FUTURE U.

Future of Satellites

Objectives

Students will be able to:

- **construct** their own self-deploying satellite model
- **perform research** to gain an understanding of how satellites function
- **develop** a proposal that articulates how satellites could be used to solve a world problem

Overview

Students join Boeing's satellite systems engineering team challenged to explore roles that satellites play today and could play in the future. After learning about the capabilities of current satellites, students will build their own self-deploying satellite model. They will research how satellites get into orbit, stay in orbit, and communicate with Earth. They will then consider how satellites could be used to help humanity and the planet, and they will ultimately develop a proposal for Boeing that outlines a focus area for their satellite work.

This lesson focuses on the following

Engineering Design Process

- Defining the problem
- Designing solutions
- Creating or prototyping

21st-Century Skills

- Communication
- Collaboration
- Critical thinking
- Creativity

Timing

Two 60-minute class periods

Materials

Day 1

- Device with the ability to project, one for the instructor
- Devices with Internet access, enough for at least half the class
- Image 1 and Image 2, to project or display
- "What are Satellites Used For?" article, one per student
- *Designing Self-Deploying Satellites* video, to display
- Handout 1: Build a Satellite, one per student
- Satellite activity materials:

- Enough of the following for half the class:
  - scissors
  - small containers or boxes (like a jewelry box or clay container)
  - large rubber bands, several
  - dowels or skewers, 6
- For the class to share:
  - tape, several
  - hole puncher, at least two
  - cardboard, several pieces
  - any other available building materials

Day 2

- Devices with Internet access, enough for at least half the class
- Handout 2: Satellite Research, one per student
- Handout 3: Boeing Satellite Proposal (two pages), one per student

Have you ever wondered…

What *is* a satellite?

NASA defines satellite as a "moon, planet or machine that orbits a planet or star." Because Earth orbits the sun and the moon orbits the Earth, the moon and Earth are both examples of natural satellites.

In this lesson, students will be exploring artificial, or man-made, satellites. There are thousands of artificial satellites orbiting Earth. Most satellites are launched into space on rockets. When satellites deploy from a rocket, they continue orbiting Earth without falling down or flying off into space because their velocity is balanced by Earth's gravity. As long as this balance is maintained, satellites can orbit Earth at different speeds and heights and along different paths.[1]

What are satellites used for?

There are many different kinds of artificial satellites. Many satellites contain cameras and other scientific sensors that are used to collect data. They may point towards Earth or towards space to gather information. They then transmit this information via an antenna to centers on Earth.[1]

Other satellites are used for communication, including telephone, Internet, radio, and television. These satellites work by helping pass radio waves from one spot on Earth to another. When a satellite in space receives a radio wave from Earth, the satellite can amplify the wave and then bounce it back down to different locations on Earth—enabling radio waves (that can only travel in straight lines) to be sent around our planet![2]

The third primary use for satellites is navigation. Thanks to satellites, our devices easily figure out our position, speed, and even local time. There are more than 30 satellites orbiting Earth that are part of a global positioning system (GPS) that constantly emits signals. When GPS receivers on Earth (in our phones, cars, etc.) receive signals from four or more of these satellites, they calculate their distance from these satellites and can then figure out their location![3]

Make Connections

How does this connect to students?

Without satellites, students' lives would be very different from what they are today!

As Brad Grady, an analyst for Northern Sky Research (NSR), told Space.com, ""As a global society, I think we are only starting to appreciate and understand the importance of space-based infrastructure to our daily lives. From Earth observation images tracking wildfires in California … to broadcasting TV signals across a country or continent, there are literally millions of services running over thousands of satellites at any given time."[4]

Without satellites, students would be unable to use most of the technology they count on today: from weather forecasts to video calls, texting, navigation apps, and more. As students learn more and more about the world around them, it's important for them to be aware of the important role satellites play and to consider the effect that satellites could have on their lives in the future.

How does this connect to careers?

Satellite system engineer: Satellite system engineers are responsible for maintaining and troubleshooting all technology related to satellites. They may also work with other engineers and technicians to design new satellite programs or improve existing ones.

Imagery analyst: Imagery analysts, also called mapping scientists or remote sensing technologists, gather imagery collected from satellites and on the ground. They then use analysis software to study the images so they can share their findings with key decision makers.

Satellite technician: Satellite technicians install, maintain, and repair satellite products on the ground, such as satellite dishes that help deliver television and/or Internet signals. They may be responsible for everything from troubleshooting and customer service to hardware and electrical system support.

How does this connect to our world?

Satellites literally connect our world! Through telephone systems and wireless networks, they help link communication across the globe.

They enable developed and developing countries to share and access medical information, gather weather data, predict and monitor storms, communicate during natural disasters, and more.

In addition, because of the data that satellites can supply on Earth's land, oceans, and atmosphere, scientists are able to better understand the state of climate change and its effects on our world. From tracking the ozone layer to coral bleaching, satellites enable scientists to keep an eye on Earth in an unprecedented way—and scientists hope that satellites will play a key role in helping us navigate the climate crisis.[5]

Sources

[1] "What is a satellite?" NASA. nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-satellite-58.html.

[2] "Satellites." Explain that Stuff! explainthatstuff.com/satellites.html#comms.

[3] "How Does GPS Work?" NASA Science Space Place. spaceplace.nasa.gov/gps/en/.

[4] "63 years after Sputnik, satellites are now woven into the fabric of daily life". Howell, Elizabeth. Space.com. space.com/satellite-technology-daily-life-world-space-week-2020.

[5] "How Satellites saved the world." NBC News. nbcnews.com/id/23213424/ns/technology_and_science-space/t/how-satellites-saved-world/

Blueprint for Discovery

DAY 1

1. Begin class by displaying or sharing Image 1 and Image 2, one at a time. As students observe each one, ask:
    - What do you think this image is portraying?
    - How do you think this image was taken?
2. Once students have shared their thoughts, explain that both of these photographs were taken by satellites.

    Share NASA's satellite definition: "A satellite is a moon, planet or machine that orbits a planet or star. Earth is a satellite because it orbits the sun. Likewise, the moon is a satellite because it orbits Earth. Usually, the word 'satellite' refers to a machine that is launched into space and moves around Earth or another body in space."

    Explain that artificial satellites, or man-made machines, took these photographs.
3. Click back to Image 1 and explain that this satellite image shows severe winter weather covering the eastern United States. From this image, meteorologists can learn the extent of the storm and its projected impact.

    Then click back to Image 2. Explain that this image was compiled from many different satellite images and it shows nighttime light around the world. Ask students: What may we learn from an image like this?

    After hearing students' thoughts, explain that researchers are using night light images like these to study world poverty. Areas with low or no levels of night light are likely to be more poverty stricken. This type of imagery has a variety of benefits, such as helping aid organizations and governments better understand where help and better policy is needed.
4. Explain that these are just two of the many ways that satellites can be used.

    Tell the class that over the next couple class sessions they will imagine they have joined Boeing's satellite systems engineering team. As members of the team, they must demonstrate that they understand what satellites are, how they function, and what they do—and select a focus area for their satellite work moving forward.
5. Divide students into pairs and distribute one copy of the "What Are Satellites Used For?" article to each student. Instruct pairs to read the article together and write a sentence summarizing each use next to the paragraph describing it. Once students have finished, ask them to share one use that they surprised to learn about.
6. Go on to explain that Boeing plays an important role in developing satellites that are used for many of these tasks.

    Access boeing.com/space/boeing-satellite-family/#/gallery and project and scroll through some of the satellite images.

    As you do, summarize the services Boeing satellites perform: helping deliver digital communications, mobile communications, Internet connectivity, telephone calls, television programming, video conferencing, and direct-to-home entertainment around the world. They also help with military and civil communications, intelligence, and national defense.

7. Explain that before students learn exactly how satellites work, they are going to participate in a hands-on satellite engineering challenge.

   Show the *Designing Self-Deploying Satellites* video and instruct students to listen for keywords that describe their challenge.

8. Then distribute one *Handout 1: Build a Satellite* to each student. Do the following to prepare the class for the activity:

   - Review the handout's steps together.
   - Explain that students will work with their partner to complete this challenge.
   - Show the students where they can find the materials for this activity.
   - Answer questions as needed.
   - Deduct 10 minutes from the end of the class period and explain that pairs will have this much time to complete their model.

   Then encourage the class to begin.

9. When there are 15 minutes left in the session, give students a five-minute warning.

10. When there are 10 minutes left in the session, bring the class back together and ask for student volunteers to show their satellite deployments in action, regardless of whether or not they actually work.

    As students share, encourage the class to look for similarities and differences among the designs, especially among those that successfully deploy and those that don't.

11. Conclude the session with a full-class discussion around the following questions:

    - What similarities do many of the successful designs share?
    - These satellites were required to have solar panels and one antenna. What else do you think satellites are likely to have?
      - Ideas include the following:
        - A propulsion system that helps the satellite move
        - Data collection devices (cameras, sensors, telescopes)
        - Communication equipment
    - Predict: Once satellites are deployed, what happens? How do you think they stay in space?

12. Wrap up by explaining that students will learn whether their predictions are correct next class session; ask them to store their work in a safe place until this time.

DAY 2

1. Begin class by instructing students to take out their annotated article and Handout 1 from the first session. Then tell students that today is a big day: Their work today will determine their future at Boeing!

2. Explain that students will begin by performing research to learn more about satellites so they are fully ready to join Boeing's satellite systems engineering team.

   Pass out one Handout 2: Satellite Research to each student and explain that students may complete this research individually or with a partner. (This may be partially determined by how many devices are available.) Read the handout's overview and then give the students about 20 minutes to complete their research.

3. Once this time has passed or the class's research is complete, review any outstanding questions the students have and guide students in answering each other's questions.
4. Then explain that—now that students have built a satellite model *and* have an understanding of how satellites work—it's almost time for them to begin their career at Boeing. But before they do, Boeing would like each student to pick an innovative satellite area on which to focus. As new employees, they will spend time exploring this focus area over the next year.
5. Pass out one *Handout 3: Boeing Satellite Proposal* (two pages) to each student and read the "Your Task" section aloud. Reiterate that students will apply what they have learned about satellites as they select a career focus area that will benefit the world at large.

   Answer student questions and then give the students another 25 minutes to complete their proposals.
6. When there are about 10 minutes left in class, invite students to share a quick overview of their proposals and make summary notes on the board to capture the students' ideas. Conclude the sharing by bringing students' attention to the notes you recorded and review the diverse ways that satellites can be used to help our world.
7. Then bring the class to a close, thank the students for their hard work, and reassure them that you envision all of their ideas will be approved by Boeing.

   Remind students that there are many careers in aerospace that seek to solve all kinds of problems and encourage the class to keep exploring this field as they continue through school.

Create a Satellite

Directions: Follow the steps below to create your own satellite model.

Step 1: Read the background section below. As you do, highlight or underline what your satellite design must include.

At Boeing, engineers design, build, and send satellites to space. Satellites come in many different shapes and sizes but they usually have two parts in common: a power source and an antenna. The antenna is used to send and receive information to and from Earth. The power source powers the satellite—and is usually in the form of a battery or solar panels. Solar panels turn sunlight into electricity.

Engineers have to think not only about how to build these parts of the satellite, but also about how the parts will be packaged so they can be sent into space safely. They have to think about the rules of different stages of the journey and make sure their designs can work at every stage. These rules are known as dynamic constraints. For example, the whole satellite needs to be small enough to fit into the nose of the rocket, but it also needs to be able to fully open to capture a lot of sunlight once it's deployed. Once these satellites are in space and fully deployed (or opened up), their solar panels are usually much larger than the satellite body! Engineers often test their designs under each of these constraints to make sure their designs work at different stages.

In this design challenge, you are going to build the body of a satellite with an antenna and solar panels. You want to think about how you are going to package, or fold up, the solar panels and antennae so they can fit inside a rocket. You are also going to design a release mechanism such as a latch—so that once your satellite is in space, it can easily open the solar panels and antennae.

Step 2: For a design idea to kickstart your thinking, watch: youtu.be/tnPSmU4q4QA.

Step 3: Look at the materials you have available and brainstorm design ideas with your partner. Remember, your satellite must include an antenna and multiple solar panels. It also must fold up and open back up again easily! Use the space below to sketch your ideas.

Step 4: Select your most promising design and build it! When it is complete, fold it into a compact position (ready to go into a rocket) and toss it into the air. The solar panels and antenna should all deploy at the same time!

Continue to optimize, or improve, your design until time is called.

Satellite Research

Overview: Because you are a new member of the satellite team, Boeing needs you to prove that you understand how satellites function *before* you begin working. To demonstrate this:

Visit the following websites to learn more about satellites:

- Website #1: tinyurl.com/goeb5ej
- Website #2: spaceplace.nasa.gov/launching-into-space/en
- Website #3: tinyurl.com/jqnmttf

Then answer the questions below.

What is a satellite? (Tip: Check out Website #1)

Why are satellites important? (Tip: Check out Website #1, but also include your own background knowledge!)

When a rocket releases a satellite, why does the satellite continue to orbit around Earth? What forces help this happen? (Tip: Check out Website #2)

Do satellites traveling closer to Earth need to fly faster or slower than satellites traveling farther from Earth? Why? (Tip: Check out Website #2)

What is the difference between geostationary satellites and polar satellites? (Tip: Check out Website #1)

How do satellites communicate with, and share their data with, Earth? (Tip: Check out Website #3)

Boeing Satellite Proposal

Your Task: Now that you've proven your satellite knowledge, it's time to pick a focus area for your upcoming work at Boeing. The sky's the limit, but your focus area must seek to help the environment and/or humanity.

Thoughtfully answer the questions below as you select and justify your focus area. Use the research you have completed to help make your decision!

1. **What global problem or need would you like to focus on?**

   You may select a global problem or need that you know satellites already help or you may select a problem or need that you believe satellites have the potential to help!

2. **Most satellites are designed for data collection/imagery, communication, or navigation. Which kind of satellite would help your problem or need? What would the satellite do or what data would it collect?**

3. **Where would the satellite collect data from *or* who would it communicate to?**

Boeing Satellite Proposal

4. **Do you think it would make more sense for this satellite to be geostationary or have a polar orbit? Why?**

5. **How would this satellite program help improve the environment and/or people's lives? Why should Boeing approve this work?**