WhispersFromSpace

Teacher Information

Background Information

The National Aeronautics and Space Administration (NASA) has been sending robotic spacecraft out into the Solar System for more than four decades. These mechanical explorers have ventured out to study Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune. These amazing robots have been our eyes and ears on their journeys to far-off planets and even to the edge of the Solar System, sending wondrous images and fascinating information back to Earth.

But none of these missions of discovery would have been possible without the Deep Space Network – a worldwide system of sensitive antennas that communicates with NASA's interplanetary spacecraft. Signals to and from the spacecraft travel millions, even billions of kilometers. Yet spacecraft communications equipment transmits signals at very low power, usually about 20 watts, about the same as a refrigerator light bulb. As the signal travels to Earth, it continues to lose energy, and signals arriving at the antennas on Earth can be as weak as a billionth of a billionth of a watt – that is 20 billion times less than the power required for a digital wristwatch. How is it possible to hear the tiny whisper of a signal from a spacecraft so far away?

The Deep Space Network is made up of complexes of antennas in three locations on the globe – Goldstone, California (in the Mojave Desert); near Canberra, Australia; and near Madrid, Spain. This arrangement compensates for Earth's rotation so that a distant spacecraft is in view of one of the Deep Space Network's antenna complexes 24 hours a day. The spacecraft signals are received at one site; as Earth turns, the spacecraft "sets" (like the Sun setting each night) and the next site picks up the signal, then the third site, and then the first again.

The largest antennas in the Deep Space Network are the 70-meter-diameter dishes – there is one at each of the three complexes. All of the complexes have additional antennas of varying sizes.

To hear the low-power spacecraft signal receiving antennas on Earth must be very large, with extremely sensitive receivers. The signal from the spacecraft travels in a straight line, and it can be focused by a curved reflector dish (parabolic antenna), so large antenna dishes with precisely shaped surfaces are crucial. The Deep Space Network's parabolic dishes are focusing mechanisms that concentrate power when receiving data and also when transmitting commands. The antennas must point very accurately towards the spacecraft because an antenna can "see" only a tiny portion of the sky (as though looking at the sky through a soda straw).

To hear the spacecraft's faint signal, the antennas are equipped with amplifiers, but there are two problems. First, the signal becomes degraded by background noise (static) emitted naturally by nearly all objects in the universe, including the Sun and Earth. The background noise gets amplified along with the signal. Second, the powerful electronic equipment amplifying the signal adds noise of its own. The Deep Space Network uses highly sophisticated technology, including cooling the amplifiers to a few degrees above absolute zero, and special coding techniques so the receiving system can distinguish the signal from the unwanted noise.

New space missions bring new challenges. NASA's Deep Space Network is continually improved and enhanced to provide communications, navigation, and tracking for distant spacecraft – our robot explorers of the cosmos.

Teacher Information (Continued)

Key Concepts and Student Information

- Parabola – A shape like a shallow bowl that focuses incoming signals to a common focal point
- antenna – device which radiates and/or receives radio signals

Materials

Directions for making antennas (1 copy per student)
Antenna pattern on cardstock (1 copy per student)
Data table sheet (1 copy per student)
Large open space (football field, soccer field, large gymnasium, etc.)
Soda bottles 1-3 liter (1 per student)
Scissors (1 per pair/group)
Tape
Measuring Tape
2 or more umbrellas of different diameters
Digital watch with timer that can be set for repeated beeping

Procedure - Prep

1. Have students gather around to listen to the sound of the beeping timer. (The beeping timer represents a communication signal sent from NASA scientists on Earth to the spacecraft or a signal sent from the spacecraft to Earth.)
2. Have students predict a distance, in meters, they think they can walk away from the source of the beeping and still hear it with their ears alone – have them write predictions in data tables.
3. Have students develop hypothesis about how they think using a parabolic antenna will affect their ability to hear the signal the farther away they walk and why.

Procedure – Experiment #1: Can You Hear Me?

1. One person (teacher or student) will be the Sender who is the transmitter or spacecraft sending a signal with the beeping timer.
2. Students should form a circle around the Sender.
3. Students should record the number of meters that they are from the signal to start.
4. Students should raise one hand as long as they hear the signal.
5. The Sender should turn around, facing the signal in the direction of each student.
6. The students should step approximately 1 meter farther away from the Sender after each time they hear the signal, until they reach a distance at which the signal is too weak to hear.
7. When students can no longer hear the signal, they should stop and record their distance from the signal.

Teacher Information (Continued)

Procedure – Experiment #2: Using a Satellite

1. Tape the beeper to the handle of an umbrella.
2. Repeat Activity #1 with the Sender holding an umbrella, pointing the handle at the students to direct the signal toward them.

Procedure – Experiment #3: Using anAntenna

1. In the classroom, students construct “ear” antennas – cardstock antennas from patterns or antennas made from plastic soda bottles.
2. Return to the field.
3. Repeat Activity #2 with students using “ears” pointed at the signal.

WhispersFromSpace

Student Sheet

You may have noticed that when you move further away from a sound, it gets softer. When you move towards a sound it gets louder. What is the maximum distance you can hear a sound though? In this activity, you will do some experiments to test that out.

Objective
To give students a mathematical model of how the Deep Space Network antennas work and how the antennas concentrate electromagnetic radio waves in a single direction.

Materials
Directions for making antennas (1 copy per student)
Antenna pattern on cardstock (1 copy per student)
Data table sheet (1 copy per student)
Large open space (football field, soccer field, large gymnasium, etc.)
Soda bottles 1-3 liter (1 per student)
Scissors (1 per pair/group)
Tape
Measuring Tape
2 or more umbrellas of different diameters
Digital watch with timer that can be set for repeated beeping

Procedure – Experiment #1: Can You Hear Me
1. One person will take a beeper that will emit 1 beep per second
2. The rest of the team will stand in a circle surrounding the person with the beeper.
3. The person holding the beeper will start to spin around slowly in the middle of the circle.
4. Every time someone in the circle hears a beep, they will take a step back.
5. Continue until nobody in the circle can hear the beep anymore.
6. Record the results and answer the questions in the _____.

Procedure – Experiment #2: Using a Satellite
1. Try the same experiment, but this time, tape the beeper onto an umbrella handle.
2. Once again, the person holding the beeper should spin around slowly – point the umbrella, handle side out, to the students in the circle.
3. Like before, the students in the circle should take steps back until they can no longer hear it.
4. Record the results and answer the questions in the _____.

Procedure – Experiment #3: Using an Antenna
1. Use the cardstock pattern construct “ears” made out of 2-liter bottles, cardboard, or anything else you can think of to help “catch” the sound. (The bigger the “ears”, the larger area of sound you can hopefully catch.)
2. Try the same experiment, but this time, students should use the “ears” by pointing them toward the beeper as they take steps back.
3. Record the results and answer the questions in the _____.

WhispersFromSpace

Student Data Sheet

EXPERIMENT #1: CAN YOU HEAR ME?

Maximum Distance Signal Can Be Heard	

Experiment #1 Questions:

1. How many steps did you take until you could no longer hear the beep? _____
2. Did everyone end up in a circle or did some people have to take more steps than others? _____
3. Why do you think this is? _____

EXPERIMENT #2: USING A SATELLITE

Maximum Distance Signal Can Be Heard	

Experiment #2 Questions:

1. How many steps did you take until you could no longer hear the beep? _____
2. Do you notice anything different this time? _____
3. Why do you think this is? _____

EXPERIMENT #3: USING AN ANTENNA

Maximum Distance Signal Can Be Heard	

Experiment #3 Questions:

1. How many steps did you take until you could no longer hear the beep? _____
2. Did your “ears” improve your hearing? _____
3. Why do you think this is? _____