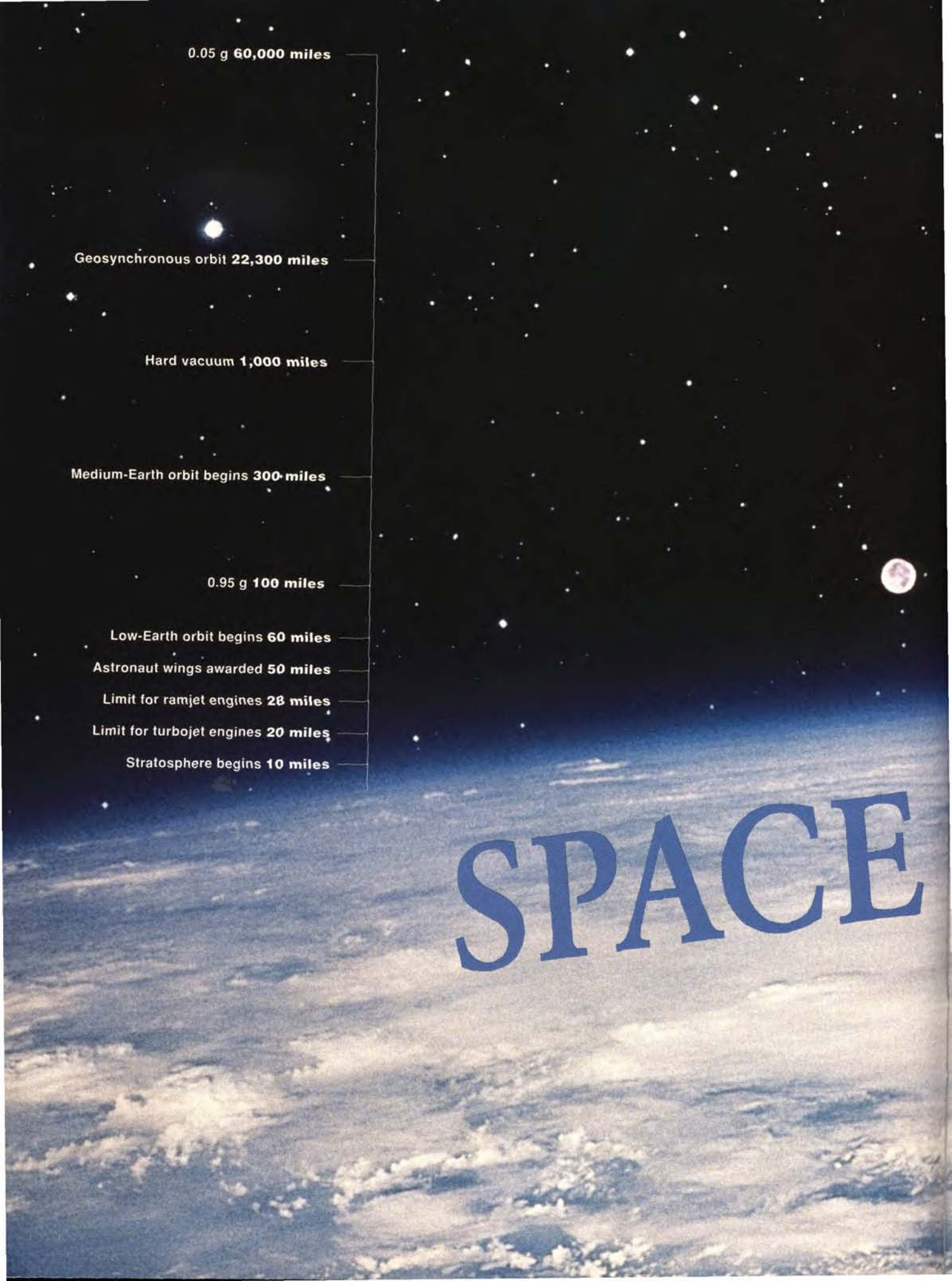
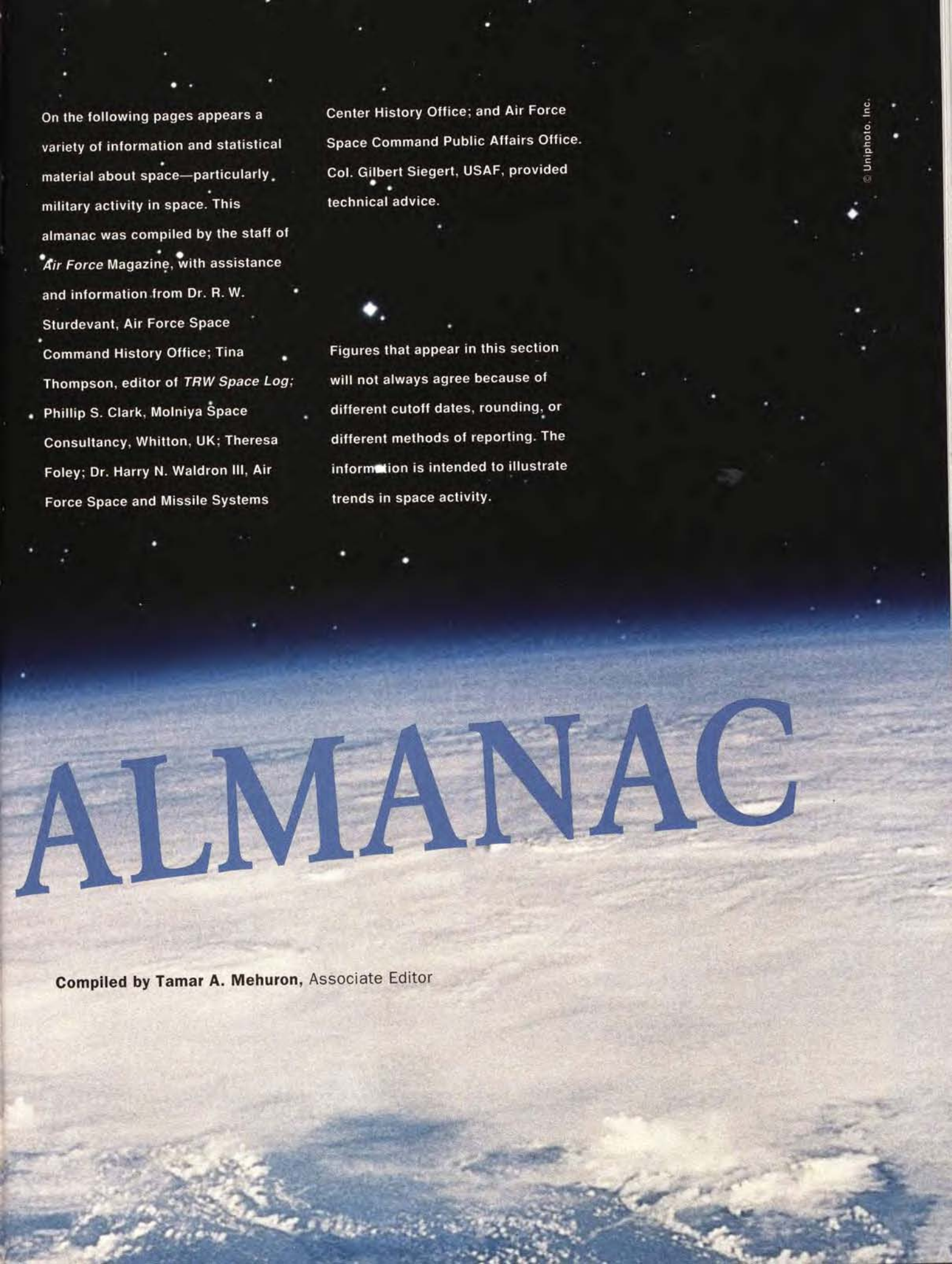

0.05 g 60,000 miles
Geosynchronous orbit 22,300 miles
Hard vacuum 1,000 miles
Medium-Earth orbit begins 300 miles
0.95 g 100 miles
Low-Earth orbit begins 60 miles
Astronaut wings awarded 50 miles
Limit for ramjet engines 28 miles
Limit for turbojet engines 20 miles
Stratosphere begins 10 miles
SPACE



ALMANAC

Compiled by Tamar A. Mehuron, Associate Editor

On the following pages appears a variety of information and statistical material about space—particularly military activity in space. This almanac was compiled by the staff of *Air Force* Magazine, with assistance and information from Dr. R. W. Sturdevant, Air Force Space Command History Office; Tina Thompson, editor of *TRW Space Log;* Phillip S. Clark, Molniya Space Consultancy, Whitton, UK; Theresa Foley; Dr. Harry N. Waldron III, Air Force Space and Missile Systems Center History Office; and Air Force Space Command Public Affairs Office. Col. Gilbert Siegert, USAF, provided technical advice.

Figures that appear in this section will not always agree because of different cutoff dates, rounding, or different methods of reporting. The information is intended to illustrate trends in space activity.

Space Terms

Aerospace. A physical region made up of Earth's atmosphere and the space beyond.

Aerospace plane. A single spacecraft able to operate effectively in both the atmosphere and space. Also known as a "transatmospheric vehicle."

Apogee. The point of greatest distance from Earth (or the moon, a planet, etc.) achieved by a body in elliptical orbit. Usually expressed as distance from Earth's surface.

Atmosphere. Earth's enveloping sphere of air.

Boost phase. Powered flight of a ballistic missile—*i.e.*, before the rocket burns out.

Burn. The process in which rocket engines consume fuel or other propellant.

Circumterrestrial space. "Inner space" or the atmospheric region that extends from sixty miles to about 50,000 miles from Earth's surface.

Constellation. A formation of spacecraft orbiting for a specific combined purpose.

Deep space. All space beyond the Earth-moon system, or from about 480,000 miles altitude outward.

Eccentric orbit. An extremely elongated elliptical orbit.

Ecliptic plane. The plane defined by the circle on the celestial sphere traced by the path of the sun.

Elliptical orbit. Any noncircular, closed spaceflight path.

Exosphere. The upper limits of Earth's atmosphere, ranging from about 300 miles altitude to about 2,000 miles altitude.

Expendable launch vehicle (ELV). A launch vehicle that cannot be reused after one flight.

Ferret. A satellite whose primary function is to gather electronic intelligence, such as microwave, radar, radio, and voice emissions.

Geostationary Earth orbit. A geosynchronous orbit with 0° inclination in which the spacecraft circles Earth 22,300 miles above the equator and appears from Earth to be standing still.

Geosynchronous Earth orbit (GEO). An orbit at 22,300 miles that is synchronized with Earth's rotation. If a satellite in geosynchronous orbit is not at 0° inclination, its ground path describes a figure eight as it travels around Earth.

Geosynchronous transfer orbit (GTO). An orbit that originates with the parking orbit and then reaches apogee at the GEO.

Ground track. An imaginary line on Earth's surface that traces the course of another imaginary line between Earth's center and an orbiting satellite.

High-Earth orbit (HEO). Flight path above geosynchronous altitude (22,300 to 60,000 miles from Earth's surface).

High-resolution imagery. Detailed representations of actual objects that satellites produce electronically or optically on displays, film, or other visual devices.

Inertial upper stage. A two-stage solid-rocket motor used to propel heavy satellites into mission orbit.

Ionosphere. A region of electrically charged thin air layers that begins about thirty miles above Earth's atmosphere.

Low-Earth orbit (LEO). Flight path between Earth's atmosphere and the bottom of the Van Allen belts, *i.e.*, from about sixty to 300 miles altitude.

Magnetosphere. A region dominated by Earth's magnetic field, which traps charged particles, including those in the Van Allen belts. It begins in the upper atmosphere, where it overlaps the ionosphere, and extends several thousand miles farther into space.

Medium-Earth orbit (MEO). Flight path between low-Earth orbit (about 300 miles in altitude) and geosynchronous orbit at an average altitude of 22,300 miles.

Mesosphere. A region of the atmosphere about thirty to fifty miles above Earth's surface.

Orbital decay. A condition in which spacecraft lose orbital altitude and orbital energy because of aerodynamic drag and other physical forces.

Orbital inclination. Angle of flight path in space relative to the equator of a planetary body. Equatorial paths are 0° for flights headed east, 180° for those headed west.

Outer space. Space that extends from about 50,000 miles above Earth's surface to a distance of about 480,000 miles.

Parking orbit. Flight path in which spacecraft go into LEO, circle the globe in a waiting posture, and then transfer payload to a final, higher orbit.

Payload. Any spacecraft's crew and/or cargo; the mission element supported by the spacecraft.

Perigee. The point of minimum altitude above Earth (or the moon, a planet, etc.) maintained by a body in elliptical orbit.

Period. The amount of time a spacecraft requires to go through one complete orbit.

Polar orbit. Earth orbit with a 90° inclination. Spacecraft on this path could pass over every spot on Earth as Earth rotates under the satellite's orbit (see "orbital inclination").

Remote imaging. Images of Earth generated from spacecraft that provide data for mapping, construction, agriculture, oil and gas exploration, news media services, and the like.

Rocket. An aerospace vehicle that carries its own fuel and oxidizer and can operate outside Earth's atmosphere.

Semisynchronous orbit. An orbit set at an altitude of 12,834 miles. Satellites in this orbit revolve around Earth in exactly twelve hours.

Single-stage-to-orbit (SSTO) system. A radically new, reusable single-stage rocket that can take off and land repeatedly and is able to boost payloads into orbit.

Stratosphere. That section of atmosphere about ten to thirty miles above Earth's surface.

Sun-synchronous orbit. A low-Earth orbit inclined at about 98° to the equator. At this inclination and altitude, a satellite's orbital plane will always maintain the same relative orientation to the position of the sun.

Thermosphere. The thin atmosphere about fifty to 300 miles above Earth's surface. It experiences dramatically increased levels of heat compared to the lower layers.

Transfer. Any maneuver that changes a spacecraft orbit.

Transponder. A radar or radio set that, upon receiving a designated signal, emits a radio signal of its own.

Troposphere. The region of the atmosphere from Earth's surface to about ten miles above the equator and five miles above the poles. This is where most clouds, wind, rain, and other weather occurs.

Van Allen belts. Zones of intense radiation trapped in Earth's magnetosphere that could damage unshielded spacecraft.

Space Firsts

February 24, 1949 Project Bumper, the first fully successful two-stage rocket-launch into space, reaches a record altitude of 244 miles.

July 24, 1950 Bumper-WAC becomes first missile launched from Cape Canaveral, Fla.

September 20, 1956 US Jupiter C rocket achieves record first flight, reaching an altitude of 682 miles and landing 3,400 miles from Cape Canaveral.

August 21, 1957 First successful launch of Soviet R7 rocket, which six weeks later will loft Sputnik into orbit.

October 4 USSR launches Sputnik 1, the first man-made satellite, into Earth orbit.

November 3 First animal in space, a dog, is carried aloft by Soviet Sputnik 2.

December 6 First US attempt to orbit satellite fails when Vanguard rocket loses thrust and explodes.

December 17 First successful Atlas booster launch.

January 31, 1958 Explorer 1, first US satellite, launched.

May 15 USSR launches first automatic scientific lab aboard Sputnik 3, proving satellites can have important military uses.

December 18 Project Score spacecraft conducts first US active communication from space.

February 28, 1959 Discoverer 1 becomes first satellite launched from Vandenberg AFB, Calif.

June 9 First engineer group arrives at Cape Canaveral to prepare Atlas booster carrying first Mercury capsule.

August 7 Explorer 6 spacecraft transmits first television pictures from space.

September 12 Soviet Union launches Luna 2, which two days later becomes first man-made object to strike the moon.

April 1, 1960 TIROS 1 becomes first US weather satellite to go aloft.

April 13 Transit 1B becomes first US navigation satellite in space.

May 24 Atlas D/Agena A booster places MIDAS II, first early warning satellite, in orbit.

June 22 US performs first successful launch of multiple independently instrumented satellites by a single rocket.

August 12 First passive communications carried via Echo 1 satellite.

January 31, 1961 Preparing for manned spaceflight, US launches a Mercury capsule carrying the chimpanzee Ham on a suborbital trajectory.

February 16 Explorer 9 becomes first satellite launched from Wallops Island, Va.

April 12 Soviet cosmonaut Yuri Gagarin pilots Vostok 1 through nearly one orbit to become first human in space.

May 5 Lt. Cmdr. Alan B. Shepard, Jr., aboard Freedom 7 Mercury capsule, becomes first American in space, climbing to 116.5 miles during suborbital flight lasting fifteen minutes, twenty-eight seconds.

October 27 First flight of Saturn rocket marks beginning of more than eleven years of Apollo launches.

February 20, 1962 Project Mercury astronaut Lt. Col. John H. Glenn, Jr., aboard the Friendship 7 capsule, completes the first US manned orbital flight.

December 14 Mariner 2 passes Venus at a distance of 21,600 miles, becoming the first space probe to encounter another planet.

June 16, 1963 Valentina Tereshkova of USSR pilots Vostok 6 to become first woman in space.

July 26 Hughes Corp.'s Syncom 2 (prototype of Early Bird communications satellite) orbits and "parks" over the Atlantic to become world's first geosynchronous satellite.

October 17 Vela Hotel satellite performs first spacebased detection of a nuclear explosion.

July 28, 1964 First close-up lunar pictures provided by Ranger 7 spacecraft.

August 14 First Atlas/Agena D standard launch vehicle successfully fired from Vandenberg AFB.

March 18, 1965 First spacewalk conducted by Alexei Leonov of Soviet Voskhod 2.

March 23 Gemini 3 astronauts Maj. Virgil I. "Gus" Grissom and Lt. Cmdr. John W. Young complete world's first piloted orbital maneuver.

June 4 Gemini 4 astronaut Maj. Edward H. White performs first American spacewalk.

July 14 Mariner provides the first close-up pictures of Mars.

August 21 Gemini 5 launched as first manned spacecraft with electrical power other than batteries; it is equipped with fuel cells.

March 16, 1966 Gemini 8 astronauts Neil A. Armstrong and Maj. David R. Scott perform first manual docking in space with Agena rocket stage.

June 2 Surveyor 1 is first US spacecraft to land softly on the moon. It analyzes soil content and transmits surface images to Earth.

January 25, 1967 Soviet Cosmos 139 antisatellite weapon carries out first fractional orbit bombardment.

January 27 First deaths of US space program occur in flash fire in Apollo 1 command module, killing astronauts Grissom, White, and Lt. Cmdr. Roger B. Chaffee.

September 8 Surveyor 5 conducts first chemical analysis of lunar soil.

October 20, 1968 Soviet Cosmos 248 and Cosmos 249 spacecraft carry out first co-orbital antisatellite test.

December 21–27 Apollo 8 becomes first manned spacecraft to escape Earth's gravity and enter lunar orbit. First live lunar television broadcast.

March 3–13, 1969 Apollo 9 crew members Col. James A. McDivitt, Col. David R. Scott, and Russell L. Schweickart conduct first test of lunar module in Earth orbit.

July 20 Apollo 11 puts first human, Neil A. Armstrong, on the moon.

November 14–24 US Apollo 12 mission deploys first major scientific experiments on the moon and completes first acquisition of samples from an earlier spacecraft—Surveyor 3.

February 11, 1970 Japan launches first satellite, Osumi, from Kagoshima Space Center using Lambda 4S solid-fuel rocket.

January 31, 1971 Apollo 14 launched; its astronauts will complete first manned landing on lunar highlands.

April 19 First space station, Salyut 1, goes aloft.

June 6 USSR's Soyuz 11 performs first successful docking with Salyut space station.

October 28 First British satellite, Prospero, launched into orbit on Black Arrow rocket.

November 2 Titan IIIC launches first Defense Satellite Communications System Phase II (DSCS II) satellites into geosynchronous orbits.

April 16–27, 1972 Apollo 16 astronauts Capt. John Young, Lt. Cmdr. Thomas K. Mattingly II, and Lt. Col. Charles M. Duke, Jr., are first to use the moon as an astronomical laboratory.

July 23 US launches first Earth Resources Technology Satellite (ERTS A), later renamed Landsat 1.

December 3, 1973 Pioneer 10 becomes first space probe to come within reach of Jupiter.

July 15, 1975 US Apollo and Soviet Soyuz 19 spacecraft perform first international docking of spacecraft in space.

August 12, 1977 Space shuttle *Enterprise* performs first free flight after release from a Boeing 747 at 22,800 feet.

February 22, 1978 Atlas booster carries first Global Positioning System (GPS) Block I satellite into orbit.

December 13 Successful launch of two DSCS II satellites puts a full four-satellite constellation at users' disposal for first time.

July 18, 1980 India places its first satellite, Rohini 1, into orbit using its own SLV-3 launcher.

April 12–14, 1981 First orbital flight of shuttle *Columbia* (STS-1) and first landing from orbit of reusable spacecraft.

December 20, 1982 First Defense Meteorological Satellite Program Block 5D-2 satellite launched.

Space Firsts (continued)

June 18, 1983 Space shuttle *Challenger* crew member Sally K. Ride becomes first American woman in space.

September 11, 1985 International Cometary Explorer becomes first man-made object to encounter a comet (Giacobini-Zinner).

September 13 First US antisatellite intercept test destroys Solwind scientific satellite by air-launched weapon.

January 28, 1986 In the first shuttle mishap, *Challenger* explodes after liftoff, killing seven astronauts.

February 22 France launches first *Satellite Pour l'Observation de la Terre* (SPOT) for remote sensing.

August 12 First launch of Japanese H-I rocket puts Experimental Geodetic Satellite into circular orbit.

May 15, 1987 USSR stages first flight of its Energia heavy launcher, designed to lift 100 tons into low-Earth orbit.

November 15, 1988 USSR makes first launch of thirty-ton shuttle *Buran* using Energia rocket.

February 14, 1989 Launch of first Block II GPS satellite begins an operational constellation.

January 17, 1991 What the Air Force calls "the first space war," Operation Desert Storm, opens with air attacks.

October 29 Galileo swings within 10,000 miles of Gaspra, snapping first close-up images of an asteroid.

May 13, 1992 The first trio of spacewalking astronauts, working from the shuttle *Endeavour,* rescues Intelsat 6 from useless low orbit.

January 13, 1993 USAF Maj. Susan Helms, flying aboard *Endeavour,* becomes first US military woman in space.

July 19 Launch of a DSCS Phase III satellite into geosynchronous orbit provides the first full five-satellite DSCS III constellation.

December 2–13 USAF Col. Richard O. Covey pilots shuttle *Endeavour* on successful $674 million mission to repair $2 billion Hubble Space Telescope, a mission for which the crew wins the 1993 Collier Trophy.

January 25, 1994 Launch of the 500-pound unpiloted Clementine spacecraft marks the first post-Apollo US lunar mission.

February 7 First Titan IV–Centaur booster launches first Milstar Block I satellite into orbit.

March 13 First launch of Taurus booster (from Vandenberg AFB), which places two military satellites into orbit.

June 29 First visit of a US space shuttle to a space station, the Russian Mir.

November 5 Ulysses, first probe to explore the sun's environment at high latitudes, completes a pass over the sun's southern pole and reveals that solar wind's velocity at high latitudes (*i.e.,* about two million mph) is nearly twice its velocity at lower latitudes.

February 6, 1995 Shuttle *Discovery* (STS-63) and space station Mir perform first US-Russian space rendezvous in twenty years, with Air Force Lt. Col. Eileen M. Collins coincidentally becoming first woman to pilot a US spaceship.

March 14 US astronaut Norman E. Thagard becomes first American to accompany Russian cosmonauts aboard Soyuz TM-21 spacecraft and, two days later, becomes first American to inhabit space station Mir.

June 29 *Atlantis* (STS-71) docks with Mir, the first docking of a US spacecraft and a Russian space station.

July 13–22, 1995 Shuttle *Discovery* (STS-70) uses an inertial upper stage developed by USAF Space and Missile Systems Center (SMC) to boost the seventh NASA tracking and data relay satellite system into a geosynchronous orbit.

July 31 Atlas IIA booster with a Centaur upper stage launches Defense Satellite Communications System III B-7, which relies on an Integrated Apogee Boost System to finally reach its geosynchronous orbit.

At White Sands Missile Range, N. M., in June, the Delta Clipper–Experimental Advanced program's Clipper Graham (right) demonstrated quick-turnaround operations for a reusable rocket, completing two test flights in twenty-six hours.

August 4 SMC awards two team contracts for the pre–engineering and manufacturing development phase of the Spacebased Infrared (SBIR) system.

August 5 Delta II launches Koreasat-1 from Cape Canaveral AS, Fla., to provide direct-broadcast television, business, and general communications services for South Korea.

August 24 SMC awards four prime contracts for the low-cost concept

validation phase of the Evolved Expendable Launch Vehicle.

August 28
Atlas IIAS propels a Japanese communication satellite into orbit.

September 7–18
Astronauts aboard the shuttle *Endeavour* (STS-69) study astronomy, complete six-hour spacewalk tests, and launch and retrieve two satellites—the Spartan free-flying platform,

which collects data on the sun's corona and solar wind, and the Wake Shield Facility, which experiments with manufacturing wafer-thin gallium arsenide samples.

September 21
SMC authorizes full production rate of the Small Tactical Terminal for receiving, processing, and displaying weather data from Defense Meteorological Satellite Program (DMSP) satellites.

September 28
SBIR program office awards five-year contracts for the Attack and Launch Early Reporting to Theater (ALERT) and Talon Shield programs to improve capabilities for theater missile detection and warning.

October 20–November 5
Shuttle *Columbia* (STS-73) astronauts perform microgravity experiments with potential applications for chemical and pharmaceutical manufacturing.

October 22
Atlas II lofts the fifth successful UHF Follow-On satellite into orbit from Cape Canaveral AS as part of the effort to replace Fleet Satellite Communications and Leased Satellite capability in support of the Navy global communications network.

October 23
First Conestoga spacelifter, with the NASA Meteor-1 experiments platform, is automatically destroyed forty-five seconds into flight because of instability four miles downrange from Wallops Flight Facility, Va.

November 4
Delta II lofts the Canadian Radar Satellite into low-Earth orbit from Vandenberg AFB, Calif., to provide coverage of Arctic sea routes and complete the first comprehensive map of Antarctica.

November 6
Titan IV booster with a Centaur upper stage launches the second Military Strategic and Tactical Relay (Milstar) communications satellite into geosynchronous orbit.

November 12–20
Shuttle *Atlantis* (STS-74), piloted by Air Force Lt. Col. James D. Halsell, Jr., completes the second shuttle-Mir docking and transfers more than one ton of food and water to the Russian space station, which also received a permanent docking module with a pair of folding solar arrays to boost the station's overloaded power supply.

December 2
Atlas IIAS rocket launches European Space Agency's $1 billion Solar and Heliospheric Observatory from Cape Canaveral into a Lagrangian orbit to survey the sun's internal composition and observe solar winds.

December 7
Galileo, launched from the shuttle *Atlantis* in October 1989, reaches Jupiter, sends a probe parachuting through the planet's atmosphere, and rockets into orbit.

December 15
Two orbiting Milstar satellites successfully crosslink by transmitting messages directly between satellites without the use of ground stations, paving the way for enhanced US military capability to provide secure, survivable, jam-resistant communications.

December 28
China launches the US EchoStar-1 direct-broadcast satellite atop a Long March (CZ-2E) booster from Xichang, China, while Russia employs a Molniya-M rocket to launch India's IRS-1C remote sensing satellite from Tyuratam, Kazakhstan.

December 30
First launch of the Delta II Avionics Upgrade Vehicle carries NASA's X-Ray Timing Explorer into low-Earth orbit for a multiyear survey of such X-ray sources as white dwarfs, neutron stars, and black holes.

January 11, 1996
National Oceanic and Atmospheric Administration's (NOAA) seventh Geostationary Operational Environmental Satellite (GOES-7) retires after nearly nine years of orbital operation, with GOES-9 picking up the mission.

January 11–20
Air Force Col. Brian Duffy commands the shuttle *Endeavour* (STS-72) mission to retrieve the Japanese Space Flyer Unit satellite, deploy and retrieve the Office of Aeronautics and Space Technology–Flyer satellite, conduct scientific investigations, and evaluate space station assembly methods.

January 14
Delta II launches Koreasat-2 from Cape Canaveral.

January 31
Atlas IIAS lofts the Palapa C-1 satellite from Cape Canaveral to provide commercial telecommunications service for Indonesia.

February 17
Near-Earth Asteroid Rendezvous spacecraft, the first asteroid orbiter and the initial satellite in NASA's Discovery program for "faster, better, cheaper" planetary exploration, is launched atop Delta II from Cape Canaveral to encounter asteroid 433 Eros in February 1999.

February 22–March 9
Shuttle *Columbia* (STS-75) deploys the third US Microgravity Payload (USMP-3) but loses Italy's $443 million Tethered Satellite System-1R because of a broken tether.

March 5–6
Approximately 400 representatives from DoD, NASA, industry, and academia attend the first Space Strategy and Architecture Symposium, in Arlington, Va., to discuss key policy issues related to the future of the US in space.

March 8
At Vandenberg AFB, the first successful launch of the Pegasus XL rocket from beneath Orbital Sciences Corp.'s modified L-1011 aircraft sends the Air Force Radiation Experiment-II satellite into polar orbit.

March 22–30
Atlantis (STS-76) completes the third shuttle rendezvous and docking with the Russian space station Mir, where US Air Force Academy graduate Ronald M. Sega supervises the first shuttle-Mir spacewalk. Biochemist Shannon W. Lucid remains aboard Mir until August.

March 27
Delta II booster launches Navstar IIA-25 from Cape Canaveral. It is the first replenishment satellite for the operational Global Positioning System (GPS) constellation.

March 29
Vice President Al Gore announces that the Clinton Administration will open the Pentagon's sophisticated GPS to full commercial access within four to ten years, which could lead to 100,000 new jobs and help emerging businesses grow eightfold into an $8 billion industry by the end of this century.

April 24
Delta II booster launches the Ballistic Missile Defense Organization Midcourse Space Experiment from Vandenberg AFB to demonstrate Brilliant Eyes sensors for discrimination and tracking of midcourse targets as well as collect data on contamination of optical instruments in orbit.

June 27
Galileo encounters and captures the first close-up images of Ganymede, a moon of Jupiter about the size of Mercury.

Global Positioning System (GPS)
Constellation of twenty-four satellites used by military and civilians to determine a precise location anywhere on Earth. A small receiver takes signals from four GPS satellites and calculates a position. The satellites transmit a highly precise signal to authorized users, permitting accurate navigation to within sixteen meters. DoD has deployed more than 100,000 GPS receivers to US government and allied users, with terminals becoming much more widely available since the 1991 Persian Gulf War. Civilians use a commercial version of the terminals, with a degraded signal with an accuracy to 100 meters. Receivers are priced as low as $200. The less accurate signal prevents adversaries from using GPS for precision weapons targeting. Civilian users are working to obtain a much better signal through auxiliary equipment, known as differential GPS, that corrects the degradation. DoD has become increasingly concerned about enemy use of GPS during a conflict and has begun an effort called NAVWARS to protect its advantage while preventing adversary use of GPS. The current constellation consists of twenty-five production satellites known as Block II/IIAs. The GPS Joint Program Office has procured twenty-one replenishment satellites known as Block IIRs. The first Block IIR will launch in early 1997. In April 1996, a contract was awarded for thirty-three Block IIF GPS spacecraft to sustain the system through 2012. The Block IIF series will begin launching in 2001.

Defense Satellite Communications System (DSCS)
Constellation of five DSCS spacecraft in geostationary orbit provides voice, data, digital, and television transmissions between major military terminals and national command authorities. Secure voice and high-data-rate communications, operating in superhigh frequency, primarily for high-capacity fixed users. Five DSCS satellites remain to be launched. The Air Force has funded a program that will allow more tactical users access on DSCS. The Pentagon is developing the architecture to replace the capacity in the next decade.

Military Strategic and Tactical Relay (Milstar)
The first two Milstars of an intended constellation of four that would provide coverage between 65° north and 65° south latitude are in orbit. The first $1 billion Milstar was launched February 7, 1994, and the second November 5, 1995. Originally conceived as a communications system that could survive a nuclear conflict and connect national command authorities to commanders of ships, aircraft, and missiles during a war, the system's design and application have been altered in the aftermath of the Cold War. Milstar currently serves tactical forces as well as strategic, and the last four Milstars (Milstar IIs) will include medium-data-rate payloads able to transmit larger volumes of data. The upgraded satellites are to be launched between 1999 and 2002. All satellites have low-data-rate payloads providing communications at five bps to 2.4 kbps. The system can handle a data stream equal to 50,000 fax pages an hour and 1,000 simultaneous users. The satellites are designed to be jam-proof and use sophisticated techniques to provide secure communications.

Defense Support Program (DSP)
Infrared detectors aboard these satellites have provided early warning of ballistic missile attack to NORAD since the 1970s. During Operation Desert Storm, operators at Space Command used DSP data to provide warnings of Scud attacks to theater commanders, though DSP was not designed to spot and track smaller missiles. Information on procurement situation, number of satellites launched, and number to be launched is classified. DoD intends to replace the system with a new spacecraft designed to spot and track the smaller, faster-burning theater missiles that have proliferated in recent years.

Spacebased Infrared (SBIR) System
Advanced early warning satellites to replace the DSP. SBIR is the latest early warning system proposed by USAF. USAF plans to select a contractor this fall to design and build the satellites, which would be better able to detect small theater missiles than DSP satellites are. SBIR's four missions are missile warning, targeting defensive missiles, providing technical intelligence, and analyzing battle situations. Satellites in two types of orbits, geosynchronous (four) and high elliptical (two), would be used. The lower-orbit satellites are called the space and missile tracking system, and a decision on whether to deploy them is to be made in 2000. A two-satellite flight demonstration of SMTS, known earlier as Brilliant Eyes, is being funded. The first geosynchronous satellite would be launched in 2002. The system may use satellites in low-Earth orbit as well, with those being launched in about 2006.

Defense Meteorological Satellite Program (DMSP)
Military weather satellites operating in low-Earth orbit that collect and disseminate global weather information via groundbased systems for armed forces and government agencies. Operating in a two-satellite constellation, each spacecraft collects high-resolution cloud imagery (visible and infrared) from a 1,800-mile-wide area beneath it. Satellites collect other specialized data, such as atmospheric temperature and moisture, snow cover, precipitation intensity and area, and oceanographic and solar-geophysical information for DoD air, sea, land, and space operations.

Fleet Satellite Communications (FLTSATCOM)
Constellation of five satellites operated by USN, USAF, and the Presidential command network. A secure link among the three, providing ultrahigh-frequency (UHF) communications. Satellites carry twenty-three channels for communications with naval forces, nuclear forces, and national command authorities. The last two FLTSATCOM satellites (Flights 7 and 8) carry extremely high-frequency (EHF) payloads. In operation since 1978 in geostationary orbit, with a minimum of four satellites needed for worldwide coverage.

UHF Follow-On (UFO) Satellites
New generation of satellites providing UHF communications to replace FLTSATCOM satellites. UFO satellites have thirty-nine channels—compared to the twenty-three on the FLTSATCOM—are bigger, and have higher power. Compatible with the same terminals used by the earlier systems. UFO-4 was first in the series to include an extremely high-frequency communications payload with enhanced antijam telemetry, command, broadcast, and fleet interconnectivity. EHF channels provide an additional eleven channels. Ten UFO satellites were ordered; six have been launched; five are operational.

Leasecraft
Spacecraft that have been providing Navy UHF satellite communications since first launch in 1984 to augment FLTSATCOM. Three satellites, each with thirteen channels, are deployed in the same orbital locations as FLTSATCOM spacecraft. Leasecraft will be decommissioned at the end of 1996.

Dark and Spooky
An undisclosed number and type of intelligence satellites are operated by the intelligence agencies in cooperation with the military. The satellites, which monitor Earth with radar, optical sensors, and electronic intercept capability, have been treated as closely guarded secrets since the start of the space age. Even the names of satellites like LaCrosse (radar imaging), Keyhole (optical imaging), White Cloud (ocean reconnaissance), and Aquacade (electronic ferret) are secret and cannot be confirmed by the intelligence agencies. However, the move to declassify the space systems has begun, leading to the release of extensive information about one now-obsolete spy satellite called Corona. The intelligence community also will release selected archival images obtained by older spy satellites for scientific use. Some observers believe more military space secrets will be disclosed as the Cold War fades.

Major US Civilian Satellites in Military Use

Advanced Communications Technology Satellite (ACTS)
NASA's ACTS was launched in 1992 on the space shuttle to demonstrate Ka-band communications and on-board switching equipment. Military use of the technology demonstration satellite included communications service to US Army troops deployed in Haiti in 1994.

Geostationary Operational Environmental Satellite (GOES)
NOAA operates GOES-8 and GOES-9. GOES-7 provides backup. A European Meteosat 3 weather satellite augments the system. Satellites hover at 22,300 miles altitude over the equator, monitoring storms and tracking their movements for short-term forecasting. Satellites are a new design that has improved spatial resolution and full-time operational soundings of the atmosphere.

International Telecommunications Satellite Organization (INTELSAT)
Established in 1964 to own and operate a global constellation of communications satellites. Has 139 members and twenty-four operational satellites. The organization is considering how to restructure itself. One possibility would be to split the organization in the next two to three years into two entities, with commercial operations spun off into a separate entity from the treaty organization that provides connectivity on a global basis. US signatory to INTELSAT is Comsat Corp. The US military uses the system for routine communications and to distribute the Armed Forces Radio and TV Services network and to set up a Very Small Aperture Terminal data network for field commanders in Bosnia-Hercegovina in 1996.

International Maritime Satellite (INMARSAT)
Established in 1979 to own and operate satellites for mobile communications. Has seventy-nine member-countries and has spun off a private affiliate—ICO Global Communications—to develop a satellite system for global mobile telephone services. INMARSAT operates five satellites, including the first of the third-generation INMARSAT 3 series, which was launched in April. Another three satellites serve as orbital spares. The spacecraft are sometimes used by military forces for peacetime mobile communications services. INMARSAT is prohibited by convention from being used for military purposes. Briefcase- and laptop-sized satellite telephone terminals are used to communicate through the satellites. INMARSAT use in Somalia and Bosnia included the transmission of medical data and supply orders.

Landsat
US government's civilian remote sensing satellite system. Used in polar orbit since 1972. Carries a multispectral scanner able to operate at a resolution of thirty meters and provide imagery that can be computer enhanced to show deforestation, expanding deserts, crop blight, and other phenomena. Eosat Co. operates the aging Landsat 5. The government plans to launch a Landsat 7 satellite in 1998. Military use of Landsat imagery has included mapping and planning for tactical operations.

NOAA-12 and NOAA-14
Two polar orbit satellites for long-term forecasting of weather, operated by NOAA. The satellites fly in a 450-nautical-mile orbit, carrying visible and infrared radiometry imaging sensors and ultraviolet sensors to map ozone levels in the atmosphere. Provide weather updates for all areas of the world every six hours to civil and military users.

Orbcomm
Private firm Orbital Communication Corp. operates two satellites, launched in April 1995, in low-Earth orbit for global data messaging and position locating services. The satellites are precursors to a twenty-four-satellite constellation that will be orbited in 1997, allowing full, global, real-time operations to begin. DoD used the two Orbcomms in fall 1995 for a demonstration of military use of the commercial system, and another demonstration is planned for fall 1996. DoD also is buying a small quantity of test terminals, so the services can experiment with military applications of the Orbcomm service.

Orion Satellite (GBS)
Leased capacity on the Orion-1 commercial communications satellite, owned by Orion Network Systems, was used this spring to provide an early version of the Global Broadcast System for troops deployed to Bosnia. The Pentagon plans to build a more elaborate Global Broadcast System to disseminate a wide variety of information to military forces around the world, using a payload aboard military satellites and then possibly a dedicated system. The military GBS would be modeled after and use technology developed by the commercial direct-to-home satellite television industry.

***Satellite Pour l'Observation de la Terre* (SPOT)**
Remote sensing satellite system developed by the French space agency, CNES. Owned and operated by a commercial firm, SPOT Image S. A. of Toulouse. Two satellites produce images with resolution as fine as ten meters and can be used for stereoscopic viewing for three-dimensional terrain modeling. A third satellite in space serves as a backup, and SPOT 4 is scheduled for launch in late 1997. DoD is a large customer, purchasing the images for mission-planning systems, terrain analysis, mapping, and humanitarian missions.

Tracking and Data Relay Satellite System (TDRSS)
NASA operates seven TDRSS satellites to form a global network that allows low-Earth orbiting spacecraft, such as the space shuttle, to communicate with a control center without an elaborate network of ground stations. The geostationary TDRSS, with its ground station at White Sands, N. M., allows mission control in Houston, Tex., to maintain nearly constant contact with the shuttle. Other satellites using TDRSS include the Hubble Space Telescope, Compton Gamma Ray Observatory, Earth Radiation Budget Satellite, and military satellites. TDRSS satellites have been used since 1983. A next-generation system is being built for use with the shuttle, the space station, and satellites. NASA has contracted for a next-generation design. It will be smaller and cheaper.

Military Functions in Space

Communications
Provide communications from national command authorities to Joint Force Commander. Provide communications from JFC to squadron-level commanders. Permit transfer of imagery and situational awareness to tactical operations. Permit rapid transmission of JFC intent, ground force observations, and adaptive planning.

Environmental/Remote Sensing
Use space systems to create topographical, hydrographic, and geological maps and charts and develop systems of topographic measurement.

Meteorological Support
Operate weather satellites to provide data on worldwide and local weather systems affecting combat operations.

Missile Defense
Employ space assets to identify, acquire, track, and destroy ballistic and cruise missiles launched against forward-deployed US forces, allied forces, or US territory.

Navigation
Operate Global Positioning System network and certain smaller Navy systems. Enable commanders to determine precise locations of friendly and enemy forces and targets. Permit accurate, timely rendezvous of combat forces. Map minefields and other obstacles.

On-Orbit Support
Track and control satellites, operate their payloads, and disseminate data from them.

Reconnaissance and Surveillance
Identify possible global threats and surveillance of specific activity that might be threatening to US or allied military forces or US territory. Reduce effectiveness of camouflage and decoys. Identify "centers of gravity" in enemy forces. Accurately characterize electronic emissions.

Space Control
Control and exploit space using offensive and defensive measures to ensure that friendly forces can use space capabilities, while denying their use to the enemy. This mission is assigned to USCINCSPACE in the Unified Command Plan.

Spacelift
Prepare satellite and booster, joining the two. Conduct checkout prior to launch, carry out launch, and conduct on-orbit checkout.

Strategic Early Warning
Operate satellites to give national leaders early warning of all possible strategic events, including launch of intercontinental ballistic missiles. Identify launch locations and impact points. Cue area and point defense systems.

Tactical Warning/Attack Assessment
Discharge the North American Aerospace Defense Command mission calling for use of all sensors to detect and characterize an attack on US territory. US Space Command carries out similar tactical warning in other theaters.

Major US Agencies in Space

Central Imagery Office (CIO)

Headquarters: Vienna, Va. (Relocates to Chantilly, Va., as of September 1996, along with the National Reconnaissance Office.)
Established: May 6, 1992
Director: Dr. Annette J. Krygiel

Mission, Purpose, Operations
Ensure responsive imagery support to the national intelligence community, DoD, National Security Council, and other US government departments and agencies; also, as a DoD combat support agency, ensure timely imagery support to military operations. Does not own imagery products but has management and oversight responsibility for imagery. Intelligence imagery continues to be archived at the CIA's National Photographic Interpretation Center. CIO is due to be incorporated into a new National Imagery and Mapping Agency, along with the Defense Mapping Agency and parts of the intelligence-collection sections of the CIA and the NRO, on a yet-to-be-determined timetable.

Structure
Policy Directorate
Operations and Tasking Directorate
Systems Technology and Standards Directorate
Support Directorate
Programs and Resource Directorate
Requirements and Analysis Directorate
Accelerated Architecture Acquisition Initiative Program Office
Personnel: Classified

Central Intelligence Agency (CIA) Office of Development and Engineering

Headquarters: Washington, D. C.
Established: 1973
Director: Dennis Fitzgerald

Mission, Purpose, Operations
Develop systems from requirements definition through design, testing, and evaluation to operations. Works with systems not available commercially. Disciplines include laser communications, digital imagery processing, real-time data collection and processing, electro-optics, advanced signal collection, artificial intelligence, advanced antenna design, mass data storage and retrieval, and large systems modeling and simulations. Work includes new concepts and systems upgrades.

Structure: Classified
Personnel: Classified

National Aeronautics and Space Administration (NASA)

Headquarters: Washington, D. C.
Established: 1958
Administrator: Daniel S. Goldin

Mission, Purpose, Operations
Explore and develop space for human enterprise, increase knowledge about Earth and space, and conduct research in space and aeronautics. Operate the space shuttle and lead an international program to build a permanently occupied space station, which will be launched starting in 1997. Launch satellites for space science, Earth observations, and a broad range of technology research and development. Conduct aeronautical research and development.

Structure
Ten centers around the US, including Johnson Space Center, Houston, Tex.; Marshall Space Flight Center, Huntsville, Ala.; Kennedy Space Center, Fla.; Lewis Research Center, Cleveland, Ohio; Langley Research Center, Hampton, Va.; Ames Research Center, Mountain View, Calif.; Dryden Flight Research Center, Edwards AFB, Calif.; Stennis Space Center, Bay Saint Louis, Miss.; Jet Propulsion Laboratory, Pasadena, Calif.; and Goddard Space Flight Center, Greenbelt, Md.

Personnel
Civilians 21,555
Contractors 177,000

National Oceanic and Atmospheric Administration (NOAA)

Headquarters: Washington, D. C.
Established: October 3, 1970
Director: Dr. D. James Baker

Mission, Purpose, Operations
Provide satellite observations of the global environment by operating a national system of satellites. Explore, map, and chart the global ocean and its resources and describe, monitor, and predict conditions in the atmosphere, ocean, and space environment. Its National Environmental Satellite, Data, and Information Service processes vast quantities of satellite images and data. Its prime customer is NOAA's National Weather Service, which uses satellite information to create forecasts.

Structure
Headquarters
National Environmental Satellite, Data, and Information Service
National Weather Service
National Ocean Service
National Marine Fisheries Service
Office of Oceanic and Atmospheric Research
NOAA Corps
Office of Sustainable Development and Intergovernmental Affairs
Coastal Ocean Program

Personnel
National Environmental Satellite, Data, and Information Service 803
Other NOAA employees 12,181
Total 12,984

National Reconnaissance Office (NRO)
Headquarters: Chantilly, Va.
Established: September 1961
Director: Keith Hall (acting)

Mission, Purpose, Operations
Provide satellite reconnaissance to the US government to ensure that the US has the technology and assets to acquire worldwide intelligence. NRO satellites collect intelligence to support monitoring of arms-control agreements, military operations and exercises, events of national interest, natural disasters, and environmental issues. Purchases and operates intelligence satellites.

Structure
NRO is a DoD agency, funded through part of the National Foreign Intelligence Program, known as the National Reconnaissance Program. Both the Secretary of Defense and director of Central Intelligence have approval of the program. Six offices and three directorates reporting up to the level of the director. Offices are management services and operations, technology, plans and analysis, systems applications, space launch, and operational support. Directorates are space systems acquisition and operations, communications systems acquisition and operations, and imagery systems acquisition and operations.

Personnel
Staffed by CIA and military and civilian DoD employees.

National Security Agency (NSA)
Headquarters: Fort Meade, Md.
Established: 1952
Director: Lt. Gen. Kenneth A. Minihan, USAF
Deputy Director: William P. Crowell

Mission, Purpose, Operations
Protect US communications and produce foreign intelligence information. Supply leadership, products, and services to protect classified and unclassified information from interception, unauthorized access, and technical intelligence threats. In the foreign signals intelligence area, the central point for collecting and processing activities conducted by the US government, with authority to produce signals intelligence in accord with objectives, requirements, and priorities established by the CIA director with the advice of the National Foreign Intelligence Board.

Structure
Established by a Presidential directive in 1952 as a separate agency within DoD under the direction, authority, and control of the Secretary of Defense, who serves as the executive agent of the US government for the production of communications intelligence information. The Central Security Service was established in 1972 by a Presidential memorandum to provide a more unified cryptological organization within the Defense Department. The NSA director also serves as chief of the CSS and controls the signals intelligence activities of the military services.

Personnel: Classified

Other Agencies
The White House Office of Science and Technology Policy; Defense Advanced Research Projects Agency; Ballistic Missile Defense Organization; US Space Command and the component commands of the Air Force, Navy, and Army; North American Aerospace Defense Command; and the US Transportation Department's Office of Commercial Space Transportation.

Air Force Space Command Headquarters, Peterson AFB, Colo.

(As of July 1, 1996)

Commander
Gen. Joseph W. Ashy

- **Space Warfare Center** • Falcon AFB, Colo.
  Commander **Brig. Gen. Glen W. Moorhead III**

14th Air Force • Hq., Vandenberg AFB, Calif.
Commander **Maj. Gen. David L. Vesely**

- **21st Space Wing,** Peterson AFB, Colo.
- **30th Space Wing,** Vandenberg AFB, Calif.
- **45th Space Wing,** Patrick AFB, Fla.
- **50th Space Wing,** Falcon AFB, Colo.

20th Air Force • Hq., F. E. Warren AFB, Wyo.
Commander **Maj. Gen. Donald G. Cook**

- **90th Missile Wing,** F. E. Warren AFB, Wyo.
- **91st Missile Wing,** Minot AFB, N. D.
- **321st Missile Group,** Grand Forks AFB, N. D.
- **341st Missile Wing,** Malmstrom AFB, Mont.

Air Force Space Acquisition Organizations

Air Force Materiel Command • Wright-Patterson AFB, Ohio
Commander **Gen. Henry Viccellio, Jr.**

Space and Missile Systems Center • Los Angeles AFB, Calif.
Commander **Lt. Gen. Lester L. Lyles**

- **Defense Meteorological Satellite SPO**[1]
- **Launch Programs SPO**
- **Space Test and Experimentation Programs**
- **Satellite and Launch Control SPO**
- **Navstar Global Positioning System JPO**[2]
- **Phillips Laboratory,** Kirtland AFB, N. M.
- **Defense Dissemination Program**

Air Force Acquisition Executive • Washington, D. C.
Director **Arthur L. Money**

Program Executive Officer for Space Programs
Brent R. Collins

- **MILSATCOM System JPO**
- **Titan SPO**
- **Spacebased Early Warning SPO**
- **Evolved Expendable Launch Vehicle SPO**

[1]System(s) Program Office
[2]Joint Program Office

Russian Space Activity, 1995

	Launches	Payloads
Communications	4	4
Military reconnaissance	3	3
Unmanned space station resupply	5	5
Space station module	1	1
Navigation	7	13
Military ocean surveillance	2	2
Remote sensing	2	2
Early warning	1	1
Electronic intelligence	2	2
Manned flight	2	2
Geodetic	0	0
Meteorology	0	0
Science	2	2
Commercial	1	4
Total	**32**	**41**

Russian Operational Spacecraft, 1995

Mission	Type	Number
Communications	Kosmos (Strela-3)	30
	Raduga/Raduga-1	12
	Gorizont	13
	Molniya-1	8
	Molniya-3	8
	Kosmos (Geizer)	3
	Kosmos (Strela-2)	2
	Kosmos (Luch)	2
	Luch-1	1
	Ekran-M	2
	Ekspress	1
	Gals	2
	Radio Rosto	1
Navigation	Kosmos GLONASS	24
	Kosmos (military)	6
	Kosmos (civil)	4
Meteorology	Meteor-2	2
	Meteor-3	2
	Elektro (GOMS)	1
Early warning	Kosmos (Oko)	9
	Kosmos (Prognoz)	3
Electronic intelligence	Kosmos (Tselina-2)	4
	Kosmos (EORSAT)	3
	Kosmos (Tselina-D)	1
Photoreconnaissance	Kosmos (5th generation)	1
Remote sensing	Okean-O	2
	Resurs-O1	1
	Sich	1
Geodesy	Kosmos (Etalon)	2
	Kosmos (GEO-IK)	1
Radar calibration	Kosmos	1
Space station activity	Mir	1
	Kvant-1	1
	Kvant-2	1
	Kristall	1
	Spektr	1
	Shuttle Docking Module	1
	Soyuz TM	1
	Progress M	1
Scientific activity	Kosmos	1
	Coronas-I	1
	Granat	1
	Interball 1	1
	MAGION 4 (Czech satellite)	1

Older spacecraft sometimes are placed in orbital standby mode.

Russian Launch Site Activity, 1995

Spacecraft	Number of launches
Baikonur Cosmodrome, Tyuratam, Kazakhstan	
Proton	7
Soyuz	8
Zenit-2	1
Tsyklon-2	2
Molniya	1
Total	**19**
Plesetsk Cosmodrome, Plesetsk, Russia	
Tsyklon-3	1
Kosmos	5
Soyuz	4
Molniya	3
Total	**13**

US Space Funding

(Millions of current dollars)

FY	NASA	DoD	Other	Total
1959	$ 261	$ 490	$ 34	$ 785
1960	462	561	43	1,066
1961	926	814	69	1,809
1962	1,797	1,298	200	3,295
1963	3,626	1,550	259	5,435
1964	5,016	1,599	216	6,831
1965	5,138	1,574	244	6,956
1966	5,065	1,689	217	6,971
1967	4,830	1,664	216	6,710
1968	4,430	1,922	177	6,529
1969	3,822	2,013	141	5,976
1970	3,547	1,678	115	5,340
1971	3,101	1,512	127	4,740
1972	3,071	1,407	97	4,575
1973	3,093	1,623	109	4,825
1974	2,759	1,766	116	4,641
1975	2,915	1,892	107	4,914
1976	4,074	2,443	142	6,659
1977	3,440	2,412	131	5,983
1978	3,623	2,738	157	6,518
1979	4,030	3,036	178	7,244
1980	4,680	3,848	160	8,688
1981	4,992	4,828	158	9,978
1982	5,528	6,679	234	12,441
1983	6,328	9,019	242	15,589
1984	6,648	10,195	293	17,136
1985	6,925	12,768	474	20,167
1986	7,165	14,126	368	21,659
1987	9,809	16,287	352	26,448
1988	8,302	17,679	626	26,607
1989	10,098	17,906	444	28,448
1990	12,142	15,616	387	28,145
1991	13,036	14,181	566	27,783
1992	13,199	15,023	624	28,846
1993	13,077	14,106	559	27,742
1994	13,022	13,166	465	26,653
1995	12,543	10,644	489	23,676
Total	**216,520**	**231,752**	**9,536**	**457,808**

Figures are expressed in current dollars and are rounded. NASA totals represent space activities only. "Other" category includes the Departments of Energy, Commerce, Agriculture, Interior, and Transportation; the National Science Foundation; the Environmental Protection Agency; and other agencies.

Worldwide Launches by Site, 1957–95

Launch Site	Nation	Launches
Plesetsk	Russia	1,426
White Sands Missile Range, N. M.	US	1,070
Tyuratam/Baikonur	Russia	987
Vandenberg AFB, Calif.	US	508
Cape Canaveral AS, Fla.	US	492
Poker Flat Research Range, Alaska	US	270
JFK Space Center, Fla.	US	92
Kapustin Yar	Russia	83
Kourou	French Guiana	80
Tanegashima	Japan	27
Shuang Cheng-tzu/Jiuquan	China	22
Uchinoura	Japan	21
Wallops Flight Facility, Va.	US	21
Xichang	China	17
Indian Ocean Platform	Kenya	9
Sriharikota	India	6
Edwards AFB, Calif.	US	5
Hammaguir	Algeria	4
Woomera	Australia	2
Taiyun	China	2
Yavne	Israel	3
Total		**5,147**

Military vs. Civilian Launches

	Military		Civilian	
Year	US	Russia	US	Russia
1957	0	0	0	2
1958	0	0	7	1
1959	6	0	5	3
1960	10	0	6	3
1961	19	0	10	6
1962	31	5	21	15
1963	26	7	12	10
1964	32	15	25	15
1965	28	25	35	23
1966	32	27	41	17
1967	24	46	34	20
1968	20	49	25	25
1969	16	51	24	19
1970	15	55	14	26
1971	10	60	22	23
1972	11	53	20	21
1973	8	58	15	28
1974	6	52	18	29
1975	7	60	21	29
1976	7	74	19	25
1977	9	69	15	29
1978	8	60	24	28
1979	4	60	12	27
1980	5	64	8	25
1981	5	59	13	39
1982	6	68	12	33
1983	7	58	15	40
1984	12	63	10	34
1985	6	64	11	34
1986	3	63	3	28
1987	6	62	2	33
1988	6	53	6	37
1989	13	42	5	32
1990	13	45	14	30
1991	9	30	9	29
1992	12	32	16	22
1993	13	26	10	21
1994	12	26	14	22
1995	9	15	18	17
Total	**466**	**1,596**	**591**	**900**

Manned Spaceflights

	US		Russia	
Year	Flights	Persons	Flights	Persons
1961	2	2	2	2
1962	3	3	2	2
1963	1	1	2	2
1964	0	0	1	3
1965	5	10	1	2
1966	5	10	0	0
1967	0	0	1	1
1968	2	6	1	1
1969	4	12	5	11
1970	1	3	1	2
1971	2	6	2	6
1972	2	6	0	0
1973	3	9	2	4
1974	0	0	3	6
1975	1	3	4	8
1976	0	0	3	6
1977	0	0	3	6
1978	0	0	5	10
1979	0	0	2	4
1980	0	0	6	13
1981	2	4	3	6
1982	3	8	3	8
1983	4	20	2	5
1984	5	28	3	9
1985	9	58	2	5
1986	1	7	1	2
1987	0	0	3	8
1988	2	10	3	9
1989	5	25	1	2
1990	6	32	3	7
1991	6	35	2	6
1992	8	53	2	6
1993	7	42	2	5
1994	7	42	3	8
1995	7	42	2	6
Total	**103**	**477**	**81**	**181**

Payloads by Mission, 1957–95

Category	US	Russia
Platforms	**0**	**471**
Earth orbital science	**218**	**207**
Automated lunar, planetary	**55**	**85**
Moon	25	34
Mercury	1	0
Venus	8	33
Mars	9	18
Outer planets	4	0
Interplanetary space	8	0
Applications	**412**	**487**
Communications	285	273
Weather	99	74
Geodesy	20	34
Earth resources	7	96
Materials processing	1	10
Piloted activities	**142**	**230**
Earth orbital	92	86
Earth orbital (related)	13	136
Lunar	20	0
Lunar (related)	17	8
Launch vehicle tests	**11**	**22**
General engineering tests	**51**	**4**
Reconnaissance	**424**	**1,078**
Photographic	247	795
Electronic intelligence	92	129
Ocean electronic intelligence	38	81
Early warning	47	73
Minor military operations	**44**	**161**
Navigation	**79**	**208**
Theater communication	**0**	**535**
Weapons-related activities	**2**	**56**
Fractional orbital bombardment	0	18
Antisatellite targets	2	18
Antisatellite interceptors	0	20
Other military	**16**	**1**
Other civilian	**2**	**1**
Total	**1,456**	**3,546**

Spacefarers

(As of end of 1995)

Nation	Persons
Afghanistan	1
Austria	1
Belgium	1
Bulgaria	2
Canada	4
Cuba	1
Czechoslovakia	1
France	5
Germany	8
Hungary	1
India	1
Italy	1
Japan	3
Mexico	1
Mongolia	1
Netherlands	1
Poland	1
Romania	1
Russia	83
Saudi Arabia	1
Switzerland	1
Syria	1
United Kingdom	1
United States	216
Vietnam	1
Total	**339**

Payloads in Orbit

(As of end of 1995)

Launcher/operator	Objects
Argentina	1
Australia	6
Brazil	6
Canada	17
China	15
Czechoslovakia	2
ESA	29
France	29
France/Germany	2
Germany	14
India	13
Indonesia	6
Israel	1
Italy	5
ITSO[1]	48
Japan	55
Luxembourg	5
Mexico	4
NATO	8
North Korea	2
Norway	1
Portugal	1
Russia	1,335
Saudi Arabia	3
South Korea	1
Spain	4
Sweden	4
Thailand	2
Turkey	1
United Kingdom	22
United States	680
Total	**2,322**

[1]International Telecommunications Satellite Organization

Other Spacefaring Nations

For eight years after Sputnik went into orbit in October 1957, the two superpowers alone were able to launch spacecraft. France broke the monopoly in 1965, establishing an independent capability. China, India, Japan, and Israel also have hurled satellites into space using indigenously built rockets. European capabilities are embodied in the European Space Agency (ESA), a group of thirteen nations.

China launched its first satellite in 1970 and has at least thirty-nine satellites on orbit. China also launches science and military reconnaissance satellites and has made commercial launches for other nations. Its primary launch site is near Jiuquan, in northern China; a newer site is near Xichang, in southeastern China, and a third is at Taiyun. The launch program relies on the Long March series of rockets, one version of which has a cryogenic upper stage. Chinese astronauts were in training in the 1970s, but the country has indefinitely deferred manned spaceflight.

ESA was formed in 1975 for civilian activities only. It has thirteen members: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the UK. A major activity is development of the Ariane rocket. France led development of the booster, which is launched from Kourou, French Guiana. Arianespace, a private company, markets Ariane and manages launches. France, Italy, and Germany all have strong programs.

India launched its first satellite, Rohini 1, into orbit in July 1980. The Indian Space Research Organization operates an offshore Sriharikota Island launch site in the Bay of Bengal. India's booster program includes the Satellite Launch Vehicle, Augmented Satellite Launch Vehicle, and Polar Satellite Launch Vehicle. The latter is capable of placing spacecraft into polar orbit. India is particularly interested in remote sensing for resource, weather, and reconnaissance purposes. An Indian cosmonaut flew on a Soviet Soyuz mission in 1984.

Israel launched its first test satellite, Ofeq 1, into orbit September 1988. Believed to have been launched from Yavne in the Negev Desert, satellites in the Ofeq series are thought to be dedicated to military purposes. Ofeq is seen as a step toward creation of a military satellite reconnaissance system. The prime booster is Shavit, possibly based on the Jericho 2 missile.

Japan put its first satellite into orbit in 1970 and has made at least forty-eight successful satellite launches. Communications, remote sensing, weather, and scientific satellites are on orbit. Japan's satellite program is run by the National Space Development Agency and the Institute of Space and Astronautical Science. Main launch sites are Kagoshima, on Kyushu, southwest of Tokyo, and Tanegashima, an island south of Kyushu. The Mu series of launch vehicles is used to orbit scientific satellites and toss spacecraft into deep space. N-1 and N-2 rockets were based on the US Delta. The H-1 has begun to replace the N-1 and N-2 boosters. The H-2 booster was first launched in 1994.

Launches

Year	France	China	Japan	Europe	India	Israel
1965	1					
1966	1					
1967	2					
1968						
1969						
1970	2	1	1			
1971	1	1	2			
1972			1			
1973						
1974			1			
1975	3	3	2			
1976		2	1			
1977			2			
1978		1	3			
1979			2	1		
1980			2		1	
1981		1	3	2	1	
1982		1	1			
1983		1	3	2	1	
1984		3	3	4		
1985		1	2	3		
1986		2	2	2		
1987		2	3	2		
1988		4	2	7		1
1989			2	7		
1990		5	3	5		1
1991		1	2	8		
1992		4	1	7	1	
1993		1	1	7		
1994		5	2	6	2	
1995		2	1	11		1
Total	**10**	**41**	**48**	**74**	**6**	**3**

Space and Missile Badges

Space/Missile Badge

Senior Space/Missile Badge

Master Space/Missile Badge

Astronaut Pilot*

Senior Astronaut Pilot

Command Astronaut Pilot

Missile Badge

Senior Missile Badge

Master Missile Badge

Missile Badge with Operations Designator

Senior Missile Badge with Operations Designator

Master Missile Badge with Operations Designator

*The astronaut designator indicates a USAF rated officer qualified to perform duties in space (fifty miles and up) and who has completed at least one operational mission. Pilot wings are used here only to illustrate the position of the designator on the wings.

Space master plan
A strategic plan to guide military spending on space systems for the next ten to twenty years is being assembled by a group working for Robert V. Davis, under secretary of defense for Space. The master plan is to be presented to Paul G. Kaminski, under secretary of defense for Acquisition and Technology, in the fall for approval. The plan is meant to address such complaints as the high cost of military space systems, the lack of coordination, and outdated technology. The position of DUSD for Space was created in December 1994 to provide a single DoD point of contact to oversee space matters within the services and intelligence communities.

Space architecture
Maj. Gen. Robert S. Dickman, USAF, was named September 14, 1995, as the first DoD Space Architect. The new function was created to integrate DoD space architectures, with the aim of eliminating overlap among systems and ensuring that space and terrestrial weapon systems work together. General Dickman has embarked on a series of architecture studies this year, with plans to issue recommendations every three months. The first plan to be delivered to the Joint Space Management Board this summer was to have been a military satellite communications architecture study that recommends methods of replacing three aging satellite systems in the next decade.

Commercial remote sensing
Three private ventures were developing commercial high-resolution satellite programs, and additional companies had received or filed for Commerce Department licenses to pursue similar ventures. EarthWatch, Inc., was expected to be the first into the business, with its three-meter-resolution satellite due for launch on a Russian rocket this September. Within two years, EarthWatch and two other firms, Orbimage and Space Imaging Inc., were to launch even better satellites with resolution finer than one meter. Civilians and foreign military forces, along with a wide variety of new users—such as farmers, land-use planning firms, and transportation companies—will be able to purchase images. The defense and intelligence communities were working with commercial firms to establish policy and procedures that would allow US ventures to lead the international market for the images at the same time national security concerns are being addressed.

Advanced Technology Launchers: X-33, X-34, EELV
US efforts to improve launch technology were focused on two programs: the Air Force Evolved Expendable Launch Vehicle (EELV) program and NASA's reusable launch vehicle (RLV) program, which include the X-33 and X-34 flight-test projects. USAF is funding four contractor teams studying EELV designs, with a plan to narrow the competition to two teams by late this year. In 1998, a single winning design will be selected. USAF had budgeted $2 billion through 2004 for the effort, including funds for three test flights. EELV is aimed at evolving current launcher systems into a common core family of medium- and heavy-lift boosters with launch costs twenty-five to fifty percent lower than the cost of today's rockets. The first medium launch is scheduled for 2001, and the first heavy launch is scheduled for 2003.

Delta Clipper DC-XA
NASA and contractor McDonnell Douglas resumed atmospheric test flights of the DC-X Delta Clipper–Experimental rocket in May 1996 after a one-year hiatus. The rocket demonstrated technology that could be used to build an orbital single-stage-to-orbit launcher with greatly reduced costs. The program has been supported by the Ballistic Missile Defense Organization and Phillips Laboratory, Kirtland AFB, N. M. NASA took over DC-X responsibility in 1995 from the Air Force, although Phillips Lab continues to play a role in the flight tests.

Declassification of satellite imagery
By May, the National Reconnaissance Office had released about 300,000 of the 800,000 satellite photos declassified by executive order of the President in February 1995. The photos, taken in the 1960s and 1970s, are from the Keyhole series of reconnaissance satellites, numbered one through six. Nearly seven million of the pictures may eventually be declassified. The images were due to become publicly available this month and can be obtained through the US Geological Survey, the National Archives, and on several sites on the Internet and the World Wide Web.

White House Global Positioning System (GPS) policy
In March, the White House issued the first policy guidelines for GPS that established free access to signals for all users, including foreign governments. The White House intended to create a more stable framework for public- and private-sector decisions on GPS. The policy also commits the Pentagon to lifting restrictions on the quality of the signal to nonmilitary users in the next four to ten years. The policy was spurred by an explosion in jobs, commercial products, and revenues from civilian uses of the military technology.

In July, NASA selected Lockheed Martin to build the reusable launch vehicle X-33. The company's winning design, VentureStar (shown in this computerized visual), is expected to have a four- to seven-day turnaround time, with payloads of up to 40,000 pounds, and an on-time reliability rate of more than ninety percent.

Launcher Concepts

Sea Launch
Boeing Commercial Space Co. and three foreign partners teamed in 1995 to develop Sea Launch, a system that will use a rocket built in Ukraine and launched from a ship at sea to put payloads weighing 5,900 kilograms (13,000 pounds) into geosynchronous transfer orbit (GTO). The venture has contracted for ten commercial missions, and the first Sea Launch is scheduled to go into orbit during the summer of 1998. Boeing's partners in the venture are RSC Energia, a Russian firm that will supply the vehicle's third stage, a Block DM-SL, and integration and support equipment; NPO Yuzhnoye, a Ukrainian aerospace firm that will provide the Zenit rocket for use as the first two Sea Launch stages; and Kvaerner a. s., a Norwegian company with experience in North Sea offshore oil platform operations that will build the launch platform and command ship.

X-33
NASA is leading the effort to flight-test an experimental vehicle that could be the precursor to a single-stage-to-orbit launcher for the next century. A subsequent phase of the program would feature a reusable launch vehicle capable of reducing launch costs by a factor of ten. In July, NASA selected Lockheed Martin from three competing contractor teams studying X-33 designs. Lockheed Martin's VentureStar design is to proceed to a series of flight tests starting in 1998. The project's five-year budget for 1996–99 was tentatively set at $941 million, with some $5 billion to $18 billion in commercial financing needed to develop the operational version. USAF's role in the X-33 is limited to managing flight-test operations through an office at Phillips Laboratory, Kirtland AFB, N. M.

X-34
In June, Orbital Sciences Corp. won a second X-34 contract from NASA for $60 million to perform two flight tests of a more limited demonstration of a reusable small launcher. Two X-34 tests scheduled for summer 1998 will test such technology as propulsion and thermal reentry systems that would be required to build the X-33 reusable launch vehicle. The contract has no commercial objectives tied to it.

Delta III
A new intermediate-class launcher, the Delta III is being developed—without government financial support—by McDonnell Douglas Corp. for a first launch in the first half of 1998. Delta III will be able to boost 8,400 pounds to GTO—more than twice Delta II's maximum payload. The rocket will have a new cryogenic upper stage and a larger fairing. The initial customer for Delta III launches is Hughes Space and Communications International Inc. Hughes and McDonnell Douglas have signed a contract for ten launches, plus options for additional launches through 2005.

Med Lite
McDonnell Douglas has signed a contract with NASA for the Medium Light Expendable Launch Vehicle Services program to fill the gap between the small launch-vehicle market and the medium-class market. Med Lite's objective is to support NASA's scientific missions, including the Mars Surveyor and Discovery programs. Launch vehicles include two- and three-stage versions of the Delta II with three strap-on solid rocket motors and Orbital Sciences Corp.'s Taurus XL.

Satellite Concepts

Combined weather satellites
Civil and military weather low-Earth orbit (LEO) polar satellites are being merged into a single system. The number of satellites will be reduced from four to three, saving $300 million through 1999. DoD and NOAA were to coordinate the purchase of remaining satellites. NOAA, DoD, and NASA will maintain a tri-agency office for the National Polar-Orbiting Operational Environmental Satellite System (NPOESS), which is to take responsibility for the Defense Meteorological Satellite Program (DMSP) after the satellites in the pipeline are launched. Operational control at the primary site in Suitland, Md., was to begin in the second quarter of 1998, with the backup site at Falcon AFB, Colo., to be operational in the third quarter. The first NPOESS satellite is scheduled for launch in 2004.

Milstar Follow-On
The last four Milstar satellites will have a higher data-rate capability added to respond to a shift in emphasis since the end of the Cold War from mostly strategic use to a more tactical use. The medium-data-rate payload uses better technology and includes two Nulling Spot Beam Antennas that give the satellite an antijam capability. The launch dates for the satellites are December 1998, December 1999, November 2000, and October 2001.

Global Broadcast System (GBS)
GBS is projected to be a high-speed, one-way, broadcast communications system that provides high-volume information directly to worldwide, in-theater warfighters. GBS will provide data to large populations of dispersed users with small mobile receive terminals. These terminals will allow data to be disseminated directly to lower-echelon forces, providing current weather, intelligence, news, imagery, and other mission-essential information. GBS will be implemented in three phases. Phase 1 will consist of leased, commercial transponders. Phase 2 will consist of GBS packages aboard three UHF Follow-On satellites. Phase 3 will be an objective system consisting of military assets, a commercial leased system, or a combination of the two.

Spacebased Infrared (SBIR) system
This advanced early warning satellite design will encompass and eventually replace the Defense Satellite Program (DSP). The SBIR system is the latest in a string of early warning satellite proposals by USAF. This fall, the Air Force plans to select a contractor to design and build the satellites, which would be better able to detect small theater missiles than the DSP can. The SBIR system's four missions are missile warning, defensive-missile targeting, providing technical intelligence, and analyzing battle situations. Satellites in two types of orbits, geosynchronous (four) and elliptical (two), would be used. The lower-orbit satellite constellation is called the space and missile tracking system (see next entry), and a decision on whether to deploy it is to be made in 2000.

Space and missile tracking system
Formerly known as Brilliant Eyes, these satellites would track small missiles and provide targeting and intelligence data for the SBIR system that will replace the DSP early warning satellites in the next decade. The demonstration satellites are to be launched in late 1998. The schedule calls for first launch of the operational satellites in 2002, with operational deployment in 2006. Between eighteen and thirty-two satellites could be deployed in the constellation. The system may use satellites in LEO as well, with those first being launched in about 2006.

Small satellites
USAF's Phillips Lab is a leader in the development of advanced technology for small satellites. Programs in this area include the Space Test Experiments Platform series of satellites; Clementine 2; a new, inexpensive series of spacecraft known as Mightysat; and a program dubbed Integrated Space Technology Demonstration, which will fly a hyperspectral imager known as Warfighter 1 on its first mission. The lab also was involved in NASA's Lewis and Clark and New Millennium small-satellite projects. The National Reconnaissance Office has come under pressure this year by Congress and other policymakers to add a small-satellite component to its existing large classified satellites.

US Space Command

	Personnel	Budget, Fiscal 1997	Activities
US Space Command Peterson AFB, Colo.	864	$17,600,000	Conducts joint space operations in accordance with the Unified Command Plan assigned missions of Space Forces Support, Space Force Enhancement, Space Force Application, and Space Force Control; plans and executes ballistic missile defense of North America operations; advocates the space and missile warning requirements of the commanders in chief.
Component			
Air Force Space Command Peterson AFB, Colo.	38,318	$1,708,000,000	Operates military space systems, groundbased missile-warning radars and sensors, missile-warning satellites, national launch centers, and ranges; tracks space debris; operates and maintains the USAF ICBM force (as a component of US Strategic Command). Budget includes funding for 11,100 contractor personnel and operations and maintenance for six bases and fifty worldwide sites.
Naval Space Command Dahlgren, Va.	442	$54,000,000	Operates assigned space systems for surveillance and warning; provides spacecraft telemetry and on-orbit engineering support.
Army Space Command Colorado Springs, Colo.	651	$52,000,000	Provides input for DoD space plans; manages joint tactical uses of DSCS; conducts planning for national and theater missile defense; operates the Army Theater Missile Defense Element force projection Tactical Operations Center; exploits leading-edge space technologies in support of warfighter needs; manages the Army Astronaut Program and Joint Tactical Ground Station.

Selected NASA Projects Fiscal Year 1997 Proposal, Current Dollars

■ **AXAF, $178.6 million.** Space science. The Advanced X-Ray Astrophysics Facility spacecraft to study the composition and nature of galaxies, stellar objects, and interstellar phenomena. Scheduled for launch aboard the space shuttle in September 1998.

■ **Cassini, $106.7 million.** Space science. Spacecraft mission to Saturn. Seeks data on formation of solar system, possible presence of chemical basis for evolution of life. Scheduled for launch in October 1997.

■ **Discovery, $74.8 million.** Space science. Spacecraft missions Mars Pathfinder and Near-Earth Asteroid Rendezvous (NEAR). Mars Pathfinder launch scheduled for December 1996. NEAR successfully launched in February 1996, now en route for a year-long rendezvous with asteroid 433 Eros in February 1999. Lunar Prospector is scheduled for launch in October 1997 and will search for resources on the moon, especially for water in the shaded polar regions. The Stardust mission, scheduled for launch in February 1999, is designed to gather dust samples from the comet Wild-2 and return the samples to Earth for analysis. Discovery is intended as NASA's low-cost planetary exploration program.

■ **Earth Observing System, $585.7 million.** Mission to Planet Earth environmental project. Series of satellites to document global climatic change and observe environmental processes. Scheduled launches start in June 1998.

■ **Explorer, $135 million.** Space science. Four missions and spacecraft development. Study of X-ray sources, solar corona, and organic compounds in interstellar clouds. Scheduled launches in 1997 and 1999.

■ **Galileo, $66.4 million.** Space science, planetary exploration. Funds to support operations of mission to explore Jupiter and its moons.

■ **Mars Surveyor, $90 million.** Space science. First launch of the Mars Global Surveyor orbiter is scheduled for November 1996, followed by a December 1996 launch of the Mars Pathfinder mission. Development of spacecraft for new Mars exploration strategy. Orbiter, small payload, communications orbiters, landers. Another orbiter launch is planned for December 1998, and a lander launch is scheduled for January 1999.

■ **New Millennium Spacecraft, $21.5 million.** Space science. Flight-technology demonstration to produce new microspacecraft with reduced weight and life-cycle costs. Technology demonstration flight test expected in 1998.

■ **Relativity (Gravity Probe-B), $59.6 million.** Space science. Major test of Einstein's general theory of relativity. Development of a gravity probe. Launch is scheduled for October 2000.

■ **Space shuttle, $3.2 billion.** Spaceflight. Program emphasizes continuing improvement of safety margins, fulfillment of the flight manifest, reduction of costs, and launch of eight flights for Fiscal 1997.

■ **Space station, $1.8 billion.** Spaceflight. International manned space facility. Capacity for six persons. Current plans call for first US crew to arrive on the station in May 1998, following a November 1997 launch. Systems design review was completed in 1994. Efficiencies gained through design changes and participation of the Russians in an international partnership.

■ **US/Russian Cooperative Program, $138.2 million.** Spaceflight. Program provides for contract with Russian Space Agency for services and hardware and joint activities with Russia on the Mir space station. The fifth, sixth, and seventh joint shuttle-Mir missions are scheduled for Fiscal 1997.

■ **Other space operations, $592.4 million.** Space science. Operation of Hubble Space Telescope, the AXAF program, the Global Geospace Science program, the Compton Gamma Ray Observatory, and the Collaborative Solar-Terrestrial Physics program.

Space Leaders

(As of July 1, 1996)

Directors, National Reconnaissance Office

Joseph V. Charyk	Sept. 6, 1961–Mar. 1, 1963
Brockway McMillan	Mar. 1, 1963–Oct. 1, 1965
Alexander H. Flax	Oct. 1, 1965–Mar. 11, 1969
John L. McLucas	Mar. 17, 1969–Dec. 20, 1973
James W. Plummer	Dec. 21, 1973–June 28, 1976
Thomas C. Reed	Aug. 9, 1976–Apr. 7, 1977
Hans Mark	Aug. 3, 1977–Oct. 8, 1979
Robert J. Hermann	Oct. 8, 1979–Aug. 2, 1981
Edward C. Aldridge, Jr.	Aug. 3, 1981–Dec. 16, 1988
Martin C. Faga	Sept. 26, 1989–Mar. 5, 1993
Jeffrey K. Harris	May 19, 1994–Feb. 26, 1996
Keith R. Hall (acting)	Feb. 27, 1996

Commanders, Air Force Space Command

Gen. James V. Hartinger	Sept. 1, 1982–July 30, 1984
Gen. Robert T. Herres	July 30, 1984–Oct. 1, 1986
Maj. Gen. Maurice C. Padden	Oct. 1, 1986–Oct. 29, 1987
Lt. Gen. Donald J. Kutyna	Oct. 29, 1987–Mar. 29, 1990
Lt. Gen. Thomas S. Moorman, Jr.	Mar. 29, 1990–Mar. 23, 1992
Gen. Donald J. Kutyna	Mar. 23, 1992–July 1, 1992
Gen. Charles A. Horner	July 1, 1992–Sept. 13, 1994
Gen. Joseph W. Ashy	Sept. 13, 1994

NASA Spending on Major Space Missions

Fiscal Year 1997 Proposal, Current Dollars

Project Office	Request
Spaceflight	$5,362,900,000
Space sciences	1,857,300,000
Mission to Planet Earth	1,402,100,000
Aeronautics	857,800,000
Space communications	712,000,000
Advanced concepts and technology	725,000,000
Life and microgravity sciences	498,500,000
Safety and mission assurance	36,700,000
Total	**$11,452,300,000**

Upcoming Shuttle Flights

Fiscal Year 1997 Proposal

Month/Year, Mission	Name
October 1996, STS-80	*Columbia*
December 1996, STS-81	*Atlantis*
February 1997, STS-82	*Discovery*
March 1997, STS-83	*Columbia*
May 1997, STS-84	*Atlantis*
July 1997, STS-85	*Discovery*
September 1997, STS-86	*Atlantis*

The Golden Age of NASA

Name	**Project Mercury**
Duration	**November 3, 1958–May 16, 1963**
Cost	$392.1 million (cost figures are in current dollars)
Distinction	First US manned spaceflight program
Highlight	Astronauts are launched into space and returned safely to Earth
Number of flights	Six
Key events	**May 5, 1961** Lt. Cmdr. Alan B. Shepard, Jr., makes first US manned flight, a suborbital trip of fifteen minutes. **February 20, 1962** Lt. Col. John H. Glenn, Jr., becomes first American to orbit Earth. **May 15, 1963** Maj. L. Gordon Cooper, Jr., begins flight of twenty-two orbits in thirty-four hours.

Name	**Project Gemini**
Duration	**January 15, 1962–November 15, 1966**
Cost	$1.3 billion
Distinction	First program to explore docking, long-duration flight, rendezvous, spacewalks, and guided reentry
Highlight	Dockings and rendezvous techniques practiced in preparation for Project Apollo
Number of flights	Ten
Key events	**June 3–7, 1965** Flight in which Maj. Edward H. White II makes first spacewalk. **August 21–29, 1965** Cooper and Lt. Cmdr. Charles "Pete" Conrad, Jr., withstand weightlessness. **March 16, 1966** Neil A. Armstrong and Maj. David R. Scott execute the first space docking. **September 15, 1966** Conrad and Richard F. Gordon, Jr., make first successful automatic, computer-steered reentry.

Name	**Project Apollo**
Duration	**July 25, 1960–December 19, 1972**
Cost	$24 billion
Distinction	Space program that put humans on the moon
Highlights	Neil Armstrong steps onto lunar surface. Twelve astronauts spend 160 hours on the moon.
Number of flights	Eleven
Key events	**May 28, 1964** First Apollo command module is launched into orbit aboard a Saturn 1 rocket. **January 27, 1967** Lt. Col. Virgil I. "Gus" Grissom, Lt. Cmdr. Roger B. Chaffee, and White die in a command module fire in ground test. **October 11–22, 1968** First manned Apollo flight proves "moonworthiness" of spacecraft. **December 21–27, 1968** First manned flight to moon and first lunar orbit. **July 16–24, 1969** Apollo 11 takes Armstrong, Col. Edwin E. "Buzz" Aldrin, Jr., and Lt. Col. Michael Collins to the moon and back. Armstrong and Aldrin make first and second moon walks. **December 7–19, 1972** Final Apollo lunar flight produces sixth manned moon landing.

Current US Launchers

Titan II

Titan IV

Atlas II

Titan II (Lockheed Martin Astronautics)

Modified ICBM. Fourteen missiles have been modified; five have been launched successfully. Puts 4,200 pounds into polar low-Earth orbit (LEO). The Air Force uses it for DMSP launches. Titan II is launched from Vandenberg AFB, Calif. It launched the Clementine mission to the moon and places NOAA satellites into orbit. In the 1960s, NASA used Titan II for the manned Gemini flights.

Titan IV (Lockheed Martin Astronautics)

Heavy-lift launcher, adapted from an ICBM as an expendable launch system. First launch in 1989. Carries DSP, Milstar, and classified satellites and will launch NASA's Cassini to Saturn. With Centaur G-prime upper stages, lifts 10,200 pounds to geosynchronous Earth orbit (GEO), 39,000 pounds to LEO, and 32,000 pounds into polar LEO. Titan IVB, with upgraded solid rocket motors, will have twenty-five percent better performance when it begins launches in 1997. The Air Force has contracted for forty-one Titan IVs; seventeen have flown.

Atlas II (Lockheed Martin Astronautics)

Current version of nation's first ICBM carries DSCS satellites and NASA and commercial payloads. The range of payloads Atlas II through IIAS can lift into geosynchronous transfer orbit (GTO) from Cape Canaveral AS, Fla., is 4,900 to 8,150 pounds and 13,650 to 15,900 pounds to LEO from Vandenberg AFB. The 100th Atlas-Centaur launch occurred in April 1996. A new configuration, the Atlas IIAR (with a Russian-designed RD-180 engine), will be used starting in 1998. It will increase the payload capability to 8,400 pounds to GTO.

Lockheed Martin Launce Vehicle (Lockheed Martin Astronautics)

Family of commercially developed boosters with varying configurations of solid motors that allow payloads weighing one to four tons to be placed into LEO, with plans to develop future versions for geosynchronous orbits. The LMLV-1 rocket, a two-stage version, failed on its first mission in August 1995. After changes to correct design problems, the rocket is due to resume operations this fall. The design is for "stack and shoot," which means the rocket can be launched within fifteen days of arrival at the SLC-6 launch site at Vandenberg AFB, although to date, no military use has been contracted for.

Multiservice Launch System (Lockheed Martin Astronautics)

Launcher is based on refurbished Minuteman II ICBMs. First suborbital use was planned for late July 1996 from Vandenberg AFB toward the Kwajalein Atoll Missile Test Range, with possible orbital versions of the rocket to fly later. Lockheed Martin's contract calls for three suborbital flights, with multiple options for other missions possible. MSLS can launch up to 830 pounds on suborbital missions with a range of 4,100 nautical miles, approximately 400 pounds into 100-nautical-mile polar orbit.

Delta II (McDonnell Douglas)

Medium launcher, in operation since 1989. Payloads include Navstar GPS, scientific, and commercial communications satellites. Launcher for a variety of NASA scientific payloads under the Medium Expendable Launch Vehicle Services program. Launch capability from both Cape Canaveral AS and Vandenberg AFB. Available in two- and three-stage configurations. Latest model lifts 11,100 pounds to LEO, 4,010 pounds to GTO. Has successfully launched twenty-five GPS satellites for USAF.

Delta II

Lockheed Martin Launch Vehicle

Space Shuttle

Space Shuttle (NASA)

Manned space transportation system operated by NASA from Kennedy Space Center, Fla., lifts 46,000 pounds to 160-nautical-mile, 28.5°-inclined orbit. The delta-winged orbiter has flown more than seventy-seven missions since its first use April 12, 1981. NASA plans to turn operations over to a private group—United Space Alliance.

Pegasus (Orbital Sciences Corp.)

Winged small launcher, dropped from a modified L-1011 Tristar aircraft or B-52 to carry payloads weighing 850 to 1,050 pounds to LEO of 100 nautical miles, 28.5° inclination. Two versions, priced at $11 million to $13 million, are available, including the more powerful XL. Pegasus flew ten missions between 1990 and spring 1996, including eight successful and two unsuccessful flights. The company resumed flights in April 1996, after nearly a year hiatus following a failure in June 1995. OSC plans approximately six more Pegasus launches in 1996 and eight in 1997.

Pegasus, mounted under an L-1011

Taurus (Orbital Sciences Corp.)

Ground-launched, four-stage rocket with some Pegasus commonality and a Peacekeeper or Castor 120 motor as the first stage. Capable of boosting 3,200 pounds to LEO of 100 nautical miles, 1,130 pounds to GTO with a Star 37 perigee kick motor. The rocket flew its first mission March 13, 1994. Additional flights are scheduled, starting in late 1996 or early 1997. Price is $19 million to $21 million.

Orbital Sites

Cape Canaveral AS, Fla.
Located 28.5° N, 80° W. One of two primary US space-launch sites. Handles piloted, lunar, and planetary launches and launches of satellites into geostationary orbit. First US satellite in space, first manned spaceflight, and first flight of a reusable spacecraft all originated here. Scene of more than 3,000 launches since 1950. Tract covers 15,000 acres. Cape Canaveral also provides range operations for NASA's shuttle, Navy ballistic missiles, and some research and development tests.

John F. Kennedy Space Center, Fla.
Located 28° N, 80° W. NASA's primary launch base for the space shuttle. Occupies 140,000 acres of land and water on Merritt Island, adjacent coastal strand, and the Indian and Banana Rivers and Mosquito Lagoon surrounding the center. NASA holdings include 84,031 acres. The Merritt Island location was better suited than nearby Cape Canaveral to serve as a launch site for the Apollo program's 363-foot-tall Saturn V, the largest rocket ever built. With the 1972 completion of the Apollo lunar landing program, KSC's Complex 39 was used to launch four Skylab missions and for the Apollo spacecraft for the Apollo-Soyuz Test Project. In the mid- to late 1970s, the Kennedy facilities were modified to accommodate the space shuttle program.

Vandenberg AFB, Calif.
Located 35° N, 121° W. Second of two primary US launch sites. Used for satellites (mostly weather, remote sensing, navigation, and reconnaissance) that must go into polar orbits. Provides basic support for R&D tests for DoD, USAF, and NASA space, ballistic missile, and aeronautical systems. Furnishes facilities and essential services to more than sixty aerospace contractors on base. Base covers 98,400 acres. Originally Army's Camp Cooke, taken over by USAF on June 7, 1957.

Spaceport Florida Facility

Located 28.5° N, 80° W. New commercial launch site at Cape Canaveral AS. Designed to meet growing demand for private-sector access to space and to tap underutilized military launch sites. Operated by the Spaceport Florida Authority (SFA), a state government agency. Launch Complex 46 launchpad is being converted to handle small to medium commercial launch vehicles, designed to lift their satellites into equatorial orbit. The Navy originally used LC-46 to support landbased testing of the Trident II fleet ballistic program. The Naval Ordnance Test Unit will maintain launch capability for future programs. Lockheed Martin is scheduled to launch NASA's Lunar Prospector in October 1997, and the SFA facility also has been selected by USAF to accommodate orbital and suborbital launches of Minuteman and other vehicles. Expected to handle up to twelve launches per year.

California Spaceport

Located 34.33° N, 120.37° W. Designed to handle polar and near-polar LEO launches, the California Spaceport is a commercial launch facility at Vandenberg AFB. Spaceport Systems International, a limited partnership formed by ITT Corp. and California Commercial Spaceport, Inc., is to build and operate the facility. The spaceport will provide both commercial launch and payload processing capability. Currently under construction, the launchpad is scheduled to become operational in late 1997. The launchpad can handle McDonnell Douglas Delta II and Delta Lite vehicles, along with Orbital Sciences' Taurus and Lockheed Martin's MLV. The launchpad will have an initial rate of fifteen launches per year.

Alaska Spaceport, Alaska
Located 57.5° N, 153° W. Designed for polar and near-polar launches, the proposed dual-use commercial launch facility will be sited on 3,100 acres at Kodiak Island, Alaska. Construction for the Kodiak Launch Complex to begin in fall 1996. The target date for initial operational capability is the end of 1997, with an eventual capacity for eight to nine launches per year. With its large launch corridor, the spaceport would provide an additional backup launch capability for both polar satellites and for DoD's ICBM launches at Vandenberg.

Suborbital Sites

Poker Flat Research Range, Alaska
Located 65° N, 147° W. Owned by the University of Alaska. Established 1968. Operated by the Geophysical Institute under contract to NASA/Goddard Space Flight Center, Wallops Flight Facility. Only US launch facility currently in polar region. Conducts launches primarily to investigate aurora borealis and other middle- to upper-atmosphere phenomena. Site of more than 270 launches.

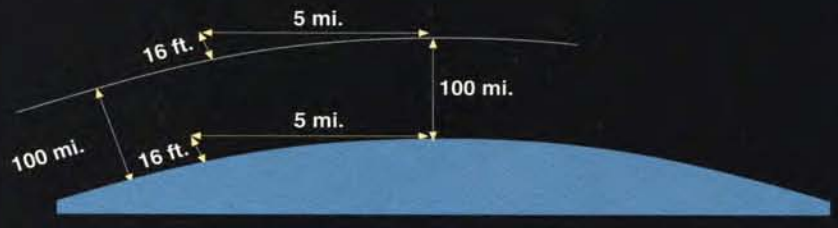
Wallops Flight Facility, Va.
Located 38° N, 76° W. Founded in 1945 on Wallops Island, Va. One of the oldest launch sites in the world. First research rocket launched July 4, 1945. Site for launches of NASA's suborbital sounding rockets and the like. Conducts about fifteen suborbital launches per year. Covers 6,166 acres on Virginia's eastern shore.

White Sands Missile Range, N. M.
Located 32° N, 106° W. Established July 9, 1945, as White Sands Proving Ground. Site of July 16, 1945, Trinity shot, world's first test of atomic bomb, and of postwar test and experimental flights with captured German V-2 rockets. Scene of February 24, 1949, launch of Bumper rocket, whose second stage achieved altitude of 244 miles—becoming the first man-made object in space. Now used for launches of suborbital sounding rockets. New Mexico is in the process of establishing a spaceport adjacent to White Sands for conducting commercial orbital launches.

The John F. Kennedy Space Center, Fla., is NASA's primary launch base for space shuttles, such as **Atlantis**, *shown here lifting off for a ten-day flight in November 1991.*

Orbits

Orbits result from the mutual attraction of any two bodies with a force proportional to the product of their individual masses and inversely proportional to the square of the distance between them. The curvature of the Earth, on average, drops sixteen feet below the horizontal over a distance of about five miles. A spacecraft circling above would "fall" that same amount over the same distance. It travels five miles in one second if gravitational pull equals one G. Therefore, spacecraft velocity of five miles per second (18,000 mph) produces perpetual orbit at constant altitude, unless the spacecraft's flight is upset by perturbations, such as solar wind or mechanical anomalies.

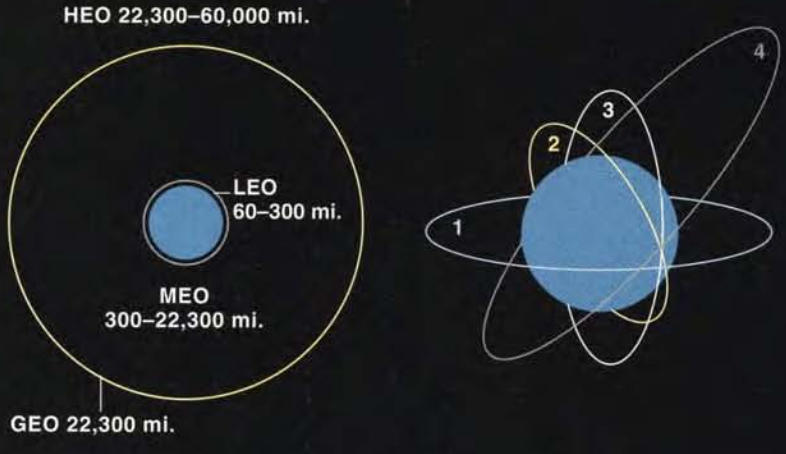


Orbital Radii

LEO—Low-Earth orbit
MEO—Medium-Earth orbit
GEO—Geosynchronous orbit
HEO—High-Earth orbit

Orbital Inclinations

1 Equatorial
2 Sun-synchronous
3 Polar
4 Eccentric



Geosynchronous Transfer Orbit

It is common procedure to pick an initial "parking" orbit, usually at LEO, then boost payloads to higher altitude. Engines are fired first (at perigee) to reach the apogee of an elliptical transfer orbit and then are fired again to put the spacecraft into a circular orbit at that higher altitude.

Illustrations are not drawn to scale.

Reading About Space

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