

FUTURE U.

Operation Refuel

Materials Store:

- Twine or thin string
- Paper towel rolls
- Toilet paper rolls
- Magnetic tape
- Magnets
- Velcro (both sides)
- Pennies
- Hot glue and hot glue gun
- Tape
- Craft sticks
- Scissors

Overview

In this challenge, students will simulate how drones can refuel in midair. They will design “drones” that can travel toward each other on ziplines and attach in order for refueling to take place, and they will discuss how this capability could affect the future of aviation.

Educator Prep

- Review the Introduction Video.
- Review the other pages included in this activity packet.
- Complete the classroom setup below prior to the session.

Classroom Set Up

1. Use thin string or twine to create two ziplines that are:
 - each at least 8–10 feet in length
 - flat
 - parallel to each other and about two inches apart
 - detachable on one side so students can load their paper towel-roll drones
2. Set up and review the Materials Store. Ensure there is enough of each item for each team.
3. Set up the Teams Tables with the following items:
 - Team Roles and Salaries sheet
 - Role handouts
 - Engineering Planning Guide
4. Divide students into teams of five people. If some teams have six people, a second mechanic can be added.

Example Team Roster

Example Team Roster	
Finance manager	
Materials manager	
Engineer	
Mechanic	
Mechanic 2	
Drone pilot	

Student Introduction

Today, you will design and build two drones that can attach in midair to refuel!

Each team member will have a role to play as you experiment with building two drones that can travel toward each other on the flightpaths provided, attach in midair, and stay attached during 10 seconds of turbulence! Once you have had 15 minutes to plan with your team and perform your roles, the refueling simulation will begin.

Team Roles and Salaries



Finance Manager: \$2,500

Responsible for the budget



Materials Manager: \$2,000

Responsible for the purchasing and inventory of the supplies



Engineer: \$3,000

Leads the group through completing the Engineering Design Planning Guide



Mechanic: \$2,500

Builds the drones



Drone pilot: \$3,000

Tests the refueling process, reports issues, and suggests modifications



Materials Manager: Cost Sheet

Items	Cost
Paper towel roll	\$9,000
Toilet paper roll	\$7,000
Magnetic tape, 1 inch	\$1,000
Magnets (2)	\$4,000
Velcro (both sides), 1 inch	\$4,000
Tape, 1 inch	\$1,000
Craft stick	\$2,000
Scissors	FREE
String (1 foot)	\$500/foot
Hot glue and hot glue gun (unlimited use)	\$2,000
Penny (for mass)	\$100/each
Trial run, using both ziplines	\$2,000/each

Finance Manager: Budget Sheet

Items	Starting Budget: \$50,000
Finance manager salary	\$2,500
Materials manager salary	\$2,000
Engineer salary	\$3,000
Mechanic salary	\$2,500
Mechanic 2 salary	
Drone pilot salary	\$3,000
Paper towel roll	
Toilet paper roll	
Magnetic tape, 1 inch	
Magnets (2)	
Velcro (both sides), 1 inch	
Tape, one inch	
Craft stick	
Scissors	FREE
String (1 foot)	
Hot glue and hot glue gun (unlimited use)	
Ending Balance:	\$ _____



Engineer Instruction Sheet



In this activity, your team must design two drones:

- Drone 1: a drone that needs to be refueled
- Drone 2: a second drone that will attach to the first drone in order to give it fuel

When it is your team's turn to simulate the midair refuel process, your team will complete the following steps:

1. Place the drones on opposite sides of the ziplines. (The zipline can be detached and threaded through your drone if needed.)
2. Help each drone take off.
3. Demonstrate how the drones travel toward each other and attach in order to refuel!

Your role is to lead your team through completing the Engineering Design Planning Guide. You will work with your team members to design and build two drones that can travel toward each other and attach midair.

Don't forget! It can be windy and turbulent in the air. Your goal is to design the drones so that they will attach for refueling and stay attached. Your instructor will be creating turbulence on the two ziplines for 10 seconds to see if your drones can survive the conditions and stay attached!

You may use any of the materials available to you as long as they are within your budget.

Mechanic Instructions Sheet



Work with your teammates to build two drones: one drone that needs to refuel and a second drone that carries the fuel! After traveling toward each other on their own ziplines, they must be able to attach to each other to simulate refueling.

It is your job to help construct these two drones. You will also analyze the drones' performance during test runs and repair, enhance, and tweak the designs as needed.

Drone Pilot Instructions Sheet



Work with your teammates to build two drone designs that you believe will be able to attach in midair.

It is your job to help test your design(s), provide feedback on the trial(s), and manage how the drones are flown during the final challenge.

As the pilot, be sure to remind your teammates that you need to figure out how each drone will fly! How will each drone get the thrust (or power) it needs to travel down the zipline? Who will be in charge of flying the second drone?

Directions: Follow the steps below to prepare for the refueling challenge. Make notes as you discuss your answers together.

▶ **Ask:** What is the problem we are trying to solve?

▶ **Imagine:** How can we solve this problem? Brainstorm solutions.

▶ **Plan:** Select one or two solutions you think will work best and explain how they will solve the problem.

▶ **Create:** Design and build your prototype.

▶ **Test:** What worked? What didn't work?

▶ **Improve:** How could you make your design better? Make these changes.

▶ **Share:** Be ready to discuss what you have learned!



Each group of students is unique. In addition to whether the drones are able to attach and stay attached during turbulence (as simulated by moving the two ziplines for 10 seconds), you may also choose other ways to judge your groups based on their grade level, your learning focus areas, and the resources available.

Additional judging criteria may include the following:

- ___ correctly completed math on the Budget Sheet
- ___ quickest attachment
- ___ most realistic appearance
- ___ least amount of money spent
- ___ completion of the Engineering Design Planning Guide
- ___ _____
- ___ _____
- ___ _____

Once you have selected multiple judging criteria, assign one point to each item above to see which group(s) have the highest number of points.

Directions: Conclude with a discussion around some, or all, of the following questions to wrap up the session:

- ▶ How did your design ideas differ from one another? How were they similar?
- ▶ What factors did you have to keep in mind in order for your refuel to be successful?
- ▶ Think about the challenges you faced today. When a real plane refuels in midair, what are some of the challenges that you believe its designers may face?
- ▶ What are some of the benefits of being able to refuel in midair?
- ▶ Could midair refueling benefit other forms of aviation as well? Why or why not? If so, which ones?