Calling All Spacecraft!

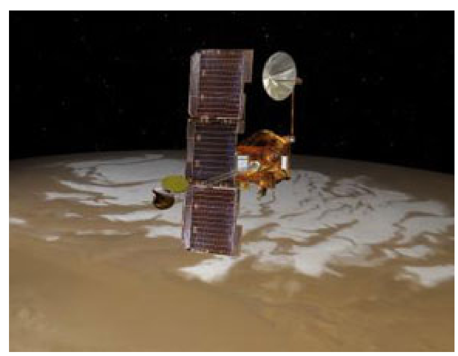
When it comes to making a long-distance call, it's hard to top NASA's Deep Space Network (DSN).

The DSN is the system that NASA uses to communicate with its many spacecraft exploring other worlds. The challenge facing the DSN is an impressive one. Imagine setting your car radio to a station, and then driving out of town. If it's a good signal, you may still pick it up after a couple hundred miles or so. In space, however, that only gets you into low Earth orbit. Some of the signals the DSN has to receive are coming from beyond the edge of our solar system. And, the transmitters on spacecraft do not have the power available to them that a radio station tower does. So, how can DSN continue to receive good information from tens of millions of times farther away than your car radio can?

The DSN is the largest and most sensitive scientific telecommunications system in the world. The DSN is a collection of three communication centers that support **interplanetary** spacecraft missions. Each complex has several antennas with diameters ranging in size from 26 meters (85 feet) to 70 meters (230 feet). In addition, the DSN conducts radio and radar astronomy observations of our solar system and beyond. Closer to home, it supports selected spacecraft in Earth orbit. One of the centers is at Goldstone in California's Mojave Desert. Another is near Madrid, Spain, with the third near Canberra, Australia. This placement puts the three facilities evenly space around the world. This allows constant contact with spacecraft as the Earth rotates. The antennas can be steered toward a given direction with very high accuracy. The two-way communications system between the ground and the spacecraft makes it possible to receive **telemetry** data from spacecraft. This would include the spacecraft's position and velocity. Scientists can then transmit commands back to the spacecraft. The DSN is operated by NASA's Jet Propulsion Laboratory (JPL). JPL operates many of the agency's interplanetary spacecraft missions.

Although the DSN wasn't formally established until 1963, its roots date back even further than that. In 1958, the year that NASA was established, the first antennas were built at the Goldstone site. Additional facilities were also being developed in Woomera, Australia, and Johannesburg, South Africa. In 1963, the director of JPL created the DSN, combining the various facilities into a global network. Since that time, the two overseas sites have been relocated, the antennas' receiving systems have been upgraded, and antennas have been added. The DSN originally used 26-meter (85-foot) antennas operating at low frequency L band (1.7 gigahertz [GHz]). Today, it makes use of 34-meter (112-foot) and 70-meter (230-foot) antennas operating at very high frequencies such as X-band (8.4 GHz) and Ka Band (32 GHz). At its beginning, the DSN usually supported only one spacecraft at a time. Today, it supports more than three dozen in a year. Some of those are so far out that getting a message to the spacecraft and receiving its response at the speed of light takes more than a day. Originally, the network could only receive 8 bits of data per second. It now regularly receives millions of bits per second.

Currently, DSN supported missions include the Mars Exploration Rovers, the Stardust comet sample return mission, and the Cassini spacecraft orbiting Saturn. Also, the Voyager 1 and 2 spacecraft have been communicating through the DSN since they were launched in 1977. Voyager 1, farther away than any other spacecraft, is now at the edge of our solar system. It is searching for the region where our Sun's influence ends and **interstellar** space begins. When the DSN sends a signal to Mars, it takes 15 minutes to reach the Red Planet. Voyager 1 is so far out that the signal takes about 13 hours just to reach the spacecraft.



While the core of the DSN is still its powerful antennas, parts of today's communication system are out of this world. NASA now is operating a communications network at Mars. Rovers on the surface have two ways of communicating with Earth. One, they can send signals directly back to Earth through the DSN. Two, they can send signals to spacecraft in orbit around Mars. Those signals are then relayed to Earth to the DSN. In fact, most of the scientific data from the rovers is relayed back to Earth by the Odyssey and Mars Global Surveyor spacecraft. Later this decade, the first step will be taken in expanding the DSN into space. NASA will launch a spacecraft to Mars with the sole purpose of being a relay communications satellite like those in orbit around the Earth.

As NASA's exploration spacecraft have spread through the solar system and beyond, the DSN has grown to provide the support they need. Perhaps, someday, people will look back on the early days when all of the DSN's antennas were still just on Earth.

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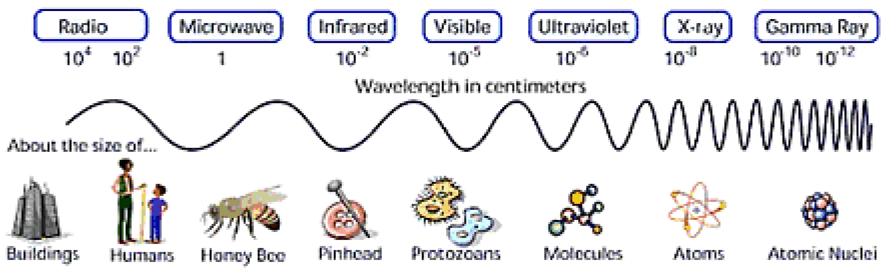
Traveling Light

Student Sheet(s)

Background Information

Radio waves are one part of the entire electromagnetic spectrum. This spectrum contains all of the forms of light ranging from radio waves all the way up through gamma rays. The radio waves are at one end of the spectrum with long wavelengths and low frequencies. The other end of the spectrum is gamma rays with short wavelengths and high frequencies. The visible spectrum is in the middle, which is the form of light with which we are most familiar. Even though each region of the electromagnetic spectrum is unique, the regions have one common factor. All forms of light travel at the same speed in a vacuum (like outer space): 3×10^8 meters per second [m/s].



To find how long it takes radio waves (light) to travel from Earth to a spacecraft, we can use the following equation: **v = d /t**, where

v is the speed of light in a vacuum (m/s),
d is the distance traveled in meters (m),
and **t** is the time elapsed in seconds (sec).

Using the information given in the chart below, you should be able to find the travel time for light from one planet to another.

Planet	Distance from Sun (m)
Mercury	5.79×10^{10}
Venus	1.082×10^{11}
Earth	1.496×10^{11}
Mars	2.279×10^{11}
Jupiter	7.783×10^{11}
Saturn	1.427×10^{12}
Uranus	2.87×10^{12}
Neptune	4.497×10^{12}
Pluto	5.914×10^{12}

Materials

- Calculators

Procedure

1. Using the data given, find the distance from the Earth to each of the planets in the solar system in meters.

From Earth To	Distance (m)	Time			Round-trip		
		sec	min	hr	sec	min	hr
Mercury							
Venus							
Mars							
Jupiter							
Saturn							
Uranus							
Neptune							
Pluto							

2. Find the time it would take light to travel to the planet from the Earth. You can record the time in any of the three units (most likely in seconds [sec]), then convert that value into the other two units (minutes [min] and hours [hr]).

3. Find the time it would take the light to travel from the Earth, to the planet, and then back to the Earth.

4. Answer the following questions:
   a. Why is it important for spacecraft or rovers to be able to handle some emergencies on their own?

   b. Currently, it would take 3-6 months to travel to Mars with existing rocket propulsion. Based on the results you found, can standard rocket propulsion take humans to planets farther away than Mars? Explain.

   c. These results were found for radio waves. Would your answer differ if you used visible light? Infrared? Gamma? Explain.