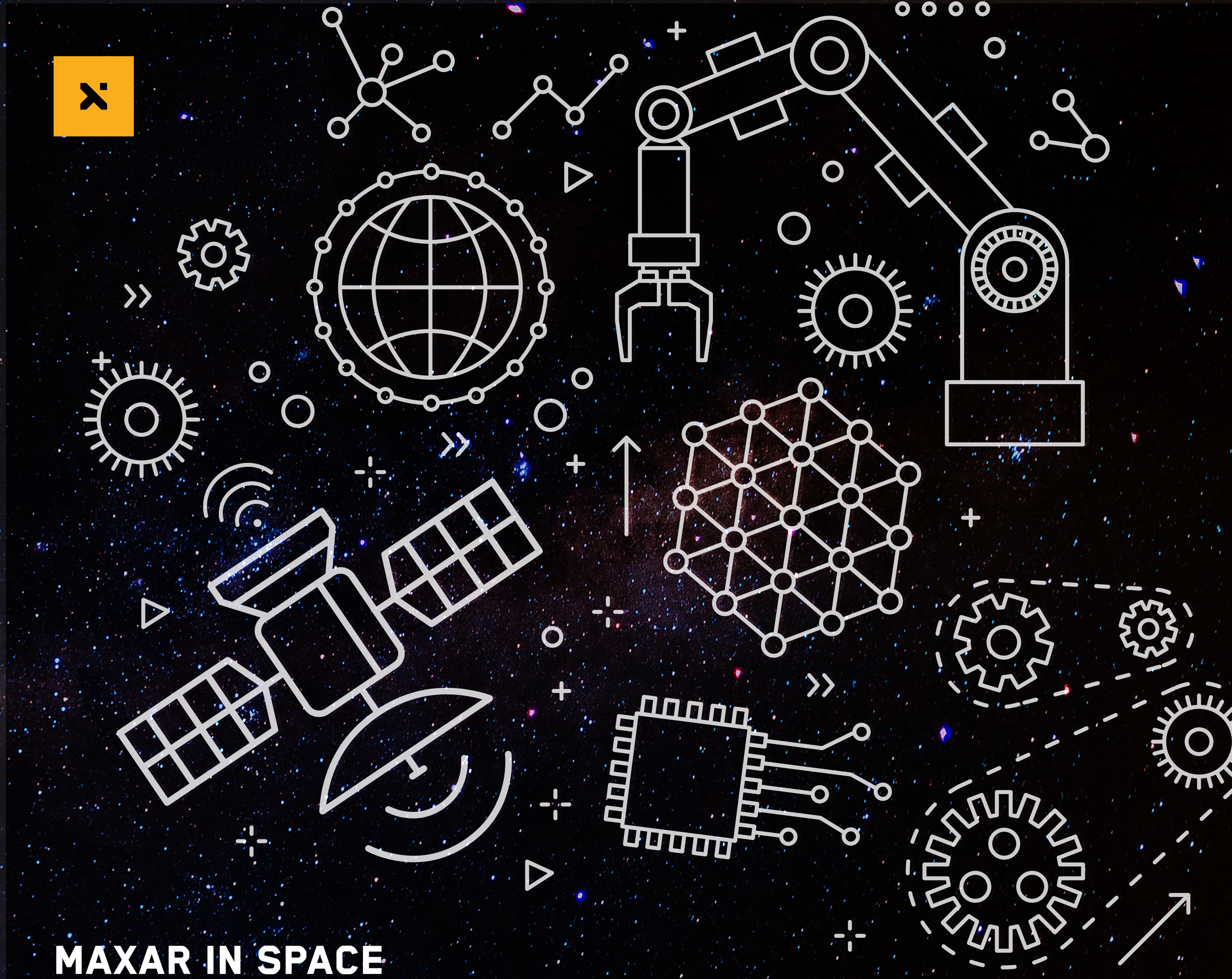
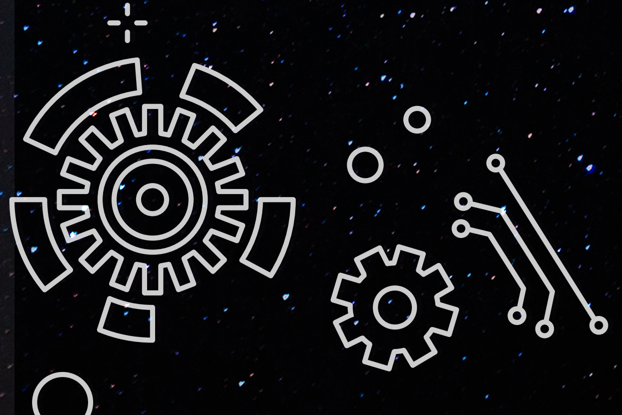


MAXAR IN SPACE

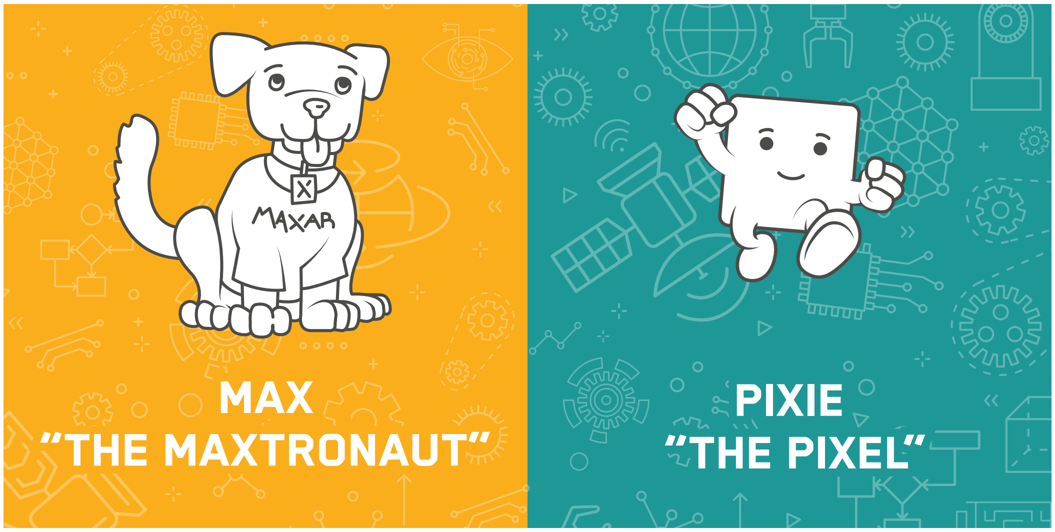
SATELLITES & ROBOTICS



MAXAR

WELCOME

LET'S LEARN AND HAVE FUN!



WELCOME TO MAXAR IN SPACE ACTIVITY BOOK!

Join Max "the Maxtronaut", Maxar's curious and adventurous dog, and Pixie "the Pixel", our tech-savvy activity presenter, as they take you on a journey to explore the wonders of space, satellites, and robotics. Get ready to have fun while learning amazing facts, running experiments, playing games, solving puzzles, and completing cool activities. These activities will help you learn about science, technology, engineering, and more, and have fun along the way!

SO, GRAB YOUR PENCILS, BECAUSE IT'S TIME TO LAUNCH INTO A WORLD OF DISCOVERY WITH ROBOTICS AND SATELLITES!

WHAT IS A SATELLITE?

A satellite is a moon, planet or machine that orbits a planet or star. For example, 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.

Earth and the Moon are examples of natural satellites. Thousands of artificial, or built by people satellites (like the ones we build at Maxar), orbit Earth. Some take pictures of the planet that help meteorologists predict weather and track hurricanes. Some take pictures of other planets, the Sun, black holes, dark matter or faraway galaxies. These pictures help scientists better understand the solar system and universe.

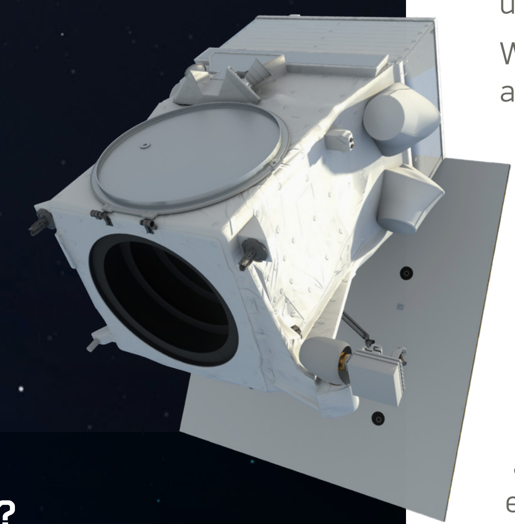
Still other satellites are used mainly for communications, such as beaming TV signals and phone calls around the world. A group of more than 20 satellites make up the Global Positioning System, or GPS. If you have a GPS receiver, these satellites can help figure out your exact location.

How do satellites orbit Earth?

Most satellites are launched into space on big rockets. A satellite orbits Earth when its speed is balanced by the pull of Earth’s gravity. Without this balance, the satellite would fly in a straight line off into deep space or fall back to Earth.

Satellites orbit Earth at different heights, different speeds and along different paths. The two most common types of orbit are “geostationary” (jee-oh-STAY-shun-air-ee) and “polar.” A geostationary satellite travels from west to east in an orbit that can only be achieved at an altitude close to 22,236 mi, and which keeps it fixed over one longitude at the equator. Since it moves in the same direction and same rate Earth is spinning, from Earth, it looks like it is standing still since it is always above the same location.

Polar-orbiting satellites travel in a north-south direction from pole to pole. As Earth spins underneath, these satellites can scan the entire globe, one strip at a time.



Did you know?

We use satellites in space to see many different things on Earth!

- Some travel as fast as 17,000 miles per hour
- Some circle Earth about 14 times a day
- Some weigh up to 5,500 pounds
- Some are 23 ft across with solar arrays deployed—almost the size of a tennis court
- The biggest ones are 12-ft tall—as tall as a school bus!

Why are satellites important?

The bird’s-eye view that satellites have allows them to see large areas of Earth at one time. This ability means satellites can collect more data, more quickly, than instruments on the ground.

Satellites also can see into space better than telescopes at Earth’s surface. That’s because satellites fly above the clouds, dust and molecules in the atmosphere that can block the view from ground level.

Before satellites, TV signals didn’t go very far. TV signals only travel in straight lines. So they would quickly trail off into space instead of following Earth’s curve. Sometimes mountains or tall buildings would block them. Phone calls to faraway places were also a problem. Setting up telephone wires over long distances or underwater is difficult and costs a lot.

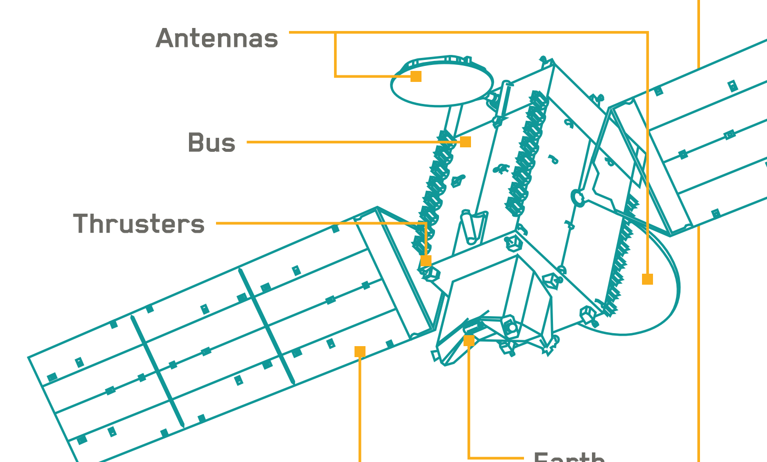
With satellites, TV signals and phone calls are sent upward to a satellite. Then, almost instantly, the satellite can send them back down to different locations on Earth.

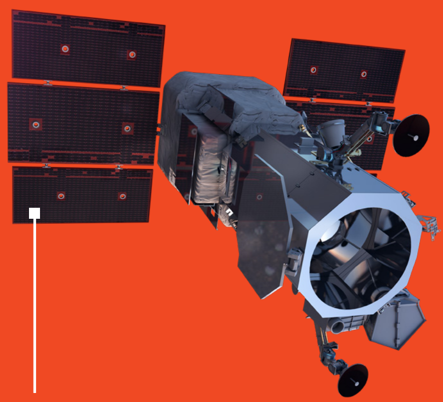
What are the parts of a satellite?

Satellites come in many shapes and sizes. But most have at least three parts in common - an antenna, a power source and the bus (the structure that we attach everything to). The antenna sends and receives information, often to and from Earth. The power source can be a solar panel or battery. Solar panels make power by turning sunlight into electricity.

Many satellites carry cameras and scientific sensors. Sometimes these instruments point toward Earth to gather information about its land, air and water. Other times they face toward space to collect data from the solar system and universe.

Credit: NASA Knows! (Grades 5-8) Series





Satellites can have either one or multiple solar panels depending on power needs and dimensions. The combination of panels and the parts used to unfurl them are called the "solar array".

BATTERIES: How we use them on a satellite?

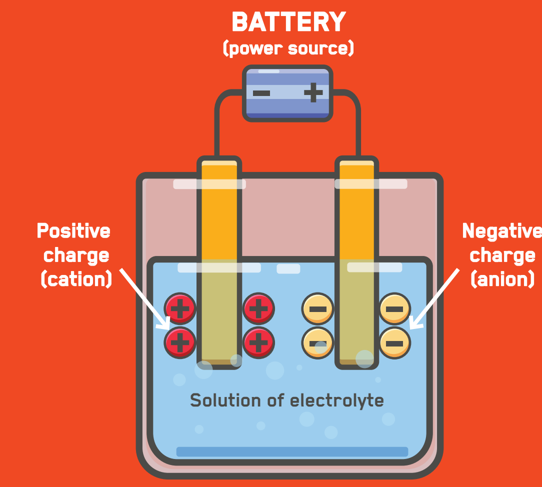
A satellite uses electric power to perform it's functions. Where do we get that power? Mostly from the sun by using lots of ***solar cells*** strung together and glued onto "wings" or panels. We call these ***solar arrays***. They supply power as long as the sun is shining on them.

Twice a year the satellite passes into the earth's shadow. This is called an eclipse and it happens for just over an hour twice a year during the spring and fall months, also known as the equinox or equal day and night. During the eclipse season the solar array power falls off and we need to use batteries on board to power the satellite.

Batteries use a chemical reaction to create electricity. Imagine you have a bottle with two compartments separated by a barrier. In one compartment, you put a positive material and in the other, you put a negative material, these are called electrodes.

Now, you add a special liquid called an electrolyte to the bottle. This liquid helps the positive and negative charges move from one electrode to the other.

When you connect the electrodes to a circuit (like a light bulb), the positive charges start to move towards the negative electrode and the negative charges start to move towards the positive electrode. This movement of charges creates electricity, which flows through the circuit and lights up the bulb.



This process is called electrolysis and it's what happens inside a battery to create the electricity that powers your toys, phones, and other devices. Cool, right?

ACTIVITY

STEM LABORATORY

LET'S BUILD A BATTERY

GOAL: Use lemons as the power source to light up an LED*.

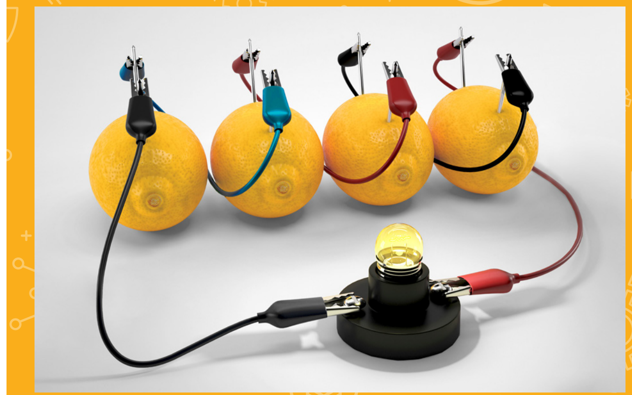
You'll need:

- 4 lemons
- 4 galvanized nails (the kind you use for wood)
- 4 pennies or pieces of copper (copper strip or wire)
- 5 clip-on wires
- 1 tiny light or LED

**You'll need help from an adult for this activity.*

Instructions:

Step 1: Squeeze the lemons to release the lemon juice and pulp.
Step 2: Stick a nail and a penny into each lemon through a small cut.
Step 3: Connect one nail from one lemon to one penny from another lemon with a clip-on wire. Do this with all 4 lemons.
Step 4: Connect the last penny and nail to the light.
Step 5: Your light will turn on using lemon power!



The STEM behind the fun

Lemon juice is acidic and similar to the electrolytes used in other batteries to conduct electricity. Pennies and nails act as positive and negative electrodes. These materials are zinc (nail) and copper (penny) that when inserted into an electrolyte like lemon juice produce electricity through a chemical reaction. The lemons combine to make a battery that provides energy to power our LED.

Lemons in space?

We can't use lemons in space! They take up too much room, probably won't work in the vacuum of space and can't be recharged. Satellite cells use different chemicals and materials, which give more energy, are lighter and longer lasting.

Our newest cell is called Lithium Ion. It uses lithium and carbon as electrodes, and they produce a lot of power: 3.7 Volts per cell and up to 72.5 Amps of current per hour (270 Watts per hour).

Lithium Ion Vs. lemon power

Li-Ion cells produce far more power than lemons by weight; a spacecraft battery about the size of a travel suitcase could power your home for 4 hours with everything in the house turned on in every room. Several truckloads of lemons would be needed for that much power!

We group the cells on the satellite in bunches of up to 24 so we can get more power, (up to 9,000 Watt-hours), with that we can run the entire power system on the spacecraft during eclipse time with power left over.

Each Lithium Ion cell could power 100 cell phones, so an entire battery could run 2,400 cell phones. That is close to the number of phones of all the students, teachers, parents in your entire junior high and high school. These batteries also take up less space, can be recharged every day, and weigh a lot less than truckloads of lemons.

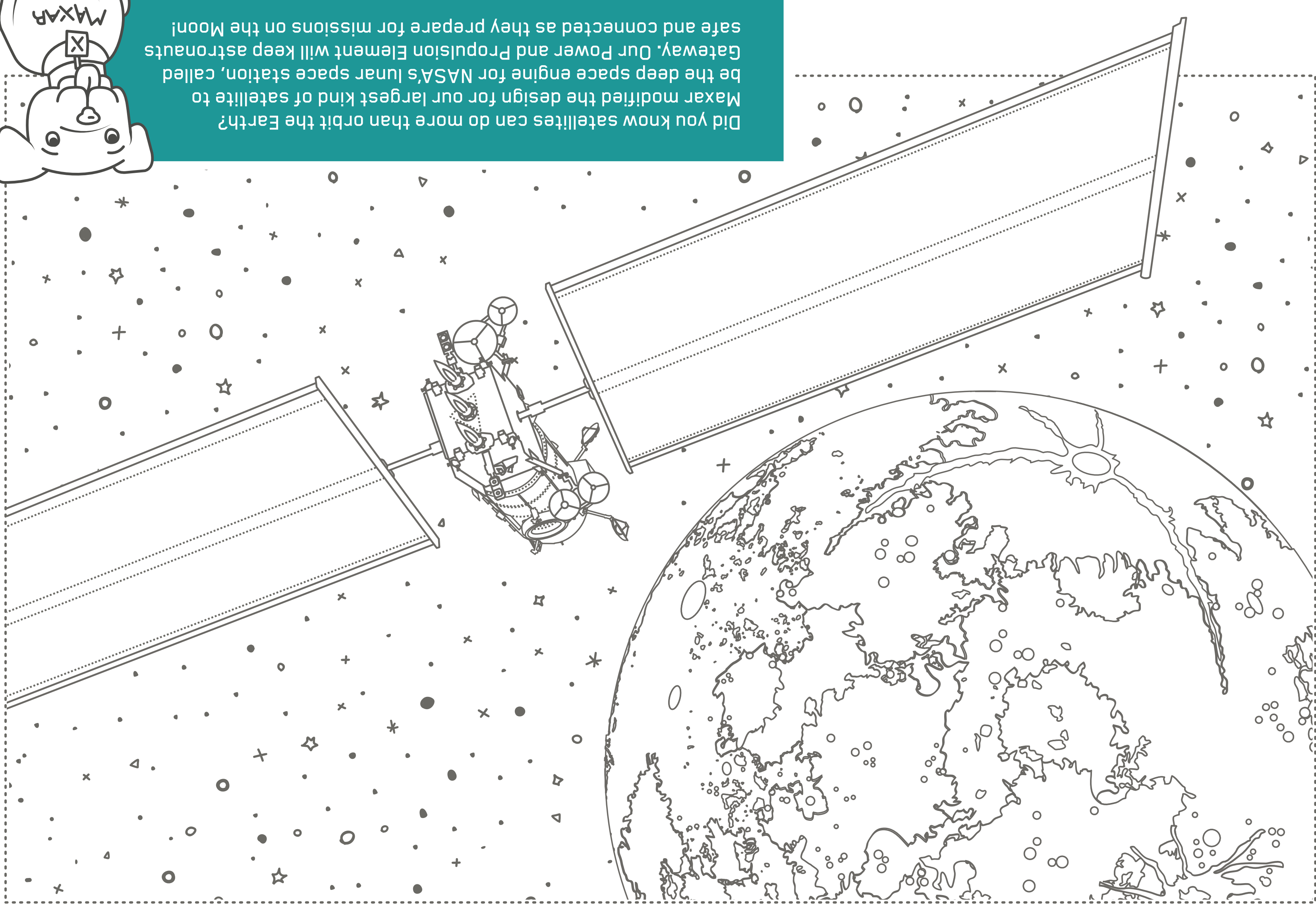
Credit: Michael Anderson, Systems Architecture Engineer at Maxar.

Q. How many lemons would it take to run a satellite? Any guesses? How many truckloads?

A. If one cell was a truck load, we'd need 24 per battery times two or 48 truck loads to run the spacecraft for just an hour. That's a lot of lemons!

GET CREATIVE AND COLOR THE MOON AND SPACECRAFT!

ACTIVITY



Did you know satellites can do more than orbit the Earth? Maxar modified the design for our largest kind of satellite to be the deep space engine for NASA's lunar space station, called Gateway. Our Power and Propulsion Element will keep astronauts safe and connected as they prepare for missions on the Moon!

WORD SEARCH

ACTIVITY

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

CAPTURE
CONSTELLATION
DATA
DETECT
EARTH
GLOBAL
IMAGERY
IMPACT
INSIGHTS
INTELLIGENCE
MAPPING
MISSION
MONITOR
MOON
NAVIGATE
OBSERVATION
ORBIT
SATELLITE
SCIENCE
SPACE
VALUES
WORLD

Maxar builds state-of-the-art robotic arms for all kinds of uses.

WHAT IS ROBOTICS?

Robotics is the study of machines that can be programmed to move and perform tasks on their own. These machines are called robots, and they can be programmed to do different things. For example, robots can be used in factories to build cars or in hospitals to help doctors with surgeries.

Robots are made up of different parts, like sensors that help them see and hear, motors that make them move, and a computer brain that tells them what to do. They can be big or small, and some of them even look like humans or animals.

They are often made with metal parts and can be powered by electricity or batteries. Robots can be used in many different fields, such as manufacturing, healthcare, and space exploration. Some robots are even

MAXAR ROBOTICS IN NUMBERS

25+ Years of robotics experience

06 Robotic arms for Mars landers and rovers

20+ Arms built

used to help with tasks around the home, like vacuuming the floor or mowing the lawn.

Robotics is a fun and exciting field to learn about because it combines science, technology, engineering, and math to create machines that can help us in a variety of ways. If you're interested in robotics, you can try building your own robot using kits and materials from a store or online. You can also learn more by taking classes or joining a robotics club.

What are robotic arms?

Robotic arms are mechanical arms that, in space, can perform several tasks such as the construction, maintenance, and repair of satellites, space stations, and other spacecraft. These arms can be remotely controlled or programmed to perform specific tasks and are equipped with tools and sensors to perform tasks in a challenging environment such as the vacuum of space. Robotic arms in space are useful for tasks that are dangerous or difficult for astronauts to perform and provide greater precision and control than can be achieved through manual operations

Examples of Maxar's space robotic arms include the ones in Mars rovers: Spirit, Opportunity, Curiosity and Perseverance; Mars lander Insight, and in the uncrewed space probe Phoenix. Other examples are the Canadian Robotics Arm (Canadarm) on the Space Shuttle and International Space Station, and the Dextre robot, a robotic "hand" that can do smaller jobs on the International Space Station.

Using robotics in space allows for complex servicing of spacecraft, assembly and manipulation tasks in low Earth orbit and beyond, including on the Moon and Mars.

What are the parts of a robotic arm?

Actuators: the motorized "joints" of the arm providing the ability to reach in different directions

Structure: the "bones" of the arm connecting the actuators and giving the arm its shape

Sensors: generate vital information for guiding the arm's movements

End effectors: the "hand" of the arm, allowing it to complete its job

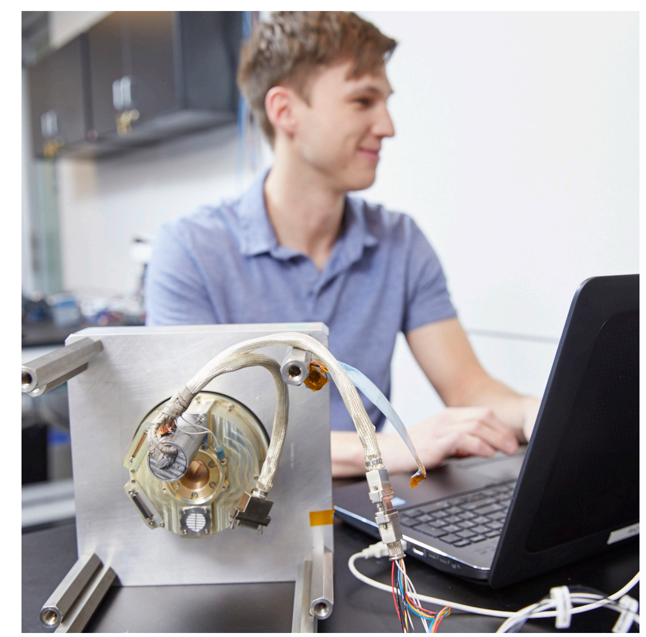
Robotics at Maxar. Engineers with many different skills work in Pasadena, California, and Westminster, Colorado, to design and develop robotic arms, which are built and tested in our Pasadena facility.

How do we use robotics to explore other worlds?

Robotics help humankind explore the solar system and the universe. Spacecraft that explore other worlds, like the moon or Mars, are all robotic. These machines include rovers and landers on the surface of other planets. The Mars rovers Spirit and Opportunity are examples of this kind of applications. Other robotic spacecraft fly by or orbit other worlds and study them from space. Cassini, the spacecraft that studied Saturn and its moons and rings, is this type of robot. The Voyager and Pioneer spacecraft now traveling outside Earth's solar system are also robots.

Unlike the robotic arm on the space station, these robots are autonomous. That means they can work by themselves. People use computers and powerful antennas to send messages to the spacecraft. The robots have antennas that receive the messages and transfer the commands telling them what to do into their computers. Then the robot will follow the commands, and in some tasks make quick decisions on their own.

In a mission, an astronaut or someone in Mission Control use robotic arms to perform tasks. They use controllers that look like joysticks used to play video games to move the arm around.



***Robotic arms receive commands.** The "brain" in the robotic machine gathers data from either the sensors or commands from the user and decides what to do next.*

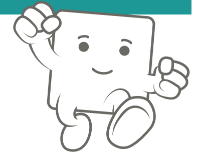
How can robotics help astronauts?

Robotic machines can also be used as scouts to check out new areas to be explored. Scout robots can take photographs and measure the terrain. This helps scientists and engineers make better plans for exploring. Scout robots can be used to look for dangers and to find the best places to walk, drive or stop. This helps astronauts work more safely and quickly. Having humans and machines work together makes it easier to study other worlds.

Credit: NASA Knows! (Grades 5-8) Series, and Maxar Robotics 101.

Q. What kind of tasks can a robotic arm perform?

A. A robotic arm can: act as a tool kit using a drill, scoop and other tools. It can also assemble and service spacecraft. One common task is to handle and acquire samples.



ACTIVITY

STEM LABORATORY
LET'S MAKE A ROBOTIC HAND

GOAL: Design and build a robotic hand using craft materials*. This hand will show us how a real robotic hand might work.

You'll need:

- Thick paper or cardboard (use a cereal, cracker, or tissue box)
- Yarn or string
- Plastic straws
- Stapler
- Scissors
- Tape or Glue
- Color paper (for decor)
- Pencil

**You'll need help from an adult for this activity.*

Instructions

Step 1: Trace a hand and arm on the cardboard and cut it out. You can also glue paper color shapes for decor if you want.

Step 2: Cut the straws into 1-inch pieces (or 1/2 inch if your hand is small!).

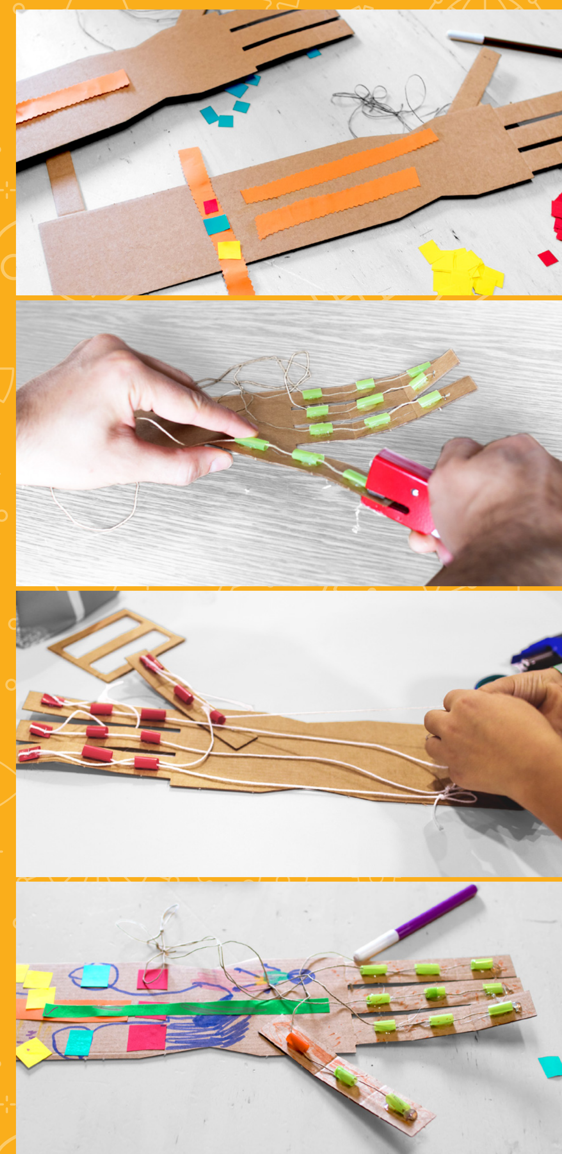
Step 3: Stick the straw pieces to the cardboard hand using tape or glue.

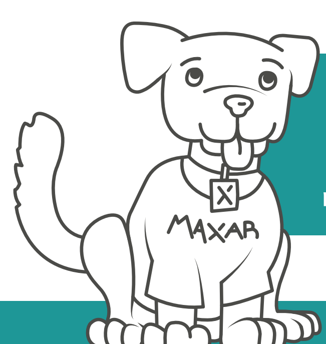
Step 4: Bend the cardboard between the straws to make joints.

Step 5: Cut 5 pieces of yarn, each 12 inches long, and tie a bead to the end of each one.

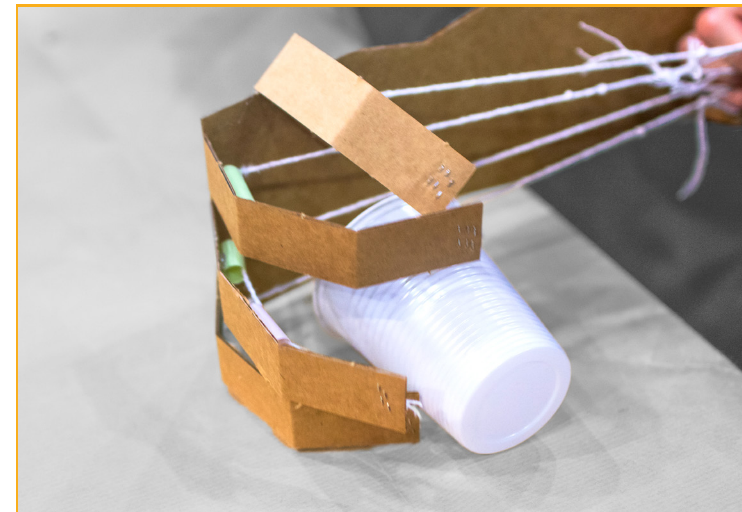
Step 6: Thread each piece of yarn through the straw pieces, starting at the fingertips and ending at the palm of your hand. Staple it on top of each finger to secure the yarn. Each finger should be controlled by one string.

Step 7: Pull the strings to control the movement of each finger! You now have a robotic hand!





Hands are so cool! You use them to play music, cook with your family, or build a robotic part! When designing robotics, the hand (or "end effector") is a really important part because it's what the robot uses to pick up and move things. Robots need to be able to grab things to get their job done.



The STEM behind the fun

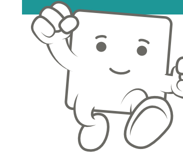
The human hand is capable of performing various actions thanks to the intricate workings within our bodies. Interestingly, our fingers don't have muscles, but instead, they rely on tendons - fine and tough fibers that connect the bones of our fingers to the muscles in our arms. When you want to make a fist or wave, your brain sends a message to your muscles to flex, which pulls on the tendons and moves the bones in your hand. It's like having a bunch of puppet strings connected to your fingers and arm that you can control to make your hand do different things!

Similarly, the robotic hand operates by the pull of strong strings that act like tendons in the human hand, moving the bones as a result of the arm muscles being flexed. When the string is released, the fingers go flat, simulating the action of the tendons releasing.

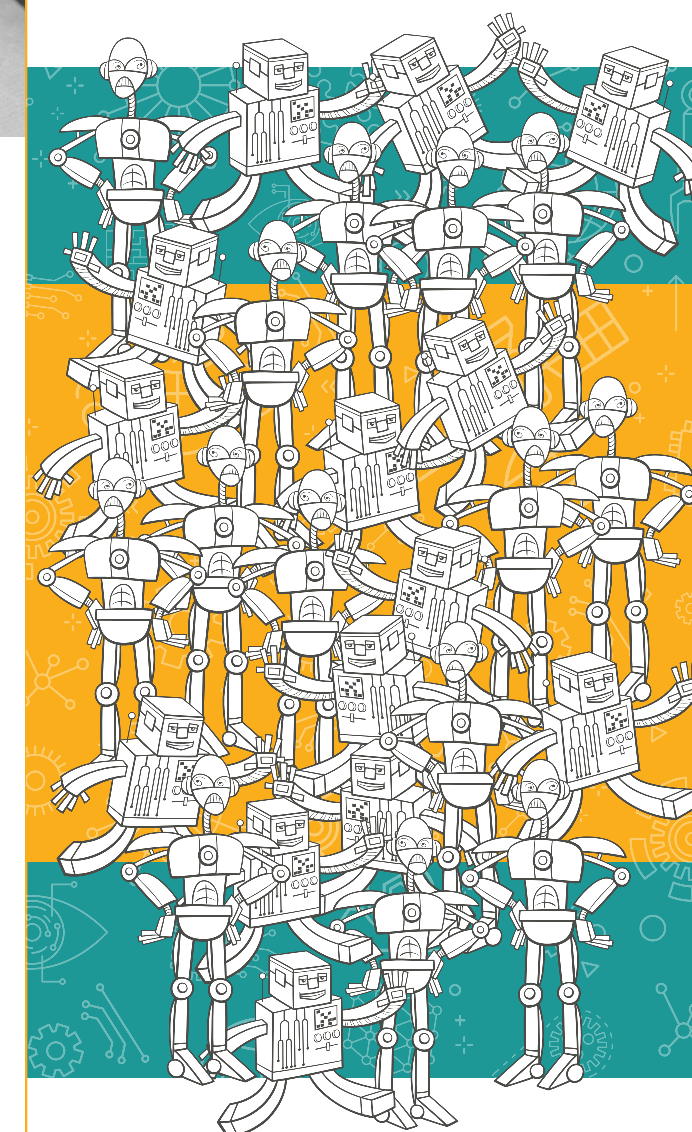
Try It!

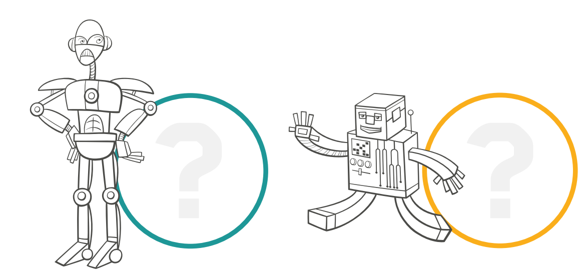
You can see the tendons in your hands by making your hand look like the photo provided. Observe and determine if what you see are bones or tendons. You can test the tendons by grabbing your right forearm with your left hand and making a fist, stretching your hand flat, or wiggling your fingers. Observe what you feel and why. Tendons are also found in other parts of the human body, but not all tendons do the same thing.

ACTIVITY



HOW MANY ROBOTS ARE THERE OF EACH KIND?



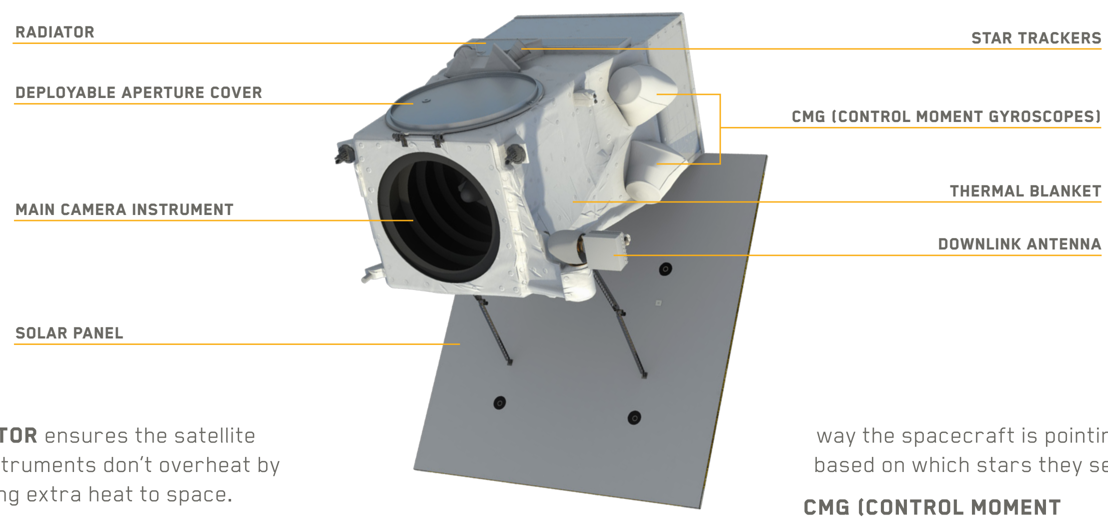


ACTIVITY

STEM LABORATORY
LET'S BUILD A SATELLITE MODEL

GOAL: Build a small-scale model of a satellite using basic materials such as paper, scissors, and glue. Let's learn some of the basic parts of WorldView Legion, a satellite that takes really close-up pictures of the Earth.

PARTS ON WORLDVIEW LEGION



RADIATOR ensures the satellite and instruments don't overheat by radiating extra heat to space.

DEPLOYABLE APERTURE COVER protects the main camera instrument during ground assembly and testing, launch and orbit raising. Think of it as a lid that covers the camera's lens. Once on orbit, it rotates 270 degrees to the open position shown above.

MAIN CAMERA INSTRUMENT is a very large camera that collects images of Earth.

SOLAR PANEL collects the sun's energy to power the electronics and main camera instrument.

STAR TRACKERS use a camera to determine which way the spacecraft is pointing based on which stars they see.

CMG (CONTROL MOMENT GYROSCOPES) are used to point and stabilize the spacecraft. Changing their rotation speed and direction makes the spacecraft react by changing its pointing direction.

THERMAL BLANKET makes sure the spacecraft's components don't freeze—space is very cold!

DOWNLINK ANTENNA sends the collected images to the ground station. This antenna can be independently pointed at the ground station to maintain contact while the spacecraft looks elsewhere to collect new imagery.

Instructions:

1. Cut out satellite from next page (15) body along dotted outline.
2. Crease along all dashed fold lines, forming a 3D rectangle with printed side of the paper facing out and non-printed side with tabs on inside. Bring numbered tabs together to form the rectangle (tab 1 to tab 1 and tab 2 to tab 2, etc.). Apply tape to hold it together.
3. Fold downlink antenna at dashed line and tape together so non-printed sides of the paper are hidden.
4. Cut out solar array and strut extension (one piece) along dotted outline.
5. Fold along dashed lines.
6. Tape middle section of the strut extension to the non-printed side of the solar array. Strut extension should now stick up from the non-printed side of the solar array.
7. Tape strut extension (5) to the 5 on satellite body. Tape solar array (6) to the 6 on satellite body.

.... Cut line   – – – – Fold line

WORLDVIEW LEGION
SATELLITE MODEL