Sample Lesson:
"Space Transportation with a Twist"

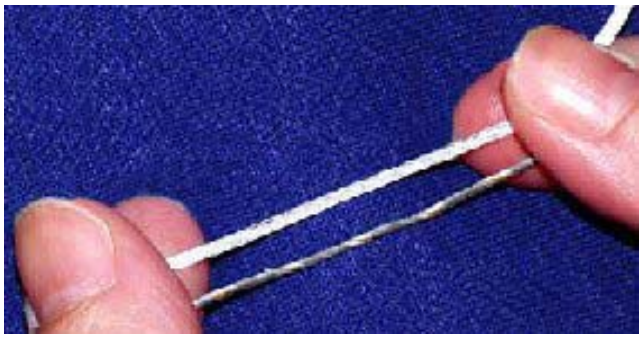
Objective

Thoroughly discuss various transportation alternatives, dealing specifically with transportation on the moon using a lunar roving vehicle, development of lunar transportation system, etc.

National Standards Met

NCSS 8–Science, Technology and Society
NSES 4–Earth and Space Science
NSES 5–Science and Technology

Space Transportation With A Twist

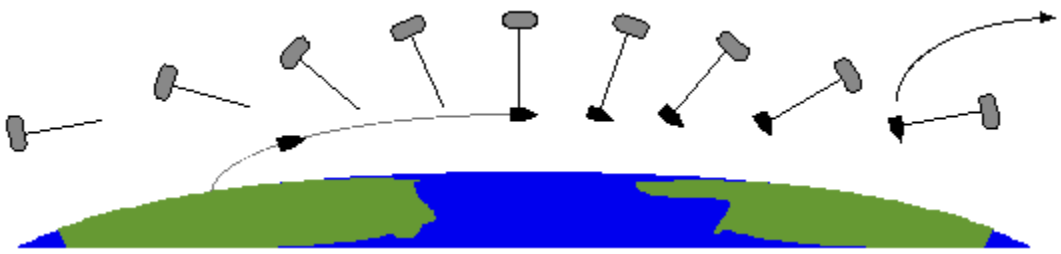


Today's scientists are already hard at work on new ideas for spaceflight in the future. New technology is being developed to help propel spacecraft into Earth orbit—and beyond. NASA researchers are studying ways to create more powerful and more efficient rockets. Engineers are considering things such as energy beamed from the ground, ions, and plasma as possible concepts for next-generation engines. Next to all of these super-high-tech ideas, one spaceflight possibility sounds remarkably simple—string.

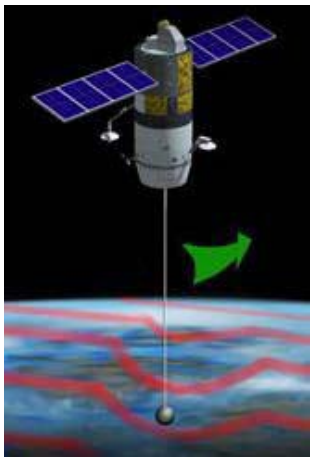
Needless to say, if it's going to help propel spacecraft and satellites into higher Earth orbits, and beyond, it has to be some high-tech string. More accurately, the technology is called space tethers. A tether is essentially just something used to tie one object to another. On Earth, tethers are generally used to keep something in place. In space, however, tethers could serve several useful purposes.

One of the uses being examined would be to move satellites into higher orbit, or even to help send spacecraft out into the solar system. This would be done using a process known as momentum exchange. The system would involve placing a satellite in orbit that would be used to boost other objects farther from the Earth. This satellite would consist of a tether with a grappling mechanism on one end that could "grab" the items being boosted. On the other end of the tether would be a counter mass, which would serve to keep the tether taut. The tether itself could be tens to hundreds of kilometers in length. Researchers are still looking into what materials would make the best space tethers. In fact, one possibility is based on fishing line! The tether will have to be able to resist the corrosion caused by atomic oxygen in the upper reaches of Earth's atmosphere, as well as damage from micrometeoroids.

When the new satellite or space probe is launched, the spinning tether system captures it and essentially "flings" it farther from the Earth. Using a method such as this would greatly reduce the altitude to which an object would have to be launched initially. This, in turn, would cut down on the needed power of the rocket used to launch it, which, of course, would reduce the cost of the launch. Researchers believe that satellites could be placed in a **geosynchronous** orbit for as little as one-half of the current launch cost.



Of course, nothing good is ever free, and that includes placing satellites into better orbits. The system is called momentum exchange because it does just that—exchanges momentum from the orbiting tether to the boosted satellite or probe. That means that the tether loses momentum, and falls closer to the Earth as the other object moves farther from it. Without a way to reboost the tether satellite, it could only perform the momentum exchange technique a very limited number of times before dropping into Earth's atmosphere. That's where another use of space tethers comes in.



Another technology NASA researchers are developing is the **Electrodynamic** Tether (EDT). As the long wire of an EDT passes through Earth's magnetic field, it sets up a voltage along the tether. This voltage makes electrons flow down the tether, like water flowing down a pipe. If the tether has the right systems to allow it to collect and emit electrons, then an electrical current (the flow of electrons) will move through the tether. Any time an electrical current flows in a magnetic field, there is a force. This may sound strange, but it is the same principle that makes every electric motor on Earth work, from the motor in a blender to the motor that spins your CDs.

Current naturally flowing through the tether can be used for power. But again, we don't get something for nothing. The force created by that flowing current slows the spacecraft down by taking energy out of its orbit. Eventually, the object would re-enter Earth's atmosphere, where, without heat shielding, it would burn up. Such a system could be used to prevent space junk from accumulating in orbit. When a satellite reached the end of its useful life span, it could **deploy** a tether that would slow it down until it burns up in the atmosphere, clearing the way for new satellites to be placed in orbit.

If we want to boost satellites up to higher orbits, we have to force the current to flow through the tether in the direction *opposite* the way it wants to go. To do this, we need energy, which can be collected from the Sun using solar panels. Forcing current in the opposite direction than it wants is **analogous** to pumping water up a pipe. The force on the tether from "pumping" current adds energy to the orbit of the tether and boosts it into a higher orbit. In fact, some NASA researchers believe that by using a tether like this, the orbit of the International Space Station could be continuously reboosted, countering the effect of atmospheric drag without requiring any additional propellant.

Traveling to and from orbit has not changed much in the last few decades. However, space tethers could open a whole, new door of opportunity. That's not bad for a long piece of high-tech string!

Related Links:
NASAexplores "Mega-Magnetism" Article
http://www.nasaexplores.com/show2_articlea.php?id=01-055

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