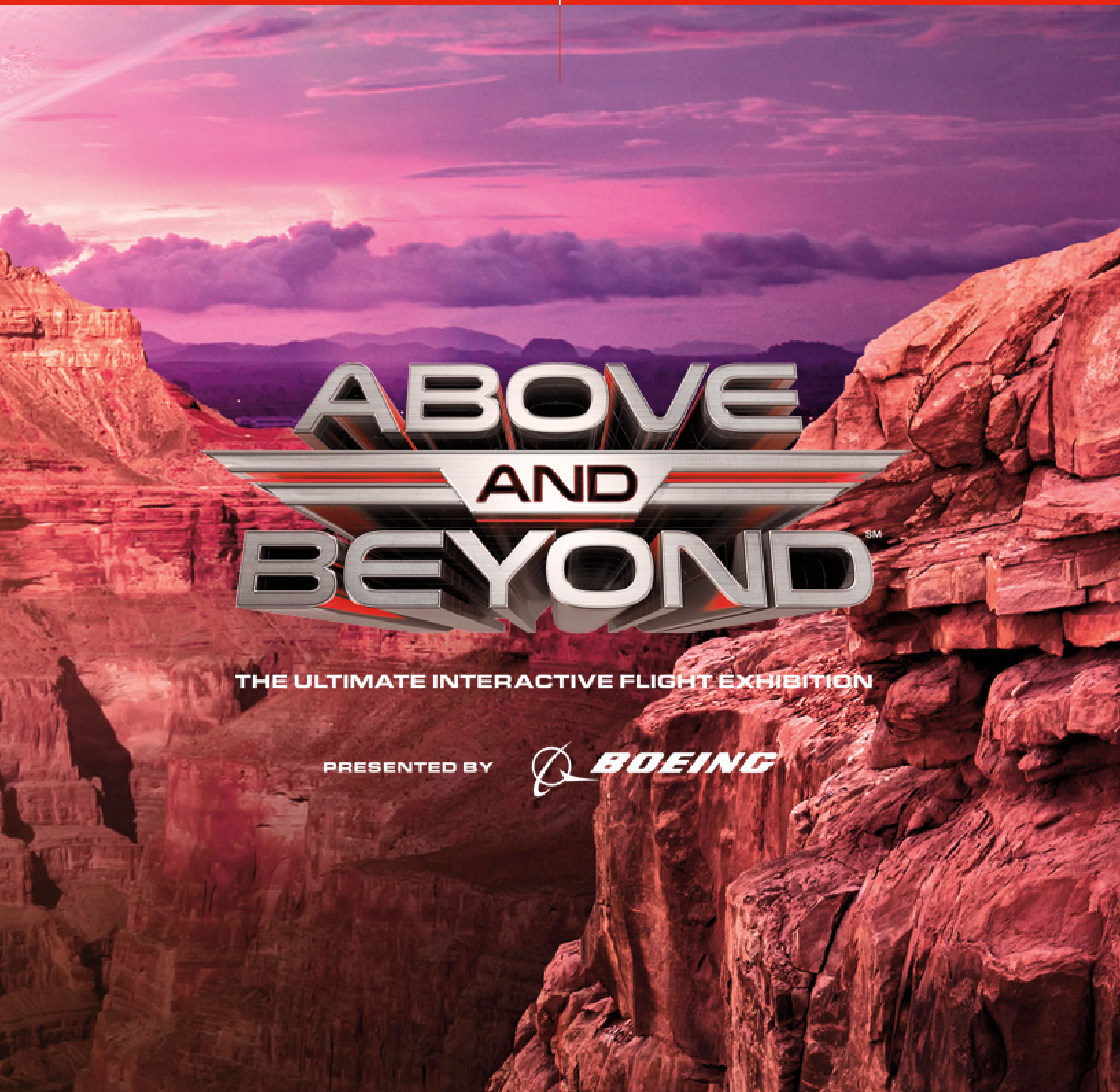
CLASSROOM TEACHER'S GUIDE

GRADES 3–5



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ABOVE AND BEYOND – THE ULTIMATE INTERACTIVE FLIGHT EXHIBITION is made possible by Boeing. The exhibition is produced by Evergreen Exhibitions in association with Boeing, in collaboration with NASA and the Smithsonian's National Air and Space Museum.

This Teacher's Guide is created by TurnKey Education, Inc., for Evergreen Exhibitions. Education advisors include NASA and the Museum of Flight.

Education resources and programming for ABOVE AND BEYOND are made possible by Boeing in celebration of its centennial and its ongoing commitment to prepare and inspire the next generation to dream, design, and build something better for the next century. Boeing Centennial education collaborative partners include The Documentary Group, WGBH, PBS LearningMedia, Iridescent, Teaching Channel. The Museum of Flight is an education collaborator.

WELCOME TO ABOVE AND BEYOND!

Looking back at the history of flight, one thing is abundantly clear: the sky was never the limit. ABOVE AND BEYOND is a multisensory flight and aerospace exhibition that invites you and your students to experience what it takes to make the "impossible" possible in and above the sky.

This unique learning opportunity is brought to you by The Boeing Company and developed in collaboration with a host of renowned aviation specialists, aerospace experts, historians, archivists, teachers, and educational programming professionals. These skilled partners bring science, technology, engineering, the arts, and math (STEAM) instruction to new heights in your classroom. ABOVE AND BEYOND offers your students direct access to immersive simulations, interactive design challenges, iconic historical touchstones, visionary concepts for the future, and inspiring stories from game-changing innovators past and present. Imagine the teachable moments!

From the time humans first got off the ground, the race was on to go above and beyond. Faster . . . farther . . . higher . . . smarter! Today, these goals propel aerospace innovators to apply the principles of STEAM learning to new discoveries and expand the boundaries of our universe. ABOVE AND BEYOND will engage your students and fellow teachers across the curriculum with its thought-provoking content. What if we could . . .

- *Get airborne wherever and whenever we wanted?*
- *Fly faster than the speed of sound with supersonic flights that don't make a lot of noise or burn too much fuel?*
- *Design ultra-green flying machines to carry more people more places and, at the same time, treat the planet better?*
- *Invent supersmart flying robots to assist us in our daily lives, such as delivery-bots, eco-bots, and more?*
- *Build a new generation of reusable space vehicles to make trips to Earth's orbit as common as air travel?*

ABOVE AND BEYOND is more than a visit to the museum. It is a way to inspire your students to aim higher and go farther in their studies. Maybe someone you know will take us all above and beyond in the near future!

EXPERIENCING ABOVE AND BEYOND: THE FIELD TRIP

During your field trip to ABOVE AND BEYOND, you can experience five interactive galleries in any order: UP, FASTER, HIGHER, FARTHER, and SMARTER. Each one features simulations and design activities related to real-life engineering challenges in the aerospace industry. Here are some of the highlights your students won't want to miss!

A field trip to ABOVE AND BEYOND celebrates the power of innovation to make dreams take flight. An expansive, multitouch timeline where students can explore the innovations and innovators that transformed our world introduces them to the history of flight. Next, a short film called Beyond the Limits immerses students into the spirit and power of aerospace innovation. Exhilarating imagery and soaring music will build anticipation for what comes next.

UP

UP gets everyone into the action as they discover what it takes to get off the ground. Learn about the breakthroughs that enabled us to join the birds in the sky. Then check out some bold new concept vehicles designed to give us more freedom of mobility in the future.

The concepts of lift, drag, thrust, and weight come to life with a group flying game called Spread Your Wings. Here, students become birds and follow their leader heading south in a V formation. These four principles of flight are further explored through a comparison of how a balloon, airship, glider, fixed-wing aircraft, rotorcraft, and rocket each reach the skies. A look at the amazing aircraft of the future shows your students how faster and greener models are already in development.

FASTER

In 1947, test pilot Chuck Yeager proved the speed of sound wasn't a barrier when he blazed past it at 700 mph in a Bell X-1 rocket plane. In 2004, NASA's unpiloted X-43A broke the speed record for an air-breathing aircraft when it flew 7,000 mph. Whether to get "there" quicker, to gain an advantage over an opponent, or for the pure adrenalin rush, the quest for speed has inspired innovative advances in flight. FASTER immerses you in the exhilarating thrills of high-speed flight.

To understand what is meant by "high-speed," your students will design and test-fly a jet in a virtual competition called Full Throttle. This supersonic fighter jet challenge demonstrates the effects of various shapes of the fuselage, wings, and tail on how well the craft flies, how fast it can go, and how easy it is to maneuver. A simulated wind tunnel test reveals how other aspects of an aircraft's shape determine where its top speed will be reached in the range from subsonic to supersonic. Students will also see small-scale aircraft models that Boeing and NASA have used in actual wind tunnel tests.

HIGHER

Just 58 years after Wilbur Wright "soared" to 10 feet in the Wright Flyer, Soviet cosmonaut Yuri Gagarin became the first person to orbit Earth. Today, astronauts regularly live and work aboard the International Space Station (ISS). However, it is still difficult and expensive to reach space. Few people can experience its wonders . . . for now! HIGHER explores high-altitude flight and the innovations that might soon make it easier to get into orbit.

The highlight of this gallery is the International Space Elevator. Your class will explore the layers of the atmosphere and the possibilities of high-altitude flight. This experience is a visually stunning, simulated ascent in a space elevator loosely inspired by concepts that might one day transport cargo and people to the orbit around Earth.

FARTHER

Across the Atlantic, around the world, to the Moon, and beyond! Since we first got off the ground, we've always wanted to fly even farther. For aircraft, the current focus is on going farther with less – using less fuel and creating less pollution. In space, we're shooting for Mars and the stars! What will it take to fly humans to Mars? Can we "sail" to the stars? FARTHER reveals the power of innovation to help us go the distance, on Earth and in space.

Marathon to Mars asks your students the very same questions aerospace engineers ponder about the challenges inherent in a months-long journey to Mars. How long will it take? What will you pack? What will you wear? Models of the future spacecraft that might someday get us to Mars – and beyond – are also on display. Students can then experiment with superstrong, lightweight composite materials that already help aircraft and spacecraft fly farther using less fuel.

SMARTER

In aerospace, there is no battle of "brains vs. brawn." You need both! SMARTER invites your students to discover what happens when flight and smart technologies unite. See how aerospace innovators are applying advances in computers, electronics, and robotics to invent more capable aircraft and spacecraft. Learn how smart technologies are transforming the way we build and operate these amazing, intelligent flying machines.

Real objects and multimedia displays tell the story of space junk – its dangers and potential solutions. Your students will see how smarter aircraft will make spaceflight safer for everyone in Space Junk. This challenge presents three out-of-this-world solutions to cleaning up orbital debris.

SMARTER also features an assortment of real unmanned aerial vehicles. Students will have an opportunity to program their own virtual UAV (unmanned aerial vehicle) to carry out a specific mission. In this Roboflyers activity, they will compare several design possibilities to evaluate the best solution based on the parameters of their mission. Mission options include flying into the eye of a storm, pollinating a green house on Mars, or tracking an endangered species. Students will also want to check out the Smart Skies video to discover how smart technologies will transform our airspace by improving efficiency, reducing pollution, decreasing weather delays, and lowering costs.

DREAMS ALOFT

At the conclusion of the field trip, you virtually "meet" young Boeing employees who will share some of the exciting projects they are working on now, their personal inspirations, and how they followed a path from the classroom to outer space. Students can then contribute their own vision of the future of flight to a collaborative wall of dreams. Cool!

ABOVE AND BEYOND is designed to ignite a passion for the greatest adventure of all: our journey of flight in the air and in space. In doing so, it honors past world-changing innovations while looking ahead and demonstrating the impact of aerospace breakthroughs in our everyday lives. This exhibition inspires your students to imagine future careers in aerospace and helps you build STEAM awareness in your classroom. Your field trip to ABOVE AND BEYOND is, simply put, out of this world!

USING THIS TEACHER'S GUIDE

As a companion to your experience at ABOVE AND BEYOND this comprehensive Teacher's Guide for Elementary School has been created to complement your classroom instruction and make the most of your school field trip. This Teacher's Guide contains original, assessable, STEAM-related classroom lesson plans for you to use and share.

The Teacher's Guide for Elementary School contains dynamic activities and assignments for students in grades three through five. There is also a Teacher's Guide for Middle School. Both of these Guides are created to be flexible; use them to best meet the needs and capabilities of your class. You know your students better than anyone else!

Following this Introduction, you will find the section containing four interdisciplinary Classroom Lesson Plans designed to correlate with your curriculum standards. The lesson plans begin with Teacher Instructions pages, which include answer keys for those activities. At the top of the Teacher Instruction page, you will find the appropriate content areas and skills addressed by the activities in the lesson. Each lesson continues with complete, ready-to-copy, Student Activity worksheets that center on key topics featured in the exhibition.

The first lesson plan is "Map It! Partners Around the World." Students will combine their geography and statistics skills while working with a diagram that shows the origins of various parts of a Boeing 787 Dreamliner. They will see how the global world of science, technology, engineering and math came together to create an airplane of the future that is ready to fly today!

"When Drag Isn't a Drag," the second lesson plan, combines geometry and physical science in an inquiry-based activity. Students will create and test rectangular and circular parachutes to figure out which shapes are used to safely land some of aircraft and spacecraft they will see on their visit to ABOVE AND BEYOND.

In the next lesson plan, "Better Suited for Mars," students will be introduced to the steps of the engineering design process as they participate in a spacesuit simulation. After attempting a series of tasks and exercises in a simulated suit, their goal is to decide what would work well in a spacesuit for a future Mars mission and to make recommendations for improvements.

The fourth lesson plan is "Logical Careers." Generally, students might think of commercial airplanes when they imagine a career with a company in the aerospace industry. However, The Boeing Company – a vibrant workforce located all over the world – also designs and builds everything from satellites to underwater manned vehicles! The logic puzzle in this lesson plan opens your students' eyes to the diversity of careers available in a company like Boeing while they practice making deductions and establishing equalities without using any numbers!

Extensions to these education materials, provided by the many contributors to ABOVE AND BEYOND and The Boeing Company's centennial celebration, are located after the Lesson Plans in a special section called "Beyond the Guide." Next, there are two Games and Puzzles related to themes in ABOVE AND BEYOND. One is a word search and the second is a cryptogram. These are excellent activities for your bus ride to and from the exhibition or to assign for extra credit as you see fit. Under "Additional Resources," you will find a recommended reading list, a detailed "Milestones of Aviation" timeline, and a glossary of terms and acronyms.

We know how important it is to be able to justify field trips and document how instructional time is spent outside of your classroom. To that end, this Teacher's Guide is directly correlated to the Common Core State Standards for Mathematics and English Language Arts along with the Next Generation Science Standards and the C3 Framework for Social Studies State Standards. The correlations are organized by content and grade level. You can readily see how they fit into your required curriculum, making it easy to connect a field trip to ABOVE AND BEYOND with your classroom instruction.

All of these education resources can be used before or after your field trip. They will help prepare students for the teachable moments found throughout ABOVE AND BEYOND as well as when you return to school to further explore connections between the themes of the exhibition and your classroom STEAM instruction. Let's get ready for takeoff!

LESSON PLAN 1: MAP IT! PARTNERS AROUND THE WORLD

Teacher Instructions

SOCIAL STUDIES, MATHEMATICS

GEOGRAPHY, DATA COLLECTION, GRAPHING

Boeing's 787 Dreamliner is proof of what happens when the best aerospace engineers from around the world work together. During your class field trip to ABOVE AND BEYOND, your students will learn about the many new ways airplanes and spacecraft are designed and built. Some of these methods, like 3D printing, creative wing shapes, and lighter materials, were used to create the newest 787 passenger jet.

The 787 is a smart airplane from the inside out. Instead of aluminum, special materials called "composites" are used in the wings and body of the plane. Composite materials are much lighter than the metals that are usually used to make airplanes. The structure of Boeing's 787 Dreamliner is more than 50% carbon composite. Lighter planes need less fuel to fly, which is better for the environment.

Teams from four continents contributed parts and expertise to this new kind of airplane. In this activity, your students will practice their geography and graphing skills to see how the global world of science, technology, engineering and math came together to create an airplane of the future that is ready to fly today!

In Part 1, your students will identify individual parts of the Dreamliner. In Part 2, they will answer questions using a diagram of the 787 that illustrates these various parts along with their countries of origin. In Part 3, they will create a bar graph to compare the number of parts for the 787 Dreamliner that are made in each country. Finally, they will locate the countries and states where the Dreamliner is made on maps of the world and of the United States. If your Social Studies textbook does not already provide blackline master maps for you to copy for your class, there are many options online including: www.eduplace.com/ss/maps/, www.worldatlas.com/webimage/testmaps/maps.htm, and www.clickandlearn.cc/FreeBlacklineMaps/FreeBlacklineMaps.htm.

SUPPLIES

- **United States map**
- **World map**
- **Color pencils or markers**

LESSON PLAN 1: MAP IT! PARTNERS AROUND THE WORLD

Answer Key

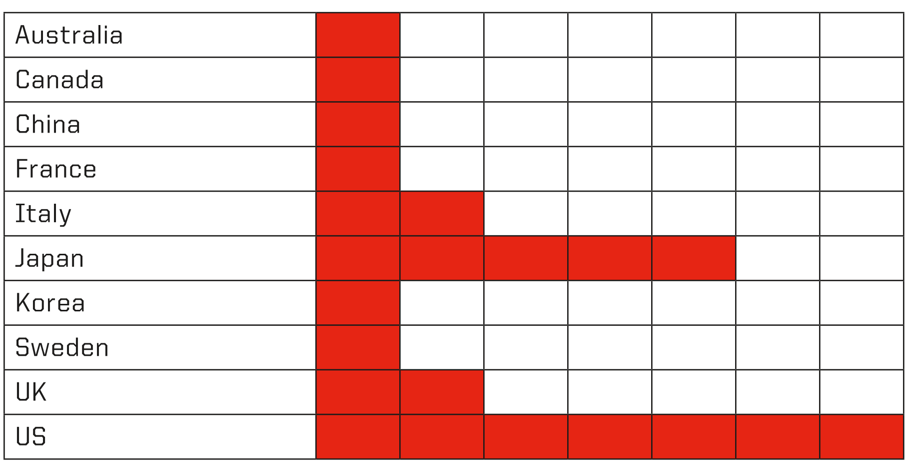
PART 1

1. b
2. e
3. a
4. g
5. c
6. d
7. f
8. h

PART 2

1. Wing tips
2. Chengdu, China
3. Foggia, Italy, and Salt Lake City, Utah/US
4. 3: Italy (center), Japan (forward), USA (aft/SC, forward/KS)
5. Wichita, Kansas, and Nagoya, Japan
6. California, Kansas, Ohio, Oklahoma, South Carolina, Utah, Washington
7. **(a.)** US, Canada; **(b.)** Australia; **(c.)** France, UK, Italy, Sweden; **(d.)** Korea, China, Japan
8. **(a.)** 2/10=1/5; **(b.)** 1/10; **(c.)** 4/10=2/5; **(d.)** 3/10

PART 3



3. 6

4. USA

5. Japan

GO BEYOND!

To realize the breakthrough innovations found in the 787 Dreamliner, Boeing had to rethink the way it makes airplanes. Introduce this revolutionary jetliner to your students by showing them the video 787: Game Changing Innovation at www.boeing.com/features/2012/02/787-game-changing-innovation-02-6-12.page. Can you think of other ways these new materials and methods can be used?

NAME______________________________ CLASS ______________________ DATE__________

MAP IT! PARTNERS AROUND THE WORLD

Student Activity

Boeing's 787 Dreamliner airplane is proof of what happens when the best aerospace engineers from around the world work together. During your field trip to ABOVE AND BEYOND, you will learn about the many new ways airplanes and spacecraft are designed and built. Some of these methods, like 3D printing, creative wing shapes and lighter materials, were used to create the newest 787 passenger jet.

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Teams from four continents contributed parts and expertise to this new kind of airplane. In this activity, you will practice your geography and graphing skills to learn about how the global world of science, technology, engineering and math came together to create an airplane of the future that is ready to fly today!

This is carbon fiber. It is used in the 787's fuselage and wings.

SUPPLIES

- **United States map**
- **World map**
- **Color pencils or markers**

TERMS TO KNOW: **aluminum, composites, expertise**

NAME____ CLASS ____________________________ DATE_________

PART 1: THE PARTS

Student Activity

Match each of these terms to their definitions. Use their positions on the Boeing 787 in the diagram to help you.

1. ____________aft

2. ____________fuselage

3. ____________horizontal stabilizer

4. ____________leading edge

5. ____________nacelle

6. ____________rudder

7. ____________trailing edge

8. ____________wing box

a. part of the tail that keeps the airplane level and keeps it from moving up and down too much

b. rear, or back end

c. part of an airplane that holds the engines, attached to the wings

d. part of the tail that keeps the airplane's nose from swinging from side to side, sometimes called a "vertical stabilizer"

e. body of the airplane, shaped like a long tube

f. rear edge of a wing or propeller

g. front edge of a wing or propeller

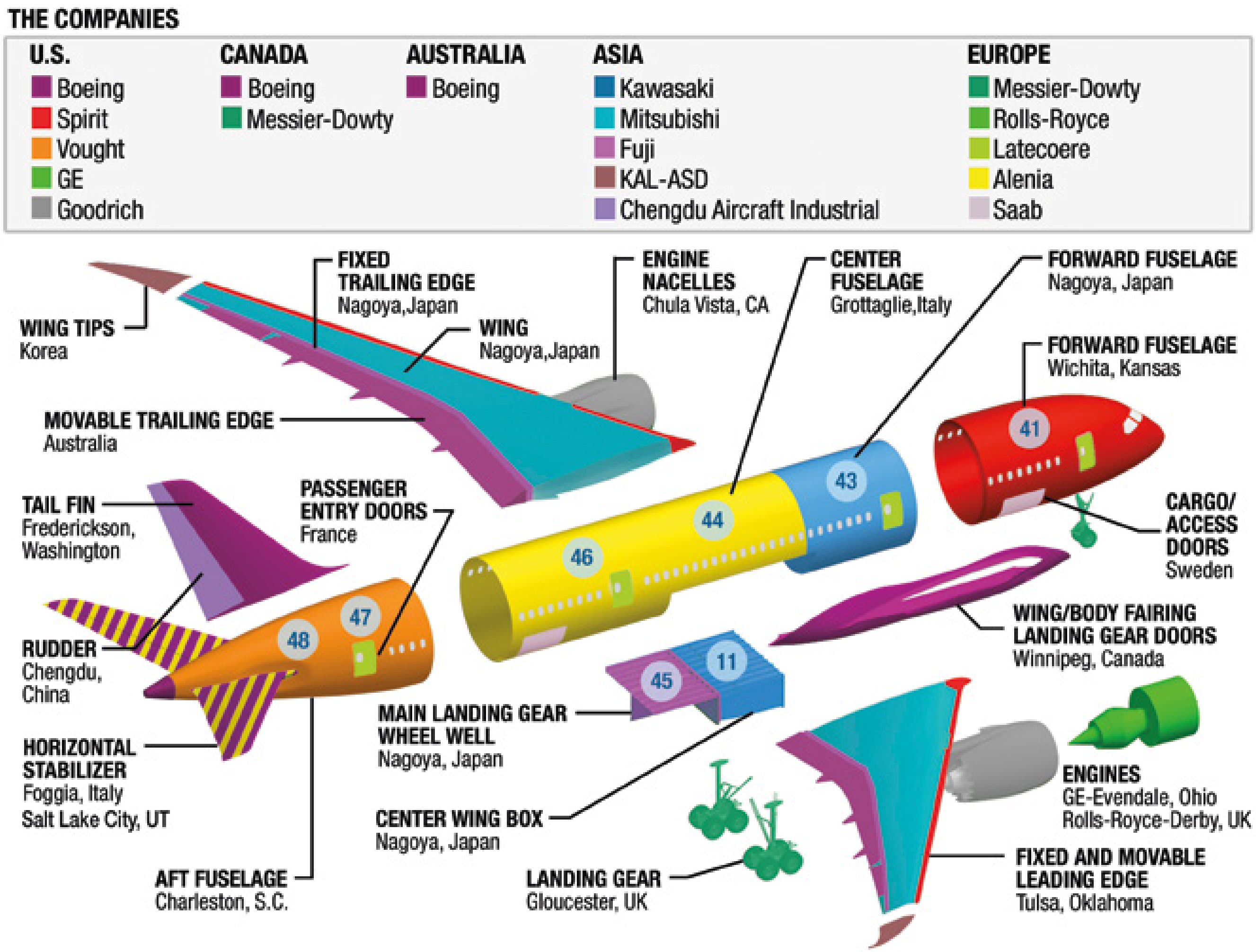
h. section under the fuselage where the wings attach to the body of the airplane

NAME______________________ CLASS ______________________ DATE__________

PART 2: THE DIAGRAM

Student Activity

This diagram shows where different parts of the Boeing 787 are made. Answer the questions below the diagram.



1. Which part of the 787 is made in Korea? ______________________________

2. Where is the rudder made? ______________________________

3. Where is the horizontal stabilizer made? ______________________________

4. How many countries make parts for the fuselage of the 787? Name these countries. (Hint! Look for countries, not states.)

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NAME____ **CLASS** __________________________ **DATE**________

PART 2: RELATIVE SIZE

Student Activity

5. Where are the two forward (front) fuselage sections made? ____

6. Name the seven American states on the diagram. ____

____

7. There are four continents represented on the diagram. Name the countries that are on each of these continents.

(a.) North America: ____

(b.) Australia: ____

(c.) Europe: ____

(d.) Asia: ____

8. Write a fraction that represents how many of the total number of countries from the diagram are on each continent. Reduce to equivalent fractions when possible.

(a.) North America: ____

(b.) Australia: ____

(c.) Europe: ____

(d.) Asia: ____

NAME________________________________ CLASS ____________________ DATE__________

PART 3: THE BAR GRAPH

Student Activity

Use the information from Part 2 to compare the number of parts for the Boeing 787 Dreamliner that are made in each country.

1. Label each row of the bar graph below with the names of the ten countries where parts are built for the 787. Write them in alphabetical order. The first one and last one have been done for you.

2. Count the number of parts made in each country and fill in the bar graph.

Australia							
US							
	1	2	3	4	5	6	7

Number of Parts

3. How many countries produce one part for the 787? ______________________________

4. Which country produces the most parts for the 787? ______________________________

5. Which country produces five parts for the 787? ______________________________

NAME________________________________ CLASS ____________________ DATE______

PART 4: THE MAPS

Student Activity

Use your Social Studies textbook, a computer, or an atlas to complete this section using the maps from your teacher.

1. (a.) Locate your own state on the United States map. Label and color it.
(b.) Locate, label, and color the seven states where parts of the 787 are made.

2. (a.) Label the continents and oceans on the world map.
(b.) Locate, label, and color the ten countries where parts of the 787 are made on the world map.

3. Explain why you think this sentence is either true or false:

The Dreamliner is an example of international cooperation.

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LESSON PLAN 2: WHEN DRAG ISN'T A DRAG

Teacher Instructions

SCIENCE, MATHEMATICS

PHYSICAL SCIENCE, GEOMETRY

If we keep going UP, FASTER, HIGHER, FARTHER, and SMARTER, do ever you wonder how we are going to get back down? One way that might come to mind is a parachute. A parachute is a canopy that fills with air in order to slow down the speed of an object as it is pulled down by gravity. The greater the mass of an object, the faster it falls through air and harder it lands. Parachutes are used to safely bring down everything – and everyone – from high-speed jets to Mars rovers to sky divers who leap out of airplanes just for fun!

As you will learn during your class visit to ABOVE AND BEYOND, parachutes are part of some of the most high-tech aerospace craft built today. They are used on the CST-100, the Boeing Crew Space Transportation vehicle featured in FARTHER. Someday soon, NASA will use this capsule to transport people and cargo to the International Space Station. The parachutes will help it land safely after returning to Earth. Parachutes are also used sideways! They help supersonic fighter jets slow down quickly on a short runway. Sometimes these are called "drogue chutes."

A parachute uses air resistance, or drag, to slow something down. Usually, aerospace engineers want to overcome the force of drag in order to go forward or upward. However, a parachute uses the force of drag for a safe landing.

The parachutes used in the aerospace industry to land jets and space capsules are almost always round or dome-shaped. However, those used by skydivers are usually rectangular or square. Why are there different shapes? What difference does the shape of the parachute make in the job it is supposed to do? In this activity, your students will work in groups to make and test model parachutes to discover the connection between form and function.

After trials with both a circular and a rectangular canopy, students should come to the conclusion that the round ones fall more slowly, which is why they are used to slow the landings and descents of heavy aircraft and spacecraft. The supplies listed are for each group of students working together. For younger grades, you can precut the 12 pieces of string or yarn. For older students, the activities in this lesson plan can be used to introduce the concepts of opposing force and Newton's Laws, which they will begin learning about in Middle School.

SUPPLIES

- **Scissors**
- **1 gallon-size plastic bag (like Ziploc®)**
- **Ruler**
- **Permanent marker (like Sharpie®)**
- **Tape**
- **Hole puncher**
- **16 pieces of string or lightweight yarn, 12" long each**
- **2 wooden clothespins**
- **Balcony, stairwell, or stepladder**
- **Stopwatch**

LESSON PLAN 2: WHEN DRAG ISN'T A DRAG

Answer Key

PART 3

1. Answers will vary based on the height from which the parachutes are dropped.
2. Answers will vary based on the height from which the parachutes are dropped.
3. **(a.)** rectangle; **(b.)** circle
4. Answers will vary based on the student's hypothesis from Part 2.
5. **(a.)** 50 square inches. **(b.)** Answers will vary and may mention that if one was bigger or smaller than the other, the surface area could have a greater effect on the speed of the descent than the shape does.
6. Answers will vary and may include the weight the materials, height for the drop, or the length of the strings.
7. Answers will vary and may mention that the path of the rectangular one was straighter while the circular one seemed to veer off course.
8. Circle. The purpose of the chute is to slow the descent for a gentler landing and round canopies land more slowly than rectangular ones.
9. Answers will vary and may include other large items such as cargo/supplies.
10. "Velocity" means speed and a low-velocity chute would descend slowly.

GO BEYOND!

Show your students how the CST-100 uses its three massive parachutes to safely land from 10,000 feet above the Nevada desert in the video Boeing CST-100 Parachute Drop Test: www.youtube.com/watch?v=ZZ-D3HPyBYU. The capsule's three main parachutes deploy to slow its descent before it lands on six airbags. Did you notice their shape?

NAME________________________ CLASS ________________________ DATE__________

WHEN DRAG ISN'T A DRAG

Student Activity

If we keep going UP, FASTER, HIGHER, FARTHER, and SMARTER, do ever you wonder how we are going to get back down? One way that might come to mind is a parachute. A parachute is a canopy that fills with air in order to slow down the speed of an object as it is pulled down by gravity. The greater the mass of an object is, the faster it falls through air and the harder it lands. Parachutes are used to safely bring down everything – and everyone – from high-speed jets to Mars rovers to sky divers who leap out of airplanes just for fun!

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Parachutes are also used sideways! They help supersonic fighter jets, like the one you can design at the Full Throttle challenge in FASTER, slow down quickly on a short runway. Sometimes these are called "drogue chutes."

In the 1950s, this F-86 Sabre Jet used a drogue chute to help it land. © Boeing. All Rights Reserved.

A parachute uses air resistance, or drag, to slow something down. Usually, aerospace engineers want to overcome the force of drag in order to go forward or upward. However, a parachute uses the force of drag for a safe landing.

The parachutes used in the aerospace industry to land jets and space capsules are almost always round or dome-shaped. However, those used by skydivers are usually rectangular or square. Why are there different shapes? What difference does the shape of the parachute make in the job it is supposed to do? Your group will make and test model parachutes with different shapes to find out why!

SUPPLIES

- **Scissors**
- **1 gallon-size plastic bag (like Ziploc®)**
- **Ruler**
- **Permanent marker (like Sharpie®)**
- **Tape**
- **Hole puncher**
- **16 pieces of string or lightweight yarn, 12" long each**
- **2 wooden clothespins**
- **Balcony, stairwell, or stepladder**
- **Stopwatch**

TERMS TO KNOW: **canopy, capsule, counteract, descend, dome, drag, drogue, velocity**

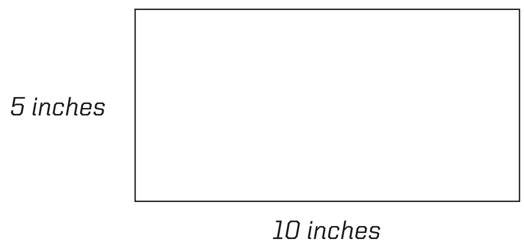
NAME______________________________ CLASS ______________________ DATE__________

PART 1

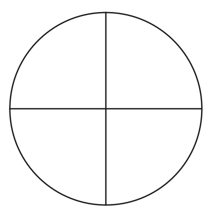
Student Activity

1. Use the scissors to cut open the seams of the plastic bag on all three sides. Cut off the strip with the Ziploc closure, too. You will have two square pieces of plastic after you cut the bag apart.

2. With the ruler and marker, measure and draw a rectangle on one piece of plastic that is 10 inches long by 5 inches wide.



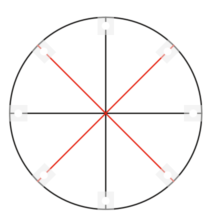
3. With the ruler and marker, make a circle with an 8-inch diameter on the second piece of plastic. To make the circle, start by drawing an 8-inch by 8-inch cross.



4. Cut out the rectangle and the circle you drew on the plastic. These are the canopies for your parachutes.

5. Fold a piece of tape over each of the four corners of your rectangle. Fold a piece of tape at the midpoint of each side of your rectangle. Punch a hole in each of the four corners and the four midpoints, through the tape and plastic. The tape will keep the yarn from ripping through your parachute.

6. With the ruler and marker, add an X to your circle. Fold a piece of tape over at each of the eight points where your lines meet the edge of the circle. Punch a hole in each of the eight pieces of tape.



7. Tie one 12" piece of string or yarn with a double knot through each of the holes you made in your canopies.

8. For both the rectangle and the circle, knot the ends of the parachute strings together. Attach a wooden clothespin at the end.

NAME______________________________ CLASS ______________________ DATE________

PART 2

Student Activity

1. First, form your hypothesis for this experiment. Which parachute shape do you think will fall faster, rectangular or circular? Which do you think will fall more slowly? Why?

____

____

____

A member of the US Navy Parachute Demonstration Team, the "Leap Frogs" returns to earth after a successful jump. US Air Force photo, released.

2. Your teacher will climb to the top of the stepladder or a member of your group will climb to the top of the stairwell or balcony with the two parachutes. You or another member of the group will stand at the bottom with the stopwatch.

3. The person at the top of the ladder will release the rectangular parachute while the other person times how many seconds it takes to reach the ground. Record the length of time in the chart below for Trial 1.

4. Repeat step #2 for the round parachute.

5. Drop each parachute two more times and record their times in the chart for Trial 2 and Trial 3.

	Rectangle	Circle
Trial 1		
Trial 2		
Trial 3		

NAME______________________ **CLASS** ______________________ **DATE**__________

PART 3

Student Activity

1. To calculate the average time it took the rectangular parachute to fall, add its three trial times together. Divide that total by 3. What was the average fall time for the rectangular canopy?

2. To calculate the average time it took the circular parachute to fall, add its three trial times together. Divide that total by 3. What was the average fall time for the circular canopy?

3. (a.) Which shape fell more quickly? **(b.)** Which shape fell more slowly?

4. Was your hypothesis correct? Why or why not?

5. The surface areas of the two parachutes are constant, which means they are the same for both even though the shapes are variable, or different. **(a.)** Based on what you know about the dimensions of the rectangular parachute, what are their surface areas? **(b.)** Why does the area of the parachutes matter in this experiment?

NAME______________________ CLASS ______________________ DATE__________

PART 3

Student Activity

6. Name at least one other constant, or condition that is the same, for the two parachutes in this experiment.

7. Did you observe any other differences in the way the two parachutes descended?

8. Which shape would provide a softer and safer landing for an air craft or spacecraft? Why?

9. What other situations can you think of where a circular parachute would be a better choice than a rectangular one?

10. Why do you think large, round parachutes are sometimes called “low-velocity” chutes?

SCIENCE, ENGINEERING

EARTH & SPACE SYSTEMS, DESIGN PROCESS

LESSON PLAN 3: BETTER SUITED FOR MARS

Teacher Instructions

After decades of innovations and inventions in science, technology, engineering and math, humans will be able to travel above and beyond the Earth – all the way to Mars. But getting there is only half the battle! Once they land, people will need places on Mars that mimic living conditions here on Earth. Mars has enough gravity to keep people on the surface, but it does not have an atmosphere like ours. It is much colder than Earth, has too much carbon dioxide in its air, and gets dangerous levels of radiation from the sun. We will need to protect ourselves from these elements in order to survive on the Red Planet.

During your field trip to ABOVE AND BEYOND, your students can plan their own missions to see if they have what it takes to complete the Marathon to Mars featured in the FARTHER gallery. Meanwhile, there are people already practicing in simulated Martian environments right here on Earth! Settings like a desert in Utah or a volcano in Hawaii serve as a pretend Mars. "Astronauts" spend anywhere from a week to a few months living and working there as though they truly are on Mars. They hope to learn about the best ways to grow plants, use solar energy, and live with strangers in very small spaces.

They can also try out different types of spacesuits to use on Mars. If the humans of the future want to go out for a walk on Mars, they will need special outerwear to protect them. Some new options like flexible, "second-skin" suits are featured at ABOVE AND BEYOND. Hopefully, these will be more comfortable and user-friendly than traditional, bulky astronaut suits.

What do you think a Mars mission suit will look like? What capabilities and tools will it need? Would the spacesuits we have today work on Mars? Ask your students to keep these questions in mind as they complete several tasks while wearing a simulated spacesuit and then make recommendations to improve it.

The supplies listed are for one simulated spacesuit per group. Groups should have four to six members. The garments are to be donned over the students' own clothes, except for their shoes. Most of the supplies can be found at a local thrift store or perhaps in your own or a colleague's closet! Use the disinfecting wipes for the head items after each student. If you prefer, the head gear can be omitted entirely without affecting the outcome of the activity.

Feel free to improvise, omit, or substitute tasks and activities to best suit your class. For example, you can reduce the number of safety pins or use paper clips to make it easier. Instead of attaching the nuts and bolts, students can pick up a specific number of toothpicks or marbles to test their dexterity. Toothpicks or skewers can also be used for stringing life savers or large beads together. Look around your school at the supplies readily available. Get inspired! Remind students to move carefully once they are suited up, in case they lose their balance or overheat. One of the roles in each group is that of a Safety Engineer, who will spot the "astronaut" during his or her mission.

For younger grades, or to reduce the number of supplies needed, you can create stations around the room that can be visited in any order. Each group will go to a station to test a component of the suit, one at a time: torso, hands, lower body, feet, and head. In this scenario, the students will choose amongst the members of their own group to decide who gets to try each challenge.

After experiencing some of the limitations inherent in an astronaut suit, students will make recommendations on how to build a better one. Finally, each team will present their design to the class, who will then vote on the best one. You can tell your students that even NASA used a voting process to help select a suit for Mars: www.nasa.gov/content/nasa-s-next-prototype-spacesuit-has-a-brand-new-look-and-it-s-all-thanks-to-you/#.VOZTOy7IxWO. The "Z-2" suit was chosen by the public after it beat out two other designs by 63% of the vote!

SUPPLIES

For each group's simulated Martian suit:

- **1 pair of large, elastic-waist pants (like sweatpants)**
- **2 sections of 4" diameter (standard) dryer vent hose (dryer vent hose is commonly available at hardware stores or online in 4" by 5' pieces that can be cut in half to provide both sections, or in individual 4" by 2' sections)**
- **2 large pairs of thick socks (in addition to student's own socks)**
- **1 pair of large galoshes or boots**
- **2 large sweaters**
- **1 large winter puffy coat**
- **2 pairs of gloves, one extra-large pair of garden or work gloves and one smaller pair of any kind to fit inside the larger pair**
- **1 helmet (football, lacrosse, or hockey)**
- **1 pair of sunglasses or safety goggles (if the helmet already has a visor, you can omit this)**

Additional, for each group:

- **Disinfecting wipes**
- **Duct tape**
- **Scissors**
- **Stopwatch or clock with second hand**
- **8 closed safety pins in a Ziploc baggie**
- **Nuts and bolts, 3 different sizes, separated**
- **Play tunnel (1 per class, groups can rotate)**

LESSON PLAN 3: BETTER SUITED FOR MARS

Answer Key

PART 3

1. Answers will vary by group but should reflect their results in the table from Part 2.
2. Answers will vary by group but should reflect their results in the table from Part 2.
3. Answers will vary by group depending on their astronaut's experience, but may include a better-fitting suit, tools to use, or no gloves.
4. Answers will vary by group and may include oxygen source, way to use the restroom, cooling system/temperature control, adjusting the size of the suit, communication systems, or a way to eat.

PART 4

Each group's final product will vary based on their own ideas and experiences. Assess for completion against the checklist provided in the Student Activity pages.

GO BEYOND!

Kavya Manyapu is a Boeing engineer who dreams of becoming an astronaut. For insight on the two weeks she spent at a simulated Martian environment, show your class Mars Attracts: www.boeing.com/features/2014/07/bds-mars-attracts-07-02-14.page. That's some science camp!

NAME________________________________ CLASS ______________________ DATE__________

BETTER SUITED FOR MARS

Student Activity

After decades of innovations and inventions in science, technology, engineering and math, humans will probably be able travel to Mars. But getting there is only half the battle! People need places on Mars that mimic living conditions here on Earth. Mars has enough gravity to keep people on the surface, but it does not have an atmosphere like ours. It is much colder than Earth, has too much carbon dioxide in its air, and gets dangerous levels of radiation from the sun. We will need to protect ourselves from these elements in order to survive on the Red Planet.

During your field trip to ABOVE AND BEYOND, you can plan your own mission and see if you have what it takes to complete the Marathon to Mars when you get to the FARTHER gallery. Meanwhile, there are people already practicing in simulated Martian environments right here on Earth! Settings like a desert in Utah or a volcano in Hawaii serve as a pretend Mars. "Astronauts" spend anywhere from a week to a few months living and working there as though they truly are on Mars. They hope to learn about the best ways to grow plants, use solar energy, and live with strangers in very small spaces.

This illustration shows how Boeing's and NASA's space launch system and Orion crew capsule might look on their way to Mars - a journey that will take about six months. © Boeing. All Rights Reserved.

They can also try out different spacesuits to use on Mars. If the humans of the future want to go out for a walk on Mars, they will need special outerwear to protect them. Some new options like flexible, "second-skin" suits are featured at ABOVE AND BEYOND. Hopefully, they will be more comfortable and user-friendly than traditional, bulky astronaut suits.

What do you think a Mars mission suit will look like? What capabilities and tools will it need? Would the spacesuits we have today work on Mars? Keep these questions in mind as your group completes several tasks while wearing a simulated spacesuit, and then makes recommendations for how to improve it.

TERMS TO KNOW: **capabilities, hardware, innovations, mimic, prototype, radiation, simulated, tasks, torso**

NAME________________________ CLASS ________________ DATE______

PART 1: GET READY

Student Activity

In Mars simulations and real space missions, people work together as a team. Assign the following roles to the members of your group.

Position	Job	Name(s)
Safety Engineer (1 or 2 students)	Makes sure the astronaut is safe during tasks and exercises	
Equipment Engineer (1 or 2 students)	Helps dress the astronaut, sets up equipment	
Astronaut	Wears the suit, performs tasks and exercises	
Data Engineer	Collects and records results	

Equipment Engineers: Use this check list to make sure your team has all the supplies necessary to complete this mission. The items below might not look much like the parts of a spacesuit, but they will mimic the way it feels to move and work in one!

Lower Body & Feet	Torso & Hands	Head & Face
2 pairs of socks 1 pair of pants 2 sections of hose 1 pair of boots	2 sweaters 1 winter coat 2 pairs of gloves	1 helmet 1 pair of sunglasses or safety goggles

Additional Supplies: duct tape, scissors

Astronaut: Begin fully dressed in your own clothes but remove your shoes. Your Equipment Engineers will assist you. Spacesuits are made of many layers!

1. Pull on the socks over your socks.
2. Put on the pants over your pants.
3. Slide a piece of hose over each leg and up past the knee. Secure the hose to the pants with tape.
4. Step into the boots.
5. Wear the sweaters over your own shirt.
6. Put on the winter coat and zip/button it closed.
7. Wear the sunglasses or goggles.
8. Put the helmet on.
9. Put on the two pairs of gloves, beginning with the smaller pair.

NAME______________________________ CLASS ____________________ DATE__________

PART 2: TESTING

Student Activity

An Equipment Engineer dressed in his or her own clothes will perform the same tasks and exercises alongside the Astronaut, for comparison. The Data Engineer will record the results in the "Mars" column for the Astronaut and in the "Earth" column for the Engineer in the data chart below. Use the stopwatch to time how long each task takes.

Safety Engineer: Stay next to the Astronaut at all times.

Task #1: Jumping Jacks
Complete 15 jumping jacks.

Task #2: Pushups
Begin in standing position. Complete 15 pushups. Return to standing.

Task #3: Tunnel
Crawl through the tunnel, which is similar in size to the entrance to a spacecraft. Begin and end in a standing position.

Task #4: Safety pins
Unzip the baggie of safety pins, open each pin, link the pins together like a bracelet, return them to the baggie, and seal the baggie.

Task #5: Writing
Write the following information from NASA, as dictated by the Equipment Engineer: The temperature on Mars may range from a high of about 70 degrees Fahrenheit at noon at the equator in the summer, or a low of about -225 degrees Fahrenheit at the poles.

Task #6: Bolts
Begin with the nuts and bolts separated and lying on the floor. Pick up all of the pieces and connect the nuts to their bolts.

Data Engineer: Record the time results here.

Tasks	Mars	Earth
1. Jumping jacks		
2. Pushups		
3. Tunnel		
4. Safety pins		
5. Writing		
6. Bolts		

On Mars, astronauts will not need to move around with an MMU, or manned maneuvering unit, attached to their suits like the one seen here.

SUPPLIES

- **Stopwatch or clock with a second hand**
- **Tunnel**
- **8 closed safety pins in a Ziploc baggie**
- **Paper and pencil**
- **3 nut and bolt sets, separated**

NAME____________________ **CLASS** ____________________ **DATE**__________

PART 3: ASSESS

Student Activity

Once the Astronaut has removed the suit, your team will discuss the mission's results and answer these questions.

1. Which task had the greatest time difference between Mars and Earth?

2. Which task had the least time difference between Mars and Earth?

3. Which was the most uncomfortable or difficult task to complete in the Mars suit? Why? What could have helped?

4. What else might an astronaut need to do while exploring Mars in a spacesuit? List two additional tools or pieces of equipment that would be useful.

NAME______________________________ CLASS ______________________ DATE__________

PART 4: REDESIGN

Student Activity

Once on Mars, geologists will study its rocks. They hope to learn more about any resources that might be useful, and whether other life forms were ever there.

Now that you have experience conducting experiments in a spacesuit, your group will make recommendations for how to build a better one – a prototype suit to be worn by the first Mars explorers!

You will need to include the basic equipment used for research in space. Remember that your design must also provide warmth (but not too much!), oxygen, and protection from radiation while still allowing astronauts to move around on Mars. Begin your planning with with the basic requirements listed under Research Tools, below. Use the checklist as you add them.

Based on the results of your earlier spacesuit mission, complete the following steps on separate paper.

Step 1: Sketch the front and back view of your design. Label the diagram to show where each of its features will be and where your equipment will be stored.

Step 2: Write out an explanation for each feature on your suit, describing how it will work.

Be prepared to present your new and improved Mars suit to the class as a team. Each group will then vote on the best design. Are you ready to suit up for this challenge?

RESEARCH TOOLS

- **A camera**
- **Binoculars**
- **A way to bring rock samples back to a laboratory**
- **Navigation system**
- **Communication system**
- **Flashlight**
- **Way to record observations**
- **Hardware (hammer, wrench, screwdriver, pliers, etc.)**

LESSON PLAN 4: LOGICAL CAREERS

Teacher Instructions

MATHEMATICS

EQUALITIES & EQUATIONS, LOGIC

In this lesson, your class will read a short story about a field trip to ABOVE AND BEYOND, then solve a logic puzzle that matches four fictitious students to the STEAM-related careers they hope to have some day at aerospace companies around the country. Logic puzzles are a fun way to practice mathematical skills without using any numbers! Your students will be making deductions and establishing equalities similar to those used in algebra: if A = B and B = C, then A = C.

To solve the puzzle, read each clue carefully. Use the chart to help you keep track of what you do and do not know about each student's career plans. Because each student in the puzzle can only have one career, and each career can only have one student, you will use the process of elimination to solve the mystery.

If a clue tells you that a person does NOT like something, then place an X in the box for that person and that career. When you are able to match a student to his or her career choice, put a checkmark in that box.

For example, the first clue says that Lorraine has no interest in working with submarines because she does not like the ocean. Because we now know that Lorraine's career choice cannot involve the Echo Ranger submarine, there should be an X in the box where the row with her name meets the column for the Echo Ranger. This first clue has been marked on the answer grid for you.

Keep reading the clues. Write an X on the answer grid for what you know is not true and use a checkmark for what you know is true until you have matched all the students with their future aerospace careers. Perhaps one of your own students will enjoy a career like these one day!

LESSON PLAN 4: LOGICAL CAREERS

Answer Key

Ann = CST-100

Mike = 777

Lorraine = Chinook

Jim = Echo Ranger

GO BEYOND!

For an inside look at the inspiring innovations dreamed and manufactured by committed Boeing employees all over the world, watch Who We Are: In the Words of Boeing Employees: https://www.youtube.com/watch?v=gduO5M3LnPY. There may be a Boeing volunteer in your area available to speak to your class about STEAM in real life!

NAME________________________________ CLASS ____________________ DATE__________

LOGICAL CAREERS

Student Activity

In this lesson, you will read a short story about a field trip to ABOVE AND BEYOND, then solve a logic puzzle that matches four students to the careers they hope to have some day at aerospace companies around the country.

To solve the puzzle, read each clue carefully. Use the chart to help you keep track of what you do and do not know about each student's career plans. Because each student in the puzzle can only have one career, and each career can only have one student, you will use the process of elimination to solve the mystery.

If a clue tells you that a person does NOT like something, then place an X in the box for that person and that career. When you are able to match a student to his or her career choice, put a checkmark in that box.

For example, the first clue says that Lorraine has no interest in working with submarines because she does not like the ocean. Because we now know that Lorraine's career choice cannot involve the Echo Ranger submarine, there should be an X in the box where the row with her name meets the column for the Echo Ranger. This first clue has been marked on the answer grid for you.

Keep reading the clues. Write an X on the answer grid for what you know is not true and use a checkmark for what you know is true until you have matched all the students with their future careers. Are you inspired to join them?

TERMS TO KNOW: **aerospace, career, elimination, emissions, grid, industry**

NAME________________________ CLASS ____________________ DATE__________

LOGICAL CAREERS

Student Activity

The Story

A class is on the bus, returning to school from a field trip to ABOVE AND BEYOND. After learning so much about the future of the aerospace industry, four students talk about the careers they hope to have in the aerospace industry when they grow up.

One student wants to help design the CST-100 in Texas, which will take astronauts to the International Space Station. Another student wants to be a test pilot in Pennsylvania for the Chinook helicopters. The third student loves the ocean and wants to work with Echo Ranger, which is a robotic submarine tested off the coast of California. The final student wants to become an environmental engineer and reduce carbon dioxide emissions by working with the next generation of eco-friendly 777 jets built in Washington.

Students

- Lorraine
- Ann
- Mike
- Jim

Careers and locations

- 777 jet in Washington
- CST-100 space capsule in Texas
- Echo Ranger submarine in California
- Chinook helicopter in Pennsylvania

Use the clues below to match each student to her or his future career.

The Clues

1. Lorraine has no interest in submarines because she does not like the ocean.

2. Jim does not want to live in the state of Washington.

3. Lorraine either wants to live in California or be a Chinook test pilot in Pennsylvania.

4. Ann, who has always been fascinated by space travel, hopes to work on the CST-100 in Houston, Texas.

	777	CST-100	Chinook	Echo Ranger
Lorraine				X
Ann				
Mike				
Jim				

NAME____________________ **CLASS** ________________ **DATE**________

THE SEARCH IS ON: WOMEN PIONEERS IN AVIATION

Student Activity

These fascinating women are responsible for many key advancements in the history of flight, including those who achieved significant "firsts" in aviation. For example, do you know which of these innovators was the first woman in America to get a pilot's license? Or the first American to make a solo flight across the Atlantic in an aircraft?

Search for the women's last names, shown in all capital letters, in the list below. You might be inspired to research the biographies of some of these early STEM champions. They set the bar pretty high!

Willa **BROWN**
Bessie **COLEMAN**
Amelia **EARHART**
Harriet **QUIMBY**
Mary **RIDDLE**
Betty **SKELTON**

C	A	K	F	F	B	Q	T	B
N	O	X	R	Q	N	S	V	N
U	W	L	A	U	Y	H	W	C
R	E	F	E	I	Y	O	D	R
I	K	Z	L	M	R	M	Y	A
D	A	P	O	B	A	E	C	R
D	T	N	B	Y	W	N	L	N
L	M	S	K	E	L	T	O	N
E	A	R	H	A	R	T	C	E

Willa Brown was the first African-American woman to receive a commission as a lieutenant in the US Civil Air Patrol. US National Archives and Records

NAME________________________________ CLASS ________________________ DATE__________

BUILDING A CRYPTOGRAM

Student Activity

The Boeing Company began in 1916. Two years earlier, its founder Bill Boeing made the famous statement in this puzzle. It later became the company motto.

This puzzle is a cryptogram, a code in which letters have been replaced by numbers. You will decipher the sentence to reveal his quote. Hints are provided and one has been filled in to get you started.

A	B	C	D	E	F	G	H	I	J	K	L	M
5	21							24		26	13	

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
9				19					1			

___		___	___	___	N	___		___	___
24		11	2	24	9	26		1	8

___	___	N		___	___	___	___	___
18	5	9		21	12	24	13	14

___		___	___	___	___	___	___
5		21	8	11	11	8	19

___	___	___	N	___	.
4	13	5	9	8	

THE SEARCH IS ON: WOMEN PIONEERS IN AVIATION AND BUILDING A CRYPTOGRAM

Answer Key

Word Search

BROWN (5,5,NE)

COLEMAN (1,1,SE)

EARHART (1,9,E)

QUIMBY (5,2,S)

RIDDLE (1,4,S)

SKELTON (3,3,E)

C	A	K	F	F	B	Q	T	B
N	O	X	R	Q	N	S	V	N
U	W	L	A	U	Y	H	W	C
R	E	F	E	I	Y	O	D	R
I	K	Z	L	M	R	M	Y	A
D	A	P	O	B	A	E	C	R
D	T	N	B	Y	W	N	L	N
L	M	S	K	E	L	T	O	N
E	A	R	H	A	R	T	C	E

Cryptogram: "I think we can build a better plane."

A	B	C	D	E	H	I	K	L	N	P	R	T	U	W
5	21	18	14	8	2	24	26	13	9	4	19	11	12	1

BEYOND THE GUIDE: LEARNING EXTENSIONS FOR TEACHERS, STUDENTS AND FAMILIES

Take advantage of these special learning extensions, created to align with ABOVE AND BEYOND exhibition content and themes.

IRIDESCENT: STUDENT AND FAMILY ENGINEERING DESIGN CHALLENGES

www.curiousitymachine.org

Iridescent's Curiosity Machine is a community of scientists, engineers, and children who create, invent, and engineer together. Their design challenges are open-ended and appropriate for children in grades K-12. With the support of a parent or mentor, even your youngest students can navigate the Curiosity Machine website, complete and upload their engineering designs, receive feedback from an online engineer-mentor and become the next generation of aerospace explorers. In addition, the design challenges are grouped into units and align with next generation science standards with new curriculum being added regularly. Through a special grant from Boeing, Iridescent has created design challenges based on the educational themes explored in ABOVE AND BEYOND. Use them all!

THE DOCUMENTARY GROUP

The Documentary Group's multipart documentary series, *The Age of Aerospace*, tells the story of the last 100 years of aviation through the lens of an aerospace giant, The Boeing Company, which today is the largest aerospace company in the world, having acquired or merged with many of the most important aerospace companies of the last century: McDonnell, Douglas, North American Aviation, Rockwell, Piaseki/Vertol and Hughes Satellites Systems. The story of these companies is the story of men and women whose intelligence and imagination were focused on engineering the future and thereby transforming our lives.

PBS LEARNINGMEDIA

www.pbslearningmedia.org

In addition to the documentary series, The Documentary Group has partnered with WGBH Boston, America's preeminent public broadcaster, to create a suite of educational resources that will be distributed on PBS's educational service, PBS LearningMedia. Using video and interactive media, these resources will give students a window into what it takes to make something fly, the scientific concepts that make flight possible, the history of aviation, as well as introduce them to some of the people who build the machines that take us into the sky. These resources support the middle and high school Engineering Design ideas and practices of the Next Generation Science Standards and state standards.

TEACHING CHANNEL: PROFESSIONAL DEVELOPMENT

www.teachingchannel.org

Teaching Channel is a thriving online community where educators can watch, share, and learn diverse techniques to help every student grow. It is a nonprofit video showcase of inspiring and effective teaching practices. Their resources provide a unique opportunity to offer professional development to your local educators as part of their experience at ABOVE AND BEYOND. Developed through a special grant with the support of Boeing, Teaching Channel engaged 20 Boeing engineers and 10 teachers to create 10 science units for grades 4-8 that align with the exhibition content, national standards and the educational themes featured in Above and Beyond.

NASA: "MUSEUM IN A BOX"

www.aeronautics.nasa.gov/mib.htm

The "Museum in a Box" program brings the physical sciences of flight to students in grades pre-K-12. These self-contained activities provide hands-on/minds-on lessons with an aeronautics theme to inspire future scientists, mathematicians and engineers. This group of exercises provided by NASA is perfectly suited for add-on programming at your venue. Think about which of these topics you want to highlight, where they best fit in to your overall plan, and how you can use them – singularly or collectively – to maximize the learning potential of ABOVE AND BEYOND.

Education resources and programming for ABOVE AND BEYOND are made possible by Boeing in celebration of its centennial and its ongoing commitment to prepare and inspire the next generation to dream, design, and build something better for the next century.

GO THE EXTRA MILE: ADDITIONAL RESOURCES

THE ULTIMATE FLIGHT LIBRARY: RECOMMENDED READING

Check this out – of your community or school library! Before or after a class trip to ABOVE AND BEYOND, you will want to use these lists as a starting point to create your own "Ultimate Flight Library." Explore the inspirational people, mind-boggling science, real-life math, and fascinating history that come together to make dreams take flight. To capitalize on individual student interests, these lists are divided by grade level based on reading abilities: Elementary School (Grades 3 – 5) and Middle School (Grades 6 – 8).

ELEMENTARY SCHOOL

Grades 3 – 5

Arnold, Nick. *Flying Machines.* Candlewick Press, 2014.

Baggett, Denise. *Smithsonian Discover: Space.* Silver Dolphin Books, 2014.

Basher, Simon. *Basher Basics: Space Exploration.* Kingfisher, 2013.

Becker, Helaine. *Zoobots: Wild Robots Inspired by Real Animals.* Kids Can Press, 2014.

Buckley, Jr., James. *Who Were the Wright Brothers? (Who Was...?).* Grosset & Dunlap, 2014.

Fleming, Candace. *Amelia Lost: The Life and Disappearance of Amelia Earhart.* Schwartz & Wade, 2011.

Gates, Phil. *Nature Got There First: Inventions Inspired by Nature.* Kingfisher Second Edition, 2010.

Hardesty, Von. *Flight (Insiders).* Simon & Schuster Books for Young Readers, 2011.

Lee, Pascal. *Mission: Mars.* Scholastic Inc., 2013.

Murphy, Pat. *Air Power: Rocket Science Made Simple.* Klutz, 2014.

Nahum, Andrew. *Flight (DK Eyewitness Books).* DK Children, 2011.

Parker, Steve. *Tabletop Scientist –The Science of Air: Projects and Experiments with Air and Flight.* Dover Publications, 2013.

Portman, Michael. *Fighter Jets (Military Machines).* Gareth Stevens Publishing, 2013.

Prior, Jennifer. *Take Off! All About Airplanes (TIME for Kids Nonfiction Readers).* Teacher Created Materials, 2011.

Rice, William B. *Blast Off to Space Camp (TIME for Kids Nonfiction Readers).* Teacher Created Materials, 2011.

Scholastic. *Drones: From Insect Spy Drones to Bomber Drones.* Scholastic Paperback Nonfiction, 2014.

Stine, Megan. *Who Was Sally Ride?* Grosset & Dunlap, 2013.

The Exploratorium. *Exploralab.* Weldon Owen, 2013.

MIDDLE SCHOOL

Grades 6 – 8

Aguilar, David A. *Space Encyclopedia: A Tour of Our Solar System and Beyond.* National Geographic Kids, 2013.

Bortz, Fred. *Seven Wonders of Space Technology.* 21st Century, 2011.

Case, Betsy. *Trailblazers: The Women of The Boeing Company.* Ironwood Lithographics, 2014.

Collins, John M. *The New World Champion Paper Airplane Book: Featuring the World Record-Breaking Design, with Tear-Out Planes to Fold and Fly.* Ten Speed Press, 2013.

Gibson, Karen Bush. *Women Aviators: 26 Stories of Pioneer Flights, Daring Missions, and Record-Setting Journeys (Women of Action).* Chicago Review Press, 2013.

Gibson, Karen Bush. *Women in Space: 23 Stories of First Flights, Scientific Missions, and Gravity-Breaking Adventures (Women of Action).* Chicago Review Press, 2014.

Gregory, Josh. *Aircraft Pilot (Cool Military Careers).* Cherry Lake Publishing, 2012.

Hardesty, Von. *Epic Adventure: Epic Flights.* Kingfisher, 2011.

Holden, Henry M. *The Coolest Job in the Universe: Working Aboard the International Space Station (American Space Missions-Astronauts, Exploration, and Discovery).* Enslow Publishing Inc., 2012.

McMahon, Peter. *Space Tourism (Machines of the Future).* Kids Can Press, 2011.

Mercer, Bobby. *The Flying Machine Book: Build and Launch 35 Rockets, Gliders, Helicopters, Boomerangs, and More (Science in Motion).* Chicago Review Press, 2012.

Mooney, Carla. *Rocketry: Investigate the Science and Technology of Rockets and Ballistics (Build It Yourself).* Nomad Press, 2014.

Nardo, Don. *Drones (Military Experience: In the Air).* Morgan Reynolds Publishing, 2013.

Rooney, Anne. *Aerospace Engineering and the Principles of Flight (Engineering in Action).* Crabtree Publishing Co., 2013.

Rusch, Elizabeth. *The Mighty Mars Rovers: The Incredible Adventures of Spirit and Opportunity (Scientists in the Field Series).* HMH Books for Young Readers, 2012.

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TIME CAPSULE: MILESTONES OF AVIATION

Use this detailed timeline of significant moments in aerospace innovation to incorporate the science, technology, engineering, art, and math of flight into your daily lesson plans. These achievements are connected to the wide variety of themes, events, people, and topics featured in this Teacher's Guide and within the galleries at ABOVE AND BEYOND.

This information can be used in your classroom:

• As a resource for biographies of key people involved in the evolution of flight.

• For exercises in historical geography, by mapping specific locations over time.

• To develop group study aids such as trivia contests and game or quiz shows.

• As writing prompts and research project topics across the curriculum.

Be as creative as you like. Remember, the sky is NOT the limit!

Theme	Date	Event
HIGHER	1783	**Hot Air Balloon:** First flight – the Montgolfier Brothers' balloon.
HIGHER	1783	**Hydrogen Balloon:** Jacques Charles' balloon flies with hydrogen, which is lighter but also more flammable.
HIGHER	1794	**Observation Balloon:** Jean-Marie-Joseph Coutelle uses balloons for spying and intimidation during the French Revolution.
HIGHER	1852	**Dirigible:** Steam power now allows balloons to be steered.
HIGHER	1858	**Pictures from the Sky:** French photographer and balloonist Gaspard-Félix Tournachon, known as "Nadar," photographs Paris from the air.
FASTER	1896	**Unpiloted Airplane:** Samuel Pierpont Langley conducts a semi-successful early airplane flight, powered by a steam engine.
FASTER	1903	**Piloted Airplane:** The Wright Brothers fly an internal-combustion-powered plane at Kitty Hawk, NC.
SMARTER	1903	**First Cockpit Instruments:** The Wright Brothers' 1903 flyer uses an anemometer and a tachometer.
SMARTER	1908	**Accident Investigation:** An aircraft piloted by Orville Wright crashes, killing Thomas Selfridge and prompting an investigation.
FASTER	1909	**Air Races:** France holds the first international flying competition at Reims.
FARTHER	1909	**Across the Channel:** Louis Charles Joseph Blériot's hydrogen balloon successfully flies across the English Channel.

FARTHER	1910	**Seaplanes:** Henri Fabre invents the seaplane, or hydroplane, called the "Hydravion."
SMARTER	1910	**Air-to-Ground Radio:** James McCurdy uses air-to-ground radio.
FASTER	1912	**Single Shell Aircraft:** An early racing aircraft has a single shell fuselage of hollow wood that reduces drag.
FASTER	1914	**Fighter Planes:** Aerial dogfighting begins in World War I.
SMARTER	1914	**Early Autopilot:** Lawrence Sperry uses gyroscopes to make the first autopilot.
HIGHER	1914-1918	**Bombs Away:** Nations demonstrate the early use of aircraft bombers in World War I.
SMARTER	1915	**NACA:** Congress creates the National Advisory Committee for Aeronautics (NACA), the organization from which NASA was created in 1958.
HIGHER	1917	**Supercharged:** Sanford Moss invents the turbo supercharger for pressurizing air in engines to adjust to high altitudes.
SMARTER	1918	**Remotely Piloted Aircraft:** The Curtiss-Sperry Flying Bomb combines autopilot with radio, resulting in a remotely piloted aircraft.
FARTHER	1919	**International Airmail:** Bill Boeing and Eddie Hubbard fly from Seattle to Victoria, Canada.
FARTHER	1919	**Across the Atlantic:** The NC-4 sea planes complete transatlantic flights, followed by the flight of John Alcock and Arthur Brown.
SMARTER	1921	**Lighting the Way:** US Postal Service installs rotating lights on towers to guide planes (aerodrome beacon).
FARTHER	1923	**Fuel Station in the Sky:** Lowell H. Smith and John P. Richter set new record for time spent in the sky, thanks to aerial refueling.
FARTHER	1924	**Around the World:** Two Douglas World Cruisers make it around the globe.
HIGHER	1926	**Liquid Rocket Fuel:** Rockets switch from solid to liquid fuel, which allows engines to throttle up and down and stop and start mid-flight.
FARTHER	1927	**Pan American World Airways:** Juan Trippe starts Pan Am, first with mail flights around the Caribbean and then adding passenger service.
FARTHER	1927	**Solo Across the Atlantic:** Charles Lindbergh flies solo from New York to Paris.
FASTER	1929	**Women Racers:** Louise Thaden wins the first all-women's air race from Santa Monica, CA, to Cleveland, OH.
SMARTER	1929	**Flight Instruments:** Jimmy Doolittle makes the first "blind" (instrument-only) flight.
FASTER	1930	**Toward the Modern Airliner:** The Boeing Monomail plane is a more streamlined craft with retractable landing gear.
FASTER	1930s	**Jet Engine:** Frank Whittle and Hans von Ohain develop the jet engine independently.

SMARTER	1930s	**Radar Tracking:** British refine use of radar leading up to WWII, which is then used by both sides in the war.
HIGHER	1931	**To the Stratosphere:** Beginning with Swiss physicist Auguste Piccard, humans visit the stratosphere – including a woman (1934).
HIGHER	1934	**Pressure Suit:** Wiley Post invents the pressure suit. Using it, he discovers the Jet Stream.
FASTER	1935	**Swept Wing:** Research shows that an angled wing design makes near-supersonic flight easier by changing air resistance.
FARTHER	1935	**Sleeper Transport:** The DC-3 Douglass Skysleeper, a hardy, but luxurious, aircraft, makes commercial air transport profitable.
SMARTER	1935	**Air Traffic Control:** Airlines group together to start air traffic control in New Jersey.
FARTHER	1938-1945	**Bigger Bombers:** World War II spurs development of bigger long-range bombers.
FARTHER	1939	**Luxury Flying Boat:** First flight – Boeing 314-Clipper.
FASTER	1939-1945	**WWII Propeller Planes:** More powerful engines and streamlined designs make propeller planes faster.
HIGHER	1940	**Pressurized Cabin:** First commercial aircraft with a pressurized cabin is the Boeing 307 Stratoliner.
FASTER	1944	**Fighter Jet:** Jets join the battle at the end of World War II.
FASTER	1946	**Speed of Sound:** Chuck Yeager goes supersonic.
FASTER	1947	**Swept-Wing Fighter:** Jet fighters with swept wings come into play, especially during the Korean War.
FASTER	1947	**Swept-Wing Bomber:** The B-47 Stratojet debuts, the first long-range jet with swept wings.
FARTHER	1949	**Nonstop Around the World:** James Gallagher flies around the world in the *Lucky Lady II*, refueling four times along the way.
SMARTER	1950s	**Air Traffic Computers:** Computers come into use in air traffic control.
FARTHER	1950s	**Cold War Bombers:** Demands of the Cold War and nuclear arms race result in bigger bombers, like the Boeing B-52 Stratofortress.
FASTER	1952	**The Jetliner:** DeHavilland Comets fly from London to Johannesburg in 23 hours.
FASTER	1953	**Mach 2:** A. Scott Crossfield goes twice the speed of sound in the D-558-2 Skyrocket.
FASTER	1956	**Mach 3:** Milburn Apt reaches Mach 3, only to be killed minutes later when the X-2 goes out of control.
HIGHER	1957	**Artificial Satellite:** Sputnik launches the satellite race!

HIGHER	1957	**Cold War Spy Planes:** The high-altitude Lockheed U-2 spy plane is introduced.
FASTER	1958	**The Jet Age:** Boeing 707 launches regular intercontinental jet travel.
FARTHER	1958	**Intercontinental Ballistic Missile:** First flight – Atlas missile.
SMARTER	1958	**Black Box:** Crash-proof flight recorders come into use.
FASTER	1959	**Escape Velocity:** Soviet Luna-1 is launched toward the moon (it misses and winds up in solar orbit).
SMARTER	1960	**Communications Satellite:** Echo 1, a passive communications satellite, lays the groundwork for future communications tech.
HIGHER	1961	**Humans in Space:** Yuri Gagarin (first human), Alan Shepard (first American), and Valentina Tereshkova (in 1963, first woman) are the first people in space.
HIGHER	1963	**Spaceplane:** Launched from a B-52, the X-15 can go to the edge of space.
FARTHER	1968	**Around the Moon:** Apollo 8 goes around the moon.
SMARTER	1968	**Apollo Guidance Computer:** A computer with less capability than your mobile phone takes 10 crews of astronauts to the moon and back.
FASTER	1969	**Fastest Humans in Flight:** Apollo 10 astronauts return to Earth.
FARTHER	1969	**Moon Landing:** Apollo 11 lands on the moon.
FARTHER	1970	**The Jumbo Jet:** The first jumbo jet, the Boeing 747, flies commercially.
SMARTER	1972	**Digital Fly-By-Wire:** F-8 Crusader demonstrates the new computer technology.
SMARTER	1975	**Heads-Up Display:** Displays projected on windscreens allow for safer flying.
FASTER	1976	**Supersonic Jet Age:** The European Concorde and Soviet Tupolev bring supersonic flight to commercial transportation.
FASTER	1976	**Fastest Human-Made Object:** First flight – Helios-B, a deep-space probe developed by the Federal Republic of Germany with NASA.
FASTER	1976	**Fastest Crewed Jet:** First flight – Lockheed SR-71 Blackbird.
FARTHER	1976	**Flight to Mars:** Viking 1 reaches Mars.
FARTHER	1977	**Sustained Human-Powered Flight:** Bryan Allen flies the *Gossamer Condor*, the first human-powered aircraft capable of controlled flight, built by Paul MacCready.

FARTHER	1977	**Wingtip Device:** Research proves that wingtip devices, like winglets, improve efficiency.
HIGHER	1981	**Space shuttle:** First Flight – Columbia, the first reusable space shuttle.
SMARTER	1982	**Glass Cockpit:** Boeing 767 integrates flat-panel digital displays into flight deck.
HIGHER	1984	**"Jet Pack" in Space:** The MMU lets astronauts move outside of a shuttle without tethers.
FARTHER	1986	**Unrefueled Nonstop Around the World:** The Rutan Model 76 Voyager, piloted by Jeana Yeager and Richard Rutan, sets a flight endurance record.
SMARTER	1993	**GPS:** Global positioning systems come into use.
SMARTER	1994	**Designed on Computer:** The new Boeing 777-200 is designed entirely on computers.
HIGHER	1998	**International Space Station:** ISS becomes the biggest manmade object in space.
FARTHER	1999	**Nonstop Around the World by Balloon:** Breitling Orbiter 3 circles the globe in 19 days.
SMARTER	2000s	**Satellite Aircraft Tracking:** Automatic Dependent Surveillance Broadcast (ADSB) goes into use.
HIGHER	2001	**Vacation in Space:** American businessman Dennis Tito takes the Soyuz up to the ISS as the world's first space tourist.
HIGHER	2001	**Solar High Flyer:** With wings covered in solar cells, remote-control pilots on the ground fly the Helios Prototype to a height of 96,863 ft.
HIGHER	2003	**Private Spaceplane:** SpaceShip One becomes the first private spacecraft and wins the Ansari X Prize after taking two trips to the edge of space in a week.
FARTHER	2005	**Longest Range Airliner:** A Boeing 777-200LR flies nonstop from Hong Kong to London.
FASTER	2006	**Fastest Launch:** NASA New Horizons probe is launched to explore Pluto in 2015.
FASTER	2010	**Hypersonic Milestone:** First flight – Boeing X-51 Waverider, an unmanned scramjet designed to fly faster than Mach 5.
FARTHER	2010	**To the Asteroids and Back:** Hayabusa, an unmanned Japanese spacecraft, returns to Earth from its trip to the asteroid Itokawa and back, begun in 2003.
SMARTER	2013	**Pilotless Jets:** A 16-seater, unmanned Jetstream is tested over UK.
SMARTER	2014	**Smart Helmets:** Lockheed-Martin adds a helmet-mounted display for fighter-jet pilots.
FARTHER	Today	**Voyager 1:** Voyager 1 leaves our solar system.

SPACE AGE: GLOSSARY OF KEY TERMS AND ABBREVIATIONS

TEACHERS: Keep this list handy for both you and your class. You might encounter some space-age words and out-of-this-world acronyms during your epic journey ABOVE AND BEYOND!

additive manufacturing	3D printing; used to make all kinds of objects, layer by layer, using materials like plastic, metal, or glass
aerodrome	airport or airfield
aerodynamics	the way air flows around an object in flight
aeronautics	the science of airplanes and flying
aerospace	the businesses that deal with travel in and above the Earth's atmosphere, and with the production of vehicles to go to such places
ailerons	the part of an airplane wing that can be moved up or down to make the airplane turn by rolling to the left or the right
airfoil	the shape of a wing as seen in a cross-section
aluminum	type of metal that is strong, light, and silvery
anemometer	an instrument that measures wind speed
beamed energy propulsion	form of thrust created when spacecraft are launched by lasers or microwaves, instead of chemical rockets
BWB	Blended Wing Body
cambered airfoil	a special wing shape that generates lift, the airplane wing has an arched upper surface similar to a bird
carbon fiber composite	a type of plastic reinforced with stiff strands of carbon that enables the construction of aircraft that are lightweight, yet superstrong
career	job or profession
CFD	Computational Fluid Dynamics; a way to conduct wind tunnel tests on computer
composites	made of different parts
CST	Crew Space Transport
CUBESATS	10cm (4-in) satellites that can be customized and combined to perform a variety of missions
cured charge	hardened result when a raw charge is pressed over a mold to form it into a shape with pressure and/or heat applied to bond the layers of carbon fiber tape together

DARPA	US Defense Advanced Research Projects Agency
deduction	something that is taken away
delta	shaped like a triangle
dimensions	sizes or measurements
drag	when air molecules push and rub against your body or the body of a vehicle, causing a resistant force; opposes thrust
efficient	making good use of resources available, without wasting materials, time, or energy
elimination	getting rid of something
emissions	producing or sending out something, like energy or gas
epoxy	a glue-like resin, seals the fibers of carbon fiber tape
ESA	European Space Agency
fuselage	the body of an airplane, usually shaped like a long, cylindrical tube
grid	chart
hover	stay in one place in midair
hybrid	a combination of different things, such as an engine that uses gasoline and electricity
hypersonic	beyond five times the speed of sound
industry	type of business
ISS	International Space Station
lift	an opposing force, greater than an aircraft's weight, that must be generated in order for the craft to ascend, or go up
Mach	used to measure the speed of sound; for example Mach 2 = twice the speed of sound

maneuverable	easy to control
metallic microlattice	a new material that is 100 times lighter than Styrofoam, yet strong and springy to the touch, invented with a new process that uses 3D printing and ultraviolet (UV) light
MMU	manned maneuvering unit
nanotubes	long, tiny, hollow structures formed by graphene, which is sheets of carbon that are only one atom thick, 100 times stronger than steel
NASA	National Aeronautics and Space Administration
orbital debris	anything human-made found in the orbit of the Earth that has no way to adjust its own orbit; space junk
ornithopter	a human-powered, wing-flapping aircraft
perpendicular	at right angles to another surface; as opposed to parallel
photovoltaic cells	solar panels
prototype	the first working version or model of something
Proxima Centauri	nearest star other than the Sun, 40 trillion km (25 trillion mi) away
rapid prototype	a model that is 3D printed, turning ideas for new aircraft and spacecraft into physical articles quickly and inexpensively
raw charge	a sheet of material created by laying carbon fiber tape down layer by layer
resin	a glue-like substance
scramjet	a supersonic combusting ramjet; while rocket engines carry the oxygen needed for combustion, scramjets scoop up oxygen in Earth's atmosphere as they move
SEP	solar electric propulsion; using solar power to electrically charge xenon gas, which is expelled to produce thrust and is more efficient than chemical propulsion
shock cone	the shape formed at supersonic speeds when shock waves bend back
shock wave	the pressure waves that build up as an aircraft approaches the speed of sound, in front of its nose and wings; can cause wing flutter and vibrations
SLS	Space Launch System
SMALLSATS	highly capable small satellites
sonic boom	when a shock cone created by an aircraft going faster than the speed of sound reaches the ground, the change in pressure causes a loud noise
subsonic	less than the speed of sound (< Mach 1)

SUGAR	Subsonic Ultra-Green Aircraft Research
supersonic	above the speed of sound (> Mach 1)
tachometer	instrument that measures rotations, or turns, per minute
tether	a cable, long cord
thrust	the force opposing drag and the one that moves an aircraft forward
transonic	getting near the speed of sound (Mach .75-Mach 1)
UAV	unmanned aerial vehicle; a drone, an aircraft without a pilot on board
unmanned	uncrewed, without humans on board
VTOL	vertical takeoff and landing
weight	a measurement of Earth's gravitational pull on you
Whipple Shield	a shield invented by astronomer Fred Whipple featuring multiple thin layers of aluminum as a way to protect against orbital debris
wingspan	the length of the wings on an aircraft or bird, from tip to tip

AIM HIGH: CURRICULUM CORRELATIONS

We know how important it is for you to be able to justify field trips and document how instructional time is spent outside of your classroom. With that in mind, the activities in this Study Guide and the experience your class will have during their field trip to ABOVE AND BEYOND have been directly correlated to national curriculum requirements in Science, Math, Language Arts, and Social Studies.

Below, you will find the recommended content standards for Grades 3 through 5 set forth by the Next Generation Science Standards, Common Core State Standards for both Mathematics and English Language Arts, and C3 Framework for State Social Studies Standards.

NATIONAL CONTENT STANDARDS

Next Generation Science Standards

Engineering Design

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.

- Science and Engineering Practices: Asking Questions and Defining Problems
- Disciplinary Core Idea: ETS1.A: Defining and Delimiting Engineering Problems
- Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World

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.

- Science and Engineering Practices: Constructing Explanations and Designing Solutions
- Disciplinary Core Idea: ETS1.B: Developing Possible Solutions
- Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World

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.

- Science and Engineering Practices: Planning and Carrying Out Investigations
- Disciplinary Core Ideas: ETS1.B: Developing Possible Solutions; ETS1.C: Optimizing the Design Solution

Grade 3

3-PS2-1. Motion and Stability: Forces and Interactions. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

- Science and Engineering Practices: Planning and Carrying Out Investigations
- Connections to Nature of Science: Scientific Investigations Use a Variety of Methods
- Disciplinary Core Ideas: PS2.A: Forces and Motion; PS2.B: Types of Interactions
- Crosscutting Concepts: Cause and Effect

3-PS2-2. Motion and Stability: Forces and Interactions. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

- Science and Engineering Practices: Planning and Carrying Out Investigations
- Disciplinary Core Idea: LS4.C: Adaptation
- Crosscutting Concepts: Patterns

3-LS4-3. Biological Evolution: Unity and Diversity. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

· Science and Engineering Practices: Engaging in Argument from Evidence

· Connections to Nature of Science: Science Knowledge is Based on Empirical Evidence

· Disciplinary Core Idea: PS2.A: Forces and Motion

· Crosscutting Concepts: Cause and Effect

Grade 4

4-PS3-3. Energy. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

· Science and Engineering Practices: Asking Questions and Defining Problems

· Disciplinary Core Ideas: PS3.A: Definitions of Energy. PS3.B: Conservation of Energy and Energy Transfer; PS3.C: Relationship Between Energy and Forces

· Cross-Cutting Concepts: Energy and Matter

Grade 5

5-PS2-1. Motion and Stability: Forces and Interaction. Support an argument that the gravitational force exerted by Earth on objects is directed down.

· Science and Engineering Practices: Engaging in Argument from Evidence

· Disciplinary Core Idea: PS2.B: Types of Interactions

· Cross-Cutting Concepts: Cause and Effect

5-ESS1-1. Earth's Place in the Universe. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.

· Science and Engineering Practices: Engaging in Argument from Evidence

· Disciplinary Core Idea: ESS1.A: The Universe and its Stars

· Crosscutting Concepts: Scale, Proportion, and Quantity

Common Core State Standards for Mathematics

Standards for Mathematical Practice: CCSS.Math.Practice.MP1, CCSS.Math.Practice.MP2, CCSS.Math.Practice.MP4, CCSS.Math.Practice.MP5, CCSS.Math.Practice.MP6

Grade 3: CCSS.Math.Content.3.OA.A.3, CCSS.Math.Content.3.OA.C.7; CCSS.Math.Content.3.NBT.A.2; CCSS.Math.Content.3.NF.A.1; CCSS.Math.Content.3.MD.A.1, CCSS.Math.Content.3.MD.A.2, CCSS.Math.Content.3.MD.B.3, CCSS.Math.Content.3.MD.B.4, CCSS.Math.Content.3.MD.C.5, CCSS.Math.Content.3.MD.C.6, CCSS.Math.Content.3.MD.C.7

Grade 4: CCSS.Math.Content.4.OA.A.2, CCSS.Math.Content.4.OA.A.3; CCSS.Math.Content.4.NBT.B.4, CCSS.Math.Content.4.MD.A.1, CCSS.Math.Content.4.MD.A.2, CCSS.Math.Content.4.MD.A.3

Grade 5: CCSS.Math.Content.5.NBT.B.5; CCSS.Math.Content.5.MD.A.1; CCSS.Math.Content.5.G.B.3

Common Core State Standards for English Language Arts

Anchor Standards: CCSS.ELA-Literacy.CCRA.R.1, CCSS.ELA-Literacy.CCRA.R.4, CCSS.ELA-Literacy.CCRA.R.7, CCSS.ELA-Literacy.CCRA.R.10

Grade 3: CCSS.ELA-Literacy.RI.3.1, CCSS.ELA-Literacy.RI.3.3, CCSS.ELA-Literacy.RI.3.4, CCSS.ELA-Literacy.RI.3.7, CCSS.ELA-Literacy.RI.3.10; CCSS.ELA-Literacy.W.3.2; CCSS.ELA-Literacy.SL.3.1

Grade 4: CCSS.ELA-Literacy.RI.4.1, CCSS.ELA-Literacy.RI.4.3, CCSS.ELA-Literacy.RI.4.4, CCSS.ELA-Literacy.RI.4.7, CCSS.ELA-Literacy.RI.4.10; CCSS.ELA-Literacy.W.4.2; CCSS.ELA-Literacy.SL.4.1

Grade 5: CCSS.ELA-Literacy.RI.5.1, CCSS.ELA-Literacy.RI.5.3, CCSS.ELA-Literacy.RI.5.4, CCSS.ELA-Literacy.RI.5.7, CCSS.ELA-Literacy.RI.5.9, CCSS.ELA-Literacy.RI.5.10; CCSS.ELA-Literacy.W.5.2; CCSS.ELA-Literacy.SL.5.1

C3 Framework for Social Studies State Standards, Grades 3 – 5

D1.4.3-5., D2.Civ.9.3-5., D2.Eco.14.3-5., D2.Eco.15.3-5., D2.Geo.1.3-5., D2.Geo.3.3-5.D2.Geo.7.3-5., D2.Geo.11.3-5., D2.His.1.3-5., D2.His.3.3-5., D2.His.14.3-5.