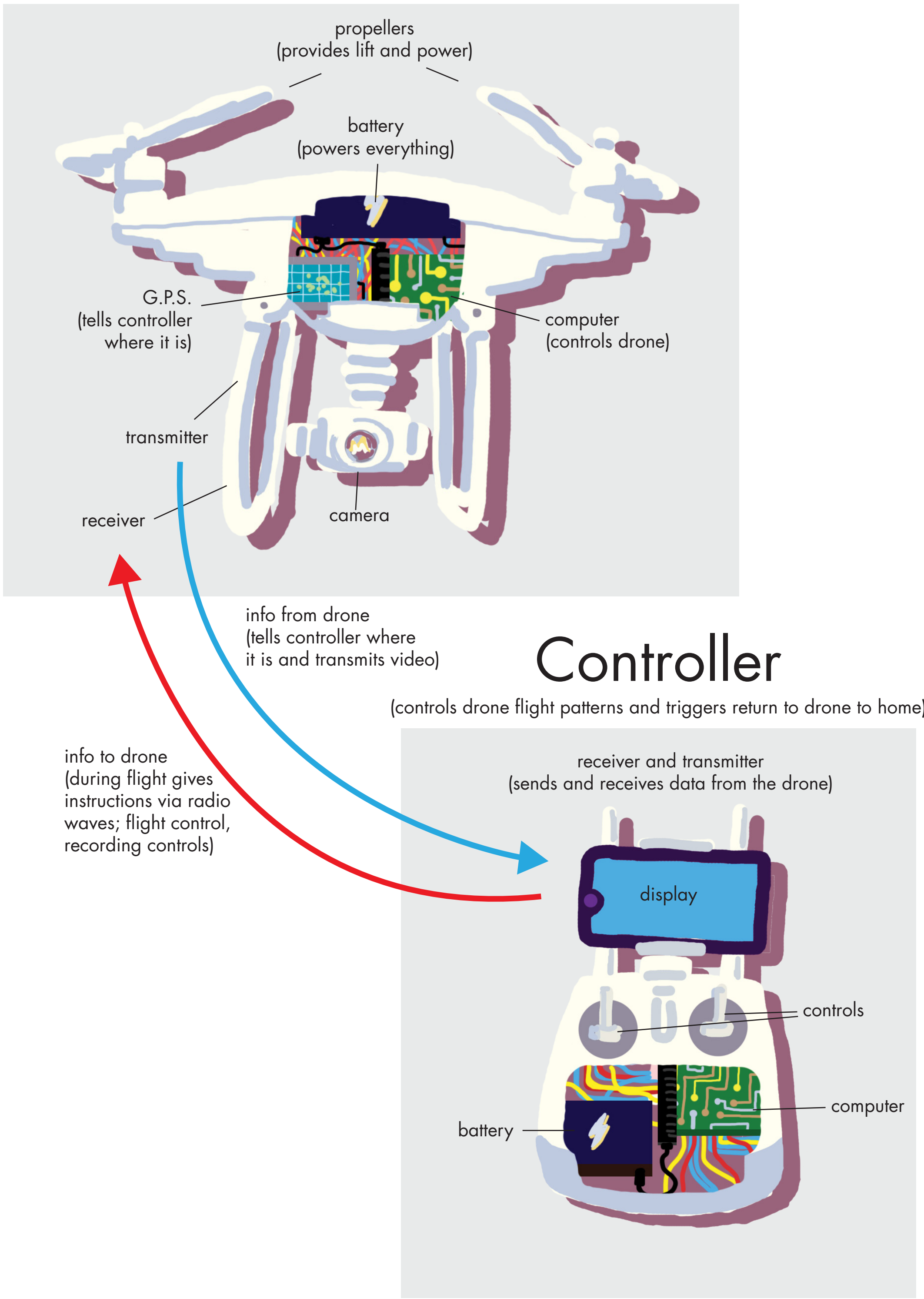
Constraints:

Possible answers include:

- cannot be too heavy to fly
- cannot crash
- cannot consume too much power

Activity 2: Down With the Drones

Drone



In the study, the drones worked most of the time, but there were problems. Try to help the team fix the problems in questions 1, 2 and 3.

1. Drone kept flying away, never to be seen again.

    a. What part of the system failed?

    Communication between drone and controller or "return to home" function

    b. What would you do to improve the system?

    Answers may vary but could include a stronger signal to have bigger range or less likelihood of failing, creation of redundant systems, etc.

    c. **Describe** how you would test your design.

    Answers may vary but should be tied to the suggested improvement. Examples include: flying the drone beyond the range of the controller to see when it loses signal and comparing the distances before and after the modification to the system.

2. The drone suddenly fell out of the sky and sunk to the bottom. When it was collected, nothing worked.

    a. What part of the system failed?

    Possibilities include the battery died or the connection from battery to the drone failed. Students may say everything died after it sunk. Accept any reasonable explanations.

    b. What would you do to improve the system?

    Possibilities include using better or bigger batteries to improve flight time or better or extra wires to ensure that the system doesn't fail easily.

    c. **Describe** how you would test your design.

    Accept reasonable answers based on the improvement. Examples include: flying the drone many times with the original and new design to see how often it fails or testing the average flight time with a new battery.

3. The drone flew perfectly, but no video was received on the controller.

   a. What part of the system failed?

   Possibilities include: the video receiver, the camera, or the video transmitter.

   b. What would you do to improve the system?

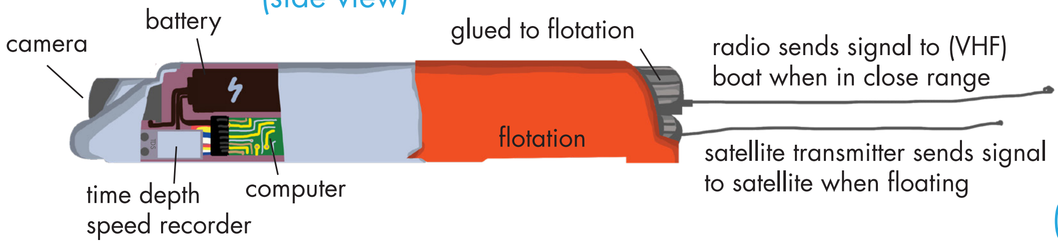
   Possibilities include: using a better camera, receiver, or video transmitter.

   c. **Describe** how you would test your design.

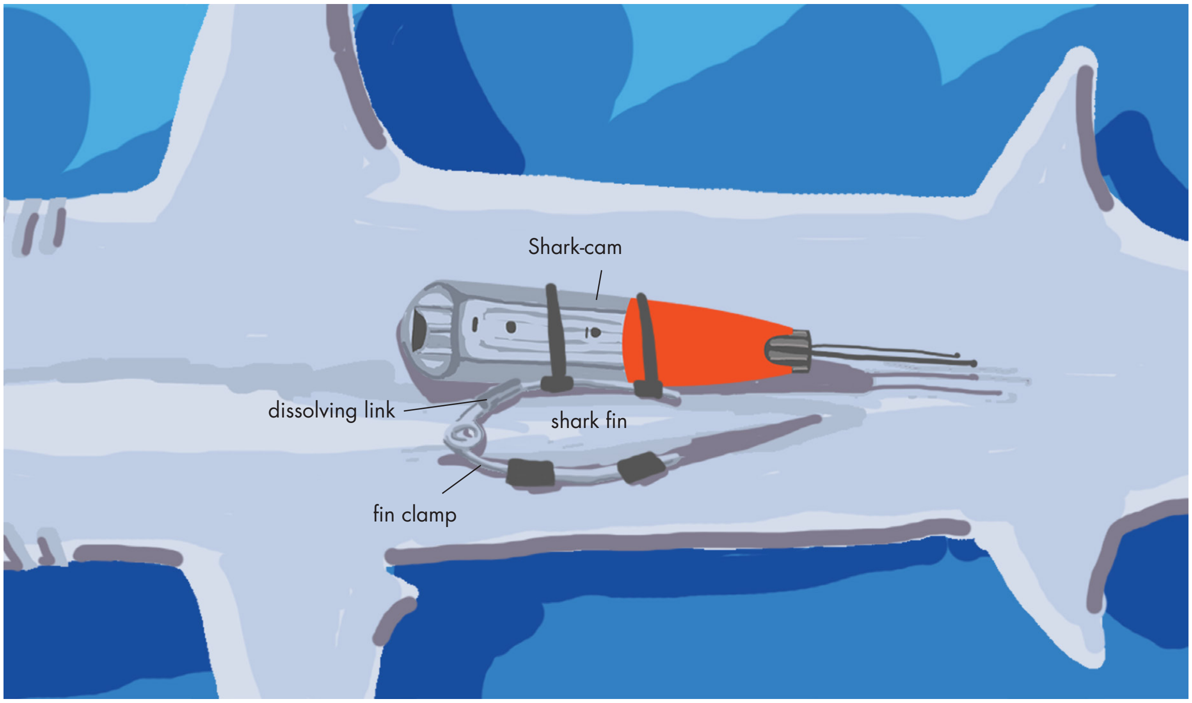
   Accept reasonable answers based on the improvement.

Activity 3: Where's the Video?

Shark-cam



(top view)



In the study, the camera attached to sharks worked most of the time. Let's try to help the team fix the problems in questions 1, 2 and 3.

1. The camera popped off too early with all the dorsal fin clamps still closed.

    a. What part of the system failed?

    the attachment system/clamp

    b. What would you do to improve the system?

    I would change the attachment system or make the clamp hold on tighter.

    c. **Describe** how you would test your design.

    Accept reasonable answers. Examples include: testing it on animals in an aquarium or observing how well it holds onto a model.

2. The camera was never heard from after it was last seen swimming away on a shark.

    a. What part or parts of the system might have failed?

    There are multiple possible answers. Examples include: the camera may have flooded, the flotation may have broken off, or the satellite transmitter may have failed or broken off.

    b. Propose some tests that would help you determine which system likely failed.

    Accept reasonable answers that link to the ideas in question 4. Some examples include: doing tests in the lab of how well pieces stay together or deploying the cameras on animals in captivity to watch how they work.

    c. Propose a design improvement to one of the systems that might have failed.

    Accept reasonable answers. Some examples include: better flotation or assembly of the tag, better satellite transmitter, and better waterproofing.

d. **Describe** how you would test your design.

There are multiple possible answers. Examples include: testing it on animals in an aquarium, observing how well it holds onto a model, or testing failure rates of electronics.

3. The camera came off the shark and was then collected. It had data on temperature and speed, but no video was recorded.

a. What part or parts of the system might have failed?

the video camera or the computer program that controlled the camera

b. Propose some tests that would help you determine which system likely failed.

Accept reasonable answers. Examples include: running the system with the same program, and trying to turn on the video camera.

c. Propose a design improvement to one of the systems that might have failed.

Possibilities include: a better video camera or better programing/wiring.

d. **Describe** how you would test your design.

There are multiple possible answers. Examples include: testing the camera in the lab, testing what happens when the camera is hit, and loading a new program and testing it before it goes out.