A new year, a new world view

by Bob Riddle

Usually I write this column from an Earth-based perspective, looking out from Earth toward the space around our planet. However, this month I'd like to reverse direction and take a look at our home through the eyes of some of the many Earth-observing satellites.

How many satellites are orbiting the Earth, and what are they observing? There are varying estimates depending on which objects are considered satellites. For example, should we count anything human-made, such as parts of expended rocket stages or pieces of satellites, or should we just count the actual number of objects created to act as satellites? Counting only the latter, most estimates put the number of satellites launched at more than 6,000, but only about 1,000 of those satellites are still in operation. Out of the still-active satellites, there are about 200 that observe Earth. These satellites represent nearly 50 countries, and about half of them are operated by government agencies. The United States and China maintain the greatest number of Earth-observing satellites; each country controls about 25% of the total number. A list including all active military, commercial, civil, and government satellites and their countries of origin can be downloaded as a spreadsheet from the Union of Concerned Scientists (UCS) website (see Resources).

Satellites and orbits

A *satellite* is an object that orbits another object. There are two types of satellites: natural and artificial satellites. *Natural satellites* are space objects that orbit other space objects, such as the Earth orbiting the Sun or moons orbiting planets, while *artificial satellites*, such as those discussed in this month's column, are made by people. Natural and artificial satellites maintain their respective orbital paths because a satellite's speed relative to the object it orbits is balanced by the gravitational attraction of the orbited object. An artificial satellite, unlike a natural satellite, must be placed in its orbit at the correct speed. If the orbital speed is too low, a satellite's orbital height will decrease until the satellite crashes. Conversely, if the orbital speed is too fast, the satellite's orbit may be too high or too elliptical, or the satellite may break away from the Earth's gravitational field (see Figure 1). Once a satellite is correctly placed into orbit, it maintains its speed because there is virtually no friction in space to slow it down.

Getting a satellite into orbit requires a launcher that has enough power to lift the combined weight of the rocket and the satellite's weight. A launched satellite initially travels upward, perpendicular to the Earth's surface, but its path gradually curves until it is traveling parallel to the curvature of the Earth. In effect, it is now traveling horizontally, and if its speed is correct, then it stays in orbit. For example, over a distance of 8 km (8,000 mi.), the Earth's curvature drops approximately 5 m. So, if a satellite is to be placed in an Earth orbit, it must travel the 8 km in the time it would take to drop 5 m, which is about 8 km/s. Therefore, in addition to power and weight considerations, the height or altitude of the satellite's orbit is a factor in the velocity needed to achieve the correct altitude. Lower velocity is needed for lower orbits, and greater velocity is needed for higher orbits.

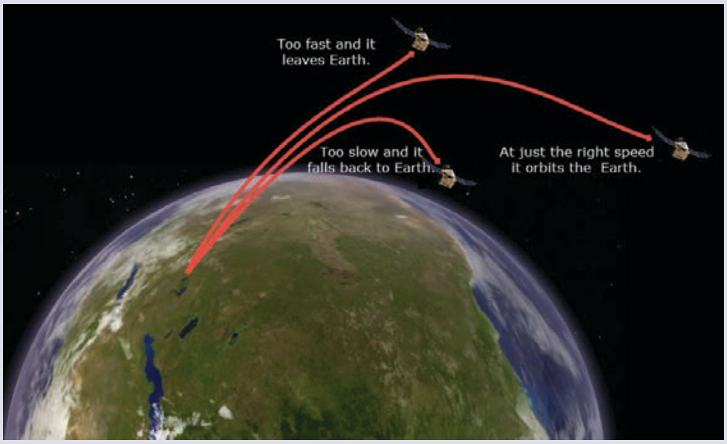
Satellites are put into orbits at a variety of altitudes, but they travel in one of two types of orbits: geostationary and polar. In a *geostationary orbit*, the satellite travels from west to east as fast as the Earth rotates. As a result, the satellite remains above the same part of the Earth. In a *polar orbit*, the satellite travels from north to south around the Earth as the planet rotates below. This allows a polar-orbiting satellite to view the entire Earth over a period of several orbits.

Students can investigate how satellites are placed into orbit with the "Launcher: How are Satellites Launched into Orbit Around the Earth?" activity (see Resources). After constructing a launch ramp, students explore launch angles as they try to launch a marble using the ramp placed at different angles.

Satellite resources

Satellites facing the Earth conduct a variety of observations and investigations, including gathering informa-

FIGURE 1 The importance of using the correct speed for getting into orbit



tion about the atmosphere (clouds, gases such as carbon dioxide and ozone, precipitation) and the Earth's surface (fires, fresh water, glaciers, oceans and sea water, volcanic activity). Much of this information is available to the public and is used in scientific research, as well as by farmers, meteorologists, urban planners, and others interested in monitoring the Earth.

In the classroom, there are many opportunities for students to learn more about our home planet by way of the websites listed in the Resources. For example, in a study about landforms and their processes, students could visit the websites featuring pictures of the Earth taken by astronauts from orbit (see "Gateway to Astronaut Photography of Earth" and "ISS Austronauts' Pictures of Earth" in Resources). This activity could be coordinated with viewing the Earth's surface in real time from video streamed from the International Space Station (ISS) (see "ISS HD Earth Viewing Experiment" in Resources). Students may ask where the ISS is. At the ISS Astronaut Pictures of Earth website, students can follow in near–real time the flight path of the ISS displayed over a map of the Earth (see Resources). Then at the Flash Earth website, students can zoom in for a closer look at the landforms or cultural areas astronauts are seeing (see Resources).

Not sure which satellite is best suited for a particular job? At the Find the Best website, students can work with a list of satellites grouped by their use (civil, commercial, government, military, or a combination) (see Resources). Click on a satellite name and read information about the satellite. Select more than one to see a side-by-side comparison of the selected satellites.

A great simulation of what it is like to work with a satellite is available from NASA's Satellite Insight website (see Resources). In this simulation, students work with a geostationary satellite observing the Earth's environment, the GOES-R satellite (Geostationary Operational Environmental Satellite R Series). Students use six instruments on board the satellite to collect data about charged particles from the Sun, clouds, the Earth's magnetic field, lightning, solar energy, and UV and x-ray radiation.

Looking down

At the writing of this column, NASA announced a new, additional mission for the ISS that will include the space station in the observation of Earth's environment from orbit. The first of two instruments slated to be taken to the ISS on resupply vessels will be the ISS-Rapid-Scat for monitoring ocean winds. The Cloud-Aerosol Transport System (CATS) will be used to monitor atmospheric particulates like dust, smoke, and other airborne pollutants.

The importance of satellites to our way of living is very significant: We now have the ability to make observations and, based on the data collected, make things such as forecasts or natural disaster tracking much more accurate.

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Sometime this month, go out before the Sun rises and look toward the east for a relatively bright star—Vega, a blue-white star shining at 0 magnitude in the small constellation of Lyra the Harp. You may know Vega as one of the three stars making up the Summer Triangle asterism along with Deneb in Cygnus the Swan and Altair in Aquila the Eagle. (An *asterism* is not a constellation but rather a star pattern made up of stars within a constellation, or as with the Summer Triangle, made up of stars from different constellations.) When you look at Vega, the starlight that reaches your eyes left Vega approximately 25 or 26 years ago—the same year that I started writing the "Scope on the Skies" column.

This particular column represents a milestone of sorts for me and for *Science Scope*, as this is our 200th "Scope on the Skies" column. Throughout all those revolutions around the Sun, I have collaborated with several wonderful editors, managing editors, and assistant editors. Without the leadership and guidance from editors Steve Rakow, Pat Warren, and Inez Liftig; managing editor Ken Roberts; and all of the editors with whom I have directly worked, the "Scope on the Skies" column might have never made it past the first couple of "test" columns. To say I will forever be grateful for the opportunity I have been given to write these columns and share with my colleagues what I have learned with my students as we explored the cosmos would be an understatement of how much this column has been an integral part of my teaching career. ■

Visible planets

Mercury will be visible over the western horizon at sunset for nearly the entire month. Watch for the faster-moving Mercury, which will catch up with Venus for a close conjunction on January 9, 10, and 11.

Venus will be visible over the western horizon at sunset throughout the month.

Mars will be visible over the western horizon at sunset.

For students

1. If a satellite's speed is too great, the satellite will fly away from the Earth. Will the satellite travel in a curved or straight path as it leaves its Earth orbit? *(The satellite moves away in a straight line. To model this, tie a block of wood to one end of a length of string. Twirl the block of wood around your head and then let go of the string. The block of wood, like the satellite, moves away in a straight line.)*
2. Which of Newton's laws of motion do the above question and answer relate to? *(They relate to Newton's first law of motion, which in part states that an object in motion stays in motion in a straight line unless an outside force acts on that object. So when the block is released, it moves in a straight line until the balance between its speed and the Earth's gravitational force changes in favor of the Earth. At this time, the block's path curves down toward the ground.)*

Jupiter will rise after sunset and will be visible all night. Look for Jupiter over the southwestern horizon at sunrise.

Saturn will be visible over the eastern horizon, rising two to three hours before sunrise.

January

1	Waxing gibbous Moon near Aldebaran
2	Moon at descending node
3	Quadrantids meteor shower peak
4	Earth at perihelion: 147,054,707 km (91,375,558 mi.)
5	Full Moon
7	Waning gibbous Moon near Jupiter
8	Waning gibbous Moon near Regulus
9	Moon at apogee: 405,410 km (251,910 mi.)
10	Close Venus and Mercury conjunction
11	*Cassini* Titan flyby
	Winter solstice on Mars
12	Moon at ascending node
	New Horizons spacecraft starts Pluto encounter operations
13	Last quarter Moon
	Moon near Spica
14	Mercury at eastern elongation
16	Waning crescent Moon near Saturn
17	Waning crescent Moon near Antares
20	New Moon
21	Moon at perigee: 359,642 km (223,471 mi.)
	Very thin waxing crescent Moon near Venus and Mercury
22	Thin waxing crescent Moon near Mars
25	Moon at descending node
27	First quarter
29	Waxing gibbous Moon near Aldebaran
30	Mercury at inferior conjunction

Resources

Cassini Solstice mission—*http://saturn.jpl.nasa.gov*
Earth Resources Observation and Science Center—*http://eros.usgs.gov*
Eyes on the Earth—*http://eyes.nasa.gov/earth/index.html*
Find the Best—*http://satellites.findthebest.com*
Flash Earth—*www.flashearth.com*
Gateway to Astronaut Photography of Earth—*http://eol.jsc.nasa.gov*
Google Earth satellite plug-in—*http://adn.agi.com/SatelliteDatabase/SatelliteDatabase.kmz*
ISS astronauts' pictures of Earth—*http://bit.ly/VFq4mC*
ISS HD Earth viewing experiment—*www.ustream.tv/channel/iss-hdev-payload*
Landsat missions—*http://landsat.usgs.gov/gallery.php*
Launcher: How are Satellites Launched into Orbit Around the Earth?—*www.education.com/science-fair/article/physical-science_launcher/*
Mars calendar—*www.planetary.org/explore/space-topics/mars/mars-calendar.html*
Meteor Showers Online—*http://meteorshowersonline.com*
NASA Earth Observatory—*http://earthobservatory.nasa.gov*
NASA Earth Observatory Worldview—*http://earthdata.nasa.gov/labs/worldview/*
NASA Space Station Live—*http://spacestationlive.nasa.gov/index.html*
New Horizons mission—*http://pluto.jhuapl.edu*
Polar-orbiting missions—*http://npp.gsfc.nasa.gov/viirs.html*
Precipitation measurement missions—*http://pmm.nasa.gov*
Satellite images of countries, states, U.S. cities, and world cities—*http://geology.com/satellite/*
Satellite Insight—*http://spaceplace.nasa.gov/satellite-insight/en/*
UCS satellite list—*http://bit.ly/1iQJ4Yv*
Visible Earth—*http://visibleearth.nasa.gov*

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