7.Satellites

What is a satellite?

A **satellite** doesn't necessarily have to be a tin can spinning through space. The word "satellite" is more general than that: it means a smaller, space-based object moving in a loop (an orbit) around a larger object. The Moon is a natural satellite of Earth, for example, because gravity locks it in orbit around our planet. The tin cans we think of as satellites are actually artificial (human-built) satellites that move in precisely calculated paths, circular or elliptical (oval), at various distances from Earth, usually well outside its atmosphere.

What do satellites do for us?

We tend to group satellites either according to the jobs they do or the orbits they follow. These two things are, however, very closely related, because the job a satellite does usually determines both how far away from Earth it needs to be, how fast it has to move, and the orbit it has to follow. The three main uses of satellites are: Communications, Photography, imaging, and scientific surveying, and Navigation.

Communications

Communications satellites are essentially used to relay radio waves from one place on Earth to another, catching signals that fire up to them from a ground station (an Earth-based satellite dish), amplifying them so they have enough strength to continue (and modifying them in other ways), and then bouncing them back down to a second ground station somewhere else. Those signals can carry anything radio signals can carry on the ground, from telephone calls and Internet data to radio and TV broadcasts. Communications satellites essentially overcome the problem of sending radio waves, which shoot in straight lines, around our curved planet—intercontinental signals, in other words. They're also useful for communicating to and from remote areas where ordinary wired or wireless communications can't reach. Calling with a traditional landline (wired phone), you need a very convoluted network of wires and exchanges to make a complete physical circuit all the way from the sender to the receiver; with a cellphone, you can communicate anywhere you can get a signal, but you and the receiver both still need to be within range of cellphone masts; however, with a satellite phone, you can be on top of Mount Everest or deep in the Amazon jungle. You're entirely free from any kind of telecommunications "infrastructure," which gives you geographic freedom and an instant ability to communicate (you don't have to wait for someone to string up telephone lines or set up cellphone masts).

The best known modern communications satellite systems are probably INMARSAT and INTELSAT. INMARSAT was originally a satellite system for ships, planes, and other travelers, though it now has many other uses as well. INTELSAT is an international consortium that owns and operates several dozen communications satellites that provide things like international broadcasting and satellite broadband Internet.

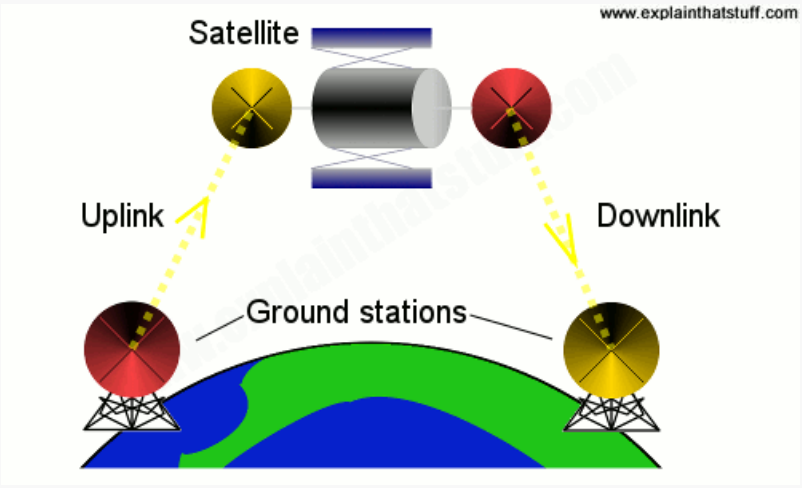
What do they do?

Communications satellites are "space mirrors" that can help us bounce radio, TV, Internet data, and other kinds of information from one side of Earth to the other.

Uplinks and downlinks

If you want to send something like a TV broadcast from one side of Earth to the other, there are three stages involved. First, there's the **uplink**, where data is beamed up to the satellite from a ground station on Earth. Next, the satellite processes the data using a number of onboard **transponders** (radio receivers, amplifiers, and transmitters). These boost the incoming signals and change their frequency, so incoming signals don't get confused with outgoing ones. Different transponders in the same satellite are used to handle different TV stations carried on different frequencies. Finally, there's the **downlink**, where data is sent back down to another ground station elsewhere on Earth. Although there's usually just a single uplink, there may be millions of downlinks, for example, if many people are receiving the same satellite TV signal at once. While a

communications satellite might relay a signal between one sender and receiver (fired up into space and back down again, with one uplink and one downlink), satellite broadcasts typically involve one or more uplinks (for one or more TV channels) and multiple downlinks (to ground stations or individual satellite TV subscribers).



Artwork: Communications satellites bounce signals from one side of Earth to the other, a bit like giant mirrors in space. A ground-based satellite transmitter dish (red) beams a signal to the satellite's receiving dish (yellow). The satellite boosts the signal and sends it back down to Earth from its transmitter dish (red) to a receiving dish somewhere else on Earth (yellow). Since the whole process happens using radio waves, which travel at the speed of light, a "satellite relay" of this kind usually takes no more than a few seconds, at most. The various transmitters and receivers on the satellite and on Earth are examples of antennas.

Satellites are like any other vehicle inasmuch as they have two main parts: the generic vehicle itself and the specific thing it carries (the payload) to do its unique job. The "vehicle" part of a satellite is called the bus, and it includes the outer case, the solar panels and batteries that provide power, telemetry (a remote-controlled system that sends monitoring data from the satellite to Earth and operational commands back in the other direction), rocket thrusters to keep it in position, and reflective materials or other systems ("heat pipes") to protect it from solar radiation and dissipate heat. The payload might include transponders for a communications satellite, computers and atomic clocks to generate time signals for a navigation satellite, cameras and computers to images back to digital data for a photographic satellite, and so on.

Satellite orbits

One of the most surprising things about satellites is the very different paths they follow at very different heights above Earth. Left to its own devices, a satellite fired into space might fall back to Earth just like a stone tossed into the air. To stop that happening, satellites have to keep moving all the time so, even though the force of gravity is pulling on them, they never actually crash back to Earth. Some turn at the same rotational rate as Earth so they're effectively fixed in one position above our heads; others go much faster. Although there are many different types of satellite orbits, they come in three basic varieties, low, medium, and high—which are short, medium, and long distances above Earth, respectively.