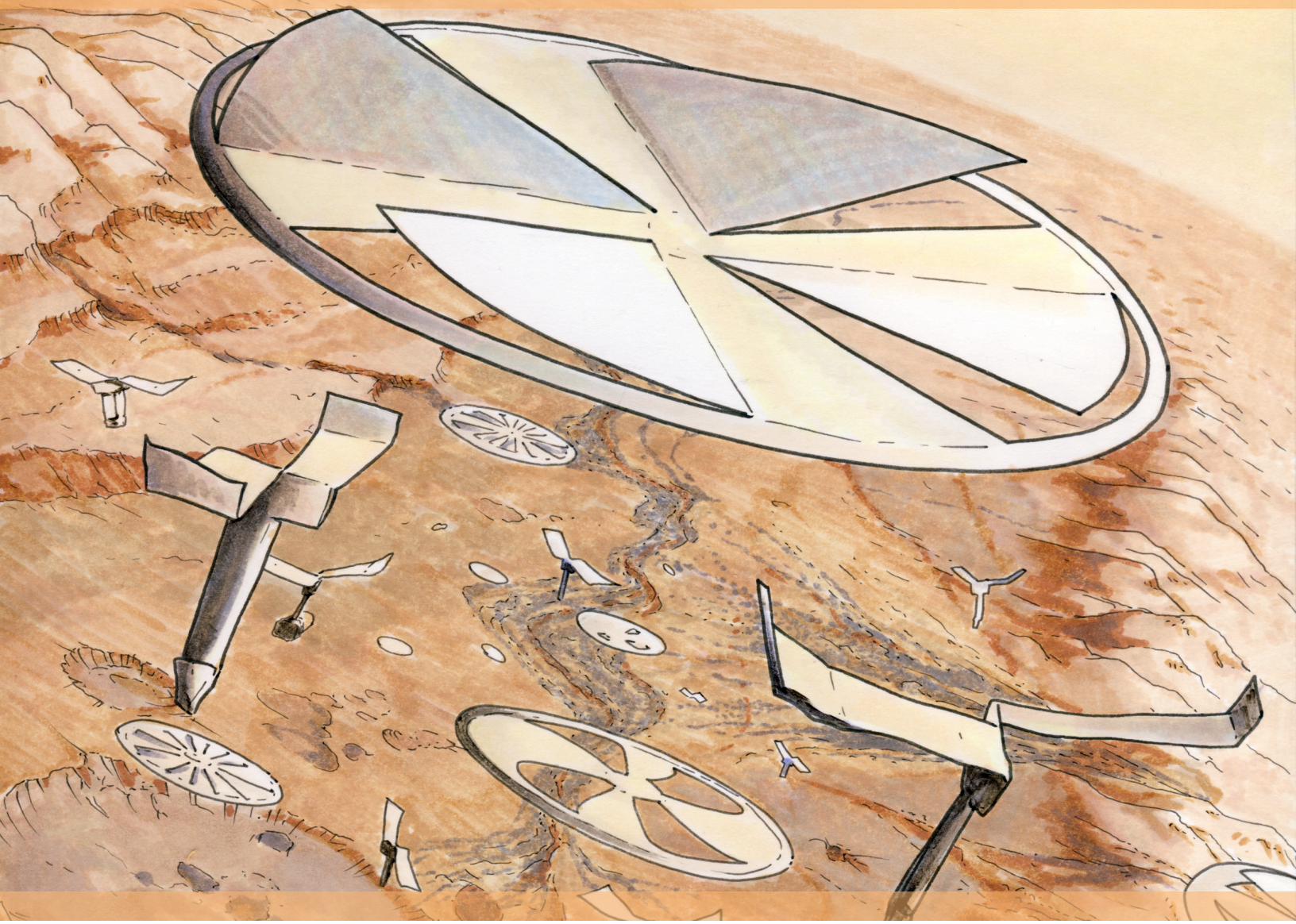
Engineering Adventures®

The Sky's the Limit: Engineering Flying Technologies

Aeronautical Engineering for Out-of-School Time • Grades 3–5



Written by the Engineering is Elementary® Team
Illustrated by Ross Sullivan Wiley and the Engineering is Elementary® Team

EiE Engineering is Elementary® | Engineering Adventures®
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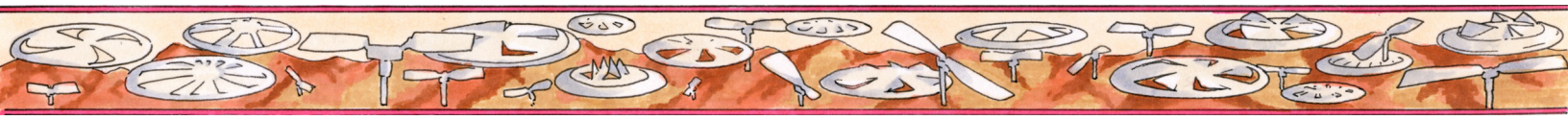

Engineering is Elementary
Museum of Science
1 Science Park
Boston, MA 02114

Written by the Engineering is Elementary Team

Project Director:
Christine Cunningham

Research and Evaluation:
Christine Gentry
Jonathan Hertel
Cathy Lachapelle
Christopher San Antonio-Tunis
Muhammad Shams
Sang Shin
Stephen Sullivan
Richard Sutton

Multimedia:
Kristina Blanchflower
Ellen Daoust

Curriculum Development:
Owen Berliner
Ian Burnette
Martha Davis
Michelle DiIeso
Melissa Higgins
Natacha Meyer
Tania Tauer
iea toner

Professional Development:
Chantal Balesdent
Jason Brewer
Erin Fitzgerald
Elissa Jordan
Shannon McManus
Elise Morgan
Corey Niemann
Kristin Sargianis
Max Siegel

Operations:
Valerie Costa
Emily Eppler
Laura Higgins
Kate Sokol

Interns and Consultants:
Nia Gipson
Eva Grant
Amy Hachigian

Outreach:
Cynthia Berger

Copy Editor:
Annie Whitehouse

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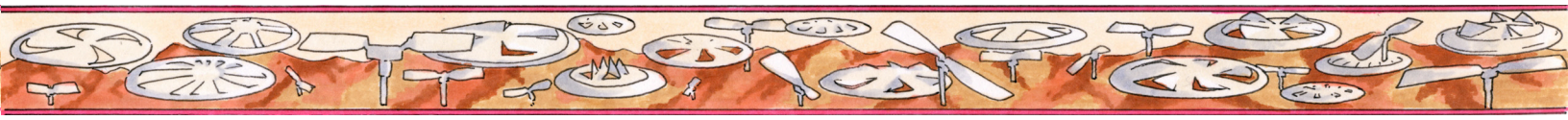
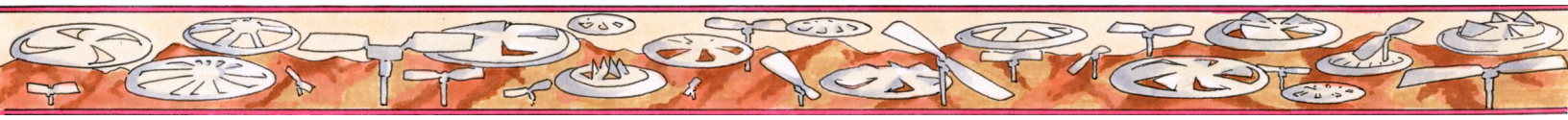


Pilot Sites for The Sky's the Limit:

This unit would not be possible without the valuable feedback from our pilot sites!

Agassiz Baldwin Community Center Cambridge, MA
Arthur T. Cummings Elementary Winthrop, MA
Charlestown Boys and Girls Club Charlestown, MA
Chinese Community Center Houston, TX
Columbus Afterschool Program Medford, MA
Egleston Square Youth Center at the YMCA Roxbury, MA
Forest Lake Elementary Columbia, SC
Fort Rucker Elementary Fort Rucker, AL
Gardner Pilot Academy Allston, MA
Lights on Afterschool Thermopolis, WY
Melrose Mathematics/Science/Technology Magnet Los Angeles, CA
Olympic Education Service District 114 Bremerton, WA
Riverside Elementary Carlsbad, NM
Siefert Elementary Boys and Girls Club Milwaukee, WI
South Boston Boys and Girls Club Boston, MA
South Boston Neighborhood House Boston, MA
STEM Middle Academy Springfield, MA
The Salvation Army Boys & Girls Club Chelsea, MA
The Salvation Army Boys & Girls Club of Pampa Pampa, TX
Tucker Elementary School Milton, MA
West Brookfield Elementary West Brookfield, MA
Westdale Heights Academic Magnet Baton Rouge, LA
Women's Housing and Economic Development Corporation Bronx, NY
YMCA Boston, MA
YMCA Lynn, MA



Unit Map

Here is an overview of the adventures in this unit and how they all fit together.

Prep Adventure 1: What is Engineering?
Kids engineer a tower and are introduced to the Engineering Design Process as a problem-solving tool.

Prep Adventure 2: What is Technology?
Kids explore the idea that they, as engineers, can design and *improve* technology.

Adventure 1: An Aeronautical Challenge
Kids will learn about NASA's aeronautical engineering work, including their aerial photography. Then, they will explore how some materials interact with air when placed in a vertical wind tunnel.

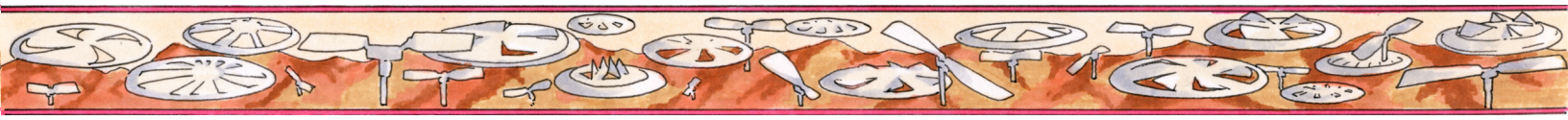
Adventure 2: Drop Copters
Kids will explore drop copters and try to design a drop copter that falls slowly.

Adventure 3: Up and Away
Kids will engineer flying discs that spin as they move through the air.

Adventure 4: Create a Flying Technology
Groups will use what they have learned about aeronautical engineering to design a model flying technology that meets a set of criteria and constraints.

Adventure 5: Improve a Flying Technology
Groups will *improve* their model flying technologies, making sure they address their criteria and constraints.

Adventure 6: Engineering Showcase
Groups present their model flying technologies and are shown examples of aerial images that would be taken by NASA aeronautical missions.



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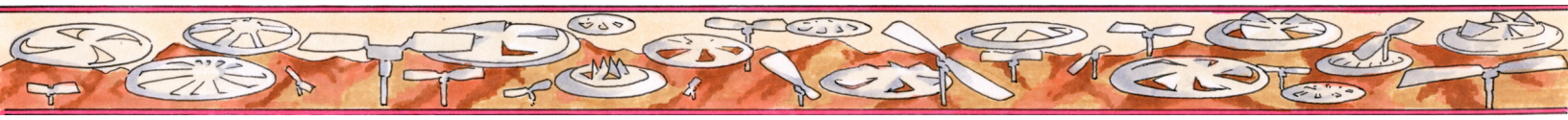


About Engineering is Elementary

Engineering is Elementary® (EiE) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, toothbrushes, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and learning how things work. Engineering is Elementary harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:

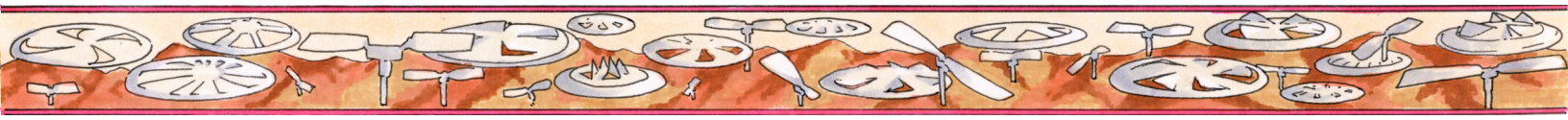
- Increase children's technological literacy.
- Increase educators' abilities to teach engineering and technology.
- Increase the number of schools and out-of-school-time (OST) programs in the U.S. that include engineering.
- Conduct research and assessment to further the first three goals and contribute knowledge about teaching and learning engineering.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. Designed for use in elementary school classrooms, this curriculum is hands-on, research-based, standards-driven, and classroom-tested. For more information about EiE, visit: www.eie.org.

In 2011, EiE began development of Engineering Adventures (EA), a curriculum created for 3rd–5th grade children in OST environments. EA is designed to provide engaging and thought-provoking challenges appropriate for the OST setting. More information about EA can be found online at: www.engineeringadventures.org.

In 2012 the Engineering Everywhere (EE) curriculum was created. EE is designed to empower middle-school-aged children in OST settings to become engineers and solve problems that are personally meaningful and globally relevant. For more information, visit: www.engineeringeverywhere.org.

EiE is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st-century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue through high school, college, and beyond. For more information, visit: www.nctl.org.



About Engineering Adventures

The mission of Engineering Adventures (EA) is to create exciting out-of-school-time activities and experiences that allow *all* 3rd–5th grade learners to act as engineers and engage in the Engineering Design Process. Our goal is to positively impact children's attitudes about their ability to engineer by providing materials uniquely appropriate for the varied landscapes of out-of-school-time settings.

The main ideas that guide the developers of EA are listed below.

We believe kids will best learn engineering when they:

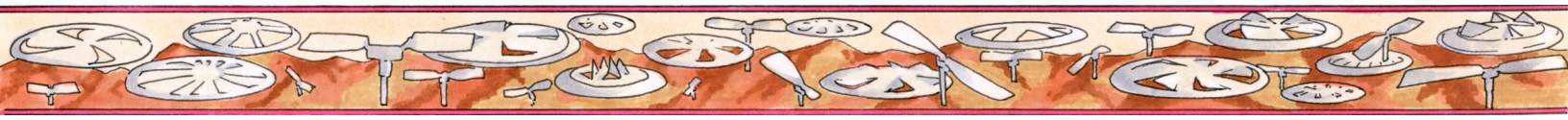
- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active problem solving.

Through EA units, kids will learn that:

- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have talent and potential for designing and improving technologies.
- they, too, are engineers.

As kids work through their engineering design challenges, they will have the opportunity to build problem-solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity for kids!

For more information on Engineering Adventures, please visit: www.engineeringadventures.org.



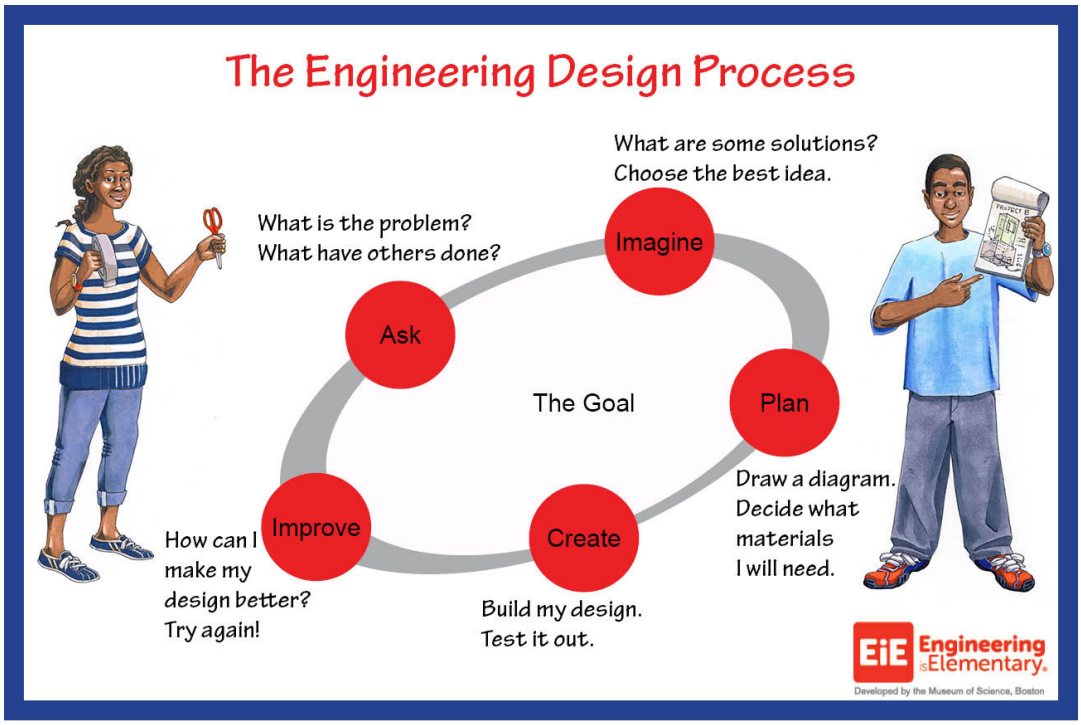
The Engineering Design Process

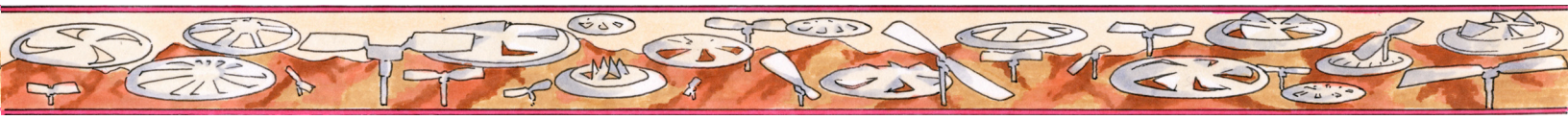
The Engineering Adventures Engineering Design Process (EDP) is the backbone of each Engineering Adventures (EA) unit. It is a five-step process that guides kids in solving engineering challenges. Our goal for each EA unit is for kids to understand the EDP can help them solve problems not only in engineering, but also in other areas of their lives.

While there are many other versions of the EDP that are used in academic and professional settings, the EiE team developed a five-step process that is accessible for elementary school kids. India and Jacob, a fictional world-traveling brother and sister duo, introduce and guide kids through the EDP in each unit. There are also questions for the educator to ask and sections in the Engineering Journal to provide an opportunity for kids to reflect on and discuss the process.

The EDP begins with the goal: the engineering challenge kids are asked to solve. The process is cyclical and flexible; kids can start a challenge at any step and may jump around to steps as they are engineering. For example, it is very common for kids to begin *creating* their technology, but then *ask* questions about materials and *imagine* new ways to *improve* their design. In EA units, kids generally start with the *ask* step, then have time to *imagine* and *plan* their designs, and *create* and *improve* their technologies.

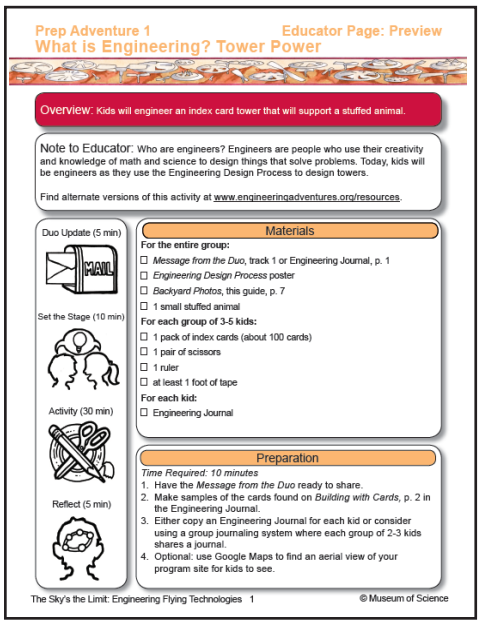
To further highlight the EDP throughout the unit, the steps are italicized in this guide. Below is the EDP used in EA units.





Each Engineering Adventure Includes

Preview pages with relevant background information, materials lists, preparatory instructions, and a preview of the journal pages needed.



Prep Adventure 1 — Educator Page: Preview
What is Engineering? Tower Power

Overview: Kids will engineer an index card tower that will support a stuffed animal.

Note to Educator: Who are engineers? Engineers are people who use their creativity and knowledge of math and science to design things that solve problems. Today, kids will be engineers as they use the Engineering Design Process to design towers.

Find alternate versions of this activity at www.engineeringadventures.org/resources.

Duo Update (5 min)
Set the Stage (10 min)
Activity (30 min)
Reflect (5 min)

Materials

For the entire group:
- ☐ *Message from the Duo*, track 1 or Engineering Journal, p. 1
- ☐ *Engineering Design Process* poster
- ☐ *Backyard Photos*, this guide, p. 7
- ☐ 1 small stuffed animal

For each group of 3-5 kids:
- ☐ 1 pack of index cards (about 100 cards)
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ at least 1 foot of tape

For each kid:
- ☐ Engineering Journal

Preparation

Time Required: 10 minutes
1. Have the *Message from the Duo* ready to share.
2. Make samples of the cards found on *Building with Cards*, p. 2 in the Engineering Journal.
3. Either copy an Engineering Journal for each kid or consider using a group journaling system where each group of 2-3 kids shares a journal.
4. Optional: use Google Maps to find an aerial view of your program site for kids to see.

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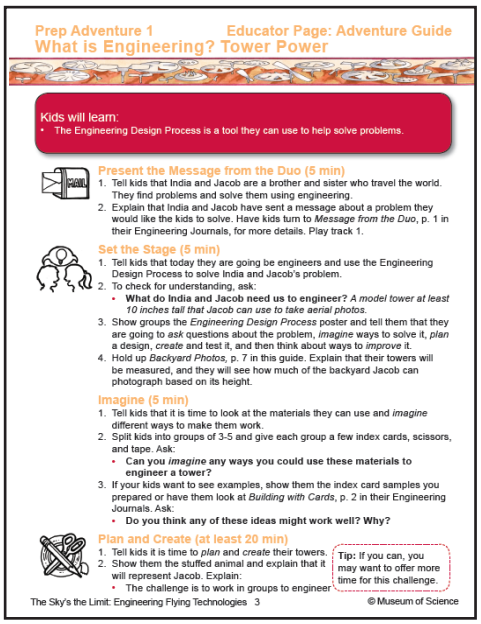
An **Adventure Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



Prep Adventure 1 — Educator Page: Adventure Guide
What is Engineering? Tower Power

Kids will learn:
- The Engineering Design Process is a tool they can use to help solve problems.

Present the Message from the Duo (5 min)
1. Tell kids that India and Jacob are a brother and sister who travel the world. They find problems and solve them using engineering.
2. Explain that India and Jacob have sent a message about a problem they would like the kids to solve. Have kids turn to *Message from the Duo*, p. 1 in their Engineering Journals, for more details. Play track 1.

Set the Stage (5 min)
1. Tell kids that today they are going be engineers and use the Engineering Design Process to solve India and Jacob's problem.
2. To check for understanding, ask:
   - **What do India and Jacob need us to engineer?** *A model tower at least 10 inches tall that Jacob can use to take aerial photos.*
3. Show groups the *Engineering Design Process* poster and tell them that they are going to *ask* questions about the problem, *imagine* ways to solve it, *plan* a design, *create* and test it, and then think about ways to *improve* it.
4. Hold up *Backyard Photos*, p. 7 in this guide. Explain that their towers will be measured, and they will see how much of the backyard Jacob can photograph based on its height.

Imagine (5 min)
1. Tell kids that it is time to look at the materials they can use and *imagine* different ways to make them work.
2. Split kids into groups of 3-5 and give each group a few index cards, scissors, and tape. Ask:
   - **Can you *imagine* any ways you could use these materials to engineer a tower?**
3. If your kids want to see examples, show them the index card samples you prepared or have them look at *Building with Cards*, p. 2 in their Engineering Journals. Ask:
   - **Do you think any of these ideas might work well? Why?**

Plan and Create (at least 20 min)
1. Tell kids it is time to *plan* and *create* their towers.
2. Show them the stuffed animal and explain that it will represent Jacob. Explain:
   - The challenge is to work in groups to engineer

Tip: If you can, you may want to offer more time for this challenge.

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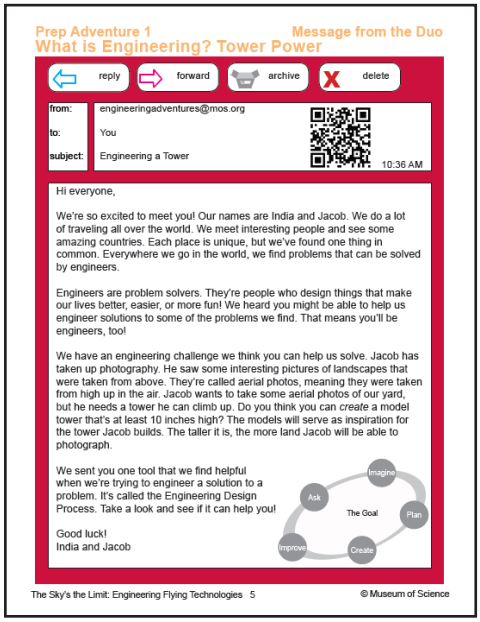
A **Message from the Duo**, India and Jacob, with information about the day's activity.



Prep Adventure 1 — Message from the Duo
What is Engineering? Tower Power

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Engineering a Tower
10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, or more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

We have an engineering challenge we think you can help us solve. Jacob has taken up photography. He saw some interesting pictures of landscapes that were taken from above. They're called aerial photos, meaning they were taken from high up in the air. Jacob wants to take some aerial photos of our yard, but he needs a tower he can climb up. Do you think you can *create* a model tower that's at least 10 inches high? The models will serve as inspiration for the tower Jacob builds. The taller it is, the more land Jacob will be able to photograph.

We sent you one tool that we find helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look and see if it can help you!

Good luck!
India and Jacob

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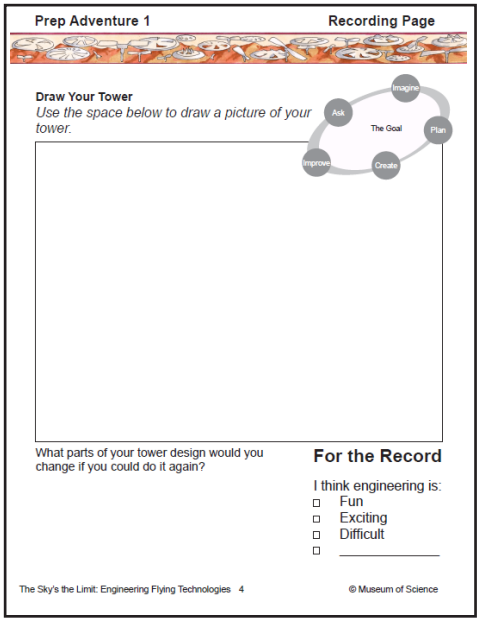
Engineering Journal pages that allow kids to record their findings and reflect on their learning.



Prep Adventure 1 — Recording Page

Draw Your Tower
Use the space below to draw a picture of your tower.

What parts of your tower design would you change if you could do it again?

For the Record

I think engineering is:
- ☐ Fun
- ☐ Exciting
- ☐ Difficult
- ☐ _____

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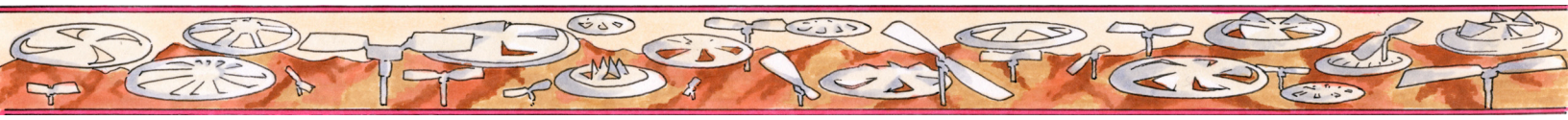
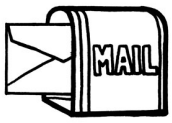


The Sections of the Adventures



Messages from the Duo

Messages from India and Jacob, a fictional world-traveling brother and sister duo, are provided as a quick, exciting way to present the real-world context for the unit's engineering challenge. Providing a context helps kids to understand the challenge and motivates them to find solutions. If you have access to a CD, MP3 player, or iOS device, we strongly suggest using the audio recordings, although reading the emails aloud will convey the same information.

Set the Stage (Ask)

The Set the Stage (or Ask) part of each adventure provides important information and questions that prepare kids for the main activity. During this section, you might ask questions prompting kids to share their prior knowledge, have them predict what they will find, or remind them of criteria that will help them as they engineer. This sets your kids up to succeed and feel confident in their ability to engineer.

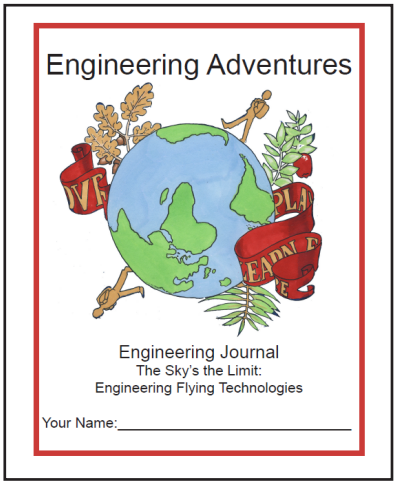
Activities

The activities are designed to get kids thinking and working together to solve the unit's engineering design challenge. As the educator, it is your role to guide kids through these activities by encouraging them to pursue and communicate their own ideas, even if you think they may not work. In engineering, there are no right or wrong answers! Every problem has many possible solutions and multiple ways to reach them.

Reflect

Each adventure includes 5-10 minutes at the end for kids to communicate with their peers by sharing their work. This gives kids the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging kids to support each other as they move through the Engineering Design Process. For more individual reflection, each adventure also includes time for kids to record thoughts and ideas in their Engineering Journal.

Engineering Journals



Make a copy of the Engineering Journal for each kid as you begin working on this EA unit. The Engineering Journal is a central location for kids to record their thoughts and ideas as they move through the unit. It includes recording pages that will guide kids through the Engineering Design Process, poses questions, and prompts kids to reflect on their learning. The 5-10 minutes kids spend with their journals during each adventure will allow them to create a personalized record of their engineering learning.

There are a few ways you can use the Engineering Journal. You may want to have groups share one Engineering Journal as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records for each adventure.

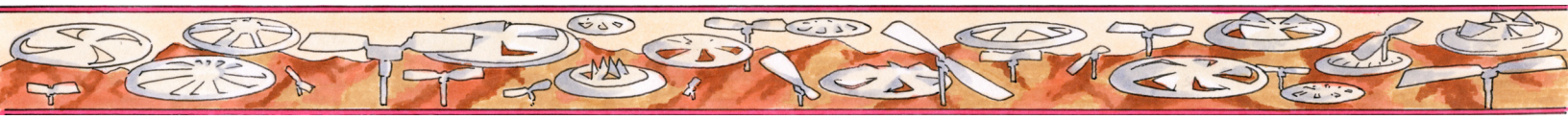
The back page of each Engineering Journal is a passport page from the country or state in which the unit takes place. Kids are encouraged to stamp the passport page when they finish a unit and collect the pages from all of the units they have completed.

Alternate Prep Adventures

The two prep adventures, "What is Engineering?" and "What is Technology?" introduce kids to engineering and technology. "What is Engineering?" gives kids the chance to collaborate, experience a mini hands-on engineering challenge, share their designs, and learn about the Engineering Design Process. This adventure sets the stage for what kids can expect in the rest of the unit.

"What is Technology?" has kids interact with technologies, working with the definition that a technology is anything designed by humans to help solve a problem. Most kids think of technology as things that can be plugged into the wall. They do not realize that the items that they interact with every day—including pencils, paper, and water bottles—are also technologies. This adventure introduces the definition of technology that the kids will refer to as they engineer their own technologies to solve the problem presented in the unit.

There are alternate activities for both of these adventures available online in the Resources section at www.engineeringadventures.org/resources. If kids complete multiple units, you may want to use an alternate activity to refresh the concepts in these activities. There may also be an activity that is more active or would be a better fit for the kids in your program. If you have questions about these activities, please email engineeringadventures@mos.org.



What You Need to Know **Before** Teaching an EA Unit

Engineering is Fun

The EA team hears this from many OST educators and kids. Engineering is a way of problem solving—a way of thinking about the world—that is very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are No Right or Wrong Answers

There are often many great ways to solve the same problem. Not only is this a good engineering lesson, it is a good life lesson for the kids in your program.

It is Okay to Try It Out

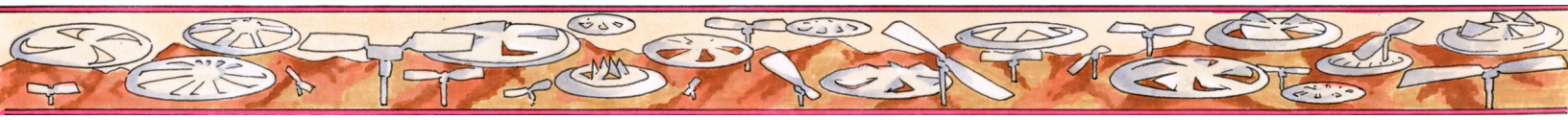
It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the kids in your program as they work through the adventures. This can help you understand the challenges the kids might face.

Scheduling the Adventures

Each adventure requires 45-60 minutes of teaching time. We recommend that you budget at least 8-9 hours in order to complete this unit, as some adventures may go longer than expected.

You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain adventures together. The chart below shows which adventures are easily taught together. Use this chart to help you plan your schedule.

Prep Adventure 1: What is Engineering? Tower Power Prep Adventure 2: What is Technology? Technology Detectives	2-3 hours
Adventure 1: An Aeronautical Challenge Adventure 2: Drop Copters	1.5-2 hours
Adventure 3: Up and Away Adventure 4: Create a Flying Technology	2-3 hours
Adventure 5: Improve a Flying Technology Adventure 6: Engineering Showcase: The Sky's the Limit	2-3 hours



Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving kids a sense of the day's adventure will help them to plan ahead and manage their time during the activity.

Facilitate Teamwork

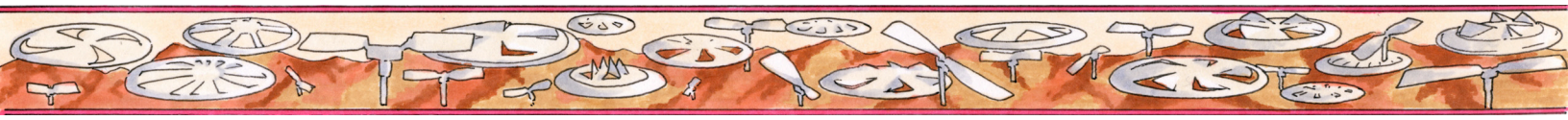
Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help kids who struggle with teamwork. Possible roles include: the recorder, the materials gatherer, the tester, and the presenter.

Timing

As groups are working, call out regular time intervals, so kids know how much time they have left to complete their task. This is especially helpful if kids have more than 20 minutes to work on a task. Letting them know when 5-minute increments have passed will allow them to budget their time and reassess where they are in their design.

Invite Others to the Engineering Showcase

The Showcase, the last adventure in the unit, is a big deal! This is a chance for kids to highlight the engineering they have done and share their accomplishments with others. Consider inviting families, program staff, and other kids to come to the Showcase.



Mobile Apps

Mobile apps can be a fun way to engage kids in out-of-school-time environments. The Engineering Adventures team has created iOS apps (compatible with most iPhones, iPod Touches, and iPads) that are designed to supplement the hands-on engineering experiences that your program provides.

You can download the Engineering Adventures apps onto your personal device or devices that belong to your site. You may also choose to encourage kids to download the apps onto their devices, so they may continue to practice their engineering skills on their own time. Encourage them to receive permission from their parents before doing so.

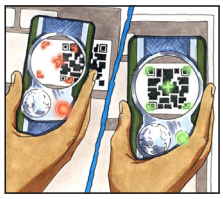
Technology Flashcards

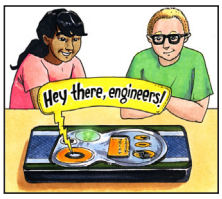
The Technology Flashcards app is designed to be used in conjunction with Prep Adventure 2. The app features a flashcard game that reinforces the idea that a technology is anything designed by a human to help solve a problem. The game allows kids to learn from their misconceptions in real time by providing them with instant feedback on why selected items are classified as technologies or not.

Search for “Technology Flashcards” in the App Store or visit: www.tinyurl.com/flashcardsapp.

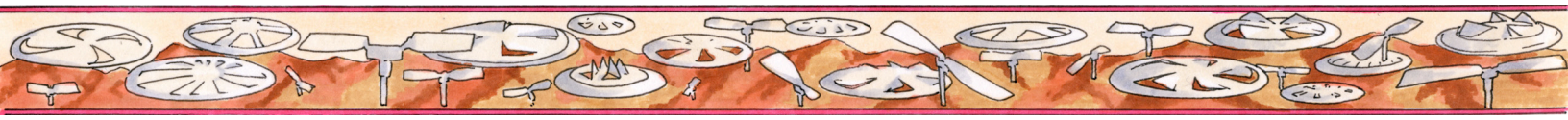
Messages from the Duo

The Messages from the Duo app is a new way for kids to listen to the audio communications from India and Jacob at the beginning of each adventure. Kids can use the scanner function in the app to scan the QR code at the top of each Message from the Duo page in the Engineering Journal. The audio of the message will play automatically as if India and Jacob are communicating directly to the kids over walkie-talkie! The app gives kids an opportunity to listen to the messages on their own for enhanced comprehension or to share with others. Educators may also choose to use the app as an alternative to a CD player or reading the messages aloud.





Search for “Messages from the Duo” in the App Store or visit: www.tinyurl.com/MFTDapp.



Background

Aeronautical Engineering

Aeronautical engineering involves designing technologies that fly through Earth's atmosphere. The atmosphere on Earth is made of air, and anything that flies through air has been designed using aeronautical engineering principles. This includes things like airplanes, gliders, and hot air balloons.

Aerospace engineers design things that fly both inside and outside of our atmosphere, while aeronautical engineers design things that only fly inside of our atmosphere. The National Aeronautics and Space Administration (NASA) is involved in both aerospace and aeronautical engineering. Aeronautical engineers at NASA design and *improve* the airplanes and other flying technologies that would take the types of aerial photos discussed in this unit. They also *improve* systems for air traffic patterns, conduct flight research, and design ways to make air travel more environmentally friendly.

The Empty Quarter

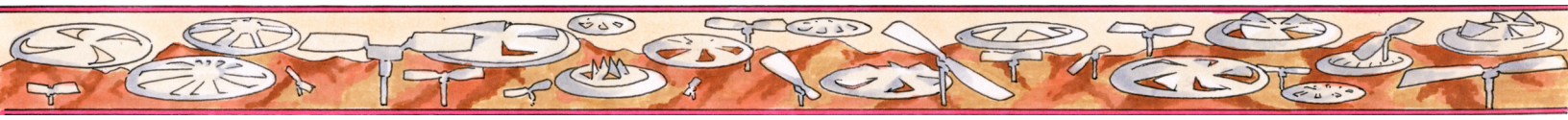
The Empty Quarter, known as *Rub' al-Khali* in Arabic, is located in the Middle East. The 250,000 square miles of the Empty Quarter cover parts of Saudi Arabia, Yemen, Oman, and the United Arab Emirates. Temperatures average well over 100 degrees Fahrenheit during the day. Nomadic Bedouin people live in and on the outskirts of the Empty Quarter, but the incredibly hot and dry climate has prevented greater settlement.

Scientists and archaeologists actively research this area to learn about the peoples and organisms that have lived or are living in this desolate area. Scientists and engineers from NASA and other space programs around the world have a particular interest in learning about these desolate areas. The harsh environment of the Empty Quarter is not unlike the harsh environments encountered on other planets.

Core Concepts

1. Context: Many people do not realize that NASA is involved in designing and *improving* technologies that fly within Earth's atmosphere. *Improving* airplanes, collecting aerial images, and testing new flying technologies in wind tunnels are just a few of the aeronautical projects NASA engineers work on.

2. Criteria and Constraints: All engineers, no matter what field they work in, have to consider criteria and constraints related to their projects. Clearly defining what a technology needs to do and calculating the limits on materials, budget, or other factors can help to determine whether an engineering project has been successful.



Online Resources

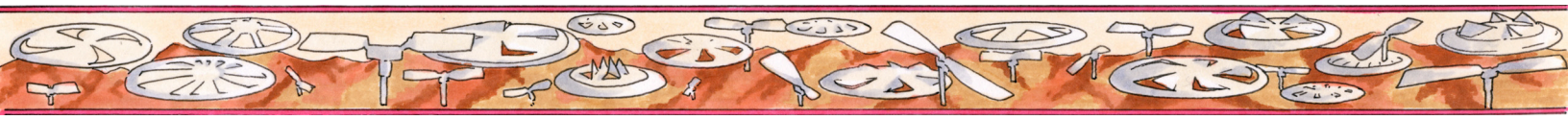
For more information about this unit, and other Engineering Adventures, visit: www.engineeringadventures.org.

NASA Image of the Day Gallery (includes aerial photos and images from space): http://tinyurl.com/2s3wso.

NASA Image of the Day, February 1, 2003 (natural color image of the Empty Quarter): http://tinyurl.com/mx4yota.

National Geographic Empty Quarter (text and videos about exploring the Empty Quarter): http://tinyurl.com/ldw2fkj.

National Geographic Empty Quarter (video from photographer George Steinmetz about his experience): http://tinyurl.com/4gk9a4.



Vocabulary

Aeronautical engineer: An engineer who designs technologies that move through the air. Aeronautical engineers design technologies that fly within Earth's atmosphere, not in outer space.

Constraints: Ways that your design is limited.

Criteria: Things your design needs to do.

Engineer: Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems.

Engineering Design Process: The steps that engineers use to design technologies to solve problems.

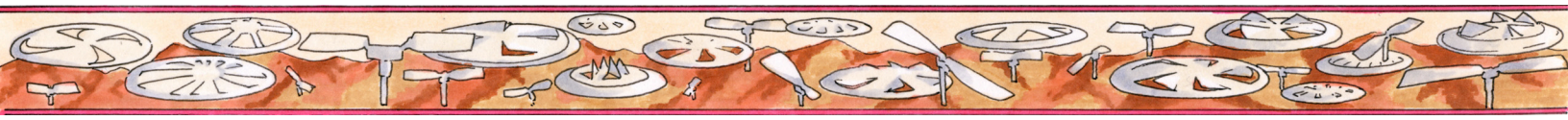
Lift: A force that opposes the downward gravity of an object moving through the air.

Technology: Anything designed by humans to help solve a problem.

Updraft: A current of air that moves upward.

Wind: The natural movement of air.

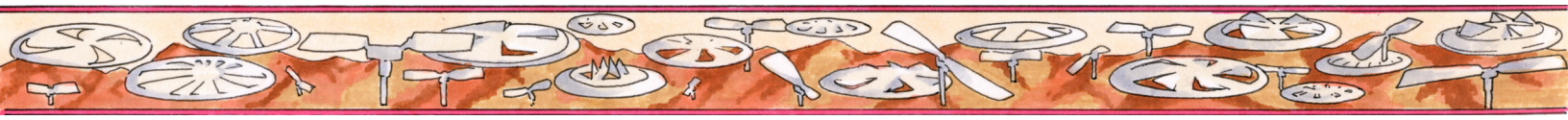
Wind tunnel: A controlled chamber that engineers use to test how air moves around objects, such as new flying technologies.



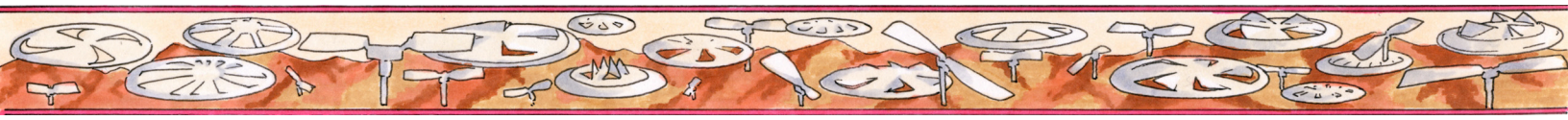
Materials List

This kit is prepared for 8 groups of 3 kids.

Quantity	Part Description
	Non-Consumable Items
1	Duo Audio CD or access to a computer
1	*Engineering Design Process* poster
1	stopwatch, optional
1	stuffed animal, small
2	circular table fans, 9”, must be able to tilt to blow air vertically
8	rulers
8 pairs	scissors
16	plastic toy people (small, 1-2”)
45	washers, 3/4” diameter
	Consumable Items
1 roll	string
1 roll	tape, packaging
2 sheets	acetate, 40" x 40”
8 rolls	tape, masking
15 sheets	cardboard, 12" x 12”
16	balloon sticks, hard plastic
20 sheets	tissue paper
30 sheets	mylar
30	rubber bands
50	cups, paper, 3 oz.
50	cups, paper, 8 oz.
50	plates, paper, regular
60	plates, paper, small
85 sheets	copy paper
95 sheets	card stock
100	paper clips, standard
800	index cards, 3” x 5”



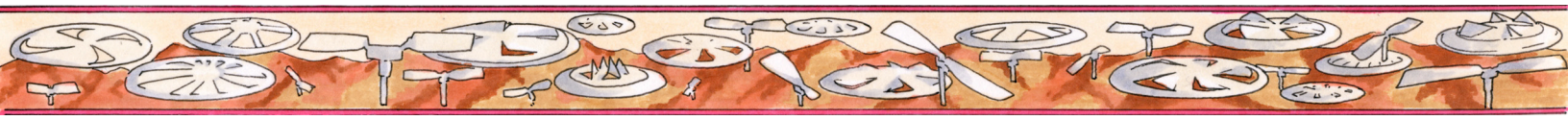
	NOT INCLUDED IN KIT
1	CD player or MP3 player
1 sheet	chart paper
1	clock/timepiece for scheduling
1	cloth or bag large enough to cover technologies, see p. 9
1	rock or leaf
8	technologies, see p. 9 in this guide
30	markers/crayons



National Education Standards

Engineering Adventures units are written with the goal of teaching engineering skills and critical thinking practices, and many also touch upon a variety of science topics and principles. The engineering standards taught in this unit and the science topic links in this unit are noted below.

		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: An Aeronautical Challenge	Adventure 2: Drop Copters	Adventure 3: Up and Away	Adventure 4: Create a Flying Technology	Adventure 5: Improve a Flying Technology	Adventure 6: Engineering Showcase: The Sky's the Limit
National Science Education Standards	Science as Inquiry	✓		✓	✓	✓	✓	✓	
	Physical Science			✓	✓	✓	✓	✓	
	Life Science								
	Earth and Space Science			✓					
	Science and Technology	✓	✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives								
	History and Nature of Science								
ITEEA	The Nature of Technology		✓		✓	✓	✓	✓	
	Technology and Society								
	Design	✓		✓	✓	✓	✓	✓	
	Abilities for a Technological World	✓		✓	✓	✓	✓	✓	
	The Designed World								



		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: An Aeronautical Challenge	Adventure 2: Drop Copters	Adventure 3: Up and Away	Adventure 4: Create a Flying Technology	Adventure 5: Improve a Flying Technology	Adventure 6: Engineering Showcase: The Sky's the Limit
Next Generation Science Standards	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.				✓				
	3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.						✓	✓	
	4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.								✓
	5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.			✓	✓	✓	✓	✓	
	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	✓		✓	✓	✓	✓	✓	
	3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem	✓		✓	✓	✓	✓	✓	
	3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	✓		✓	✓	✓	✓	✓	

How to Recognize Success Rubric

How do you know if you are leading an Engineering Adventures activity successfully? This tool will help you keep track of your kids' successful moments and will ask you to identify how your own actions enabled your kids to succeed.

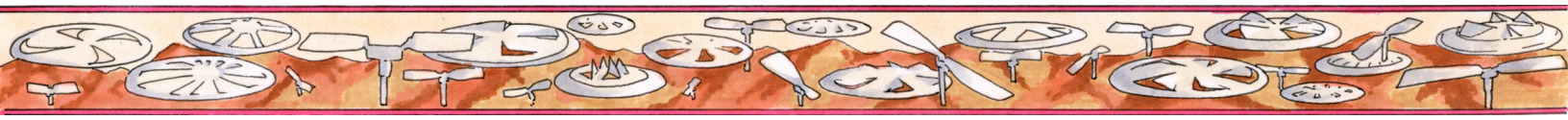
Elements of success	What does this look like?	How does the guide help me facilitate this?
Kids are engaged and challenged by the activity. They persist through difficulties.	• Kids are on-task. • Kids are trying out their ideas. • Kids identify what is working well in their designs. • Kids troubleshoot their own work. • Kids *improve* their designs.	• Use the Message from the Duo to **set a real-world context** that will engage kids in the activity. • Use the bold prompts to **ask open-ended questions** to help kids troubleshoot their work. • Use the bold prompts to **ask kids about what they think is working well** in their designs and what they would like to *improve*. This will help kids feel more confident about their problem-solving abilities.
Kids do most of the talking, sharing their ideas with each other during the entire activity.	• Kids bring their own ideas to the activity and are comfortable sharing them. • Kids brainstorm and debate within their groups. • Kids share their designs with others. • Kids talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage kids to share and explain their thinking**. • Have kids **work in groups** so they can brainstorm and create a design together. • Use the bold prompts in the Reflect section to **help kids share their new ideas about designs.**
Kids value their engineering work as a process, not just as the end result.	• Kids go beyond talking about their design to talking about how they thought of it and why they designed it. • Kids use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask kids how they use the Engineering Design Process.** Spending time talking and thinking about their process will help kids see the value in it. • Use the bold prompts to **ask kids about *improving*** their designs, even if their designs are working well. • **Encourage kids to reflect individually** in their Engineering Journals to give them time for their experiences to sink in and be remembered.

How to Recognize Success Rubric Template

How do you know if you are leading an Engineering Adventures activity successfully? This tool will help you keep track of your kids' successful moments and will ask you to identify how your own actions enabled your kids to succeed.

Date: Adventure:

Elements of success	Evidence: Did I see this during the activity?	What was my role in making this happen?
Kids are engaged and challenged by the activity. They persist through difficulties.		
Kids do most of the talking, sharing their ideas with each other during the entire activity.		
Kids value their engineering work as a process, not just as the end result.		



Dear Family, Date: _____

We are beginning an engineering unit called *The Sky's the Limit: Engineering Flying Technologies*, which is part of the Engineering Adventures curriculum developed by the Museum of Science, Boston. Engineering Adventures is a curricular program that introduces children to engineering and the Engineering Design Process. Throughout this unit, children will learn about aeronautical engineering and work to engineer technologies that fly through the air in different ways. The unit is set in a real-world context: children will learn about the huge Middle Eastern desert called the Empty Quarter and will be asked to help engineer flying machines to take aerial photos of the region.

There are many reasons to introduce children to engineering:

- **Engineering projects reinforce topics that children are learning in school.** Engaging students in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills**, including problem formulation, creativity, planning, and testing alternative solutions.
- **Children are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when children are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

Because engineering projects are hands-on, materials are often required. Several materials necessary for this unit are listed below. If you have any of these materials available, please consider donating them to us.

If you have expertise about aeronautical engineering or the countries comprising the Empty Quarter, or have any general questions or comments about the engineering and design unit we are about to begin, please let me know.

Sincerely,

If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: _____ . Thank you!

_____ _____

_____ _____

_____ _____

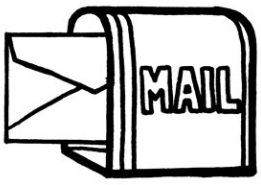
What is Engineering? Tower Power

Overview: Kids will engineer an index card tower that will support a stuffed animal.

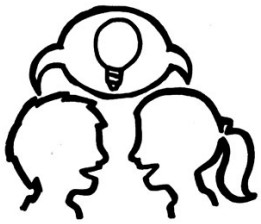
Note to Educator: Who are engineers? Engineers are people who use their creativity and knowledge of math and science to design things that solve problems. Today, kids will be engineers as they use the Engineering Design Process to design towers.

Find alternate versions of this activity at www.engineeringadventures.org/resources.

Duo Update (5 min)

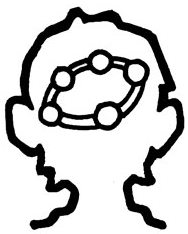


Set the Stage (10 min)



Activity (30 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 1 or Engineering Journal, p. 1
- ☐ *Engineering Design Process* poster
- ☐ *Backyard Photos*, this guide, p. 7
- ☐ 1 small stuffed animal

For each group of 3-5 kids:

- ☐ 1 pack of index cards (about 100 cards)
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ at least 1 foot of tape

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 10 minutes

1. Have the *Message from the Duo* ready to share.
2. Make samples of the cards found on *Building with Cards,* p. 2 in the Engineering Journal.
3. Either copy an Engineering Journal for each kid or consider using a group journaling system where each group of 2-3 kids shares a journal.
4. Optional: use Google Maps to find an aerial view of your program site for kids to see.

Journal Pages for Prep Adventure 1

Message from the Duo, p. 1

Prep Adventure 1 **Message from the Duo**

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Engineering a Tower
10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, or more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

We have an engineering challenge we think you can help us solve. Jacob has taken up photography. He saw some interesting pictures of landscapes that were taken from above. They're called aerial photos, meaning they were taken from high up in the air. Jacob wants to take some aerial photos of our yard, but he needs a tower he can climb up. Do you think you can *create* a model tower that's at least 10 inches high? The models will serve as inspiration for the tower Jacob builds. The taller it is, the more land Jacob will be able to photograph.

We sent you one tool that we find helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look and see if it can help you!

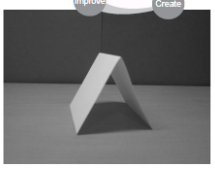
Good luck!
India and Jacob

Building with Cards, p. 2

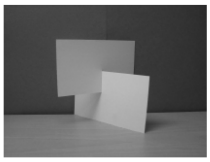
Prep Adventure 1 **Building With Cards**

Here are three ways to build with index cards.

Roll it!



Fold it!



Cut it!

Will any of these ideas help your group build a tower? What other ideas do you have?

Talk with your group to figure it out!

Backyard Photos, p. 3

Prep Adventure 1 **Backyard Photos**

10 inches and up

7-10 inches

5-7 inches

3-5 inches

0-3 inches

Recording Page, p. 4

Prep Adventure 1 **Recording Page**

Draw Your Tower
Use the space below to draw a picture of your tower.

What parts of your tower design would you change if you could do it again?

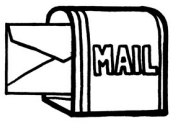
For the Record

I think engineering is:

- ☐ Fun
- ☐ Exciting
- ☐ Difficult
- ☐ _____

What is Engineering? Tower Power

Kids will learn:
- The Engineering Design Process is a tool they can use to help solve problems.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob are a brother and sister who travel the world. They find problems and solve them using engineering.
2. Explain that India and Jacob have sent a message about a problem they would like the kids to solve. Have kids turn to *Message from the Duo*, p. 1 in their Engineering Journals, for more details. Play track 1.

Set the Stage (5 min)

1. Tell kids that today they are going be engineers and use the Engineering Design Process to solve India and Jacob's problem.
2. To check for understanding, ask:
   - **What do India and Jacob need us to engineer?** *A model tower at least 10 inches tall that Jacob can use to take aerial photos.*
3. Show groups the *Engineering Design Process* poster and tell them that they are going to *ask* questions about the problem, *imagine* ways to solve it, *plan* a design, *create* and test it, and then think about ways to *improve* it.
4. Hold up *Backyard Photos,* p. 7 in this guide. Explain that their towers will be measured, and they will see how much of the backyard Jacob can photograph based on its height.

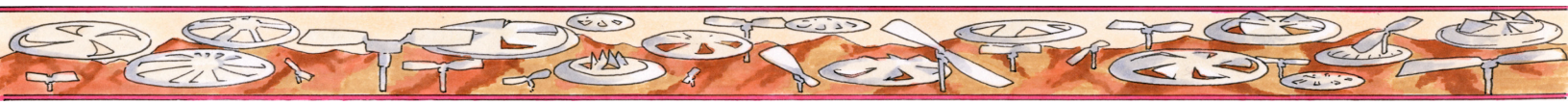
Imagine (5 min)

1. Tell kids that it is time to look at the materials they can use and *imagine* different ways to make them work.
2. Split kids into groups of 3-5 and give each group a few index cards, scissors, and tape. Ask:
   - **Can you *imagine* any ways you could use these materials to engineer a tower?**
3. If your kids want to see examples, show them the index card samples you prepared or have them look at *Building with Cards*, p. 2 in their Engineering Journals. Ask:
   - **Do you think any of these ideas might work well? Why?**

Plan and Create (at least 20 min)

1. Tell kids it is time to *plan* and *create* their towers.
2. Show them the stuffed animal and explain that it will represent Jacob. Explain:

Tip: If you can, you may want to offer more time for this challenge.



- The challenge is to work in groups to engineer a tower that can hold the animal 10 inches in the air for at least 10 seconds.
- Each group will have (at least) 20 minutes.
- Groups can only use index cards and tape in the tower. The scissors and rulers are tools and cannot be used in the tower.
- Groups can hold the stuffed animal briefly, but they cannot test it on their tower until the 20 minutes are up.

Tip: You may choose to offer unlimited tape, or to challenge groups by limiting the tape to 1 or 2 ft.

3. Give each group a pack of index cards and let them begin.
4. As groups work, circulate around the room. Ask questions like:
   - **Why do you think your design will work well?**
   - **Which step of the Engineering Design Process are you using right now? How do you know?**

Tower Showcase (10 min)

1. As each group presents their tower, ask questions like:
   - **Can you tell me about your design?**
   - **Which steps of the Engineering Design Process did your group use?**
2. Use a ruler to measure the tower. Compare the measurement to the pictures on *Backyard Photos*. Give one kid the stuffed animal and have him or her place it on top of the tower. Count to 10 and observe what happens. Ask:
   - **What parts would you *improve* if you could design your tower again? Why?**

Reflect (5 min)

1. Go through the *Engineering Design Process* poster with kids and have them talk about how they used each step to solve the problem. Ask questions like:
   - **How did you use this step of the Engineering Design Process to solve the problem?** *We* asked *about the challenge; we* imagined *ways to build with cards; we* planned *when we decided what design to use; and we* created *and* improved *when we built and fixed the tower.*
   - **Why do you think it is important to use these steps?** *It helps us keep track of our ideas and make sure we are meeting our goal.*
   - **Do you think you are an engineer?**
2. Tell kids that they have just used the same steps that engineers use to solve problems. This means that they are engineers, too! Tell kids they will have the opportunity to engineer solutions to even bigger problems with India and Jacob later on.
3. Give kids time to record their thoughts on *Recording Page*, p. 4 in their Engineering Journals. Allowing kids to draw and write about their work in this adventure will help them remember what they learned.

What is Engineering? Tower Power

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Engineering a Tower

10:36 AM

Hi everyone,

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Engineers are problem solvers. They're people who design things that make our lives better, easier, or more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

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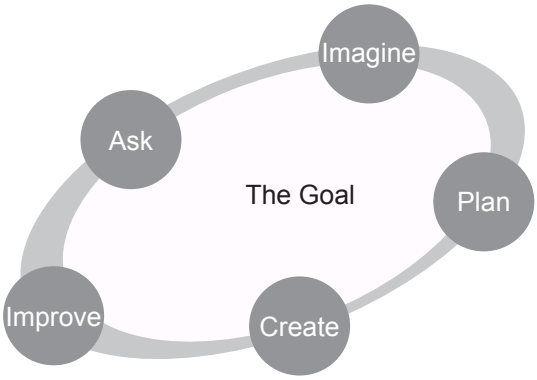
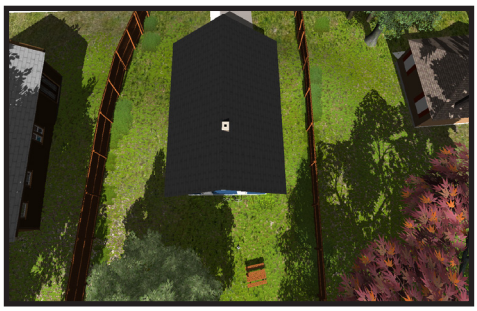


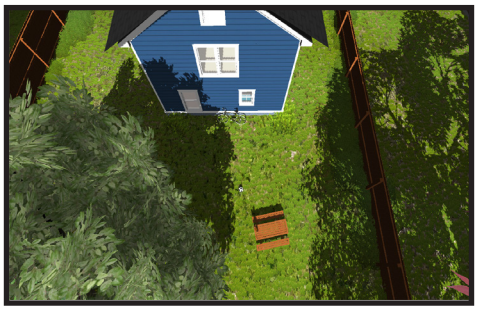
Good luck!
India and Jacob

10 inches and up

7-10 inches



5-7 inches



3-5 inches

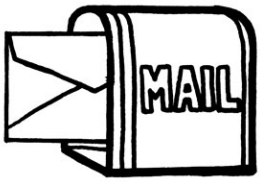
0-3 inches

What is Technology? Technology Detectives

Overview: Kids will examine some technologies and *imagine* ways to *improve* them.

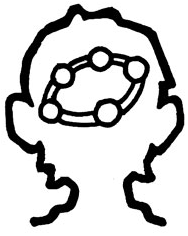
Note to Educator: Many people only think of technologies as things that are electronic or "high-tech." Technology is actually anything designed by humans to help solve a problem.
Find alternate versions of this activity at: www.engineeringadventures.org/resources.

Duo Update (5 min)



Activity (15 min)

Reflect (20 min)



Materials

For the whole group:

- ☐ *Message from the Duo*, track 2 or Engineering Journal, p. 5
- ☐ *Engineering Design Process* poster
- ☐ a large sheet of paper or other writing space
- ☐ a small rock or leaf
- ☐ a cloth or bag large enough to cover all technologies

Technologies (choose 8):

- ☐ bag
- ☐ book
- ☐ button
- ☐ construction paper
- ☐ dice
- ☐ electronic device (e.g. phone or calculator)
- ☐ glue stick
- ☐ hair clip
- ☐ hat
- ☐ juice box
- ☐ key
- ☐ roll of tape
- ☐ ruler
- ☐ scissors
- ☐ spoon
- ☐ stapler
- ☐ stuffed animal
- ☐ sweater
- ☐ water bottle

For each kid:

- ☐ Engineering Journal

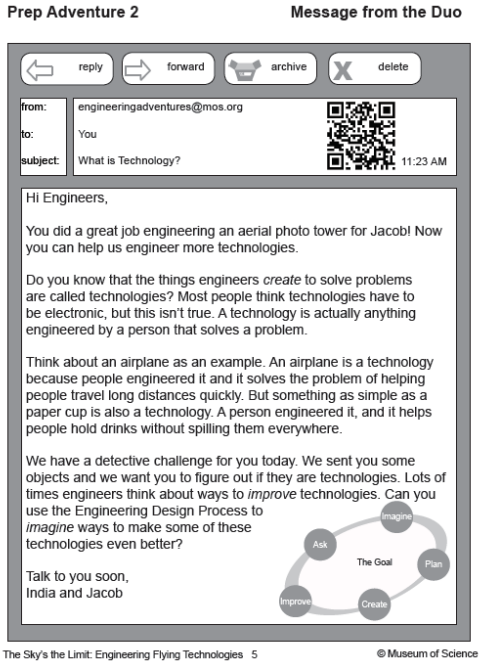
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Place the eight technologies (see above) on a table or floor and cover with a cloth or bag.
4. On a sheet of large paper, make the *Technology Detective Tool* chart as shown on the next page.

Journal Pages for Prep Adventure 2

Message from the Duo, p. 5



Prep Adventure 2 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: What is Technology? 11:23 AM

Hi Engineers,

You did a great job engineering an aerial photo tower for Jacob! Now you can help us engineer more technologies.

Do you know that the things engineers *create* to solve problems are called technologies? Most people think technologies have to be electronic, but this isn't true. A technology is actually anything engineered by a person that solves a problem.

Think about an airplane as an example. An airplane is a technology because people engineered it and it solves the problem of helping people travel long distances quickly. But something as simple as a paper cup is also a technology. A person engineered it, and it helps people hold drinks without spilling them everywhere.

We have a detective challenge for you today. We sent you some objects and we want you to figure out if they are technologies. Lots of times engineers think about ways to *improve* technologies. Can you use the Engineering Design Process to *imagine* ways to make some of these technologies even better?

Talk to you soon,
India and Jacob

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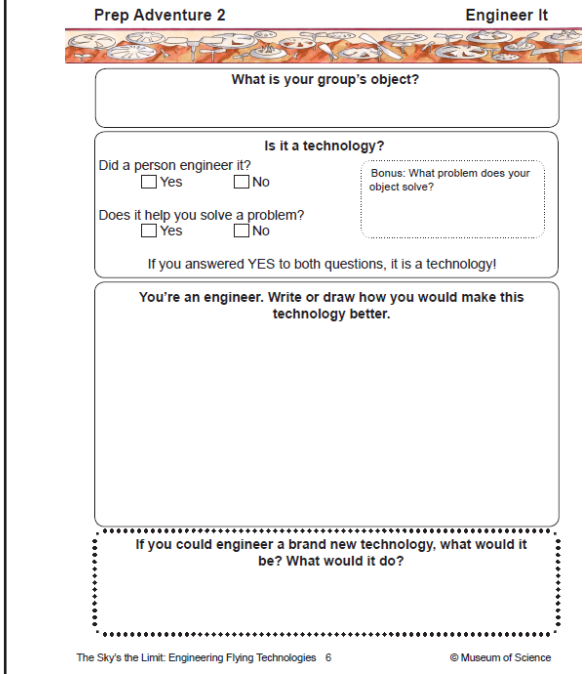
Engineer It, p. 6



Prep Adventure 2 — Engineer It

What is your group's object?

Is it a technology?

Did a person engineer it?
☐ Yes ☐ No

Bonus: What problem does your object solve?

Does it help you solve a problem?
☐ Yes ☐ No

If you answered YES to both questions, it is a technology!

You're an engineer. Write or draw how you would make this technology better.

If you could engineer a brand new technology, what would it be? What would it do?

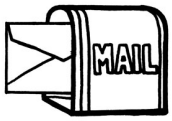
The Sky's the Limit: Engineering Flying Technologies 6 © Museum of Science

Chart for Prep Adventure 2

Technology Detective Tool
Did a person engineer it?
Does it help you solve a problem?
If you answered YES to both, it is a technology!

What is Technology? Technology Detectives

Kids will learn:
- Technology is anything designed by people to help solve a problem.
- Engineers design and *improve* technologies.



Present the Message from the Duo (5 min)

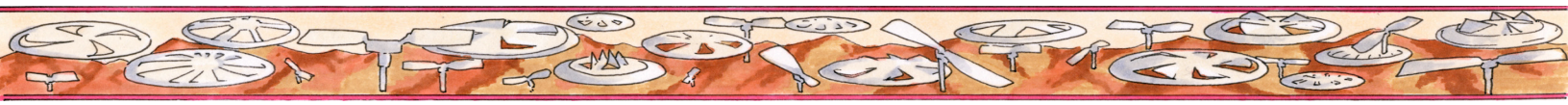
1. Tell kids that India and Jacob sent them a message with more information about what engineers do. Have kids turn to *Message from the Duo,* p. 5 in their Engineering Journals, to follow along. Play track 2.
2. To check for understanding, ask:
   - **India and Jacob said that a technology is anything designed by people to solve a problem. What are some technologies you can think of?** *Accept all answers at this point.*
3. Give the kids about one minute to name all the technologies they can think of. If kids are only naming electronics, remind kids that India and Jacob mentioned that things like paper cups are also technology.

Tip: You may want to write down what the kids say is technology, so you can refer back to it at the end of the adventure.

Undercover Detectives (15 min)

1. Explain to kids that now they will get the chance to think about more technologies—some that might surprise them.
2. Tell kids that under the cover on the table are some objects that may or may not be technologies. They will use detective skills and teamwork to figure out which objects are technologies and what problems they solve.
3. Split kids into groups of 3-5.
4. Show them the *Technology Detective Tool* chart and explain that they can use it to help figure out if the objects are technologies.
5. Pull the cloth and give groups a minute to decide which object they will take.
6. Have each group choose one object they would like to focus on in their groups.
7. Tell kids that they will now think like an engineer. They will use the *Technology Detective Tool* to decide whether their object is a technology. Then, they will *imagine* ways to *improve* the object they chose.
8. Have kids open to *Engineer It,* p. 6 in their Engineering Journals. Give groups about 10 minutes to complete the first three boxes.

Tip: If kids are having trouble understanding what it means to engineer something, let them know that words like invent, design, and improve have a similar meaning. The more you use the term engineer, the more comfortable they will become with it!



If groups are struggling, ask:

- **How can you make your technology more fun?**
- **How can you make your technology easier to use?**

Reflect (20 min)

1. Tell kids that they are going to present their technology ideas to their fellow detectives. Encourage them to use the *Technology Detective Tool* chart and the *Engineer It* page in their Engineering Journals to help them present. Ask each group:
   - **What is your technology?**
   - **How do you know that it is a technology?** *Refer to the* Technology Detective Tool *chart.*
2. After all groups have presented, check for understanding about technology. Ask:
   - **Were all of the objects you saw technologies? Why or why not?** *Yes, because people engineered them and they help solve a problem.*
3. Tell kids you have one more object for them to think about. Show them the rock/leaf. Ask:
   - **Is this a technology? Why or why not?** *No, because a person did not engineer it.*
4. Tell kids that they were engineers today by thinking about technologies that already exist and how to *improve* them. Engineers also *imagine* brand new technologies that no one has thought of before!
5. Have kids think about the engineering they have already done. Ask:
   - **Why do you think the towers you made before were technologies?** *Because we designed them to solve a problem.*
6. Tell kids that in this unit they will be working in groups to engineer technologies that fly. Ask:
   - **What flying technologies can you think of?** *Airplane, hot air balloon, glider, paper airplane, etc.*
7. Let kids know that they will explore how things move in the air in the next adventure.
8. Give kids a few moments to complete the last box on *Engineer It,* p. 6 in their Engineering Journals. Thinking about things they might engineer in the future will help kids see themselves as engineers.

Tip: A rock, leaf, or any other natural objects on their own are not technologies. If people turn those objects into tools, however, they could become technologies! For example, using a rock to grind corn or making it into an arrow head makes the rock a technology.

Tip: If you have enough time, encourage kids to share their ideas about technologies they would like to engineer with a partner.

What is Technology? Technology Detectives

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	What is Technology?

11:23 AM

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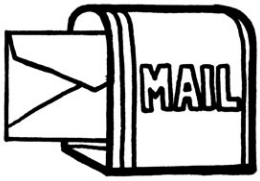
Talk to you soon,
India and Jacob

Overview: Kids will be introduced to their challenge and will begin to learn about how things fly by observing what happens when different materials are dropped into a vertical wind tunnel.

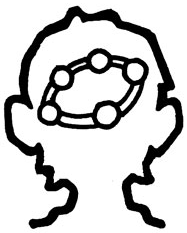
Note to Educator: People often think that NASA works primarily with technologies that fly outside of our atmosphere, like space shuttles. NASA is also a leader in aeronautical engineering, which involves any technologies that fly through our atmosphere.
Save the wind tunnels built today for use in Adventures 3–6.

Duo Update (5 min)



Ask (30 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 3 or Engineering Journal, p. 7
- ☐ *Engineering Design Process* poster
- ☐ chart paper and markers
- ☐ 1 roll of packing tape, clear
- ☐ 2 acetate sheets, 40” x 40”
- ☐ 2 fans that can be tilted to blow vertically, 9” diameter
- ☐ 5 sheets of cardboard
- ☐ 10 paper cups, 3 oz.
- ☐ 10 rubber bands
- ☐ 10 sheets of copy paper
- ☐ 10 sheets of mylar
- ☐ 10 sheets of tissue paper
- ☐ 10 small paper plates
- ☐ 25 paper clips
- ☐ optional: world map

For each group of 3-5 kids:

- ☐ 1 roll of tape
- ☐ 1 pair of scissors

For each kid:

- ☐ Engineering Journal

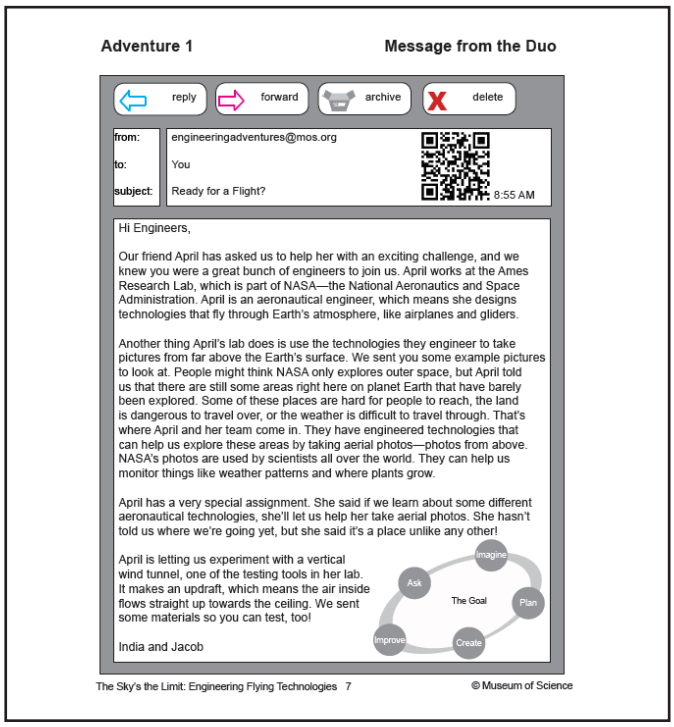
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set up a Materials Table with all materials listed above.
4. Kids will work in groups to build the two vertical wind tunnels they need for testing. Directions can be found on p. 10 in their Engineering Journals. **If you feel it will be difficult for kids to create the tunnels on their own, consider preparing them yourself.** This will add about 10-15 minutes of prep time.
5. You may want to implement safety rules about how kids interact with the wind tunnel. For example, consider telling kids that they can only look from the side, not into the opening at the top.

Journal Pages for Adventure 1

Message from the Duo, p. 7



Adventure 1 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Ready for a Flight? 8:55 AM

Hi Engineers,

Our friend April has asked us to help her with an exciting challenge, and we knew you were a great bunch of engineers to join us. April works at the Ames Research Lab, which is part of NASA—the National Aeronautics and Space Administration. April is an aeronautical engineer, which means she designs technologies that fly through Earth's atmosphere, like airplanes and gliders.

Another thing April's lab does is use the technologies they engineer to take pictures from far above the Earth's surface. We sent you some example pictures to look at. People might think NASA only explores outer space, but April told us that there are still some areas right here on planet Earth that have barely been explored. Some of these places are hard for people to reach, the land is dangerous to travel over, or the weather is difficult to travel through. That's where April and her team come in. They have engineered technologies that can help us explore these areas by taking aerial photos—photos from above. NASA's photos are used by scientists all over the world. They can help us monitor things like weather patterns and where plants grow.

April has a very special assignment. She said if we learn about some different aeronautical technologies, she'll let us help her take aerial photos. She hasn't told us where we're going yet, but she said it's a place unlike any other!

April is letting us experiment with a vertical wind tunnel, one of the testing tools in her lab. It makes an updraft, which means the air inside flows straight up towards the ceiling. We sent some materials so you can test, too!

India and Jacob

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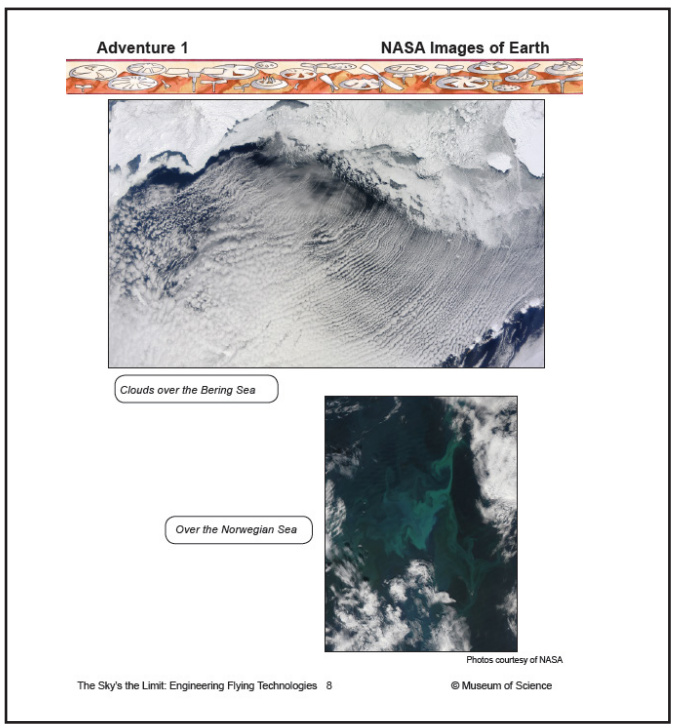
NASA Images of Earth, p. 8



Adventure 1 — NASA Images of Earth

Clouds over the Bering Sea

Over the Norwegian Sea

Photos courtesy of NASA

The Sky's the Limit: Engineering Flying Technologies 8 © Museum of Science

NASA Images of Earth p. 9

Adventure 1 — NASA Images of Earth

A Storm Over Australia

Above the Middle East

Where in the World?
Can you find each of these locations on a world map? Do the photographs look like what you would expect?

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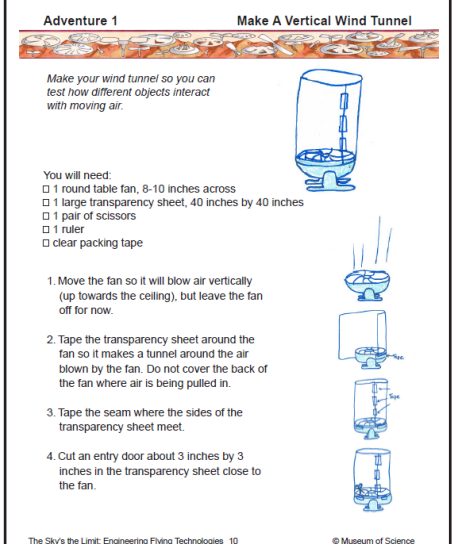
Make a Vertical Wind Tunnel, p. 10



Adventure 1 — Make A Vertical Wind Tunnel

Make your wind tunnel so you can test how different objects interact with moving air.

You will need:
- ☐ 1 round table fan, 8-10 inches across
- ☐ 1 large transparency sheet, 40 inches by 40 inches
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ clear packing tape

1. Move the fan so it will blow air vertically (up towards the ceiling), but leave the fan off for now.
2. Tape the transparency sheet around the fan so it makes a tunnel around the air blown by the fan. Do not cover the back of the fan where air is being pulled in.
3. Tape the seam where the sides of the transparency sheet meet.
4. Cut an entry door about 3 inches by 3 inches in the transparency sheet close to the fan.

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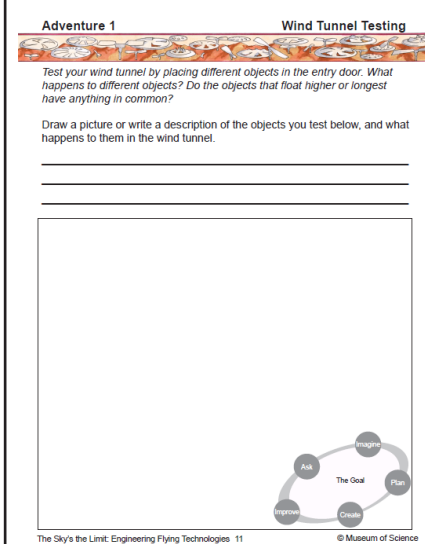
Wind Tunnel Testing, p. 11



Adventure 1 — Wind Tunnel Testing

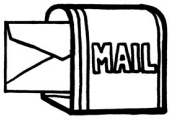
Test your wind tunnel by placing different objects in the entry door. What happens to different objects? Do the objects that float higher or longest have anything in common?

Draw a picture or write a description of the objects you test below, and what happens to them in the wind tunnel.

The Sky's the Limit: Engineering Flying Technologies 11 © Museum of Science

An Aeronautical Challenge

Kids will learn:
- Aeronautical engineers design technologies that fly within Earth's atmosphere.
- Many properties of an object (including shape, size, weight, etc.) impact how it moves in a vertical wind tunnel.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob sent a message about an engineering challenge they need help with. Have kids turn to *Message from the Duo,* p. 7 in their Engineering Journals, to follow along. Play track 3.
2. To check for understanding, ask:
   - **What did India and Jacob say aeronautical engineers do?** *They design technologies that fly through the air. Some of these technologies help take pictures from far above the Earth.*
   - **Have you ever flown anything through the air? How do you think it worked?** *For now accept all answers about how the objects flew through the air. Kids may mention kites, paper airplanes, toys, etc.*
   - **What do India and Jacob want us to experiment with today?** *How different objects behave in a vertical wind tunnel.*
3. Review the term updraft. Explain that wind is the movement of air. If air is moving up, it is called an updraft. Let kids know that they will make wind tunnels to test how objects move through the air in an updraft.
4. Point out *NASA Images of Earth,* pp. 8–9 in kids' Engineering Journals. Explain that these show some pictures gathered from NASA's aeronautical missions. Let kids know that these are the types of pictures they will be helping April gather as they work through this unit.

See It: More pictures can be found here: www.nasa.gov/multimedia/imagegallery/.

Tip: You may want to have kids use a map to locate the area of the world where the images in their journal were taken.

Build a Wind Tunnel for Testing (15 min)

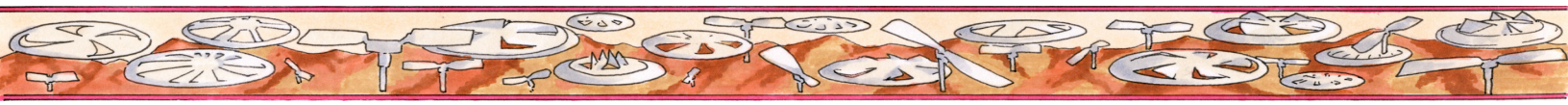
1. Explain that kids will now make the vertical wind tunnels to experiment with.
2. Have kids turn to *Make a Vertical Wind Tunnel*, p. 10 in their Engineering Journals. Explain that you are going to have kids work in small groups to create two wind tunnels.
3. Let kids know that engineers at NASA use wind tunnels to help them test in similar ways!
4. Break kids into two groups. Have them collect the materials they will need at the Materials Table and make their two wind tunnels.

Ask: Wind Tunnel Testing (15 min)

1. Explain that India and Jacob have sent along some materials to test.
2. Show kids a small paper cup. Ask:
   - **What do you think would happen if we put a cup in the wind tunnel?**
3. Place the wind tunnel on the floor, so it is easy to reach into.
4. Have a volunteer place the cup in the wind tunnel by using the 'doors' cut in the lower part of the acetate sheet. For comparison, have another volunteer drop the same type of paper cup outside the wind tunnel (to the ground). Ask:
   - **How would you describe what you are seeing?** *Words that might be useful include hovering, floating, flying, bouncing, etc.*
   - **What features, or properties, of the cup do you think make it react like that?** *It is lightweight, the shape catches air, etc.*
5. Explain to kids that they will have about 10 minutes to experiment with the wind tunnel by inserting any of the objects on the Materials Table into it. They can cut, fold, or change the objects. They may also use paper clips as weights, but should only put them inside the wind tunnel if they are attached to something. If kids design large objects, they should insert them through the top of the wind tunnel when the fan is not on, rather than the door below.
6. Kids can record their findings on *Wind Tunnel Testing*, p. 11 in their Engineering Journals.
7. As kids are experimenting, ask questions like:
   - **How would you describe what your object is doing in the wind tunnel?** *Words that might be useful include hovering, floating, etc.*
   - **Why do you think it behaves that way?** *Because of its shape, size, etc.*
8. After kids have a chance to explore, challenge them to make something that floats in the upper half of the wind tunnel.

Reflect (10 min)

1. Gather all the kids together. Ask:
   - **Were there any objects that moved in the wind tunnel in surprising ways? Why do you think they moved that way?**
   - **Do you think these materials would move differently through the air if they were not in a wind tunnel? Why?** *Yes, many would fall directly to the ground without a lot of air blowing against them. Some might catch some air and drift down slowly.*
2. Tell kids that in the next adventure, they will explore some ways to engineer objects that fly through the air when there is no wind blowing up (updraft).
3. Have kids look at the *Engineering Design Process* poster. Ask:
   - **What steps of the Engineering Design Process did you use today?** *We* asked *about how objects fly/behave in a wind tunnel.*
4. Give kids time to finish filling out *Wind Tunnel Testing,* p. 11 in their Engineering Journals. Having time to reflect on what they did in the adventure will prepare them for next time.



Optional Extension: World Cup Soccer Ball and Wind Tunnels

Let kids know that the official 2014 World Cup soccer ball was put in a wind tunnel to test the aerodynamics of the ball. Show the video *Testing the World Cup Ball in a NASA Wind Tunnel* (1:59): http://tinyurl.com/oju25wy.

Afterwards, ask:

- **How did Dr. Mehta define aerodynamics?** *It is the study of fluid flow around objects.*
- **What is a wind tunnel?** *It is a chamber that air flows through.*
- **What affects the aerodynamics of a soccer ball?** *The structure and material of the ball.*
- **Have you ever played soccer? Does the ball ever seem to go in an odd direction?**
- **How could you *improve* the aerodynamics of a soccer ball?** *The World Cup soccer ball had panels that increased the seam length.*

Explain that just like NASA aeronautical engineers, they will spend the rest of the unit observing how objects move through the air and engineering their own aerodynamic flying technology.

If you would like to read a more in-depth article, you may want to review *NASA Turns World Cup into Lesson in Aerodynamics:* http://tinyurl.com/nuz5elb.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Ready for a Flight?

8:55 AM

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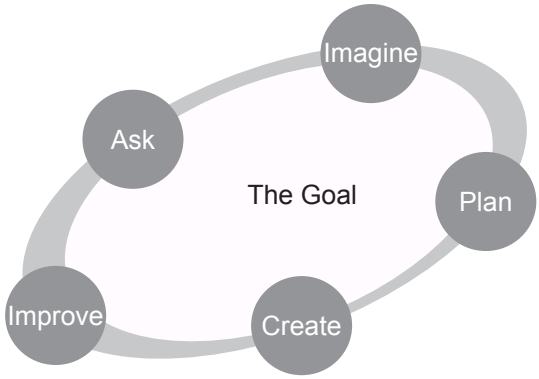
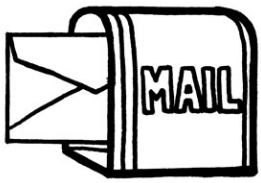


India and Jacob

Overview: Kids will engineer drop copters with the goal of designing one that will fall as slowly as possible.

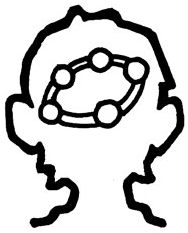
Note to Educator: Drop copters fly through the air by spinning to the ground, similar to the way a helicopter would land. They move relatively slowly because they have blades that create air resistance. This force counteracts the gravity pulling the drop copters toward the ground.

Duo Update (5 min)



Activity (35 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 4 or Engineering Journal, p. 12
- ☐ *Engineering Design Process* poster
- ☐ markers or crayons
- ☐ 100 standard paper clips
- ☐ stopwatch (optional)

For each group of 3-5 kids:

- ☐ *Copter Templates,* this guide, pp. 29–31
- ☐ 1 pair of scissors
- ☐ 1 roll of tape
- ☐ 5 sheets of card stock
- ☐ 5 sheets of paper

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set up a Materials Table with all of the materials listed above.
4. Copy a set of *Copter Templates* for each group. You may want to copy a few templates on card stock so kids do not have to trace the template.
5. Using a piece of paper and tape, follow the instructions on the *Copter Templates* to create one or two drop copters.

Journal Pages for Adventure 2

Message from the Duo, p. 12

Adventure 2 **Message from the Duo**

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Stop, Drop, and Spin! 9:18 AM

Hello Engineers!

India and I had a great time testing materials in the vertical wind tunnel. We learned a lot about how objects react in an updraft of wind.

This got us wondering about what would happen if there isn't a lot of air moving. How could a technology hover or fly over an area without strong wind pushing against it? April explained that all flying technologies rely on the air around us. Some technologies, like drop copters, are designed so that air pushes against them as they fall. Drop copters spin like helicopters when you drop them. As they fall, air pushes against their blades and slows them down. The more slowly they fall and spin, the more photos we would be able to take for April before they hit the ground.

Speaking of the ground, we still don't know what part of the world we'll be helping to take pictures of. April did give us one hint. She said we'll be on the sand, but not at the beach. Do you have any guesses?

The criteria for your drop copter designs is that they should fall as slowly as possible. India and I sent you some templates you may want to try, but we know you'll be able to use the Engineering Design Process to *imagine*, *plan*, and *create* drop copters that fall even more slowly than our examples! Try playing around with different materials, shapes, numbers of blades, and even adding paper clips as weights. We can't wait to hear how it goes!

Jacob

The Sky's the Limit: Engineering Flying Technologies 12 © Museum of Science

My Drop Copter, p. 13

Adventure 2 **My Drop Copter**

Criteria
What your technology needs to do

Try to design a drop copter that falls more slowly than the template drop copters.

Constraints
Ways that you are limited

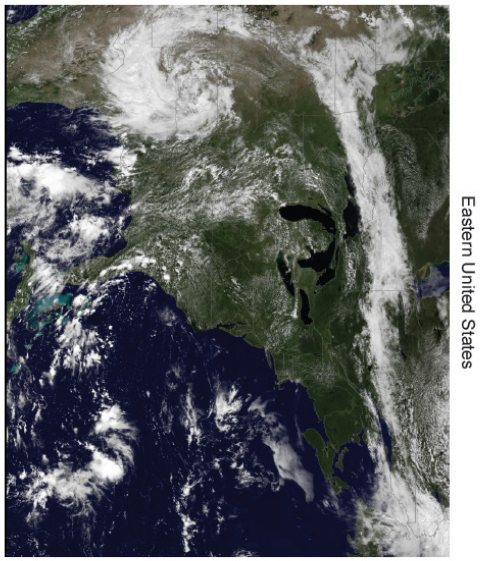
You can only use the materials provided at the Materials Table.

Use this space to sketch out any drop copter ideas you have. Be sure to record if you added any paper clips as weights. Circle which drop copters fell most slowly.

The Sky's the Limit: Engineering Flying Technologies 13 © Museum of Science

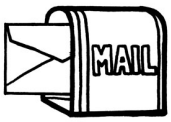
Drop Copter Image, p. 14

Adventure 2 **Drop Copter Image**



The Sky's the Limit: Engineering Flying Technologies 14 © Museum of Science

Kids will learn:
- Changing the shape, size, or other aspects of a drop copter can affect the speed at which it falls.



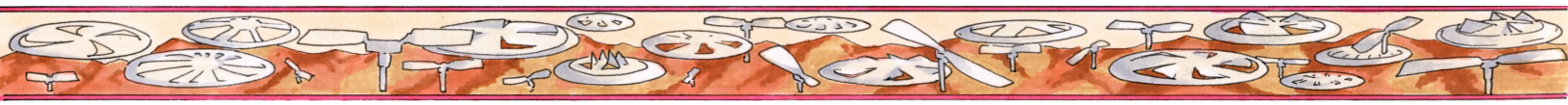
Present the Message from the Duo (5 min)

1. Tell kids that Jacob has sent them a message with more information about a new technology that he would like them to engineer today.
2. Have kids turn to *Message from the Duo*, p. 12 in their Engineering Journals, to follow along. Play track 4.
3. To check for understanding, ask:
   - **What technology does Jacob want us to engineer and test?** *Drop copters.*
   - **How does he say drop copters move?** *They spin and fall slowly through the air because of the air pushing on their blades.*
   - **Why is it useful to have it fall slowly?** *The longer it takes for the technology to fall, the more photos we can take.*
4. Show kids the example drop copter you created. Ask a volunteer to drop the copter in front of the group. Have the volunteer hold the drop copter up in the air as high as he/she can and then drop it. Count or time the seconds it takes for it to fall (see the tip below). After it falls, ask:
   - **What do you observe about how it moves?** *It turns as it falls, the wings fan out, etc.*
   - **What do you think you might change about the drop copter if you wanted it to fall more slowly?**

Create Drop Copters (35 min)

1. Show kids the *Drop Copter Templates* that India and Jacob sent along. Remind them that they can use these templates as a starting point, but their goal is to design drop copters that fall more slowly than the ones made from the templates.
2. Tell groups they can add paper clips to their drop copters to experiment with weight in different areas. If you have a stairwell or similar location, consider allowing kids to drop their copters from a high point.
3. Split kids into groups of 3-5. Let them visit the Materials Table to gather their materials.

Tip: Kids could gauge the 'slowness' of their drop copters either by dropping them in pairs to see which lands first, or by counting (one-Mississippi, two-Mississippi, etc.). Alternately, you could choose to have them time with stopwatches or a clock.



4. As groups work, ask questions like:
   - **Are your designs falling as you thought they would?**
   - **How did adding weights affect your drop copter?**
   - **Which parts of your drop copter are you redesigning?**
   - **Why do you think that will make it fall more slowly?**
5. Let groups know when the time to clean up is approaching. Tell them that each group will get a chance to share their most successful drop copters with everyone else before they leave today.

Tip: It might be confusing that adding weight to the drop copters can sometimes help them fall more slowly. It is not critical for kids to understand why this happens, but if they are interested, you can talk to them about how the weights can sometimes stabilize the drop copters as they fall. When they are not flapping back and forth, they may have better air resistance, which makes them fall more slowly.

Reflect (5 min)

1. Gather kids together and show them the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process did you use today?** *Many groups likely used all of the steps of the Engineering Design Process.*
2. Ask each group to send a representative to the front of the room holding the slowest-falling drop copter they designed today. Have the kids hold up their drop copters so everyone else can see them. Ask:
   - **Do you see any similarities between our slowest drop copters? Differences?** *Encourage kids to think about materials and weight.*
3. Have kids drop their copters.
4. Let kids know that as a reward for their aeronautical engineering work today, April sent them another NASA image to look at. It is similar to the types of photos India and Jacob will take when they arrive at their mystery destination! Have kids turn to *Drop Copter Image*, p. 14 in their Engineering Journals, to see the image.

Tip: You might also have groups share by conducting a gallery walk or conferencing with one other group.

See It: If kids are interested in learning more about the work of aeronautical engineers, check out the video *Scientist Profile: Aeronautical Engineer* (3:36): http://tinyurl.com/kuoop4l.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Stop, Drop, and Spin!

9:18 AM

Hello Engineers!

India and I had a great time testing materials in the vertical wind tunnel. We learned a lot about how objects react in an updraft of wind.

This got us wondering about what would happen if there isn't a lot of air moving. How could a technology hover or fly over an area without strong wind pushing against it? April explained that all flying technologies rely on the air around us. Some technologies, like drop copters, are designed so that air pushes against them as they fall. Drop copters spin like helicopters when you drop them. As they fall, air pushes against their blades and slows them down. The more slowly they fall and spin, the more photos we would be able to take for April before they hit the ground.

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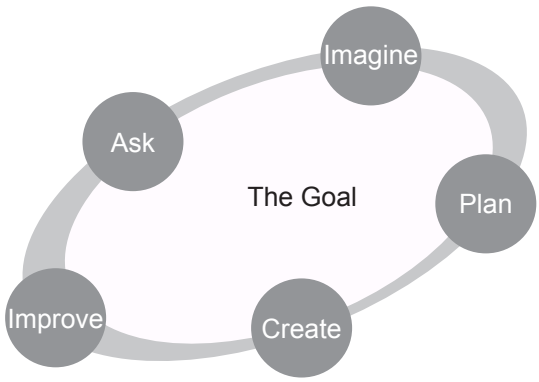
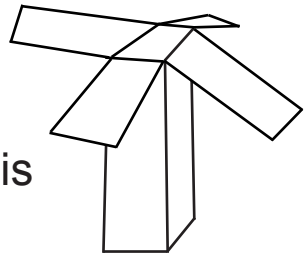


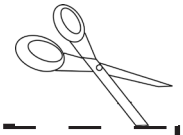
Jacob

Drop Copter Template 1

1. Cut along the dotted lines.
2. Fold along the solid lines.
3. Tape along the two edges that come together.

This drop copter should look like this when it is done.



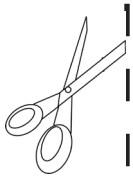


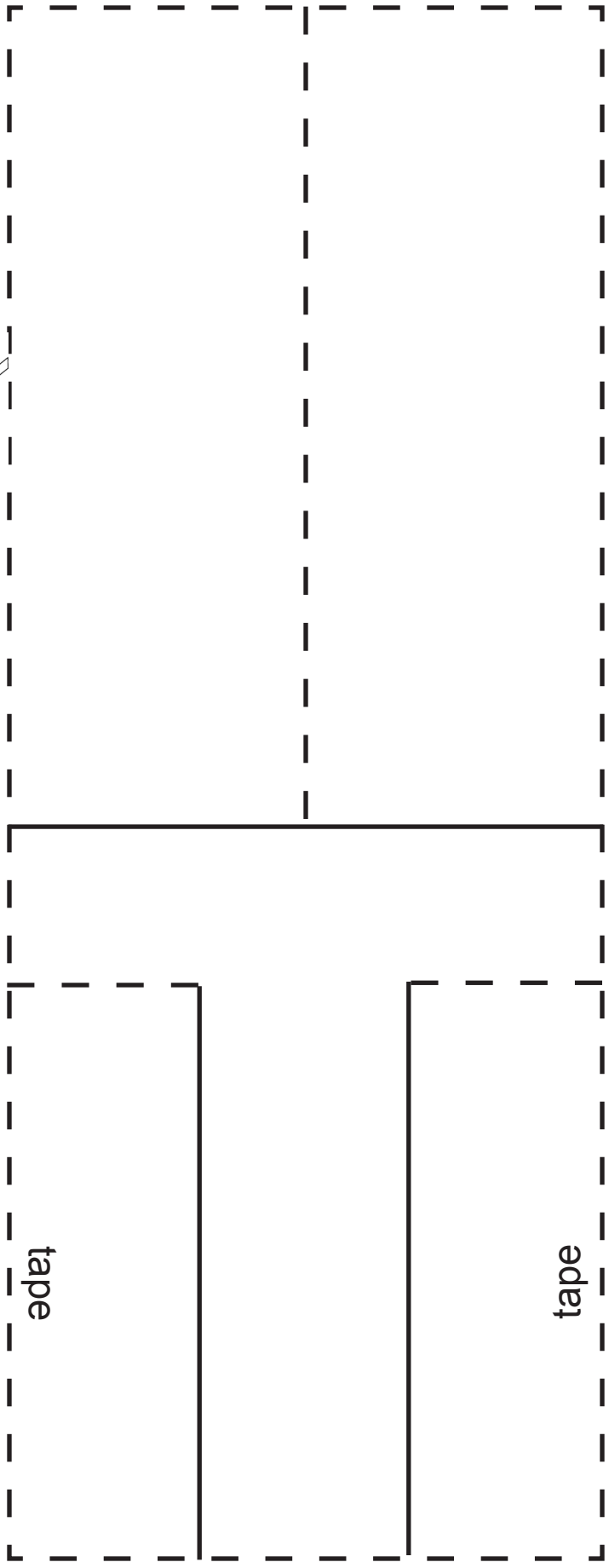
tape

tape

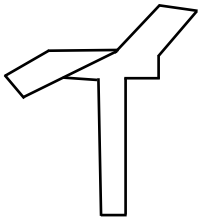
Drop Copter Template 2

1. Cut along the dotted lines.
2. Fold along the solid lines.
3. Tape along the two edges that come together.





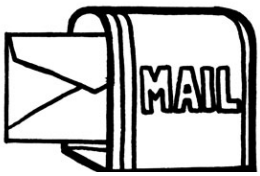
This drop copter should look like the picture below when it is done.



Overview: Kids will design flying discs that spin as they move through the air.

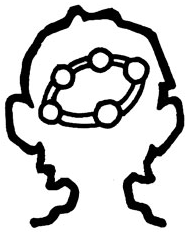
Note to Educator: There are two different ways that kids can approach today's activity. They can either design a disc that they can launch using their hands, or a disc that they can place inside the vertical wind tunnel. Both actions explore the idea of lift, which is a force created by an object moving through the air.

Duo Update (5 min)



Activity (30 min)

Reflect (15 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 5 or Engineering Journal, p. 15
- ☐ *Engineering Design Process* poster
- ☐ 2 pieces of string, 5 feet long
- ☐ 2 wind tunnels from Adventure 1
- ☐ 5 cardboard sheets, 12" x 12"
- ☐ 8 balloon sticks
- ☐ 10 paper cups, 3 oz.
- ☐ 10 paper cups, 8 oz.
- ☐ 10 regular paper plates
- ☐ 10 small paper plates
- ☐ 20 sheets of card stock

For each group of 3-5 kids:

- ☐ *Flying Disc Templates*, this guide, pp. 39–41
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape

For each kid:

- ☐ Engineering Journal

Preparation

Time Required: 15 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Make a Materials Table with all of the materials listed above.
4. Tape the strings to the center of the fans.
5. Create two example spinning discs using paper plates and the templates, pp. 39–41 in this guide. Copy the templates for kids. You may want to copy some on card stock.
6. Tape one of the discs you created to a balloon stick, as shown on the template. Test the disc by holding the balloon stick between your hands and spinning it away from you.
7. Slide the other disc you made onto the string you have attached to the center of the wind tunnel fan. Test this disc by turning on the fan and watching to see if the disc spins.
8. Designate testing areas for the wind tunnels and hand launchers.

Journal Pages for Adventure 3

Message from the Duo, p. 15

Adventure 3 **Message from the Duo**

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Taking Flight

3:45 PM

Hi everyone!

Jacob and I spent a lot more time engineering drop copters to try to get some that fell very slowly. We feel like we're drop copter experts. How about you?

We decided to try designing something else that spins. Jacob was thinking about the propellers on a helicopter. April said lift is the force that holds the helicopter up. As the propellers spin and move through the air, they create lift. Jacob showed us a flying disc toy. When you spin it, lift is created and the toy flies up. We want to engineer our own flying discs! Our goal is to design a flying disc that spins and creates lift as it moves through the air.

April was so impressed with all the aeronautical engineering that we've done that she finally revealed where we'll be traveling to take our aerial photos. It's the biggest sand desert on Earth, and it is called the Empty Quarter. It is in the Middle East and covers parts of Saudi Arabia, Yemen, Oman, and the United Arab Emirates. The desert is 250,000 square miles and the temperatures can reach over 130 degrees Fahrenheit. NASA, scientists, and engineers all over the world are interested in studying the Empty Quarter, since the desert is similar to the environments of some moons and planets. Studying lots of harsh environments will help the scientists and engineers at NASA *plan* for the technologies they'll send into space.

Try engineering some spinning discs of your own. Remember your goal: to design flying discs that spin and create lift as they move through the air.

Good luck!
India

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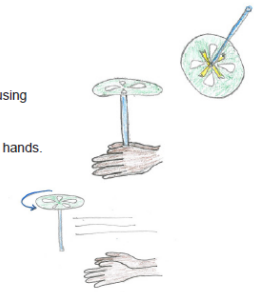
How to Launch Flying Discs, p. 16

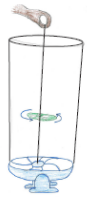
Adventure 3 **How to Launch Flying Discs**

There are two ways you can launch your flying discs.

Launch with your hands

1. Make your flying disc.
2. Attach your disc to a straw using tape.
3. Hold the stick between your hands.
4. Move your hands back and forth to spin the stick and release.





Launch with the wind tunnel

1. Make your flying disc.
2. Slide your flying disc down the string attached to the fan.
3. Hold the top of the string.
4. Turn on the fan.

The Sky's the Limit: Engineering Flying Technologies 16 © Museum of Science

Flying Discs, p. 17

Adventure 3 **Flying Discs**

Criteria
What your technology needs to do

Design a disc that spins through the air.

Constraints
Ways that you are limited

You can only use the materials provided at the Materials Table.

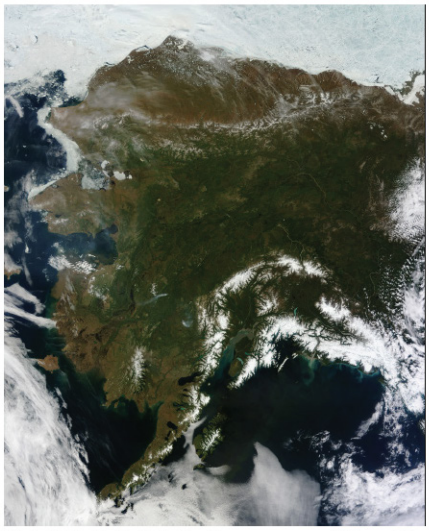
Use this space to imagine *and* plan *your flying disc designs. Circle which ones spun through the air.*

The Sky's the Limit: Engineering Flying Technologies 17 © Museum of Science

Flying Disc Image, p. 18

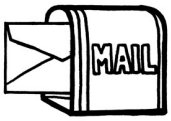
Adventure 3 **Flying Disc Image**

Alaska



The Sky's the Limit: Engineering Flying Technologies 18 © Museum of Science

Kids will learn:
- The shape, size, and weight of a material affects how it moves through the air.
- Engineers often work in teams and share ideas with each other.



Present the Message from the Duo (5 min)

1. Tell kids that today India and Jacob would like them to experiment with engineering flying discs. India sent a message to tell them more about it.
2. Have kids turn to *Message from the Duo,* p. 15 in their Engineering Journals, to follow along. Play track 5.
3. To check for understanding, ask:
   - **What is India asking you to do?** *Design flying discs that spin as they move through the air.*
   - **India said they will help to photograph a part of the world called The Empty Quarter. Why is it useful to photograph this area from the air?** *Because the Empty Quarter is a huge, hot, sandy desert that can be difficult to explore. It is similar to some of the harsh environments that NASA explores in space.*

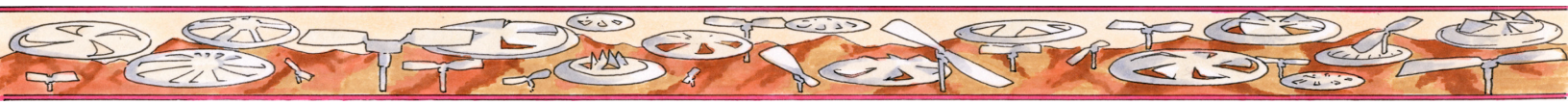
Tip: How big is the Empty Quarter? You may want to do an exercise with kids to compare the size of your town or city to the Empty Quarter. How many square miles is your town? How many copies of your town would fit in the 250,000 square miles of the Empty Quarter?

Imagine, Plan, and Create (15 min)

1. Show kids the example disc you created. Show them how to spin the balloon stick between their hands to launch the disc. Have them look at *How to Launch Flying Discs*, p. 16 in their Engineering Journals.
2. Show kids the vertical wind tunnels and point out the string you attached to the center. Turn on the fan to show kids how this type of disc works. Let them know that they can choose to test using either the fan or their hands.
3. Let groups know that you have some templates available at the Materials Table that they can choose to use as a starting point. Encourage kids to think about the different designs, materials, and sizes they could try.
4. Have kids gather in their groups. Explain that when they are ready to test, they should move

Tip: The string can be taped to the top of the wind tunnel in between testings so kids do not have to reach into the wind tunnel to grab the string each time.

Tip: It is fine if kids just observe their discs, but for discs launched by hand, they may want to estimate how long it takes for them to reach the ground by counting seconds (one-Mississippi, two-Mississippi), using a stopwatch, or trying to count the number of spins.



to the testing area you set up. For safety reasons, testing should *only* happen in the testing area.

5. Give groups time to *imagine*, *plan*, and visit the Materials Table to *create* their flying discs.

Testing Flying Discs (15 min)

1. As groups test their flying disc designs, ask questions like:
   - **What do you observe about the way your flying discs move?** *Guide kids to focus on whether or not the disc spins, and whether it moves upwards. You may want to bring up the idea of a helicopter with spinning propellers.*
   - **Do you think you could change anything to make the discs spin longer?**
2. Let groups know that once testing time is up, they will be asked to share some of their designs with the group. They can write or draw notes on *Flying Discs*, p. 17 in their Engineering Journals.
3. If kids have time, encourage them to collaborate with other groups to *improve* their designs.

Reflect (15 min)

1. Once testing is done, gather kids around the *Engineering Design Process* poster. Have each group hold up an example of a flying disc that spun well. Have kids look around at the discs being held in the air. Ask:
   - **Are there any ways in which these discs are similar? Different?** *Likely sturdy, lightweight discs with some sort of holes or arms to create propellers worked well.*
2. Now ask kids to hold up an example of a disc that may not have worked so well. Ask:
   - **Would anyone like to share why they think this disc did not work very well?** *It might be too flimsy or angled in a way that did not allow blades to catch the air well.*
   - **Which steps of the Engineering Design Process did you use today?** *All of them. We* asked *and* imagined *flying disc shapes and materials,* planned *some designs,* created*, tested, and* improved *them.*
3. Let kids know that as a reward for their aeronautical engineering work today, April sent them another NASA image to look at. Have kids turn to *Flying Disc Image*, p. 18 in their Engineering Journals, to see the image.

Tip: The term “lift” can be confusing. While lift can refer to objects, like airplanes, literally being lifted in the air, lift is technically a force created when a solid object moves through a fluid (and air is considered a fluid!). If kids are creating discs that spin, then they are achieving lift, even if the discs are not flying high up into the air.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Taking Flight

3:45 PM

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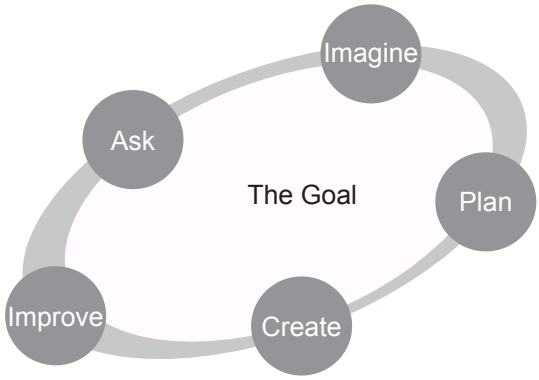
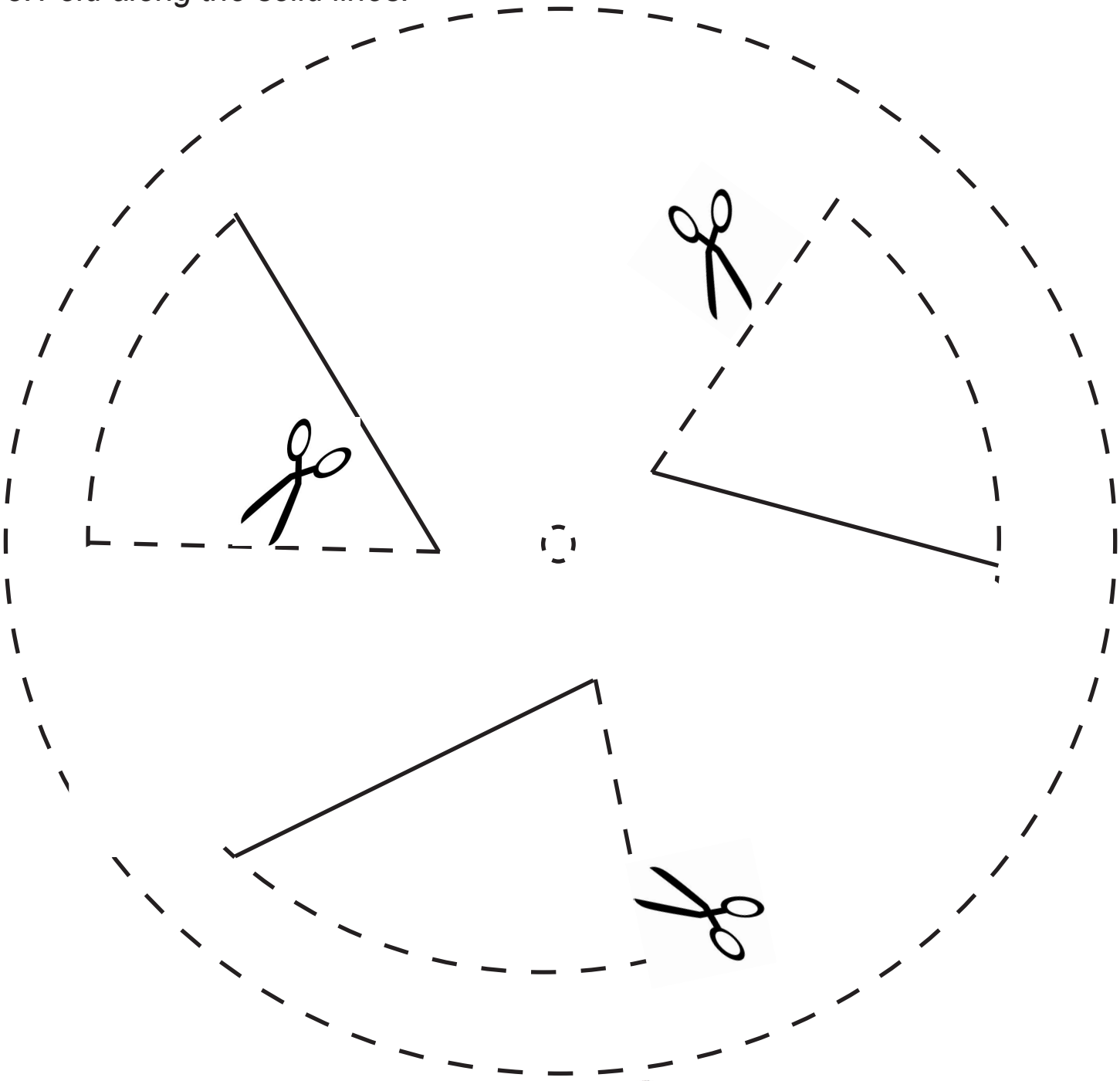
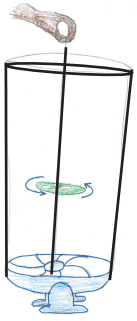


Good luck!
India

1. Tape this template to a piece of card stock or paper plate.
2. Cut along the dotted lines.
3. Fold along the solid lines.

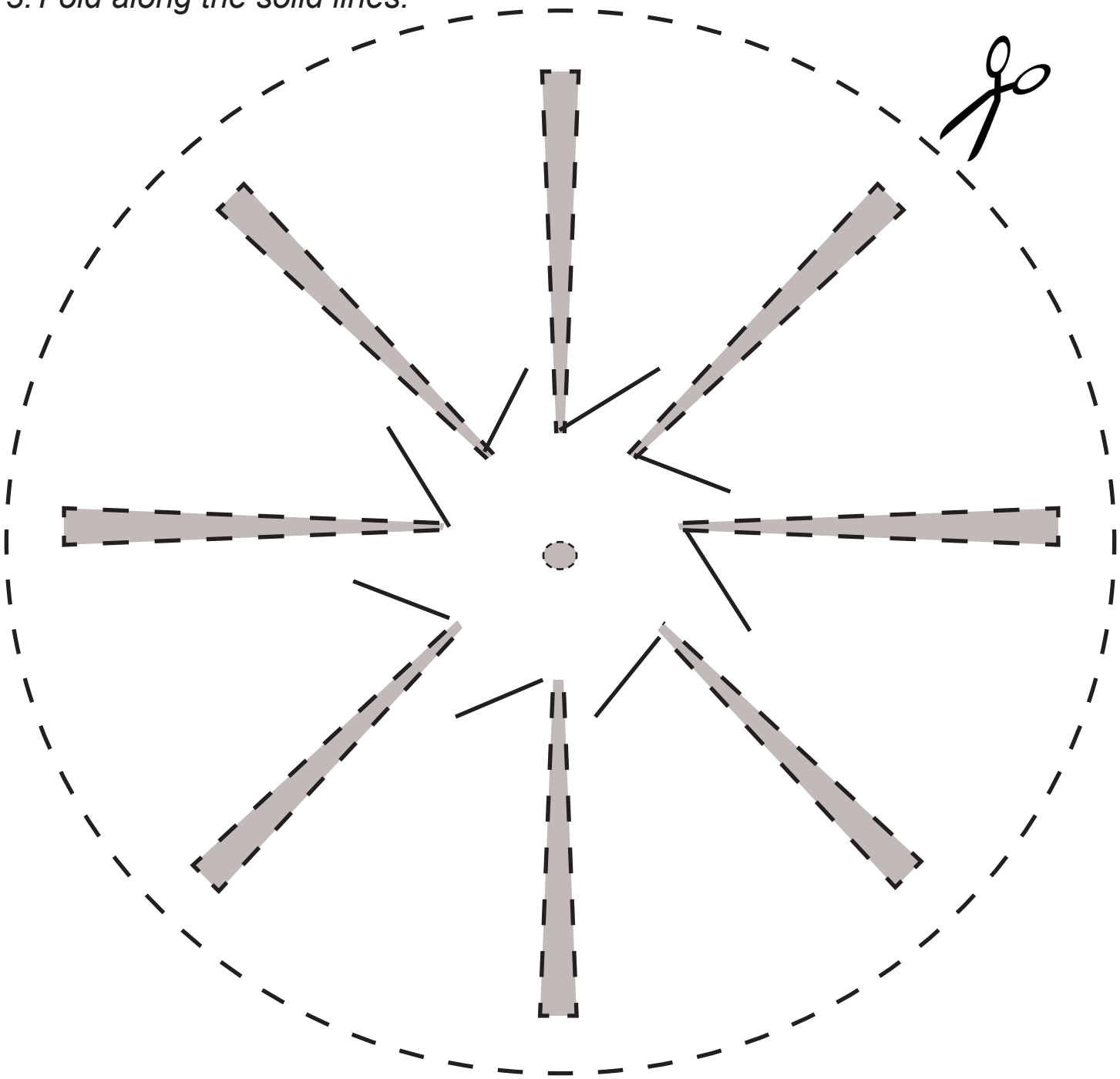


Then, use your disc in the vertical wind tunnel or make a spinner you launch with your hands by taping a stick to your design. Adjust the folds if the disc does not spin when you test.

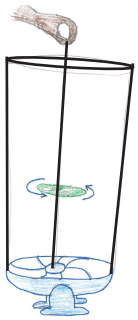


Flying Disc Template 2

1. Tape this template to a piece of card stock or paper plate.
2. Cut along the dotted lines (gray areas will be cut out.)
3. Fold along the solid lines.



Then, use your disc in the vertical wind tunnel or make a spinner you launch with your hands by taping a stick to your design. Adjust the folds if the disc does not spin when you test.

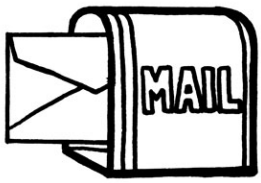


Create a Flying Technology

Overview: Kids will decide what type of aeronautical technology they would like to engineer and will begin *imagining, planning, creating*, and testing their technologies.

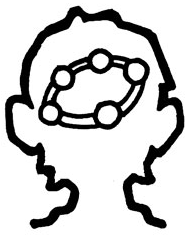
Note to Educator: Be sure to save the technologies groups engineer today so that they can continue working on them during the next two adventures.

Duo Update (10 min)



Activity (35 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 6 or Engineering Journal, p. 19
- ☐ *Engineering Design Process* poster
- ☐ optional: computer or device to play video
- ☐ *Map Areas*, pp. 49–55, this guide
- ☐ 2 wind tunnels from Adventure 1
- ☐ 5 cardboard sheets
- ☐ 8 balloon sticks
- ☐ 10 sheets of mylar, 12” x 12”
- ☐ 10 sheets of tissue paper
- ☐ 16 plastic toy people
- ☐ 20 rubber bands
- ☐ 20 washers (or other weights)
- ☐ 30 large paper cups
- ☐ 30 large paper plates
- ☐ 30 sheets of card stock
- ☐ 30 sheets of copy paper
- ☐ 30 small paper cups
- ☐ 30 small paper plates

For each group of 3-5 kids:

- ☐ 1 pair of scissors
- ☐ 1 roll of tape
- ☐ 1 ruler

For each kid:

- ☐ Engineering Journal

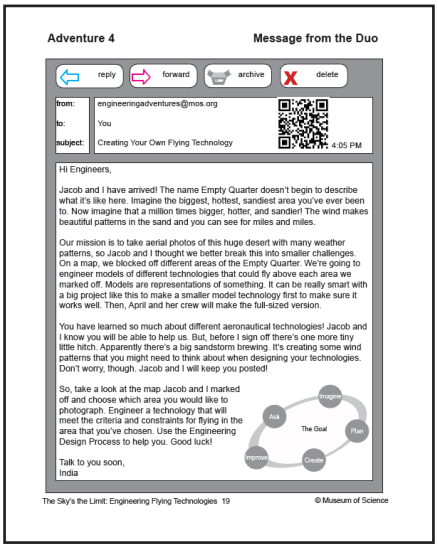
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Set up a Materials Table and Testing Stations.
4. Post the *Map Area,* pp. 49–55 in this guide, as shown on the next page.
5. Designate a testing area. Tape a “Drop Height” mark 5 feet from the ground. Place a safe and stable stool or low table in the area if kids will need to climb up on something to reach the 5-foot mark.
6. Optional: watch and prepare to play all or parts of the following National Geographic video of an aerial photographer in the Empty Quarter, *Empty Quarter* (8:00): http://tinyurl.com/khxdlef.

Journal Pages for Adventure 4

Message from the Duo, p. 19



Adventure 4 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Creating Your Own Flying Technology
4:05 PM

Hi Engineers,

Jacob and I have arrived! The name Empty Quarter doesn't begin to describe what it's like here. Imagine the biggest, hottest, sandiest area you've ever been to. Now imagine that a million times bigger, hotter, and sandier! The wind makes beautiful patterns in the sand and you can see for miles and miles.

Our mission is to take aerial photos of this huge desert with many weather patterns, so Jacob and I thought we better break this into smaller challenges. On a map, we blocked off different areas of the Empty Quarter. We're going to engineer models of different technologies that could fly above each area we marked off. Models are representations of something. It can be really smart with a big project like this to make a smaller model technology first to make sure it works well. Then, April and her crew will make the full-sized version.

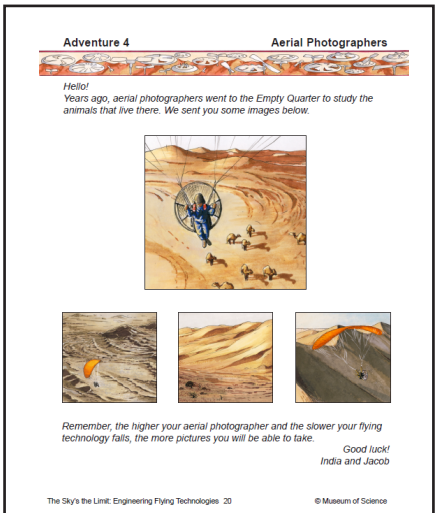
You have learned so much about different aeronautical technologies! Jacob and I know you will be able to help us. But, before I sign off there's one more tiny little hitch. Apparently there's a big sandstorm brewing. It's creating some wind patterns that you might need to think about when designing your technologies. Don't worry, though. Jacob and I will keep you posted!

So, take a look at the map Jacob and I marked off and choose which area you would like to photograph. Engineer a technology that will meet the criteria and constraints for flying in the area that you've chosen. Use the Engineering Design Process to help you. Good luck!

Talk to you soon,
India

The Sky's the Limit: Engineering Flying Technologies 19 © Museum of Science

Aerial Photographers, p. 20



Adventure 4 — Aerial Photographers

Hello!
Years ago, aerial photographers went to the Empty Quarter to study the animals that live there. We sent you some images below.

Remember, the higher your aerial photographer and the slower your flying technology falls, the more pictures you will be able to take.

Good luck!
India and Jacob

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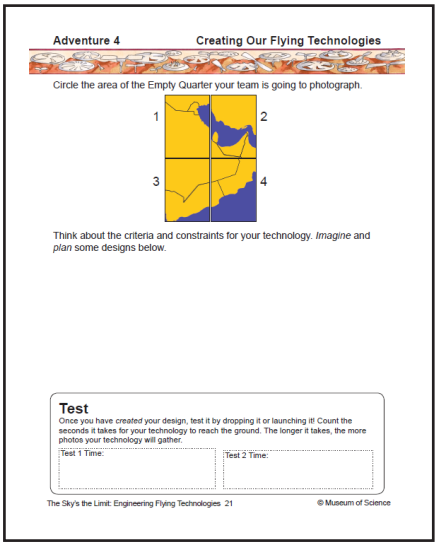
Creating Our Flying Technologies, p. 21



Adventure 4 — Creating Our Flying Technologies

Circle the area of the Empty Quarter your team is going to photograph.

Think about the criteria and constraints for your technology. *Imagine* and *plan* some designs below.

Test

Once you have created your design, test it by dropping it or launching it! Count the seconds it takes for your technology to reach the ground. The longer it takes, the more photos your technology will gather.

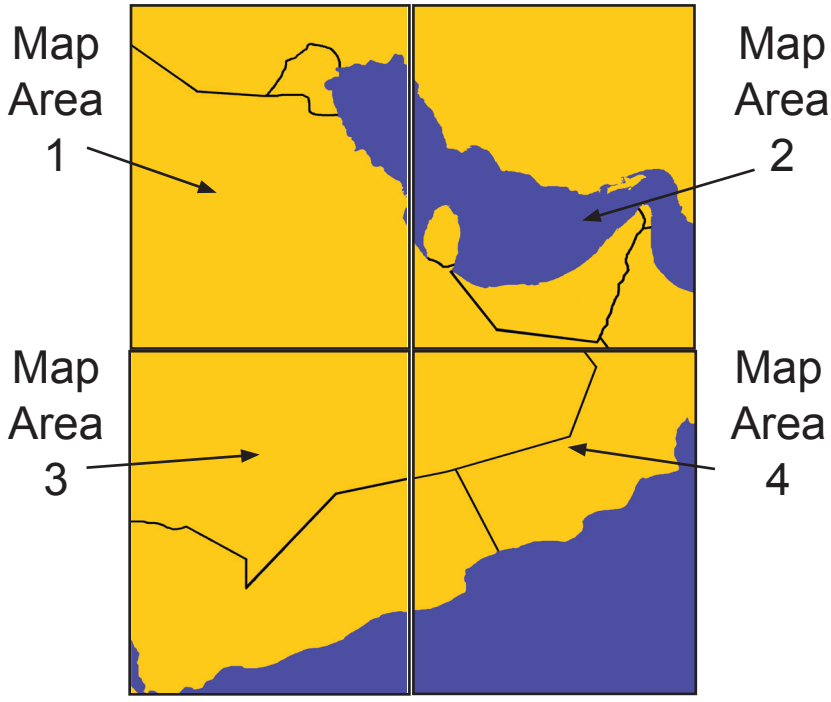
Test 1 Time: | Test 2 Time:

The Sky's the Limit: Engineering Flying Technologies 21 © Museum of Science

Map for Adventure 4

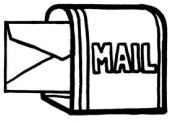
Piece together the map pages as shown here. Fold down the edges of the sheets so the map fits together without any white space between sections.

Note that the Empty Quarter covers parts of Saudi Arabia, Yemen, Oman, and the United Arab Emirates. This map includes areas surrounding the Empty Quarter as well.



Create a Flying Technology

Kids will learn:
- A model is a representation of something.
- Technologies that are designed to meet different goals might look and work very differently.
- Engineers often test, redesign, and retest.



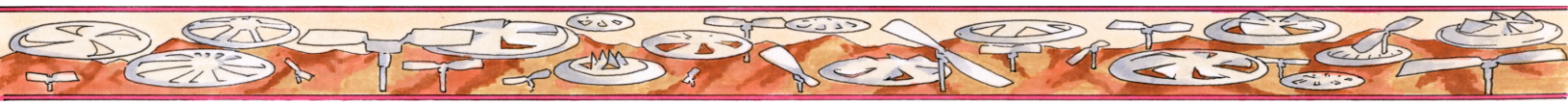
Present the Message from the Duo (10 min)

1. Tell kids that India has sent another message.
2. Have kids turn to *Message from the Duo,* p. 19 in their Engineering Journals, to follow along. Play track 6.
3. To check for understanding, ask:
   - **What is India asking us to do?** *Choose what area we want to photograph, then use the Engineering Design Process to* create *a model technology that will fly well above that area.*
   - **Why is it important for us to make a model first?** *To make sure our technologies work well before April builds the final version.*
4. Optional: show all or parts of the following video of a photographer who has taken aerial photos in the Empty Quarter to give kids a deeper understanding of the challenge. *Empty Quarter* (8:00): http://tinyurl.com/khxdlef.
5. Have kids turn to *Aerial Photographers*, p. 20 in their Engineering Journals to see the images India and Jacob sent of an aerial photographer over the Empty Quarter.

Imagine and Plan (15 min)

1. Show kids the map you created using *Map Areas*, pp. 49–55 in this guide. Point out that there are specific criteria and constraints listed on each section of the map, as well as information about the wind patterns and details of each area.
2. Split kids into groups of 3-5.
3. Give kids a few minutes to review the map, and then have groups decide which part of the Empty Quarter they would like to photograph. It is fine if some groups would like to design technologies to photograph the same area, but point out that if no group chooses a certain area then that portion of the photograph will be missing.

Tip: You may want to review with kids the type of information NASA engineers pull from aerial photos (weather patterns, land surfaces, etc.) and ask them to compare the list to what can be learned from the pictures they have already received. This can help to confirm why aerial photos provide important information.



4. Show kids the materials they will be able to use to engineer their flying technologies.
5. Point out the plastic figures that will represent their photographers.
6. Point out the Testing Stations that you have created. Let kids know that if they are designing a technology that is dropped, they will need to drop it from at least 5 feet, and they may need to stand on a stool to reach. Show kids where the testing fan is and remind them to turn the fan off when they are not testing.
7. Give groups a few minutes to *imagine* what their flying technology might be and *plan* the materials they will need. They may want to use *Creating Our Flying Technologies*, p. 21 in their Engineering Journals, to record their ideas.

Create Your Technology (20 min)

1. Once groups have decided on a *plan*, they should visit the Materials Table and begin *creating* their technologies.
2. As kids work, encourage them to test. Ask:
   - **What are the criteria and constraints for your technology?**
   - **What is working well?**
   - **What needs to be *improved*?**
3. To determine how long their technology hovers or remains in the air, kids should count the seconds or use a stopwatch.

Tip: You might want to establish how kids will count the seconds. You could have them use a stopwatch or clock, but you may also have them count (one-Mississippi, two-Mississippi, etc.).

Reflect (5 min)

1. Tell kids that they will have an opportunity to continue *planning*, *creating*, *improving*, and testing their technologies in the next adventure.
2. Have a few groups share their designs so far. Ask:
   - **Which part of the Empty Quarter will you be photographing?**
   - **How does your technology address some of the criteria and constraints of that area?**
3. Show kids the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process were the most helpful to you today?** *Accept all answers, but encourage kids to think about how they* planned, created, *and* improved.
4. Congratulate kids on using the Engineering Design Process and sharing their engineering ideas.

Message from the Duo

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Create Your Own Flying Technology

4:05 PM

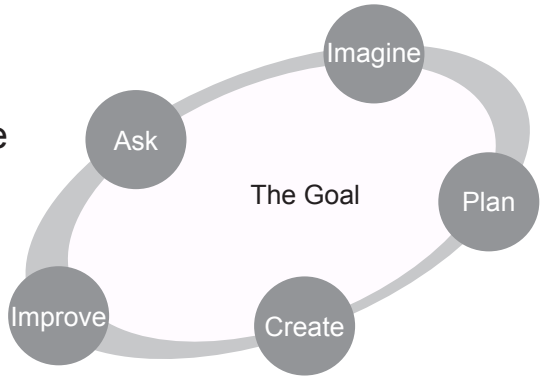
Hi Engineers,

Jacob and I have arrived! The name Empty Quarter doesn't begin to describe what it's like here. Imagine the biggest, hottest, sandiest area you've ever been to. Now imagine that a million times bigger, hotter, and sandier! The wind makes beautiful patterns in the sand and you can see for miles and miles.

Our mission is to take aerial photos of this huge desert with many weather patterns, so Jacob and I thought we better break this into smaller challenges. On a map, we blocked off different areas of the Empty Quarter. We're going to engineer models of different technologies that could fly above each area we marked off. Models are representations of something. It can be really smart with a big project like this to make a smaller model technology first to make sure it works well. Then, April and her crew will make the full-sized version.

You have learned so much about different aeronautical technologies! Jacob and I know you will be able to help us. But, before I sign off there's one more, tiny, little hitch. Apparently there's a big sandstorm brewing. It's creating some wind patterns that you might need to think about when designing your technologies. Don't worry, though. Jacob and I will keep you posted!

So, take a look at the map Jacob and I marked off and choose which area you would like to photograph. Engineer a technology that will meet the criteria and constraints for flying in the area that you've chosen. Use the Engineering Design Process to help you. Good luck!



Talk to you soon,
India

Map Area 1 Criteria and Constraints:

Criteria

Your technology should:

- carry at least one photographer.
- fly up in the air for at least 5 seconds before falling to the ground.

Constraint

Your technology cannot:

- use more than eight materials.

Map Area 2 Criteria and Constraints:

Criteria

Your technology should:

- carry at least two photographers.
- float in the air for at least 5 seconds in an updraft.
- be tested in the fan.

Constraint

Your technology cannot:

- use more than five materials.

Map Area 3 Criteria and Constraints:

Criteria

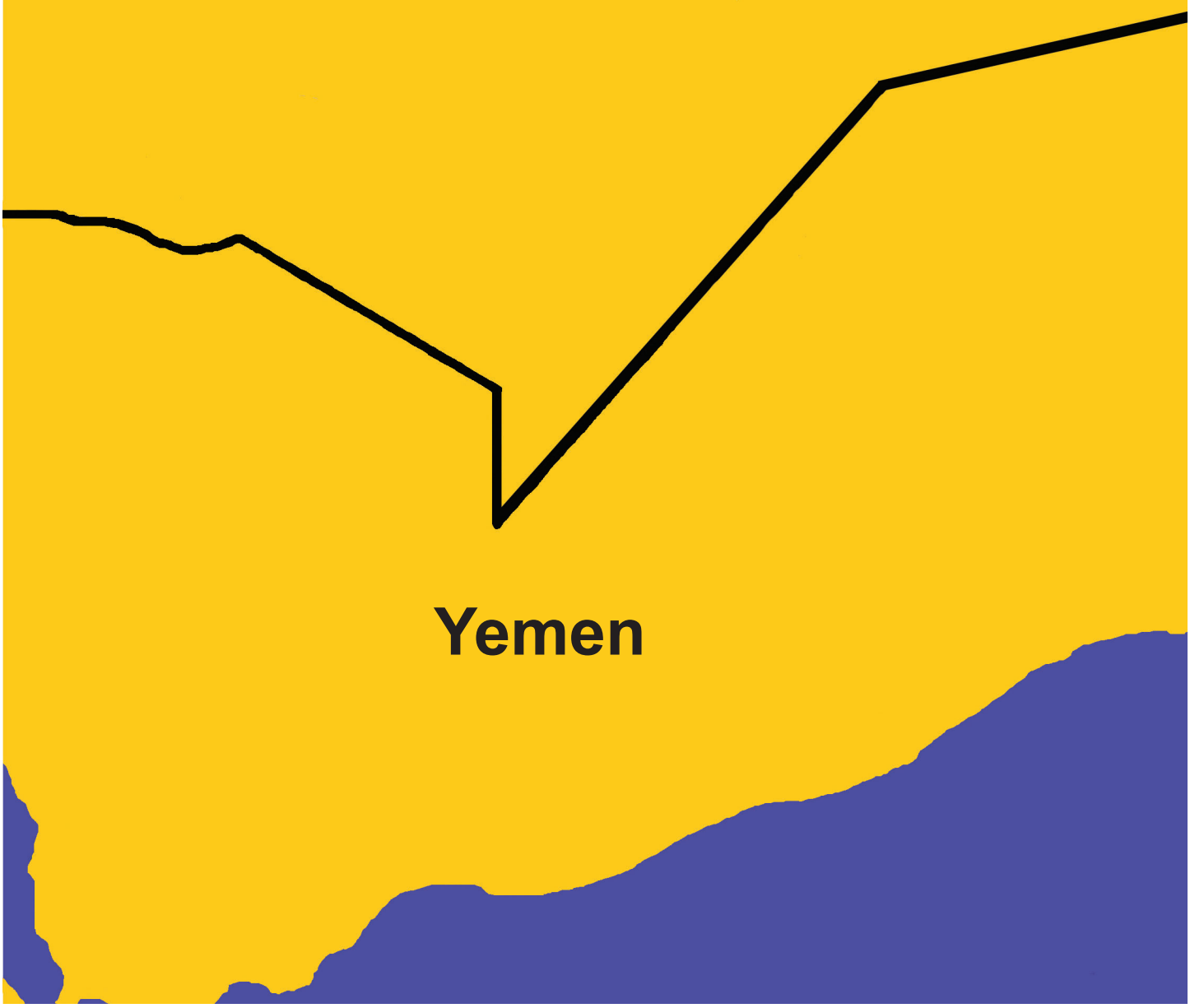
Your technology should:

- carry at least one photographer.
- fly up in the air for at least 3 seconds before falling to the ground.

Constraint

Your technology cannot:

- use more than five materials.



Map Area 4

Map Area 4 Criteria and Constraints:

Criteria

Your technology should:

- carry at least three photographers.
- stay in the air for at least 2 seconds.

Constraint

Your technology cannot:

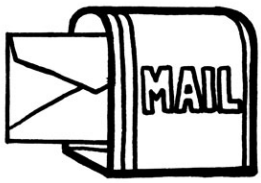
- use more than eight materials.

Improve a Flying Technology

Overview: Kids will *improve* their flying technologies.

Note to Educator: There are a few options for groups in this activity. Groups should first *improve* their technologies, then decide if they want an additional challenge of adding weight or making another technology. Be sure to save the technologies that groups design so they can share them in Adventure 6, which is the Engineering Showcase. You may want to consider inviting other kids, staff, and community members to the Showcase.

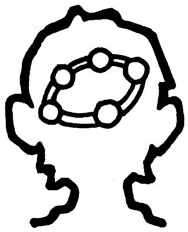
Duo Update (5 min)



Ask (5 min)

Activity (25 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 7 or Engineering Journal, p. 22
- ☐ *Engineering Design Process* poster
- ☐ 2 wind tunnels from Adventure 1
- ☐ *Map Areas*, this guide, pp. 49–55

Remaining materials from Adv. 4:

- ☐ balloon sticks
- ☐ cardboard sheets
- ☐ card stock sheets
- ☐ copy paper sheets
- ☐ large paper cups
- ☐ large paper plates
- ☐ mylar sheets
- ☐ plastic toy people
- ☐ rubber bands
- ☐ small paper cups
- ☐ small paper plates
- ☐ tissue paper sheets
- ☐ washers (or other weights)

For each group of 3-5 kids:

- ☐ 1 pair of scissors
- ☐ 1 roll of tape
- ☐ 1 ruler

For each kid:

- ☐ Engineering Journal

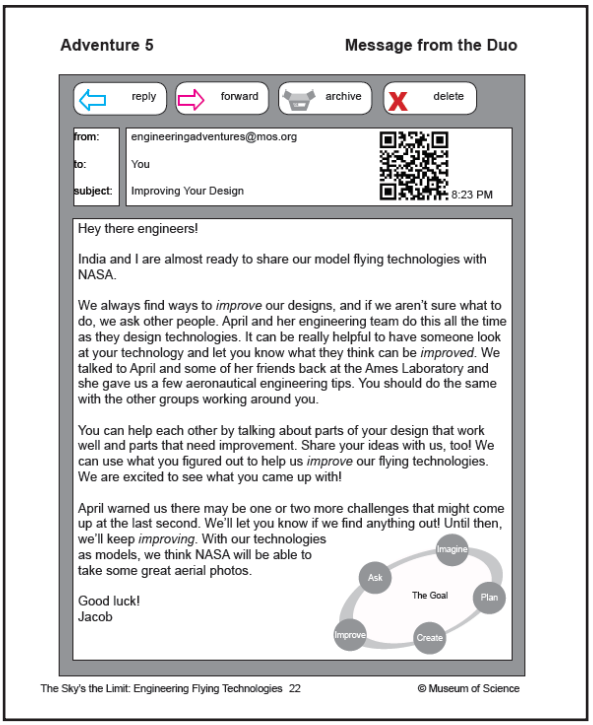
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Repost the Empty Quarter Map from the previous adventure, pp. 49–55 in this guide.
4. Stock the Materials Table with all of the remaining materials from Adventure 4.
5. Designate a section of the room as the testing area.
6. Optional: Make a few copies of *Additional Challenge*, p. 63 in this guide, and have the *Message from the Duo* ready, track 8.

Journal Pages for Adventure 5

Message from the Duo, p. 22



Adventure 5 **Message from the Duo**

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Improving Your Design
8:23 PM

Hey there engineers!

India and I are almost ready to share our model flying technologies with NASA.

We always find ways to *improve* our designs, and if we aren't sure what to do, we ask other people. April and her engineering team do this all the time as they design technologies. It can be really helpful to have someone look at your technology and let you know what they think can be *improved*. We talked to April and some of her friends back at the Ames Laboratory and she gave us a few aeronautical engineering tips. You should do the same with the other groups working around you.

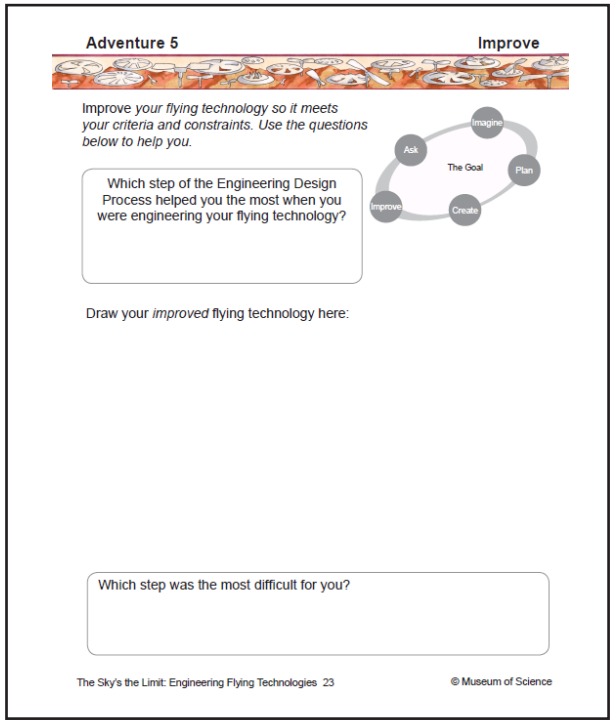
You can help each other by talking about parts of your design that work well and parts that need improvement. Share your ideas with us, too! We can use what you figured out to help us *improve* our flying technologies. We are excited to see what you came up with!

April warned us there may be one or two more challenges that might come up at the last second. We'll let you know if we find anything out! Until then, we'll keep *improving*. With our technologies as models, we think NASA will be able to take some great aerial photos.

Good luck!
Jacob

The Sky's the Limit: Engineering Flying Technologies 22 © Museum of Science

Improve, p. 23



Adventure 5 **Improve**

Improve *your flying technology so it meets your criteria and constraints. Use the questions below to help you.*

Which step of the Engineering Design Process helped you the most when you were engineering your flying technology?

Draw your *improved* flying technology here:

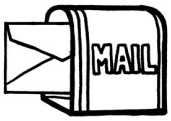
Which step was the most difficult for you?

The Sky's the Limit: Engineering Flying Technologies 23 © Museum of Science

Improve a Flying Technology

Kids will learn:

- Sharing findings and offering advice to other groups, just as real engineers do, can be helpful.
- Engineers have to *improve* a design many times before it is complete.



Present the Message from the Duo (5 min)

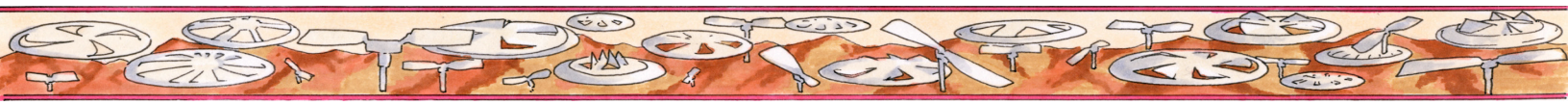
1. Tell kids that Jacob has sent another message.
2. Have kids turn to *Message from the Duo,* p. 22 in their Engineering Journals, to follow along. Play track 7.
3. To check for understanding, ask:
   - **What is Jacob asking you to do?** *Jacob is asking us to share our designs and give each other advice to* improve.
4. Explain that after the advice exchange, groups will have a chance to *improve* their designs, then take on additional challenges if they would like.

Advice Exchange (5 min)

1. Explain that groups will first pair up with another group to discuss any problems they are having with their designs, as well as the parts that are working well. As one group shares, the other will act as consultants and offer ideas as to how the group may be able to *improve* their technology. Suggest that the consultants ask the other group questions like:
   - **What part of the Empty Quarter will you photograph? What are your criteria and constraints?**
   - **What parts of your design are you struggling with?**
2. Pair up the groups and have them share their designs with each other.

Improve (25 min)

1. Let groups know that they will have about 25 minutes to *improve* their designs. They can test along the way and should make sure to assess how well their model meets the criteria and constraints for their section of the Empty Quarter.
2. Explain that when groups feel their design is complete, there are two possible additional challenges they can try to solve, just as Jacob mentioned there might be. The first challenge is that April and her team are working on different cameras and landing gear for the photographers, which will add more weight to the design. Groups taking on this challenge must add three washers to each photographer, making sure their technologies still meet the criteria and constraints for the area they will photograph.
3. India and Jacob sent an additional message about the second challenge. April and her team want to get pictures right inside a storm. To do this, they need an unmanned camera that would be able to be picked up by the storm,



and hover to take pictures as the winds constantly change. Groups can listen to the Message from the Duo, track 8, and read along by looking at *Additional Challenge*, p. 63 in this guide.

4. As groups are working, ask questions like:
   - **What parts of your technology still need work?**
   - **How can you *improve* your technology to better meet the criteria and constraints?**

Reflect (10 min)

1. Tell kids that they will present their model flying technologies in the next adventure, and they will get to see the aerial photos of the Empty Quarter taken by NASA.
2. Show kids the *Engineering Design Process* poster. Ask:
   - **How did you use the Engineering Design Process to *improve* your model flying technology?** *We went back and* asked *questions to figure out how to* improve, *and then we* imagined*,* planned*, and* created *our* improved *models.*
   - **Did you use any of the advice offered by another group?**
   - **Do you think engineers need to *improve* their designs?** *Yes, engineers* improve *their designs many times before they are done.*
   - **Why do you think engineers work in groups ?** *Encourage all answers, but kids may suggest that they can share more ideas, give each other advice, etc.*
3. Congratulate kids on using the Engineering Design Process. Let them know that thanks to their great aeronautical engineering work, they will be able to see aerial photos of the Empty Quarter during the next activity.
4. Explain to kids that the next activity is the Engineering Showcase, where they will share their designs with each other and visitors. You may want to encourage them to invite their families and friends, or ask other staff members to attend.
5. Give kids time to fill out *Improve*, p. 23 in their Engineering Journals. Having kids write about what they worked on will reinforce some of the key points they learned as they engineered.

Countdown: Improve a Flying Technology

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Improving Your Design

8:23 PM

Hey there Engineers!

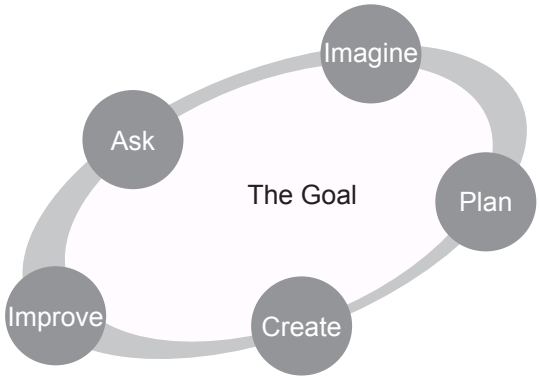
India and I are almost ready to share our model flying technologies with NASA.

We always find ways to *improve* our designs, and if we aren't sure what to do, we ask other people. April and her engineering team do this all the time as they design technologies. It can be really helpful to have someone look at your technology and let you know what they think can be *improved*. We talked to April and some of her friends back at the Ames Laboratory and she gave us a few aeronautical engineering tips. You should do the same with the other groups working around you.

You can help each other by talking about parts of your design that work well and parts that need improvement. Share your ideas with us, too! We can use what you figured out to help us *improve* our flying technologies. We are excited to see what you came up with!

April warned us there may be one or two more challenges that might come up at the last second. We'll let you know if we find anything out! Until then, we'll keep *improving*. With our technologies as models, we think NASA will be able to take some great aerial photos.

Good luck!
Jacob



Sandstorm Unmanned Camera

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	One More Challenge!

4:05 PM

Hi Aeronautical Engineers!

April told us about yet another challenge. Her team wants to get pictures right in the middle of a storm! To do this, they would leave a camera on the ground before the storm. The storm winds would pick up the camera so it would take aerial photos during the storm. Her team would pick up the camera after the storm to download the pictures. Since the camera will be in a storm, it needs to be protected, and needs to be able to move through the quickly changing wind patterns without hitting the ground. Below are directions for how to make a model of the camera and how to test your technology.

Good luck!
India and Jacob

Camera Model:

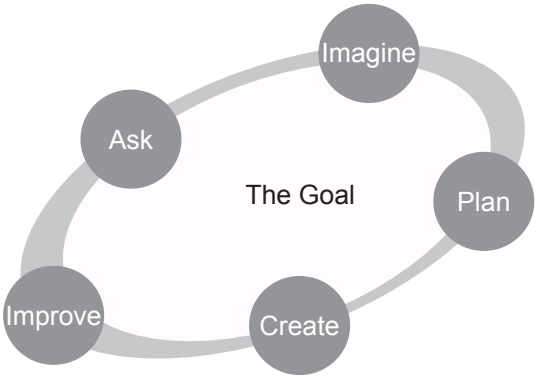
- Tape 5 washers together to model the camera.

Materials:

- Balloon sticks, cardboard sheets, card stock, paper, paper cups, paper plates, mylar, rubber bands, tape, tissue paper, washers

Test:

- Start with the fan of the wind tunnel off.
- Hold your technology inside the wind tunnel about 3 inches from the fan.
- Turn the fan on for 20 seconds. Your technology should lift up by itself.
- Turn the fan off for 5 seconds, then back on. Your technology should not hit the fan, but be able to hover within the wind tunnel.

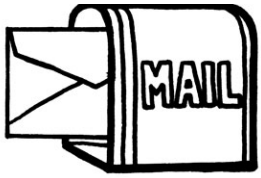


Engineering Showcase: The Sky's the Limit

Overview: Kids will do a final test of their aeronautical technologies and participate in a Showcase to explain how they used the Engineering Design Process. They will finally get to see the image of the piece of the Empty Quarter that their flying technology was engineered to photograph.

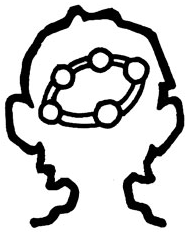
Note to Educator: This is a time for your group to share all of their hard work with family and friends! Consider inviting guests to the Engineering Showcase, and encourage kids to share the specific challenges that their group worked on and overcame.

Duo Update (5 min)



Activity (30 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 9 or Engineering Journal, p. 24
- ☐ *Engineering Design Process* poster
- ☐ *Empty Quarter Images*, this guide, pp. 71–77
- ☐ 1 roll of tape

For each group of 3-5 kids:

- ☐ completed model flying technologies

For each kid:

- ☐ Engineering Journal

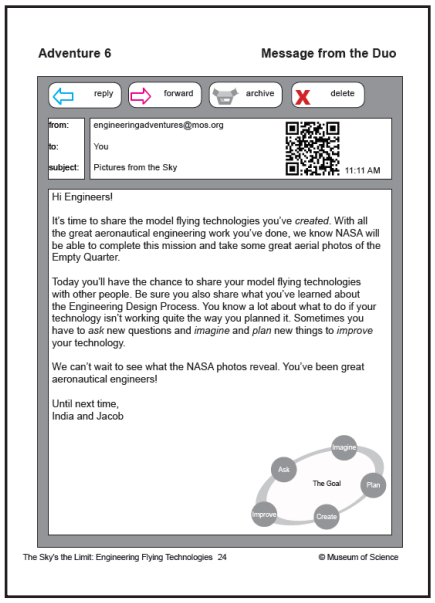
Preparation

Time Required: 10 minutes

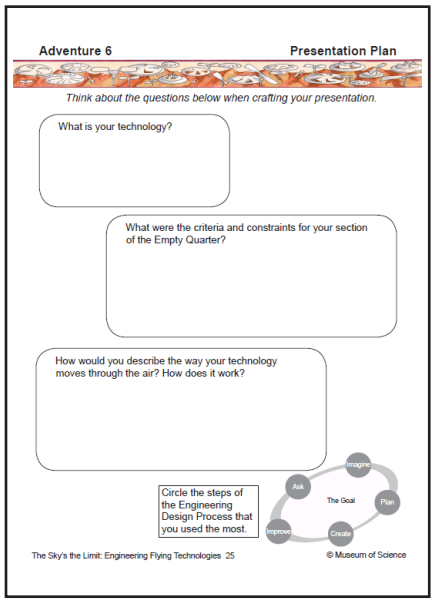
1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Prepare the *Empty Quarter Image* as shown on the next page so it is ready to post once groups have completed their final test. Place the image in a location where groups will not be able to view it until the end of the adventure.
4. Designate a section of the room for testing. Be sure to make a 5-foot mark on the wall to indicate drop height.
5. Optional: You may want to take video of the presentations, or create a video in advance and show a digital presentation.

Journal Pages for Adventure 6

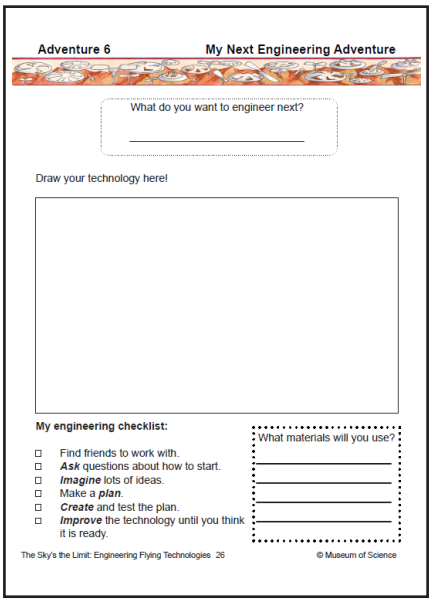
Message from the Duo, p. 24



Presentation Plan, p. 25

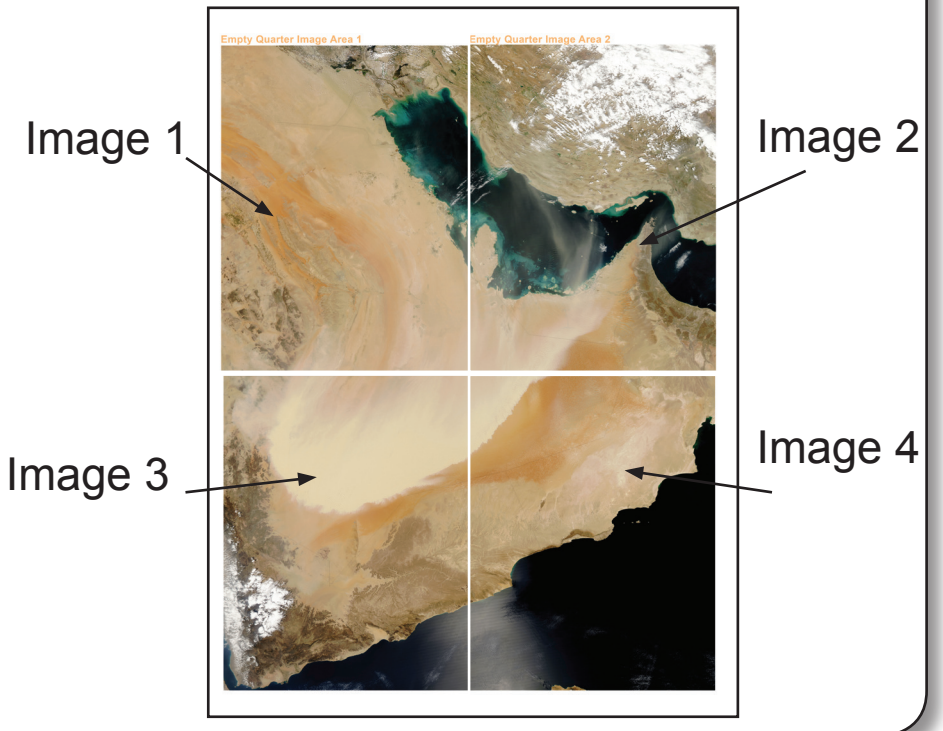


My Next Engineering Adventure p. 26



Empty Quarter Images for Adventure 6

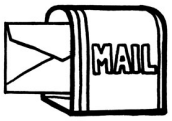
Piece together image pages as shown here. Fold down the edges of the sheets so the image fits together without any white space between sections.



Engineering Showcase: The Sky's the Limit

Kids will learn:

- The Engineering Design Process can be used to engineer many technologies, including things that fly through the air.
- They are engineers!



Present the Message from the Duo (5 min)

1. Tell kids that today they will share information about the model flying technologies that they designed, and they will get to see photographs of different areas of the Empty Quarter taken on real NASA missions using flying technologies like the ones they engineered. India and Jacob sent a message to tell them more.
2. Have kids turn to *Message from the Duo,* p. 24 in their Engineering Journals, to follow along. Play track 9.
3. To check for understanding, ask:
   - **What are India and Jacob asking you to do?** *Share how we used the Engineering Design Process, present our aeronautical technologies, and check out the Empty Quarter photos the NASA mission gathered.*

Prepare/Plan (5 min)

1. Have groups discuss how they will present their designs. They should use *Presentation Plan*, p. 25 in their Engineering Journals, to see what questions they will be asked. They can use this page to take notes on.
2. Kids also may want to reference the notes they made on *Improve*, p. 23 in their Engineering Journals.

Showcase (25 min)

1. Have groups take turns presenting their aeronautical technologies. Ask questions like:
   - **What is your technology?**
   - **What were the criteria and constraints for your section of the Empty Quarter?**
   - **Can you describe how your technology works?**
   - **How did you use the steps of the Engineering Design Process to engineer your technology?**
2. Have the kids launch or drop their technology in front of the group.
3. If kids would like, give them an opportunity to share any unmanned cameras they designed in Adventure 5.
4. After testing, reveal the *Empty Quarter Images* you pieced together. Give kids time to review the photo carefully. Ask:
   - **What can you tell from these pictures?** *Cloud/weather patterns, terrain, where plants are growing.*

- **What information would be particularly useful to NASA?** *NASA could use all of the information. Weather information can help them think about how weather impacts aeronautical technologies that move through the air, and information about the land can help them plan for future missions to environments in space.*

Reflect (10 min)

1. After reviewing the NASA image, gather kids together and ask:
   - **Why do you think aeronautical engineering is important?** *Aeronautical engineers design things that help people and things fly around the world, and they help us learn more about our own planet.*
2. Show kids the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process helped you the most?**
   - **Do you think you will use this process again?**
3. Have kids fill out *My Next Engineering Adventure,* p. 26 in their Engineering Journals. This reflection reinforces that they are successful engineers and can use the Engineering Design Process to solve many other problems!

Engineering Showcase: The Sky's the Limit

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Pictures from the Sky

11:11 AM

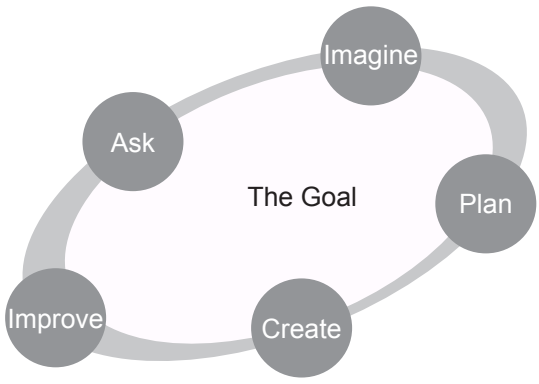
Hi Engineers!

It's time to share the model flying technologies you've *created*. With all the great aeronautical engineering work you've done, we know NASA will be able to complete this mission and take some great aerial photos of the Empty Quarter.

Today you'll have the chance to share your model flying technologies with other people. Be sure you also share what you've learned about the Engineering Design Process. You know a lot about what to do if your technology isn't working quite the way you planned it. Sometimes you have to *ask* new questions and *imagine* and *plan* new things to *improve* your technology.

We can't wait to see what the NASA photos reveal. You've been great aeronautical engineers!

Until next time,
India and Jacob

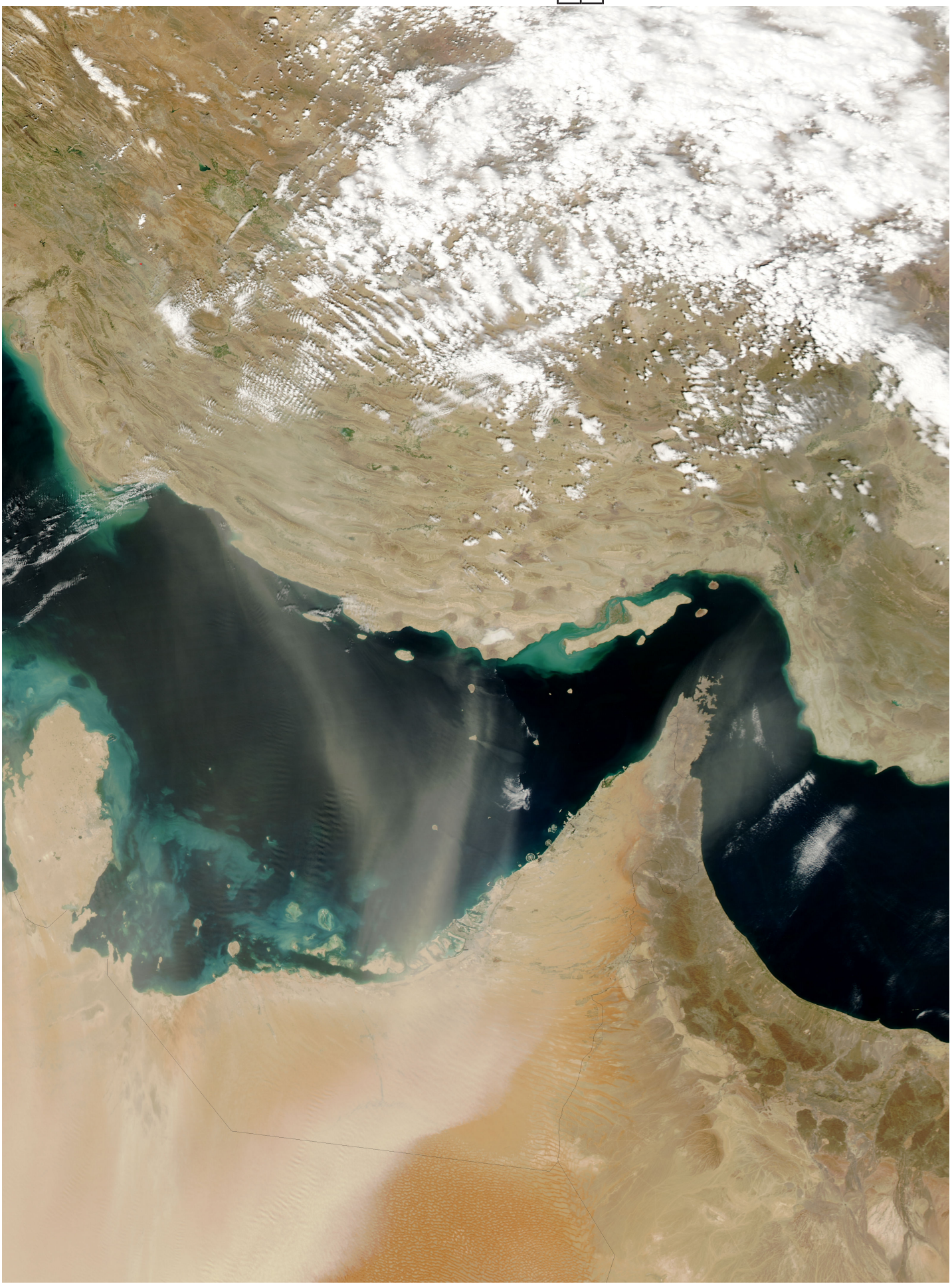


Empty Quarter Image Area 1

Photos courtesy of NASA

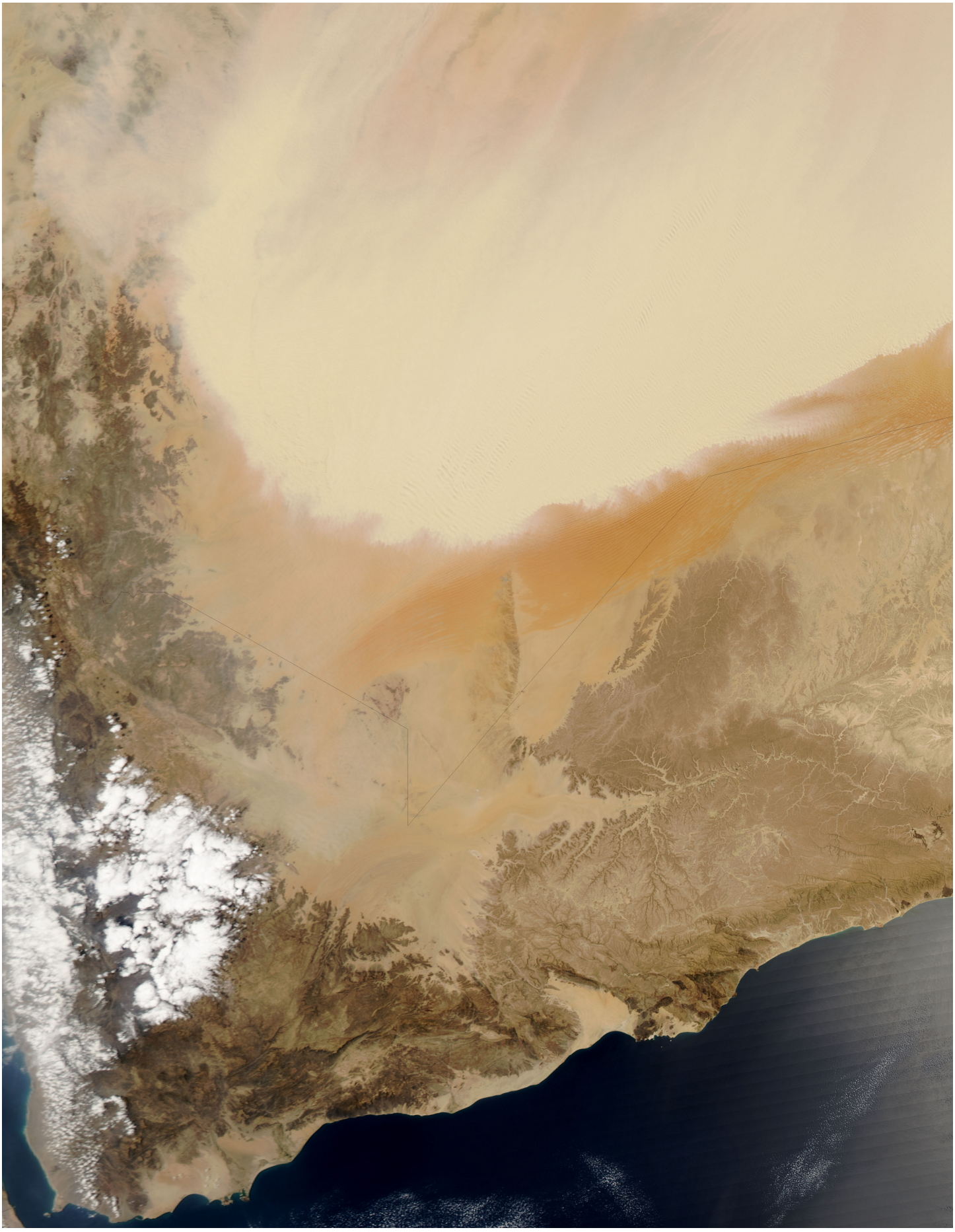
Empty Quarter Image Area 2

Photos courtesy of NASA



Empty Quarter Image Area 3

Photos courtesy of NASA



Empty Quarter Image Area 4

Photos courtesy of NASA