Laser Communication Relay

For the Teacher

Challenge

Design a communication device to send a message 6 meters using string and cups to discover how sound travels.

Materials

Students will test several different types of materials to determine which produces the best communication device. Place all provided materials in a central location for students.

Items required for activity:

- Fishing line, waxed dental floss, and embroidery or regular thread (6 meters of each, per team)
- Variety of plastic/paper cup sizes, Styrofoam cups, soup cans, etc. (at least 2 of each type, for each team)
- Large paper clips (at least 2 per team)
- Scissors (one for each team)
- Digital scale or balance

Motivate

- Ask students how they think sound travels. Sound travels through media like air or string. There are many activities and resources to explore how sound travels. *http://quest.arc.nasa.gov/aero/events/regimes/speed.html*
- Activities about the electromagnetic spectrum can be found at: *http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html*
- Today's challenge involves developing a communication device. What are some ways we communicate with each other? (Writing, verbal, nonverbal, and visual.)
- Ask students for suggestions of possible problems that can occur in communication. (Poor reception or connection, interference, noise, cloud cover, language barrier, etc.)

Pre-Activity Set-up

This challenge activity encourages students to design and create the communication device on their own using string and two cups/cans.

They will need to determine which type of string to use, which type of cup, how tight to pull the string, and how to best communicate a distance of 6 meters.

If the students are having trouble with the string popping out of the bottom of the cup as they try to pull it tight, guide students to put a paperclip on the inside of the cup and tie the string to it. Most teams will figure it out on their own as the paperclips were provided to them!

This activity should be done in an area the students can spread out and hear without excess noise. If possible, use hallways or between two classrooms for final testing.

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- NASA uses radio waves (see links below for more information and activities) to carry messages through space. NASA's network of satellites, spacecraft, astronauts, ground station antennas, etc. is used to communicate throughout space. This network can sometimes takes a long time to relay information. *https://www.spacecomm.nasa.gov/spacecomm/programs/space_network.cfm*
- Connect the challenge with real time information. NASA is developing a Laser Communication Relay system, which is an infrared laser that will improve the amount of data that can be communicated at one time. For example, instead of just getting one small message every minute, you get 5 messages every minute. Videos and more information can be found on the *Background Page* and at *http://www.nasa.gov/mission_pages/tdm/lcrd/index.html*. A NASA-produced overview video is available at *http://www.youtube.com/v/f8LL2rRnw9o*.

Ask

- Students will write out any questions they may have about radio waves, communication, and the challenge.

Imagine

- Students will draw out their ideas for a communication system using the provided materials.

Plan

- Students will determine how they want to set up their communication system. Each member of the team will need to have a role.

Create

- Students work to create their own communication system and transmit messages.

Experiment

- Students will test and improve their communication devices by transmitting simple messages 6 meters. When the team has determined they have a communication device they are satisfied with, students should complete further testing as described on the *Experiment and Record* student pages.
- Students will exchange communication systems to complete the *Quality Assurance* student pages.

Improve

- After completing testing, students make modifications to their designed communication system. Improvements should focus on reducing any problems with transmitting messages and clarity.

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For the Teacher

Challenge Closure

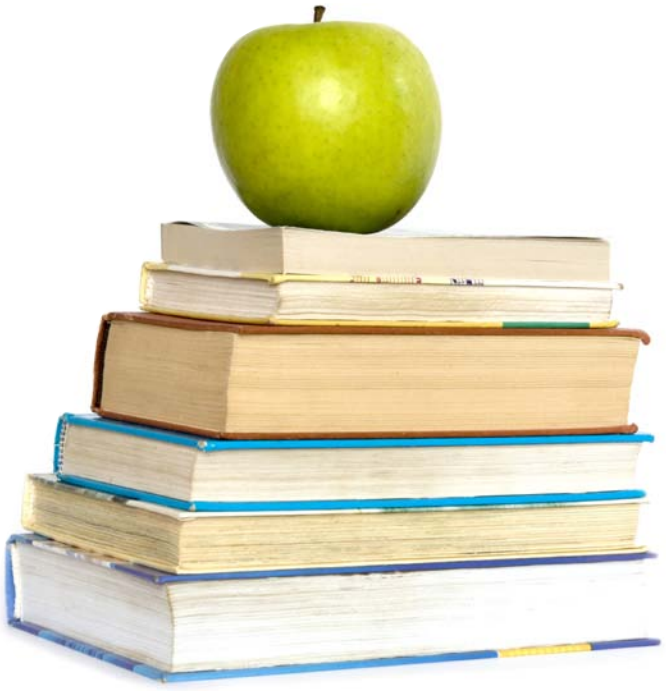
Engage the students in a discussion by reviewing and posing the following questions:

- Which design characteristics provided the most reliable results?
- What happened if your string was not pulled tight?
- What happened if someone/something was touching the string in the middle? Did the sound still travel? Why or why not?
- What other materials could you try to improve the clarity and the volume of your messages?
- What impact did the length of your message have? (This relates directly to the Laser Communication Relay Technology. We have the means to communicate now, but if large messages get jumbled up and delayed, it loses the effectiveness of the communication system. The LCR will be able to handle the larger messages.)
- How would your message work over a longer distance? 12 meters? What about around a corner?
- What did you learn about your team's design while testing another group's design?

Safety Concerns

In this activity, keep common sense safety in mind. Possible things to be aware of:

- Students walking into strings spread across the room or hallways.
- Students using scissors to poke holes in bottoms of cups.
- Instructors can pre-puncture holes in cans for students.



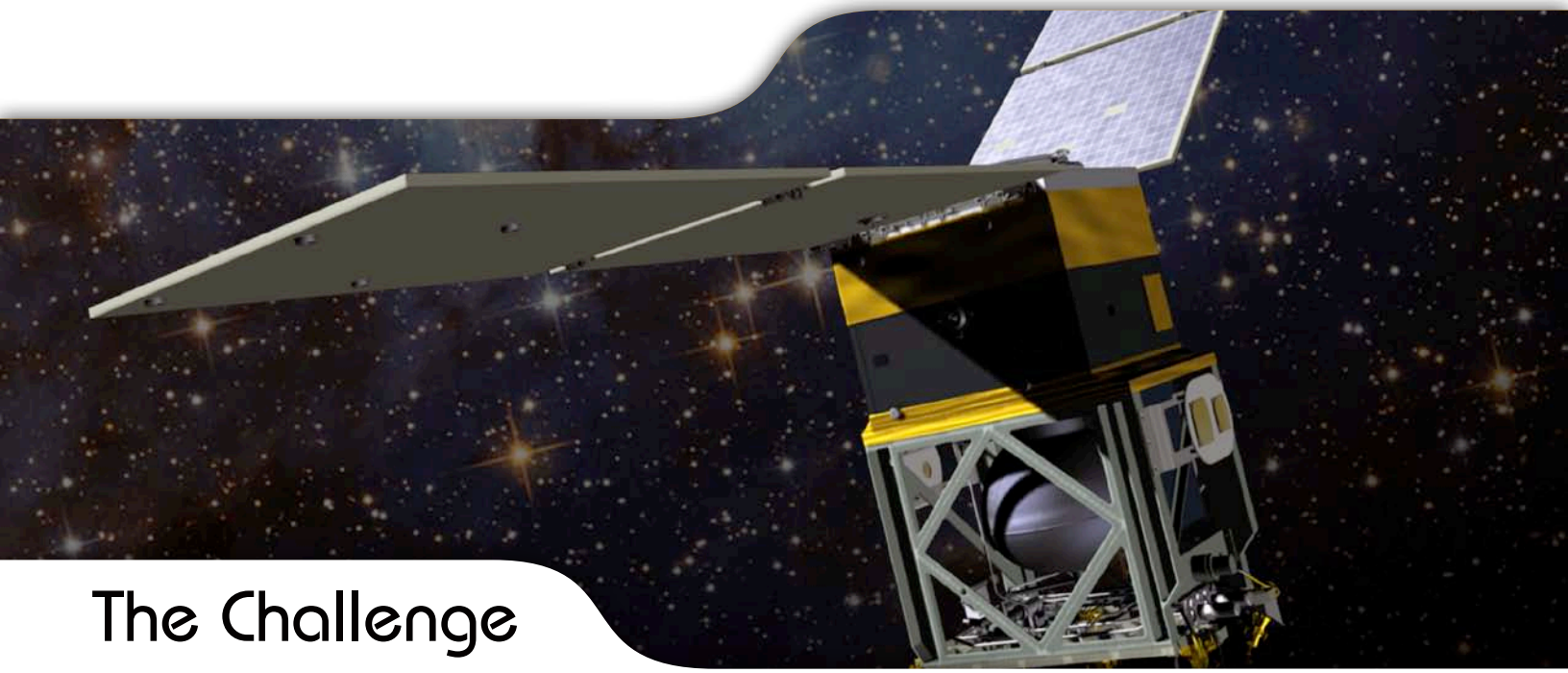
Background

Laser Communication Relay

The Laser Communication Relay Demonstration mission will revolutionize the way we send and receive data, video, and other information in space. This new technology will use the infrared portion of the electromagnetic spectrum to transmit data. The infrared waves are "tighter" and transmit using a narrower beam. We can fit more "bits" of data (a.k.a. more binary code) on each smaller wave, therefore transmitting more data with each transmission. This new technology will not only bring faster communication speeds but will also be done with less mass and power.

This new technology will enable scientists to send and receive large amounts of data at one time, instead of in small bits. Currently an average Radio Frequency satellite can transmit a full-length HD movie from space to Earth in 9 hours. With this new technology, that same full-length, HD video will transmit from space to Earth in just 8 minutes!

Find more information at *http://www.nasa.gov/pdf/742122main_LCRDFactSheet3.pdf* An overview video can be found at *http://www.youtube.com/v/f8LL2rRnw9o*



The Challenge

Design a communication system to transmit messages 6 meters using string and two cups.

- Use only provided materials.
- Use at least 6 meters of string.
- Use only two cups.

Reminder For All Challenges

- Be sure to document all testing results.
- Make any necessary design changes to improve your results and retest.
- Complete all conclusion questions.

Our Team's Plan

Laser Communication Relay

ASK

Today you will design a communication system to transmit a message 6 meters.
What questions do you have about today's challenge?

IMAGINE

What special features will your communication system have?

PLAN

Draw and label your communication system.

Be sure to include measurements!

Write instructions on how to use your communication system for another team.

Experiment & Record

Team Name _____

After your team has determined that you have a communication device that will transmit a message 6 meters, complete these experiments to further test your communication device.

Record the mass of your communication system: _____

1. Communicate a message of one word. Word attempted to communicate:

_____

Attempt #1 Results	Attempt #2 Results	Attempt #3 Results

Make any modifications to your communication system, and repeat the one-word communication until it is successful.

2. Communicate a sound (like whistle or humming). Sound attempted to communicate:

_____

Attempt #1 Results	Attempt #2 Results	Attempt #3 Results

Make any modifications to your communication system design.

3. Communicate a short message of 15 words. Message attempted to communicate:

_____

Attempt #1 Results	Attempt #2 Results	Attempt #3 Results

Make any modifications to your communication system design.

Experiment & Record

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3. Exchange communication systems. Your team received another team's communication system. Follow the instructions provided and fill out the *Quality Assurance Form*. Return the *Quality Assurance* page back to the team.

4. After reviewing your team's *Quality Assurance* page, how will you improve the design of your communication system?

Challenge Closure

1. Which design characteristics provided the most reliable results?

2. What happened if your string was not pulled tight?

3. What happened if someone/something was touching the string in the middle? Did the sound still travel? Why or Why not?

4. What other materials could you try to improve the clarity and the volume of your design?

5. What impact did the length of your message have?

6. How would your device work over a longer distance? 12 meters? What about around a corner?

7. What did you learn about your team's design while testing another group's design?

Quality Assurance

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Each team is to review another team's design and model, then answer the following questions.

Team Name	Yes	No	Notes
Did you receive a copy of the communication system and instructions to use it?			
Were you able to successfully communicate a one-word message?			
Were you able to successfully communicate a sound?			
Were you able to successfully communicate a short sentence of 15 words?			

List the specific strengths of the design.

List the specific weaknesses of the design.

Inspected by: _____

Signature: _____

More Fun With Engineering

Laser Communication Relay

Activity One:

The infrared waves used in the Laser Communication Relay system that NASA is developing, are the same ones used on your TV remote control. You are unable to see the infrared waves emitted from the remote, but you know you have to point them in the right direction to change the channel.

There are two issues the LCR team faces; one is cloud cover and the other is pointing. If someone stands in between you and the TV, the remote will not be able to transmit to the TV. For Laser Communication, clouds are just like someone standing in front of the TV and blocking the signal. What are some solutions that you can think of to help the engineers solve this problem?

The other issue the engineers face is keeping the laser pointing at the exact same spot as the spacecraft orbits, and the laser beam must travel distances of over 22,300 miles!

To demonstrate this, use a laser pointer and try to continually point to the same spot on the wall, while moving your arm in a circle, like you are orbiting. Can you keep it on the spot? Try keeping on the same target from 8 meters away. What ideas do you have for engineers to help reduce these jitters?

In Unit 4 Down to Earth, of Space-Based Astronomy Educator Guide, the activity Binary Number and Paint by the Numbers, demonstrates the imaging process of astronomical satellites. It familiarizes students with the process of data transmission to Earth.

The activity can be found at: *http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Down_to_Earth.html*

Activity Two:

NASA, the American Geosciences Institute and Arizona State University School of Earth and Space Exploration have a guide for the New Horizons mission called *New Horizons Earth Calling*. This is a middle school-level activity exploring spacecraft radio communication concepts, including speed of light and the time delay for signals sent to and from spacecraft.

http://www.agiweb.org/education/NASA/tr/invest/activities/NewHorizonsEarthCalling.pdf