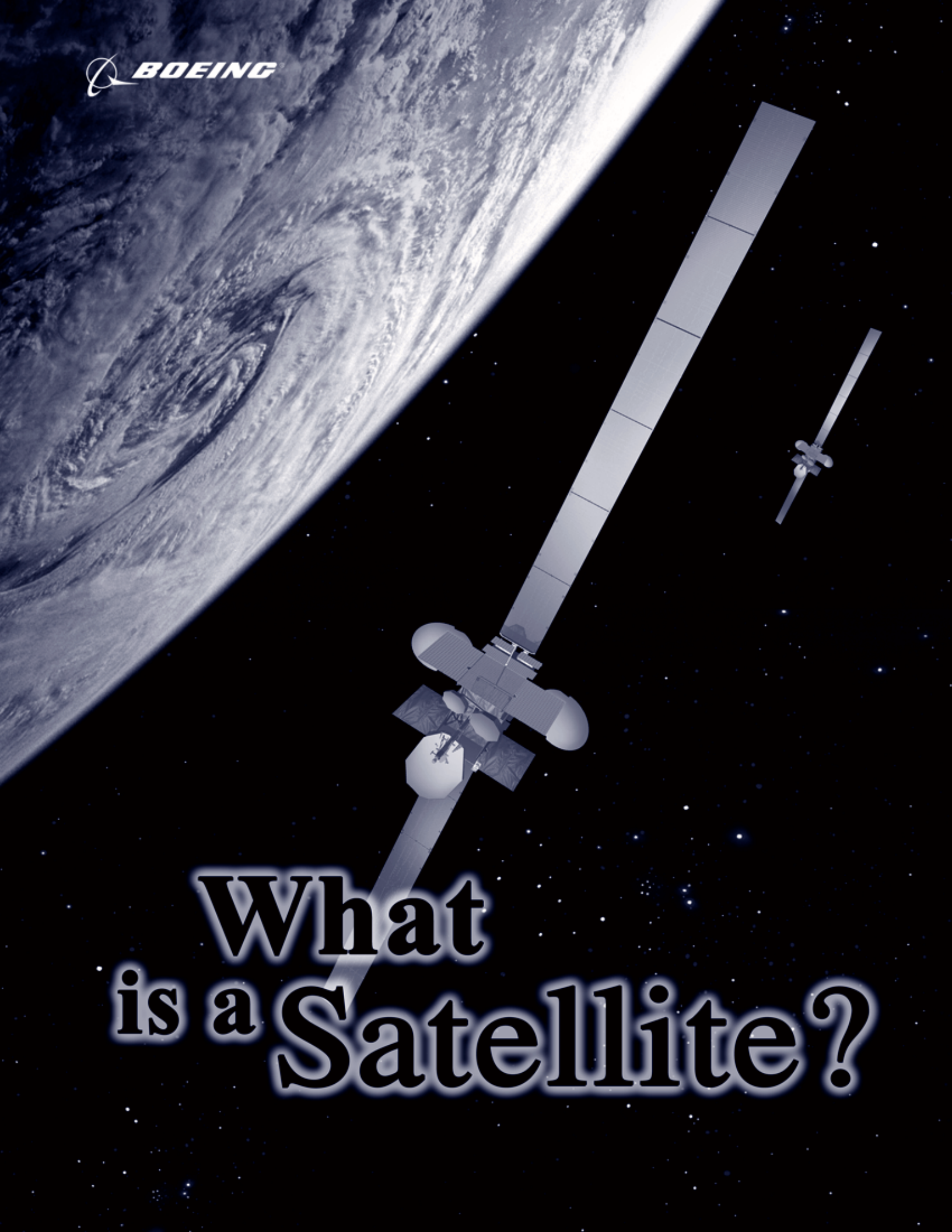

BOEING
What
is a Satellite?

What Is a Satellite?

A satellite is something that goes around and around a larger something, like the Earth or another planet. Some satellites are natural, like the moon, which is a natural satellite of the Earth. Other satellites are made by scientists and engineers to go around the Earth and do certain jobs.

Some satellites send and receive television signals. The signal is sent from a station on the Earth's surface. The satellite receives the signal and rebroadcasts it to other places on the Earth. With the right number of satellites in space, one television program can be seen all over the world.

Some satellites send and receive telephone, fax, and computer information. Satellites make it possible to communicate by telephone, fax, Internet, or computer with anyone in the world.

Other satellites observe the world's weather, sending information to giant computers that help scientists know what the weather will be. Those scientists identify weather patterns, like severe thunderstorms or blizzards, and let people know when they may be in danger. The weather reporters on your favorite TV news show get their information from those scientists.

Still other satellites take very accurate pictures of the Earth's surface, sending back images that tell scientists about environmental changes that are going on around the world and about crops, water, and other resources.

The most powerful commercial satellite in the world is the Boeing 702. Designed and built by the Boeing Satellite Development Center, this giant has a wingspan of nearly 157 feet.

Boeing 702

This is another kind of satellite—the Boeing 601— built by the Boeing Satellite Development Center. The Boeing 601 is a slightly less powerful satellite than the Boeing 702. The Boeing 601 wingspan is about 90 feet. Both these satellites are used for many purposes, including direct broadcast TV, a system for receiving television using a very small satellite dish. They also relay telephone, fax, and computer information.

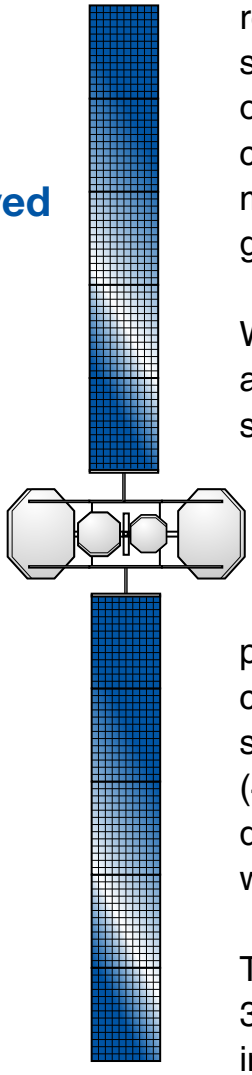
Boeing 601

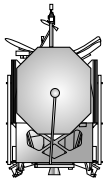
How Big Is a Satellite?

With a Boeing 702, you can put two or three smaller satellites' worth of communication electronics in orbit using one satellite and one launch. When the Boeing 702 is stowed for launch, it is about 23 feet (7 meters) high. When the satellite is deployed, the solar panels extend to a width of 157 feet (48 meters). The average Boeing 702 weighs 6505 pounds (2950 kg) when it arrives in orbit.

Boeing 702

Deployed





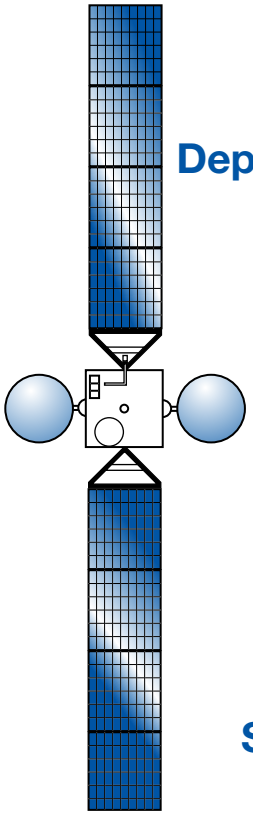
Stowed

The Boeing 601 has a box-shaped center with several antenna reflectors that look like big dinner plates. Long, wing-like structures attach on two sides. These are the solar panels. The outside of the solar panels is covered with **solar cells**, which convert the sun's energy to electricity. The bigger the panels, the more solar cells are exposed to the sun, so the satellite can generate more power.

When a Boeing 601 is launched, its antenna reflectors and solar panels are stowed—that is, put away—so it can fit inside a launch vehicle. After launch, the satellite travels through space until it reaches its assigned orbital position. Then its reflectors and solar panels unfold—that is, open—into the correct position for doing their work. A stowed Boeing 601 is about 14 feet (4.3 meters) high. When the satellite is deployed, the solar panels extend to a width of about 90 feet.

Boeing 601

Deployed



Stowed

The average Boeing 601 weighs about 3800 pounds (1727 kg) when it arrives in orbit. Although this sounds heavy, satellites are built to weigh as little as possible because the heavier the satellite, the more expensive it is getting it into orbit.

What Is an Orbit?

When a satellite is launched, it is placed in a path around the Earth. The Earth's gravity holds the satellite in this path as it goes around the Earth, and that path is called an "orbit." There are several kinds of orbits. Here are three of them.

LEO, or Low Earth Orbit

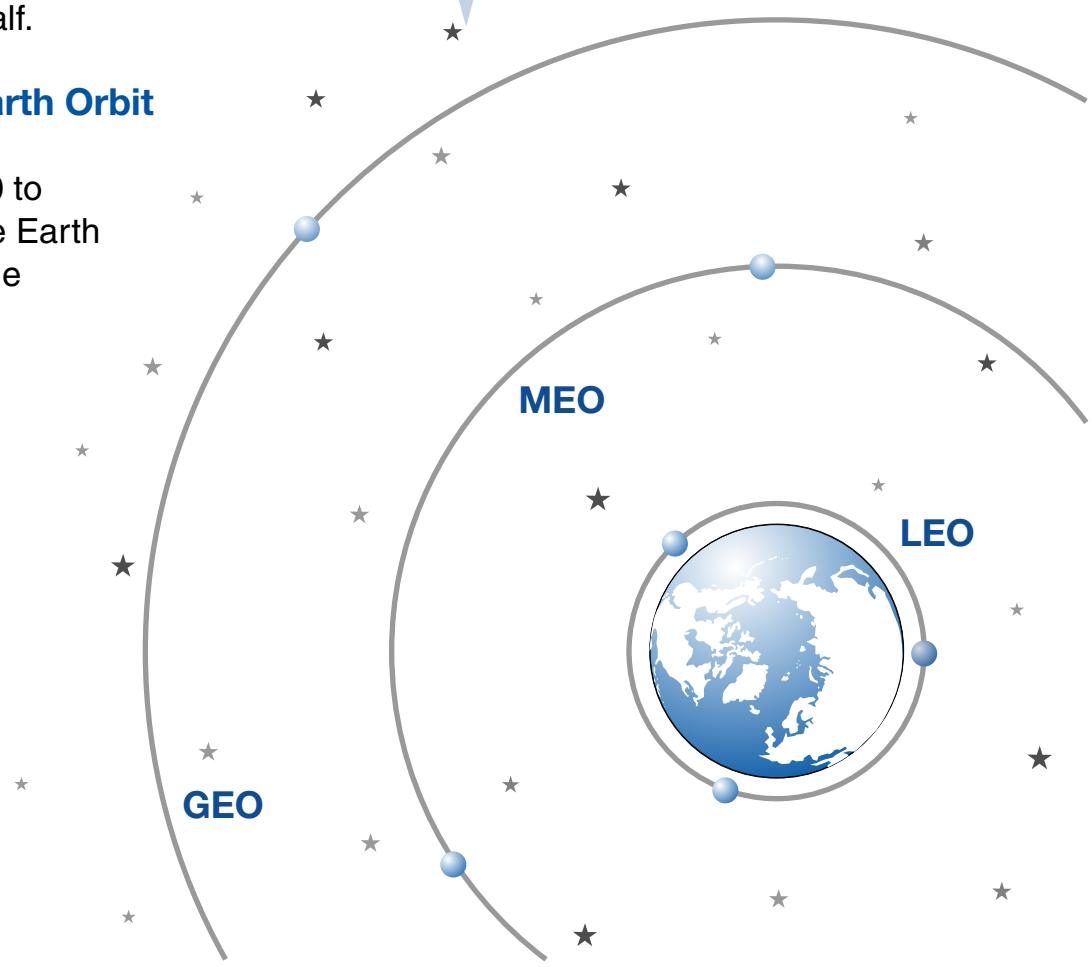
A satellite in low Earth orbit circles the planet 100 to 300 miles above the planet's surface. Because it is close to the Earth, it must travel very fast to avoid being pulled out of orbit by gravity and crashing into the Earth. Satellites in low Earth orbit travel about 17,500 miles per hour. These satellites can circle the Earth in about an hour and a half.

MEO, or Medium Earth Orbit

Satellites circling 6,000 to 12,000 miles above the Earth are in a medium-altitude orbit. In these larger orbits they stay in sight of a ground receiving station for 2 hours or more, compared to about 10 minutes for LEOs. It takes MEO satellites from 4 to 8 hours to go around the Earth.

GEO, or Geosynchronous Earth Orbit

A satellite in geosynchronous orbit circles the Earth in 24 hours—the same time it takes the Earth to rotate one time. If these satellites are positioned over the equator and travel in the same direction that the Earth rotates, they appear "fixed" with respect to a given spot on Earth—that is, they hang over the same spot on the Earth all the time. Satellites in GEO orbit are 22,300 miles above the Earth. In this high orbit, GEO satellites are always over the receiving stations below, and their signals can cover a large part of the planet. Three GEO satellites can cover the globe, except for the North and South poles.



How Does a Satellite Get Into Space?

The satellite is packed carefully onto a rocket and carried into space, powered by a powerful engine.

Satellites are launched from only a few places in the world, including Cape Canaveral, Florida; Kourou, French Guiana; and Baikonur, Kazakhstan. The best places to launch satellites are near the ocean, so that when the rocket falls away, it lands in the water and not on people.

Another launch site for geostationary orbits actually travels to the perfect launch spot.The Sea Launch company rebuilt a big platform once used for oil drilling at sea. The platform carries satellites from Long Beach, California, to the equator, far out in the Pacific Ocean, for launch.

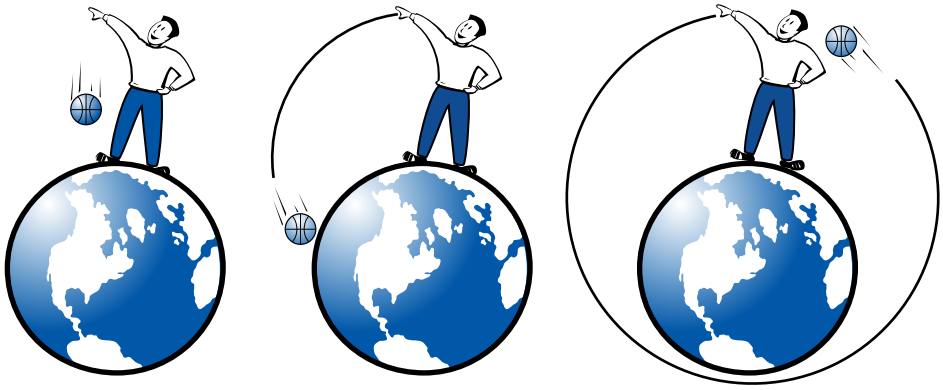
Putting everything together for a launch is very complicated. Many people in many companies and sometimes in many countries have to work together so that everything will be ready for a launch. One of the ways things are coordinated is the countdown. In a countdown, we count down instead of up, because we are counting hours or minutes until liftoff—the moment when the rockets fire and the launch vehicle rises into the air. The last ten seconds of the countdown sound like this: 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, liftoff. The countdown actually starts long before the day of the launch.

At launch, the rocket lifts the satellite off the launch pad and into space, where it circles the Earth in a temporary orbit. When the rocket has used all its fuel, it drops away and one or more engines attached to the satellite move it into its permanent orbit. The engine is started up for a certain amount of time, sometimes just one or two minutes, to push the satellite into place. When one of these engines is started, it's called a burn. It may take many burns over a period of several days to move the satellite into its correct position.

When the satellite reaches its orbit, an engine points it in the right direction and its antennas and solar panels unfold, or deploy.

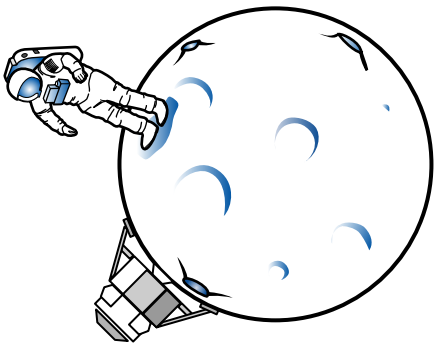
When the Spaceship Lands on the Moon, Why Doesn't It Fall Off?

The same force that keeps you on the Earth is the same force that does not let a spaceship fall off the Moon. That force is called gravity. Gravity is the force that pulls any two objects toward each other, no matter their size. The bigger the objects, the stronger the force.



We are very familiar with the measurement of this force; it is called "weight." Because the Moon is smaller than the Earth, the force of gravity is less on the Moon. For example, if you weigh 100 pounds on Earth, you would only weigh about 16 pounds on the Moon. The same is true for a spaceship; it weighs less on the Moon but more than enough to avoid falling of its surface. The largest planet in our solar system is Jupiter. It is much larger than the Earth, so instead of 100 pounds you would weigh more than 250 pounds.

Gravity is at work everywhere in space. Not only is it the force that keeps the spaceship from falling off the moon, it is the force that keeps all the planets revolving around the Sun, and the Moon around the Earth. To understand how this works is as simple as throwing a ball.



Imagine you are on top of a tall building holding a ball in the air and let it go. Gravity pulls the ball toward the Earth and it falls straight down. Now throw the ball as you would to a friend. The ball still falls and hits the ground (gravity working) but it also travels away from you before it hits the ground. The harder you throw the ball, the farther it travels before hitting the ground. If you were a superhero and could throw the ball very, very fast, it would travel all the way around the Earth and come back to you before it hit the ground. Gravity makes it curve around the Earth. So just how fast would you have to throw the ball? The answer is about 17,000 miles per hour—a true superhero throw!

We use rockets as our "superhero" to launch satellites. In the case of a geostationary satellite, the rocket first needs to lift the satellite to 22,300 miles above the Earth and then "throw" it at about 6,800 miles per hour. When the rocket does this, the satellite will travel once around the Earth every 24 hours.

What Does a Satellite Do?

Satellites do many things for people. Their most important job is helping people communicate with other people, wherever they are in the world.

- A satellite can carry a camera as it travels in its orbit and take pictures of the whole Earth. Mapmakers can use these pictures to make more accurate maps. Satellite pictures can also help experts predict the weather, because from the satellite, the camera can actually see the weather coming. When you watch the weather forecast on TV, you are seeing pictures of the Earth taken by a camera riding on a satellite.

- Satellites in orbit can send messages to a special receiver carried by someone on a ship in the ocean or in a truck in the desert, telling that person exactly where he or she is.

- A satellite can relay your telephone call across the country or to the other side of the world. If you decide to telephone your friend in Mexico City, your call can be sent up in space to a satellite, then relayed to a ground station in Mexico and sent from there to your friend's telephone.

- A satellite can relay your computer message, fax message, or Internet data as well. With the help of satellites, we can fax, e-mail, or download information anyplace in the world. When the satellite sends a message from your computer or fax to another computer or fax, it's called data transmission. The satellite is transmitting, or sending, information, or data.

- A satellite can transmit your favorite TV program from the studio where it is made to your TV set—even if the studio is in Japan and your TV set is in Los Angeles. From the studio where it is made, a TV program is broadcast to a satellite. This is called an uplink. Then it is rebroadcast from the satellite to another place on the Earth. This is called a downlink. To link means to connect. So uplink is connecting upward to the satellite and downlink is connecting downward to Earth. This allows news events to be transmitted around the world instantly.

When words or pictures or computer data are sent up to a satellite, they are first changed to an invisible signal. The signal travels up through space to the satellite and then travels down from the satellite to its destination, where it is changed back to a voice message, a picture, or data, so that the receiver can receive it.

Who Owns the Satellites?

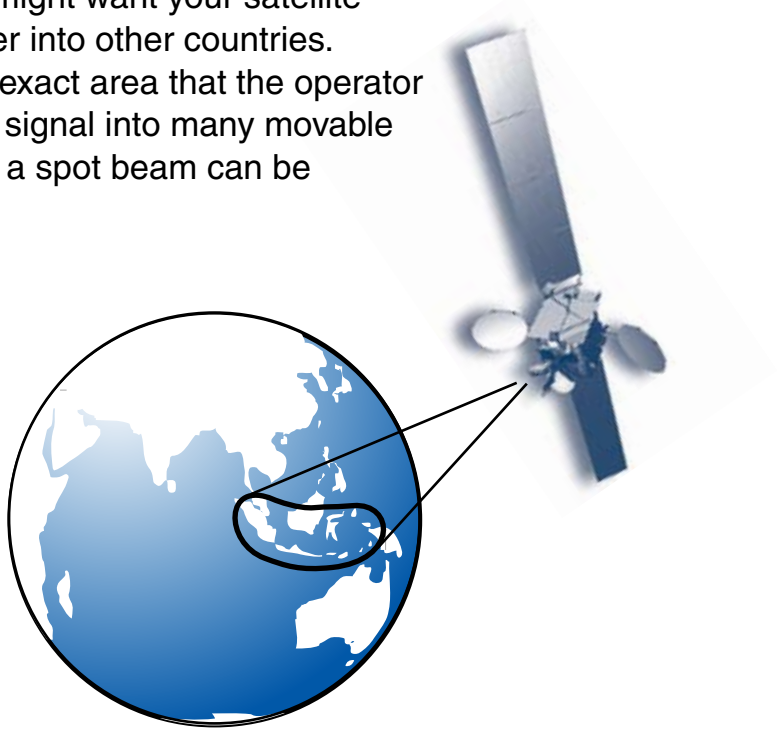
Satellites are usually owned by companies or countries. The companies that own satellites usually want to make money by renting out part of the satellite to other companies. The countries or government agencies that own satellites want to make people's lives better by improving the communication networks in their countries.

For example, Indonesia is a country made up of 13,677 islands whose people speak more that 250 languages. Imagine how much time and money it would take to connect them all with wires and telephone poles. Using satellites, Indonesia bridged all the islands at once and helped people learn the national language.

Being able to communicate better with people all over the world helps countries develop trading opportunities, increase business, and get information they need. Many countries—including Australia, Brazil, Canada, China, Japan, Luxembourg, Malaysia, Mexico, Norway, Sweden, Thailand, and the United States—are now increasing opportunities for their people by buying satellites.

Many large companies also own and operate satellites. They may rent space on the satellite to other companies and businesses. For example, a large communication company might buy a satellite and then rent space on the satellite to television companies, telephone companies, Internet service companies, and businesses who want to do business in other parts of the world.

A satellite operator can let its satellite "see" as much as one-third of our planet at a time, or it can shape the signal to reach a smaller area. For example, if you were the Indonesian telecommunications company, you might want your satellite signal to cover only Indonesia, and not spill over into other countries. The satellite signal can be shaped to cover the exact area that the operator wants to reach. Some satellites can divide their signal into many movable spot beams. Like a tight, bright flashlight beam, a spot beam can be aimed at an exact small area on Earth, then moved elsewhere to reach new or different customers.



The area of the Earth's surface covered by a satellite's signal is called the satellite's footprint.

What's Inside a Satellite?

Satellites have a great deal of equipment packed inside them. A satellite has seven subsystems, and each one has its own work to do.

1. The **propulsion subsystem** includes all the motors that bring the spacecraft to its permanent position and help keep the satellite in its assigned place in orbit. Satellites drift out of position because of solar wind or gravitational or magnetic forces. When that happens, the motors are fired to move the satellite back into the right position in its orbit.

2. The **power subsystem** keeps the satellite going. It generates electricity from solar panels located on the outside of the spacecraft. The solar panels also store electricity in storage batteries, which provide power when the sun isn't shining on the panels. A Boeing 702 generates enough power at the end of its service life to operate two hundred 75-watt light bulbs.

3. The **communications subsystem** receives signals from the Earth, amplifies or strengthens them, and sends them to another satellite or to a ground station.

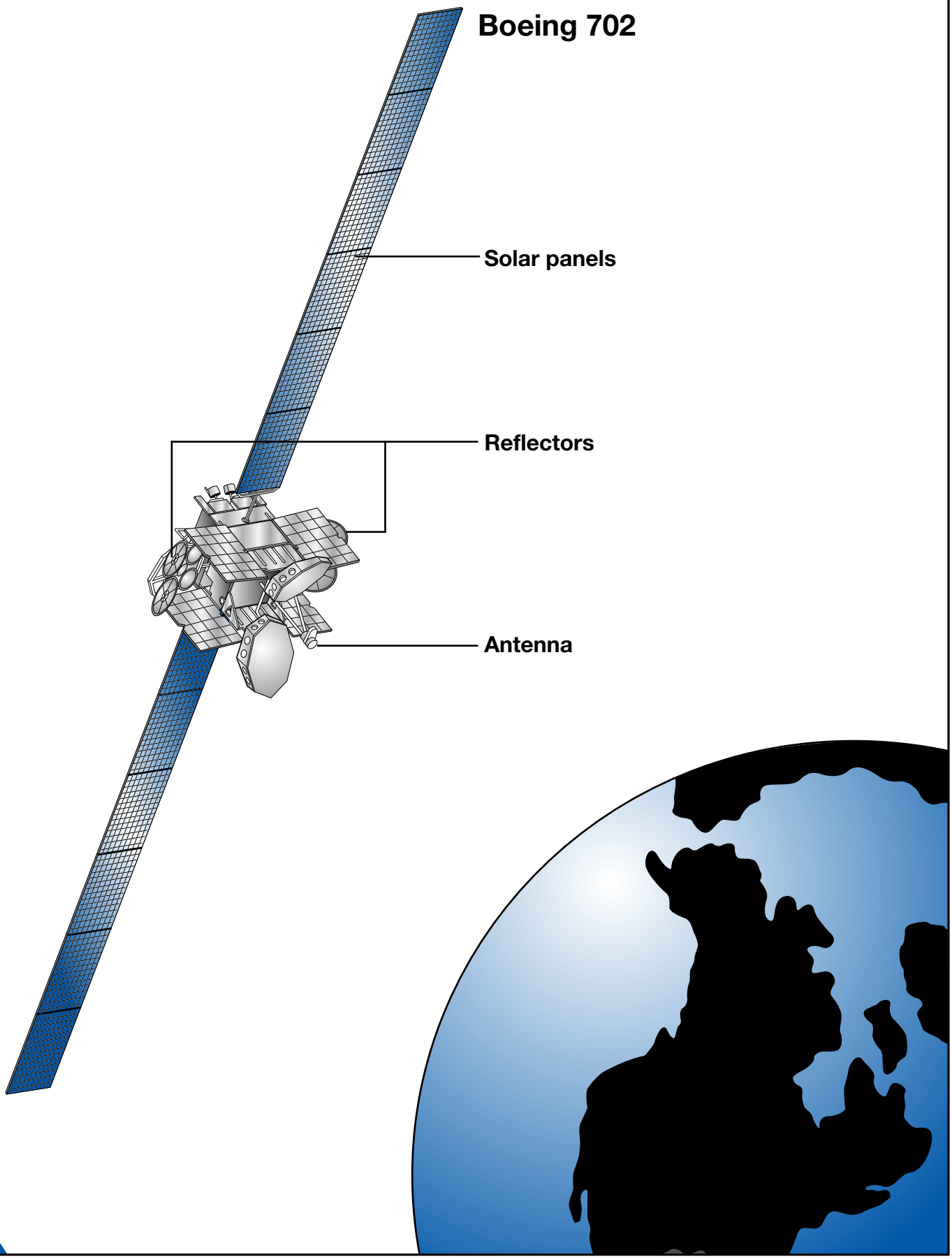
4. The **structures subsystem** distributes the stresses of launch and acts as a strong, stable framework for attaching the other parts of the satellite.

5. The **thermal control subsystem** keeps important parts of the satellite cool enough to work properly. It does this by directing the heat that is generated by satellite operations out into space, like a car's radiator.

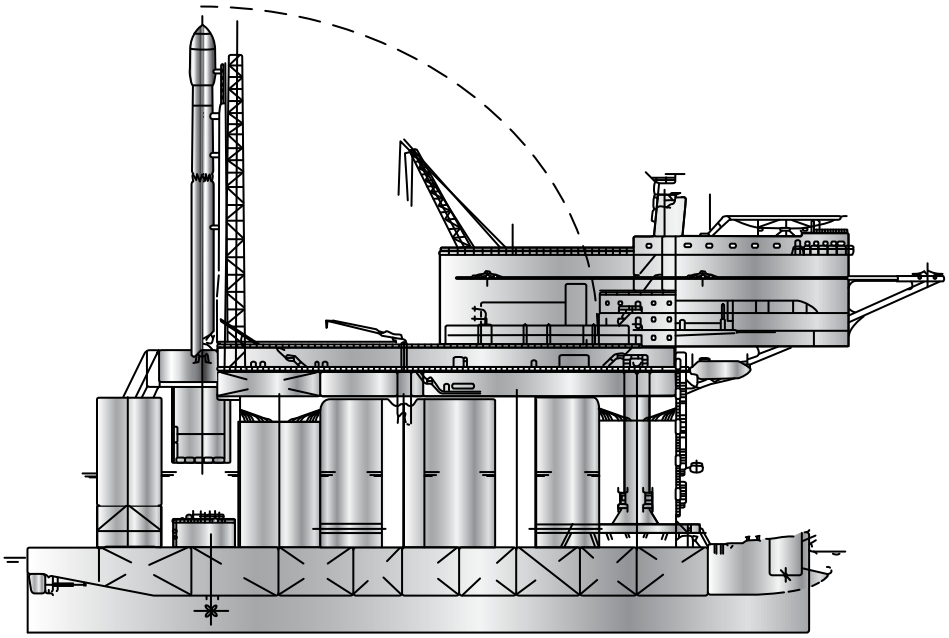
6. The **attitude control subsystem** helps the satellite stay in the correct location. Satellites can't be allowed to jiggle or wander, because if a satellite is not exactly where it belongs, pointed at exactly the right place on the Earth, the television program or the telephone call it transmits to you will be interrupted. When the satellite gets out of position, the attitude control system tells the propulsion system to fire a thruster that will move the satellite back where it belongs.

7. Operators at the ground station need to be able to transmit commands to the satellite and to monitor its health. The **telemetry and command subsystem** provides a way for people at the ground stations to communicate with the satellite.

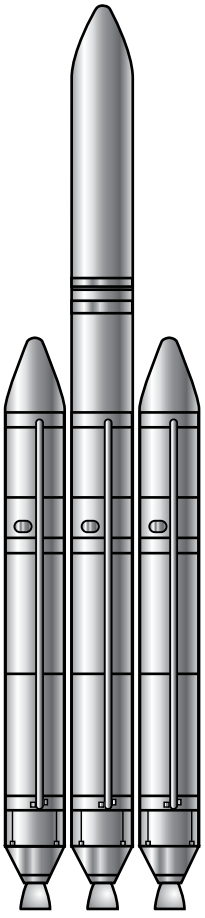
Satellite



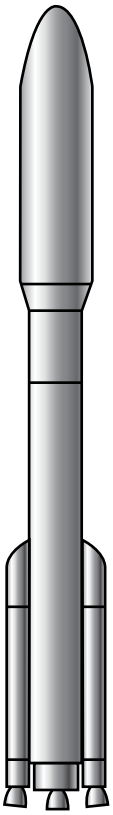
Satellite Launch Vehicles



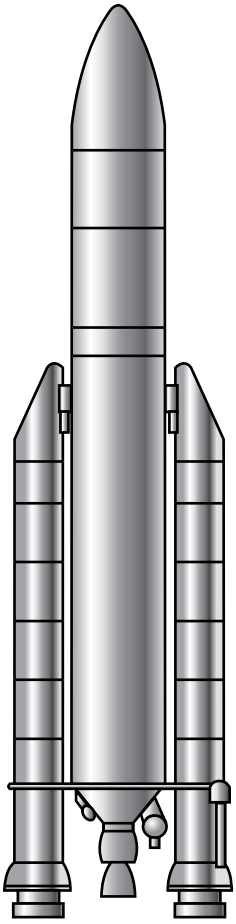
ZENIT Sea Launch
United States



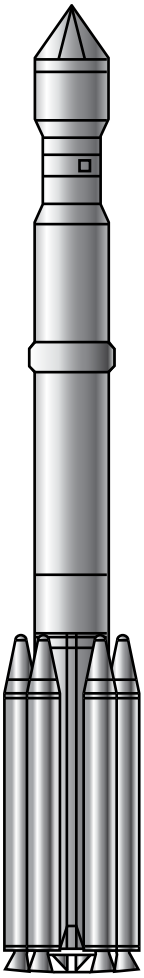
DELTA IV
United States



ATLAS V
United States

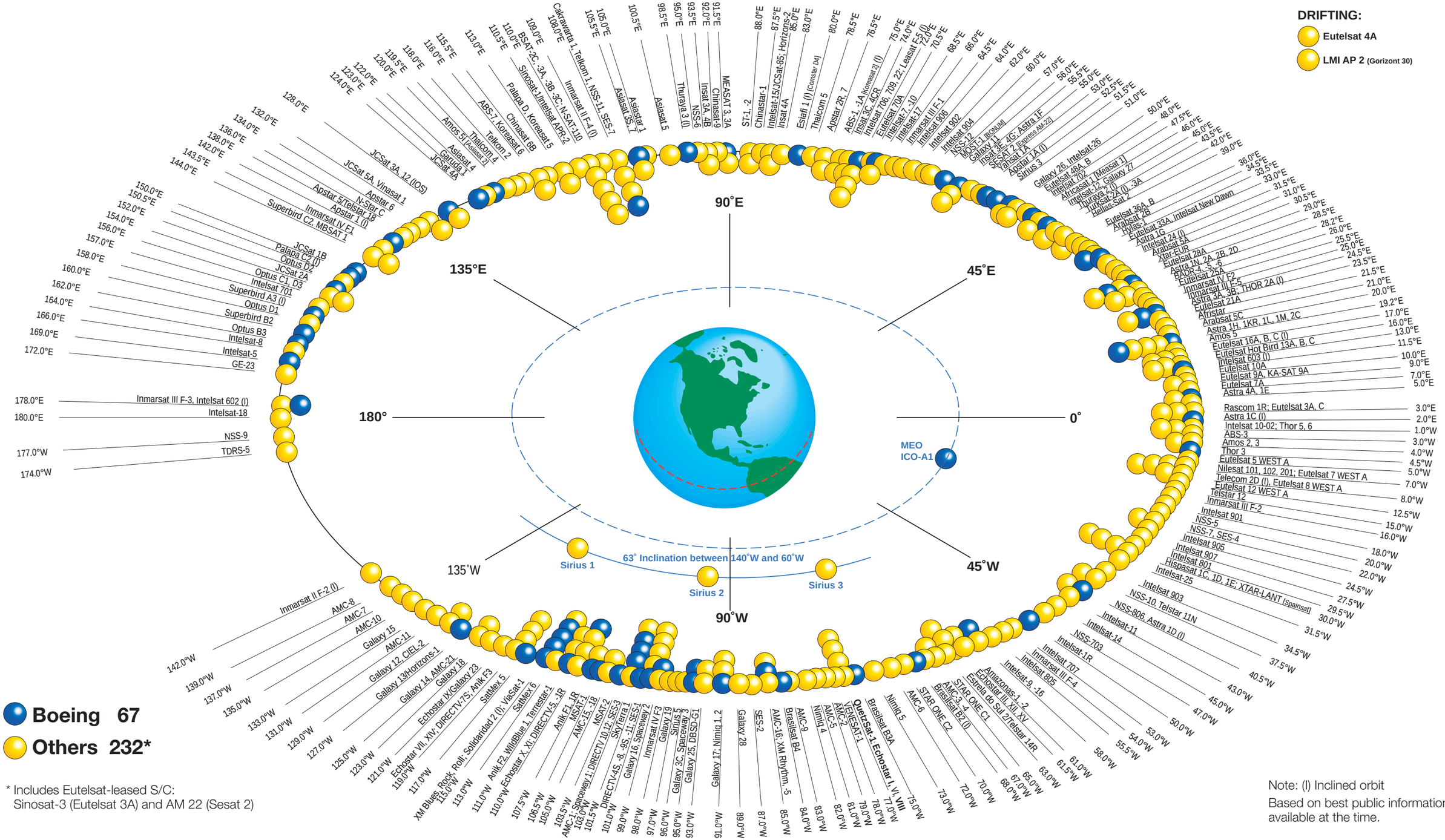


ARIANE 5
France



PROTON
Russia

Commercial Communications Satellites
Geosynchronous Orbit



* Includes Eutelsat-leased S/C:
Sinosat-3 (Eutelsat 3A) and AM 22 (Sesat 2)

Note: (I) Inclined orbit

Based on best public information available at the time.

31 Mar 2012 / 223714-001.ai