

Glossary

Asteroid — one of the many small celestial bodies revolving around the Sun, most of the orbits being between those of Mars and Jupiter. Also known as minor planet or planetoid.

Asteroid belt — the collection of asteroids orbiting the Sun between Mars and Jupiter, where most asteroids are found.

Atmosphere — the gaseous envelope surrounding a planet or celestial body. Saturn's largest moon, Titan, is the only moon in the Solar System known to have a substantial atmosphere.

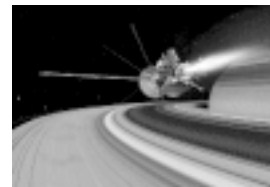
When used as a unit of measure, one atmosphere is equal to the air pressure measured at mean sea level on Earth.

Attitude-control propellant — the propellant used by attitude-control thrusters on a spacecraft to maintain or change the spacecraft's orientation. For Cassini, this propellant is the chemical hydrazine (H_2NNH_2).

Aurora — beautiful, shimmering curtains of light in the night sky, generally visible at high latitudes when the sky is dark. Auroras (or aurorae) are caused when energetic electrons from Earth's magnetosphere collide with gases in Earth's upper atmosphere, making the gases glow like a neon sign.

Binary numbers — a system of numbers that has 2 as its base instead of 10. The zeroes and ones of a base-2 system are used by computers to numerically code data from spacecraft.

Bit — the most basic unit of information used in computing, in which one of two possible values (i.e., 1 or 0) designates one unit (binary digit) of information. There are 8 bits in a byte.



Byte — a sequence of bits that are combined and operated upon as a unit in a computer. For example, it takes one byte of information to express a letter like "A" or a number like "8" in a computer. The novel *Moby Dick* has about one million characters (letters or numbers), and thus to store it in a computer would require a million bytes (about a megabyte) of memory.

CD-ROM — Compact Disc Read-Only Memory. A CD-ROM is a disc 12 cm (4.5 in.) in diameter, used for the permanent storage of about 600 megabytes of data.

Charged particles — particles (usually atoms) that have lost one or more electrons and now have a positive electrical charge. Electrons are negatively charged particles.

Closest approach — the point at which a spacecraft is the closest to a moon or planet.

Comet — a "dirty snowball" in orbit about the Sun. Comets are a few kilometers in size and are composed mainly of ice and dust. As a comet comes close to the Sun, some of its material is vaporized to form a gaseous head and extended tail. Comet orbits range from almost circular to very narrow ellipses, and have inclinations to the orbital plane of the planets from 0° to 90°.



Deep Space Network — the collection of radio antennas and ground-support equipment located in California, Spain, and Australia that allows NASA to communicate with spacecraft.

Density — the mass of a given substance per unit volume, generally measured in grams per cubic centimeter (g/cm^3). The density of water is $1 \text{ g}/\text{cm}^3$. The average density of Saturn is only $0.7 \text{ g}/\text{cm}^3$. This means that Saturn would float if we could place it in a large enough tub of water!

Diameter — the line segment that passes through the center of a circle or sphere, and whose end points lie on the circle or surface of the sphere. The radius is half the diameter. The diameter of Saturn is about 120,000 km, which is 9.5 times greater than Earth's diameter.

Direct sensing — the gathering and recording of information involving direct contact with the object or area being investigated. Cassini's Cosmic Dust Analyzer is an example of a direct-sensing instrument.

Doppler shift (effect) — apparent shifts in the wavelengths/frequencies of sound or light as the distance along the line of sight between the emitter and the receiver changes. If the emitter and receiver are moving closer together, the shift is toward higher frequency/shorter wavelength (blue shift). If the emitter and receiver are moving farther apart, the shift is toward lower frequency/longer wavelength (red shift).



Dust particles — very small, solid particles (so small you can barely see the largest of them with your eyes).

Electromagnetic radiation — coupled electric and magnetic travelling waves of various lengths (wavelengths): radio waves, microwaves, infrared, visible, ultraviolet, x-rays, and gamma rays. All forms of electromagnetic radiation travel at the speed of light. Cassini's instruments are able to detect radio, infrared, visible, and ultraviolet radiation.

Electromagnetic spectrum — the complete span of all wavelengths of electromagnetic radiation, from the lowest energy (longer wavelength) radio waves to the highest energy (shortest wavelength) gamma rays. Light visible to human eyes comprises only a very narrow range of the electromagnetic spectrum. See *Appendix 4* for an illustration.

Electron — a low-mass component of an atom carrying a negative electrical charge.

Energy — the capacity for doing work. A deep space mission like Cassini offers a marvelous context for considering many different forms of energy and how one is transformed into another. For example, gravity assist transforms gravitational energy to kinetic energy, and RTGs transform the heat from radioactivity to electrical energy that powers the spacecraft's instruments and transceivers.

Equinox — a point in a planet's orbit around the Sun at which the planet is tilted neither toward nor away from the Sun. For Earth, this occurs in the fall (autumnal equinox is 21 September) and in the spring (vernal equinox is 21 March). On these dates, Earthlings experience equal time for day and night at all



latitudes except 90°. When Saturn is in its equinox position, Earthlings may observe ring-plane crossings with the rings viewed edge-on.

Expendable launch vehicle — a rocket that can be used only once to place a payload into orbit. Its stages usually fall into the ocean. The Titan IV that launched Cassini–Huygens is an expendable launch vehicle.

f **Field of view** — the area in space or on a planet or moon that can be “seen” at any one time by a science instrument that makes images or collects particles from a limited range of directions.

Flyby — a close approach of a spacecraft to a target planet in which the spacecraft does not impact the planet or go into orbit around it. Also known as a swingby when the spacecraft receives a gravity assist. Cassini–Huygens’ trajectory to Saturn involves flybys of Venus, Earth, and Jupiter.

Frequency — the number of waves that pass a point in 1 second. Frequency is usually expressed in units of hertz (waves or cycles per second). Higher frequency electromagnetic waves carry more energy than lower frequency waves.

Fuel — the chemical that combines with an oxidizer to burn and produce thrust in an engine.

g **Gamma rays** — the highest-energy electromagnetic radiation, with wavelengths shorter than 10^{-12} m.

Gravity — the attractive effect that any massive object has on all other massive objects.

The greater the mass of the object, the stronger its gravitational pull. The closer the centers of two massive objects, the stronger the gravitational attraction between them. Surface gravity is the gravitational attraction experienced by objects at the surface of a planet or other celestial body. The surface gravity of Earth is 9.8 m/sec^2 .

Gravity assist — a way of using the gravitational pull of a massive planet on a spacecraft in order to transfer momentum and energy from the planet to the spacecraft that is flying (or “swinging”) by it. When the Voyager spacecraft flew by Jupiter, Voyager gained 16 km/sec of speed relative to the Sun at a cost of initially reducing Jupiter’s orbital motion around the Sun by about 30 cm (1 ft) every trillion years!

h **Heliopause** — the transition zone between the region of space influenced by our Sun’s solar wind (the heliosphere) and the interstellar medium. The two Voyager spacecraft are looking for this region of space, which is very far beyond the orbit of Pluto, the outermost planet in our Solar System.

High-gain antenna — a large, dish-shaped radio antenna that can send and receive more information than a low-gain antenna. For Cassini, the high-gain antenna is the large white dish on the top of the spacecraft. The antenna must be pointed at Earth for communications to and from Earth.

Hydrocarbon — one of a very large group of chemical compounds composed only of hydrogen and carbon. The largest source of hydrocarbons on Earth is petroleum (crude oil). Hydrocarbons called ethane and methane may be present in lakes on Saturn’s largest moon, Titan.



Infrared (IR) — electromagnetic radiation with wavelengths from about 0.75–0.8 micrometer (the long-wavelength limit of visible red light) to 1,000 micrometers (the shortest microwaves). One micrometer is 10^{-6} m.

Interstellar space — the vast space between the stars.

Ion — an atom or molecule that is electrically charged, having lost one or more electrons.

Jetstream — on Earth, a relatively narrow, fast-moving wind current usually observed at midlatitudes where jet airplanes fly. Saturn appears to have a broader equatorial jetstream with much faster wind speeds.

Jovian planets — the four giant gaseous planets (Jupiter, Saturn, Uranus, and Neptune) at a greater distance from the Sun than are the terrestrial planets (Mercury, Venus, Earth, and Mars).

K

Kepler's Laws — three laws, discovered by Johannes Kepler, that describe the motions of planets in their orbits around the Sun.

Kepler's First Law states that the orbits of the planets are ellipses with the Sun at a common focus. Kepler's Second Law states that as a planet moves in its orbit, an imaginary line joining the planet and the Sun sweeps the same amount of area in equal intervals of time. Kepler's Third Law says that the square of the orbital period of a planet is proportional to the cube of its mean distance from the Sun. These



laws may be more generally applied to any system in which gravity is the force acting to keep objects in orbit. Well after their discovery, these laws were found to be derivable from Newton's Laws of gravity and motion.

Lagrangian Points L4 and L5 — Points of gravitational stability where a particle can be trapped 60° ahead (L4) or 60° behind (L5) in the same orbit traveled by an object (e.g., a moon) around its primary (e.g., a planet).

Light — this term often refers to electromagnetic radiation that the human eye can perceive (visible light); however, terms such as ultraviolet light and infrared light are also frequently used. Also see “speed of light.”

Magnetic field — one of the elementary fields in nature, found in the vicinity of a magnetic body (like a magnet or planet) or a current-carrying medium (like a wire). Magnetic fields are also present along with electric fields in electromagnetic radiation.

Magnetosphere — the region around a planet or moon in which the body's magnetic field is the controlling influence on the physical processes that take place. For Earth, the magnetosphere is usually considered to begin at an altitude of about 100 km (60 mi) and to extend outward to a distant boundary that marks the beginning of interplanetary space. Saturn has an extensive magnetosphere that will be explored by the Cassini spacecraft.

Mass — a measure of the total amount of material in a body. Mass can be measured either by how much effort it takes to move the body or by its gravitational influence on other bodies.



Meteoroid — any solid object moving in interplanetary space that is smaller than a planet or asteroid but larger than a molecule. If a meteoroid enters Earth's atmosphere, we call it a meteorite after it falls to the surface. The light that it produces as it passes through the atmosphere is called a meteor.

Methane — a colorless, tasteless, odorless gas with a chemical composition of carbon and hydrogen (CH₄). On Earth, methane is a chief component in natural gas; it can also be found emanating from swamps and marshlands. Gerard Kuiper first discovered the atmosphere of Saturn's moon Titan by detecting indications of methane in his observational data.

Micrometeoroid — a very small meteoroid with a diameter generally less than a millimeter. Although they are small, micrometeoroids can do serious damage to a spacecraft zooming through interplanetary space, and thus a spacecraft must have some shielding to protect it.

Microwaves — electromagnetic radiation with shortwave radio wavelengths of about 10⁻² m.

Momentum — a measure of the state of motion of a body. The momentum of a body is the product of its mass and velocity (i.e., momentum = mass × velocity). Thus, bodies of the same mass moving at the same velocity have equal momentum.

Moon — a natural satellite of a planet. There are about 60 known moons in the Solar System. Earth has only one moon (which we call the Moon), but Saturn has at least 18 moons.

Nanometer — one billionth of a meter (10⁻⁹ m).

Nitrogen — a chemical element, normally in a gaseous state, symbolized by the letter N. Nitrogen in molecular form (N₂) makes up approximately 78% of Earth's atmosphere. Nitrogen is also abundant in Titan's atmosphere.

Nominal mission — the mission that will be accomplished if no problems occur. Cassini's nominal mission is due to end in 2008 after a 4-year tour of the Saturn system. If all goes well, the mission could be extended.

Objective lens or mirror — a telescope's primary light collector (large lens or mirror); sometimes called the primary lens or mirror.

Occultation — the passage of an object of large angular size in front of an object of smaller apparent size; e.g., the Moon in front of a distant star as viewed from Earth or Saturn's rings in front of a distant star as viewed by cameras on board the Voyager spacecraft. During occultation events, we can learn about the structure and dimensions of the object in the foreground.

Orbit — a path followed by a particle or body (e.g., the trajectory of a celestial body) under the influence of gravity. The properties of the orbital path are dependent on the gravitational force between two bodies — our Moon orbits Earth; Titan orbits Saturn; the Cassini spacecraft will be in orbit around Saturn.

Organic chemistry — the study of the composition, reactions, and properties of chemicals or compounds with a molecular structure involving chains or rings of carbon atoms.

Parking orbit — a temporary orbit placing a spacecraft in position before sending it on its desired trajectory. The Centaur upper stage placed Cassini-Huygens in a parking orbit.



Period — this term is used in three different contexts. 1) *Rotational period*: the time to make one complete rotation; e.g., the rotational period of Earth is 24 hours. 2) *Orbital period*: the time to complete one orbital revolution; e.g., the orbital period of Earth around the Sun is 1 year. 3) *Period of an electromagnetic wave*; i.e., the time to complete one cycle of the wave.

Plasma — an electrified gas; the fourth state of matter. Heat a solid, you get a liquid; heat a liquid, you get a gas. Heat a gas to the point where some of the atoms begin to lose electrons, and you get a gas of electrically charged particles (ions and electrons) called a plasma. Most of the matter in the Universe is believed to be in the plasma state. The Cassini spacecraft has instruments to measure the properties of the plasma in Saturn's magnetosphere.

Plasma wave — a disturbance of a plasma involving oscillation of its constituent particles and of an electromagnetic field. A plasma wave propagates from one point in the plasma to another without net motion of the plasma.

Power — a measure of energy expended or consumed as a function of time. A watt is a unit of power. A 100-watt light bulb uses more energy in an hour than a 60-watt light bulb. An 800-watt RTG is more powerful than a 500-watt RTG because it can deliver more energy per second to run Cassini's instruments.

Primary launch period — the first and most advantageous period of time during which to launch a spacecraft toward a particular destination. Cassini's primary launch period ran from 6 October to 15 November 1997.

Propellant — the fuel or oxidizer that, when combined with its counterpart, burns to produce a rocket thrust that propels a spacecraft to a desired destination.



Radio waves — electromagnetic radiation with the longest wavelengths, ranging from approximately 10^4 to 10^{-3} m. Radio receivers are designed to be sensitive to such waves. Radio waves can be used deliberately for communication and they can be generated naturally via interactions between charged particles and magnetic fields. Of course, Cassini is equipped to detect both!

Radioisotope thermoelectric generator (RTG) — a device for converting nuclear energy to electrical energy. The heat produced by the radioactivity of a radioisotope (like Pu-238) is used to produce a voltage in a thermocouple circuit. Cassini uses three RTGs to provide electricity for its science instruments, engineering equipment, and transmitters.

Reflector telescope — a telescope in which a mirror is used to gather light and form an image of a distant object. Also known as a reflecting telescope.

Refractor telescope — a telescope in which a lens is used to gather light and form an image of a distant object. Also known as a refracting telescope.

Remote sensing — the gathering and recording of information without direct contact with the object or area being investigated. Cassini's cameras are remote-sensing instruments, as are human eyes.

Resolution — the degree to which fine details in an image can be seen as distinctly separated or resolved. Cassini's highest-resolution cameras can distinguish objects that are about 350 millionths of a degree apart.



Ring (around a planet) — a “band” of icy, rocky, and/or dusty material encircling a planet. The various bits and boulders of the rings orbit around the planet as tiny moons. All the Jovian planets (Jupiter, Saturn, Uranus, Neptune) have rings, but Saturn’s rings are by far the most elaborate in the Solar System.

Ring-plane crossing — this event occurs every 14 to 15 years, when Saturn is tilted neither toward nor away from the Sun so that Earth observers see the rings of Saturn edge-on. Because the rings are nearly invisible during this time, ring-plane crossings offer good opportunities to search for moons. Several of Saturn’s 18 known moons were discovered during ring-plane crossings.

Ringlet — a narrow region in Saturn’s planetary ring system where the density of ring particles is high. The Voyager spacecraft discovered that the rings visible from Earth are actually composed of tens of thousands of ringlets.



Robot — a mechanical device that can be programmed to perform a variety of tasks under automatic or remote control. The Cassini spacecraft is a robot.

Rotation — spinning on an axis. One full rotation of Earth takes 24 hours. One full rotation of Saturn takes 10 hours, 40 minutes.

S

Satellite (as in a ring particle or moon) — a relatively small, solid body moving in orbit around a planet. Moons and ring particles are satellites of Saturn.

Solar wind — the supersonic flow of hydrogen and helium plasma that flows continu-

ously from the Sun outward through the Solar System, with velocities of 300 to 1,000 km/sec (180 to 600 mi/sec).

Solstice — the two days (actually, instants) during the year when Earth is located in its orbit so that the inclination of the rotation axis (about 23.5°) is maximally toward the Sun; the dates are around June 21 for the North Pole being inclined toward the Sun, and around December 21 for the South Pole.

Space physics — the study of the Sun, the solar wind, and their interactions with planetary magnetospheres and plasma environments. Space physicists investigate fundamental physical processes that have broad applicability across the entire plasma universe.

Spectrograph (or spectrometer) — a remote-sensing instrument used for dispersing and recording a particular range of wavelengths of the electromagnetic spectrum. Cassini will carry several of these instruments operating at different wavelengths.

Spectroscopy — the study of the way in which atoms absorb and emit electromagnetic radiation. Spectroscopy allows astronomers to determine the chemical composition of stars, planets, moons, interstellar clouds, and so on. Because the way atoms absorb or emit light is influenced by temperature, line-of-sight motion, the strength of magnetic fields, and other physical conditions, spectroscopy also permits astrophysicists to measure these properties from afar.

Speed of light — light, and electromagnetic radiation of any type, travels at the speed of light, which is 300,000 km/sec (186,000 mi/sec) in a vacuum.



Supersonic — something moving faster than waves traveling at the speed of sound.

Surface gravity — the downward pull or acceleration at the surface of a planet or other celestial body. The acceleration of gravity at the surface of Earth is 9.8 m/sec^2 . The strength of the surface gravity depends on both the size and the mass of the body. If a body has the same mass as another but is smaller, it will have the stronger surface gravity because its mass is more concentrated.

Swingby — similar to a flyby, except the term indicates that the course of the spacecraft has been altered by the gravity of the moon or planet as the spacecraft went by.



Teleoperation — the operation of a robot from a distance.

Tidal force — the difference between the gravitational tug on the near side of an object compared with the gravitational tug on the far side caused by another nearby body. Tidal forces can heat the interior of a moon, resulting in (for example) the volcanoes on Jupiter's moon Io and the possible ice geysers on Saturn's moon Enceladus.

Trajectory — the curved path a spacecraft follows through space.

Translucent — property of a medium that allows light to pass through, but the light is so diffused that objects cannot be seen distinctly.



Ultraviolet (UV) — electromagnetic radiation with wavelengths ranging from approximately

10^{-7} to 10^{-8} m. Cassini has an instrument package called UVIS (ultraviolet imaging spectrograph) to study UV emissions in the Saturn system.

Upper stage — a smaller rocket carried aloft by a larger one (called a booster, first stage, or lower stage). A powerful Centaur upper stage was used with a Titan IV vehicle to send Cassini-Huygens on its trajectory to Saturn.



Visible light — electromagnetic radiation with wavelengths ranging from approximately 400 to 700 nanometers. Visible light is the narrow strip of the electromagnetic spectrum in which humans can see. Detecting other parts of the electromagnetic spectrum requires instruments that extend our senses. See *Appendix 4* for an illustration.



Watt — a unit of power in the meter-kilogram-second system (see “power”).

Wavelength — the distance between one wave crest to the next wave crest (or one trough to the next trough).



X-rays — electromagnetic radiation with wavelengths ranging from approximately 10^{-8} to 10^{-10} m.

