FUTURE U.

Satellite Team Classroom Visit

Shades of Grey

Overview

After a discussion on how satellites work, students will use a photo mosaic to further understand how satellites collect information, break it down, and reassemble it to deliver light images to Earth. For their final activity, students will work as partners to complete a grid art, where different shades are given a numerical value to create a picture representing the Boeing Tracking and Data Relay Satellite TDSR.

Background

Boeing has been working on space communications for over sixty years. Scientists, the military, and businesses all rely on these satellites to keep our lives safer, more informed and enjoyable.

Boeing has partnered with NASA for over forty years, providing satellites to improve space communications. The Tracking and Data Relaying Satellite (TDRS-13) is a satellite that launched in 2018. It provides high-bandwidth communications to spacecraft in low-Earth orbit. The TDRS network allows continuous communication with the International Space Station, the Hubble Space Telescope, the Earth Observing System and other programs supporting human space flight. “The TDRS fleet is a critical connection delivering science and human spaceflight data to those who can use it here on Earth,” says Dave Littmann, the TDRS project manager at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. “TDRS-M will expand the capabilities and extend the lifespan of the Space Network, allowing us to continue receiving and transmitting mission data well into the next decade.” With Boeing being the literal middleman between Earth and the universe, endless space discoveries have been and will continue to be made.

The Hubble Space Telescope is the length of a large school bus and weighs as much as two adult elephants. Traveling at 5 miles per second, it is equivalent to going from the east coast to the west coast of the U.S. in 10 minutes. HST has taken over a million images, including the birth and death of stars, and comets crashing into Jupiter’s gases. These images have helped astronomers make incredible discoveries such as finding black holes, dark energy, gamma-ray bursts and estimating that the universe is about 14 billion years old!

Materials (per group of 2)

- Transparent 10x10 Grid (Appendix A)
- White Paper 10x10 Grid (Appendix A)
- Picture of Boeing satellite with strong contrasts (Appendix B)
- Numeric Shade Chart between 0-3 (Appendix C)
- Pencils

Introduction (10 minutes)

1. Introduce yourself and your role at Boeing. What is your background and what made you want a career in STEM? Begin to build relationships with the students by asking them how they think they use satellites every day. How have they seen telescopes or satellites used in TV or movies?
2. Next, ask if any of them can explain what a satellite is and what its function is.
3. Explain the role Boeing has played in space communications, building satellites like the TDRS that works with the International Space Station and the Hubble Space Telescope. Satellites receive and transmit information from the ISS and the HST to computers on Earth.

   Visual from NASA here: https://www.nasa.gov/sites/default/files/thumbnails/image/4_tdrs_iss_slow-sm.gif Astronomers can then use this information to learn more about the biggest mysteries out there, like observing the birth and death of stars, looking at galaxies billions of light-years away, and estimating just how old the universe is (almost 14 billion years old).

   Satellites and telescopes stay in space for many, many years, constantly collecting data. Since it isn't feasible to use film, or for a satellite to have enough memory to store millions of images, the best way to send images to Earth is to collect bits of light from images in space. These bits of light are broken down into numerical information, each shade being given a different number, which is then transmitted down to Earth via satellites. Once there, image processing computers put the numbers in order and reassign their color shade. As the colors of black, white, and many shades of gray come together, a clear image from space is formed.
4. Zoom in to the following image and let students observe as you zoom out. Invite students to share their observations of what is happening. Students should notice as more pixels are revealed, an image becomes clearer: https://www.flickr.com/photos/mosaicmaniac/3102286740

   Ask if any of them have heard of pixels. What devices and hobbies use pixels? Explain to students their phone, TV, tablets, and video games all use pixels to create images. Millions of pixels are put together from telescopes and satellites to give astronomers clear images to study.

Activity (30 minutes)

1. Let the students know that they will now work in pairs. One partner will be the Hubble Space Telescope and TDRS satellite, taking in light from space, converting those light images into numerical data and sending those data through a satellite to Earth. The other partner will be the radio receiver and image processing computer, taking the numbers and converting them back to an image.
2. Divide students into pairs or ask the teacher to help with that as you hand out materials.
3. Give the first student in each pair the paper copy of the blank grid. Let them know that they are the computers on Earth. Give the other student in each pair the picture of a Boeing satellite and the transparent grid. Let them know they are space computers and satellites and tell them not to show their picture to their partner.
4. Explain that the picture is an object being observed at a great distance. It will be scanned by the Hubble Telescope and an image will be created on the paper.
5. Have the first student place the transparent grid over the picture. They should look at the brightness of each square defined by the grid lines and assign it a number according to the chart above the picture. They will then call out the number to their partner being the computer on Earth. If a particular square covers an area of the picture that is both light and dark, it should be assigned an estimate average of brightness.
6. After receiving a number from the satellite student, the Earth partner will shade the corresponding square on the grid. If the number is 0, the square should be shaded black. If it is 3, the square should be left blank.
7. When the grids are completed, have them compare the original picture with the image sketched on the paper.

Wrap Up (5 minutes)

1. Have groups share their created images. Discuss their findings and what could be done to refine the images. For instance, the smaller the grid (more squares) and the more shades of gray, the more detailed and accurate the picture will be. According to NASA, “With the HST, the grid consists of more than 2.5 million pixels and they are shaded in 256 steps from black to white instead of just the 4 shades used here.”
2. Although theirs was a crude image, they now understand how data is received and transmitted by satellites. Challenge them to do this activity with a family member at home. They can choose their own photo; they just need to assure it is black and white and of high contrast.

Extensions

If time allows, students can redo the activity with a grid that has twice as many pixels. This will take twice as much time, so they will not finish within your timeframe, but could return to the project in another session or take it home to complete.

References

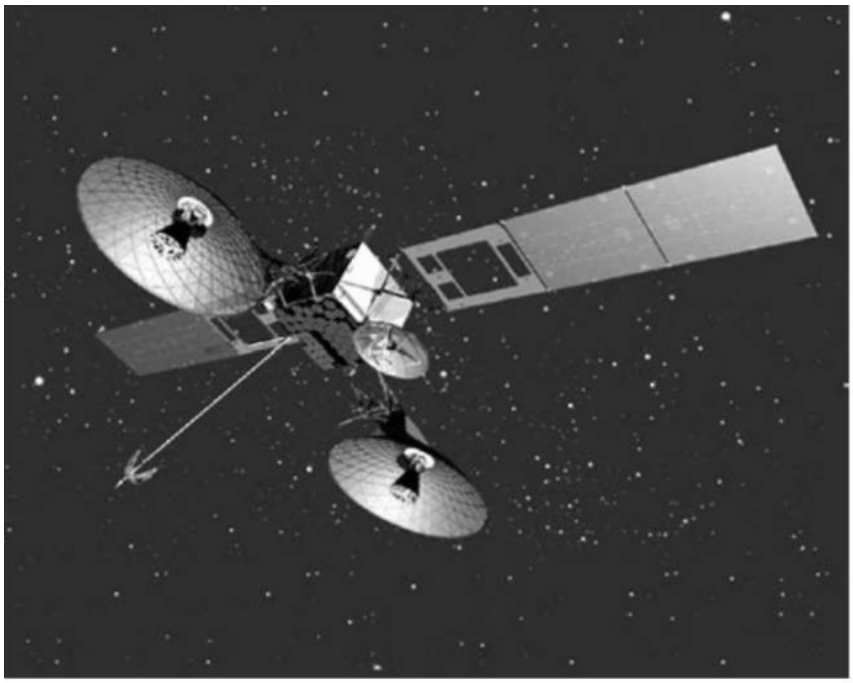
- https://www.boeing.com/space/
- https://www.boeing.com/space/boeing-satellite-family/
- https://boeing.mediaroom.com/news-releases-statements?item=129996
- https://www.intelligent-aerospace.com/satcom/article/16544512/ula-launches-boeingbuilt-tdrsm-satellite-to-complete-nasa-space-communications-network
- https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-the-hubble-space-telecope-58.html
- https://www.nasa.gov/feature/goddard/2017/tdrs-an-era-of-continuous-space-communications/
- https://www.flickr.com/photos/mosaicmaniac/3102286740
- https://www.nasa.gov/pdf/319891main_Down_to_Earth.pdf

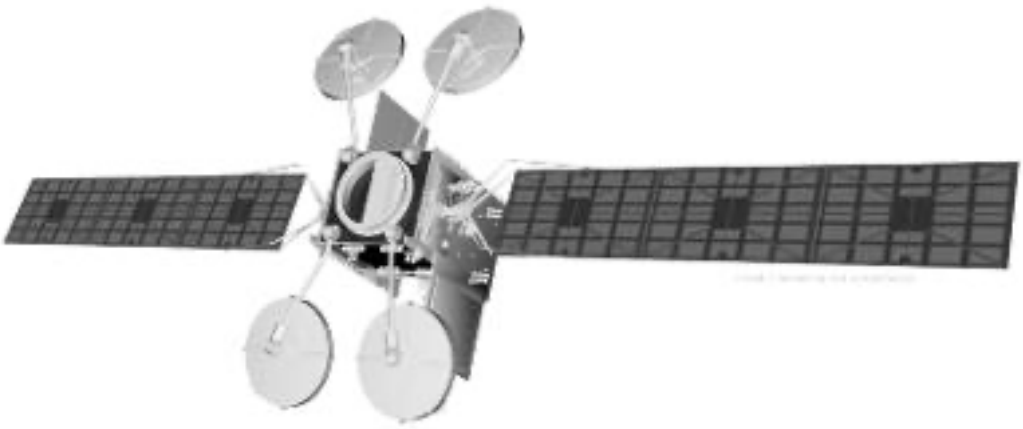
Example Grid for both the transparency and paper copy.

1	2	3	4	5	6	7	8	9	10	
										A
										B
										C
										D
										E
										F
										G
										H
										I
										J

15x15 Grid Option:

Example photograph of high-contrast satellite that could be used, although white background would take less time and have more contrast:





Shading Values

0 1 2 3