National Aeronautics and Space Administration

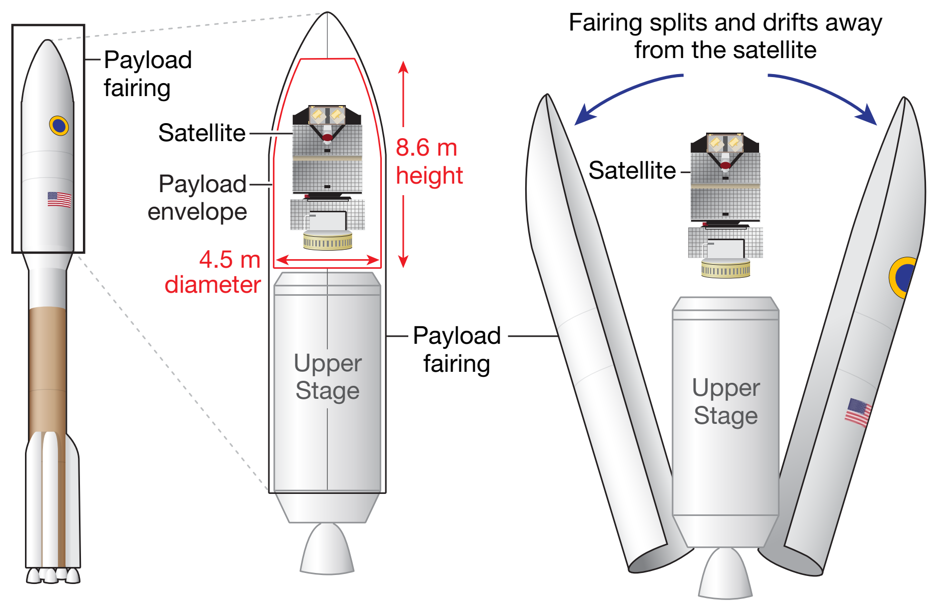
ACTIVITY SHEET

NASA Space Communications and Navigation

Geometry of Circles

GRADES 9–10

The National Aeronautics and Space Administration (NASA) reaches for new heights and reveals the unknown for the benefit of humankind. To accomplish this objective, NASA launches spacecraft with science instruments that can study the universe. During launch and operations, NASA's space communications and navigation infrastructure enables the spacecraft to communicate to operators on Earth. The rockets that launch these missions must be streamlined—built smooth and tapered—so that they are as aerodynamic as possible.



Often, NASA must construct a shell, called a **fairing**, to fit over the spacecraft (and sometimes the upper stage) at the very tip of the rocket. The fairing protects the spacecraft during launch and keeps the rocket aerodynamic. Once the rocket has left the atmosphere, the fairing can be ejected, or jettisoned, and either discarded or, sometimes, recovered.

Payload designers—the engineers who build spacecraft and satellites—need to make sure that spacecraft can fit inside a rocket's fairing. While many payloads are carefully folded or hinged to fit inside, in this exercise you will practice with simpler boxes.

Currently, NASA uses radio frequency (RF) transmitters, but is also developing optical communications technologies that use infrared lasers to send more data than traditional RF. Optical terminals are also smaller and lighter than comparable RF dishes, which can leave more room on the spacecraft for science instruments.

PROBLEMS

Say that NASA is launching two small communications satellites to evaluate different methods of sending data home to Earth. The optical transmitter satellite is 41 cm by 31 cm by 21 cm. The RF transmitter satellite is 35 cm by 48 cm by 22 cm. The experiment requires two different rocket flights, one for the RF payload and one for the optical payload.

1. Sketch a diagram of each box-shaped payload.

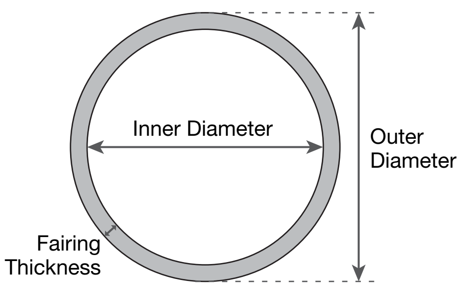
2. Our two communications satellites have a few rockets to pick from. Larger rockets tend to be more expensive, so we want to use the smallest possible rocket that will still fit our payload. First, let's consider an easy way to simplify: When placing each payload inside the rocket fairing, which face should be oriented toward the base of the rocket so that it fits in the smallest space? For this exercise, assume that NASA can manufacture fairings as tall as needed, so height is not a constraint. Explain your reasoning.

(continued)

PROBLEMS *(continued)*

3. Now we want to determine the smallest fairing each of our two payloads can use. This is complicated by the fact that the outer diameter of the rocket fairing does not represent the volume we have to work with; we must account for the thickness of the fairing shell. What is the smallest usable fairing for each payload?

Consider a rectangle centered on the circles' centers. How will the length and width of the rectangle relate to the diameter of the circles? Remember the Pythagorean theorem, where a right triangle's hypotenuse, $c = \sqrt{(a^2 + b^2)}$ with a and b being the lengths of the other two sides.



Rocket type	Fairing outer diameter	Fairing thickness
Rocket A	0.26 m	2 cm
Rocket B	0.44 m	3 cm
Rocket C	0.50 m	4 cm
Rocket D	0.76 m	8 cm

a. Assuming that we center the payload in the fairing, determine the largest radius of the payload's footprint.

b. Determine the largest radius that would fit inside each of our four rocket fairing options. Think carefully about how you factor the fairing thickness into your equation!

c. Convert your payload radii and rocket fairing radii to common units.

d. Compare each of the rocket fairing radii to the payload radii. Which payloads can fit in which rockets? What's the least expensive (smallest) rocket we can use for each of our two payloads?

NASA's Laser Communications Relay Demonstration (LCRD) is the next step in optical communications.

Hosted on a U.S. Space Force spacecraft, LCRD will demonstrate optical technology in geosynchronous orbit 22,300 miles above Earth's surface. LCRD is built and managed by NASA's ***Goddard Space Flight Center*** in Greenbelt, Maryland.

LCRD is a technology demonstration that will pave the way for future optical communications missions. When NASA has developed a new way to solve a problem and wants to show how it works, they create a technology demonstration. LCRD's first orbiting experimental user will be the International Space Station's Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (***ILLUMA-T***). The terminal will receive science data from experiments and instruments aboard the space station and then transfer the data to LCRD, which will then transmit them to a ground station. After the data arrive on Earth, they will be delivered to operation centers and scientists to help make decisions about the mission.

LEARN MORE

Learn more about LCRD's predecessor, the Lunar Laser Communications Demonstration (LLCD), at ***http://go.nasa.gov/LLCD_history***.

Learn more about LCRD at ***http://go.nasa.gov/LCRD_overview***.