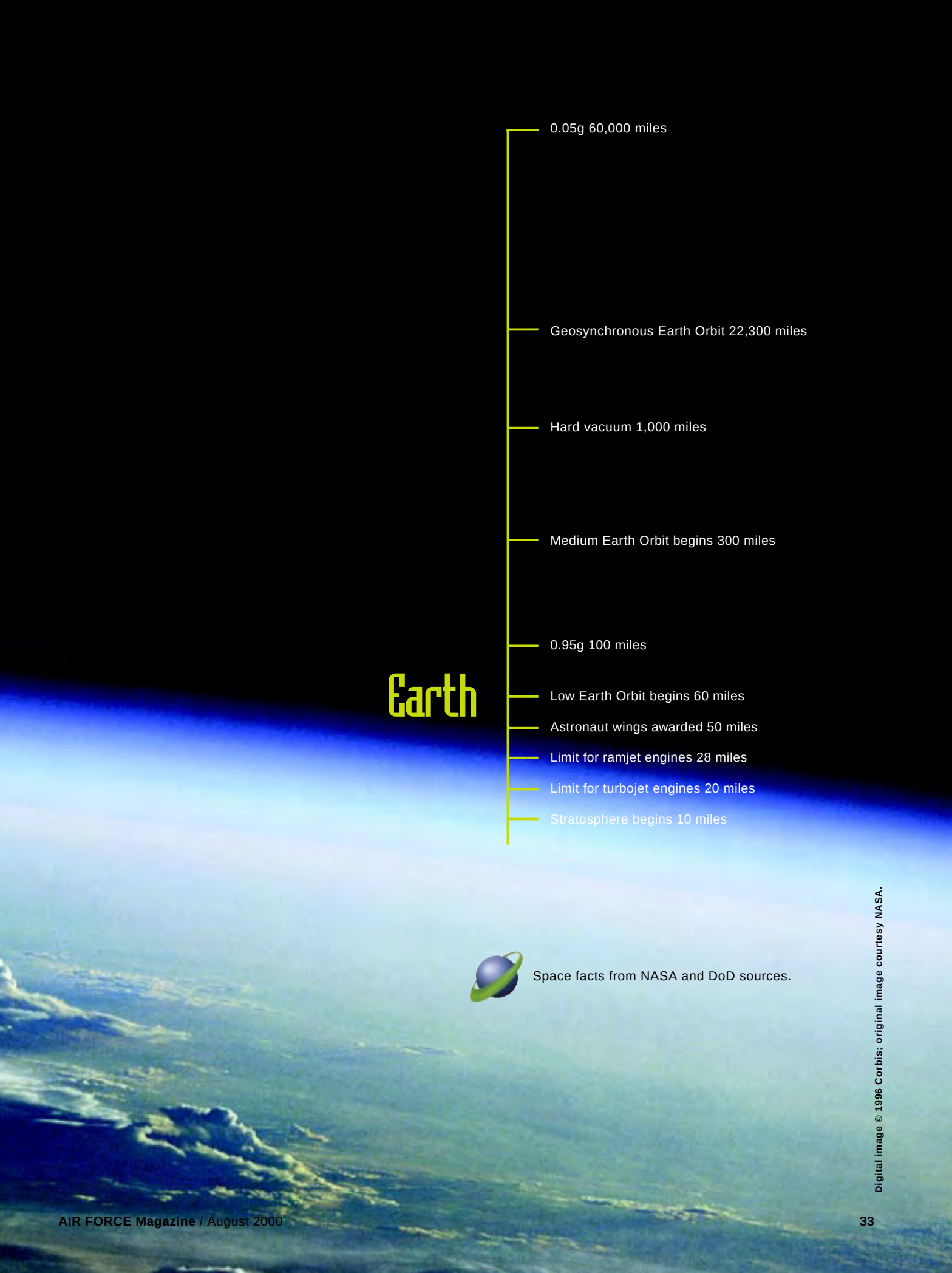
On the following pages appears a variety of information and statistical material about space—particularly military activity in space. This almanac was compiled by the staff of Air Force Magazine, with assistance and information from R.W. Sturdevant, Air Force Space Command History Office; Steve Garber, NASA History Office; Tina Thompson, editor of TRW Space Log; Phillip S. Clark, Molniya Space Consultancy; Joseph J. Burger, Space Analysis and Research, Inc.; and US and Air Force Space Command Public Affairs Offices.

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 Almanac 2000

Compiled by Tamar A. Mehuron, Associate Editor



Space facts from NASA and DoD sources.

Introduction

What's Up There

As of May 31, 2000

Country/Organization	Satellites	Space Probes	Debris	Total
USA	741	46	2,359	3,146
CIS (Russia/former USSR)	1,335	35	1,666	3,036
Iridium	88	0	0	88
Japan	66	4	20	90
Intl. Telecom Sat. Org.	56	0	0	56
Globalstar	52	0	0	52
Orbcomm	35	0	0	35
France	31	0	11	42
People's Republic of China	27	0	304	331
European Space Agency	24	2	144	170
India	20	0	0	20
United Kingdom	17	0	0	17
European Telecom Sat. Org.	17	0	0	17
Canada	16	0	0	16
Germany	13	2	1	16
Indonesia	10	0	0	10
Intl. Maritime	9	0	0	9
Brazil	9	0	0	9
Luxembourg	9	0	0	9
Italy	8	0	1	9
NATO	8	0	0	8
Sweden	8	0	0	8
Arab Sat. Comm. Org.	7	0	0	7
Australia	7	0	0	7
South Korea	7	0	0	7
Mexico	6	0	0	6
Spain	6	0	0	6
Argentina	4	0	0	4
Czech Republic	4	0	0	4
Thailand	4	0	0	4
Asia Sat. Telecom Co.	3	0	0	3
Israel	3	0	0	3
Norway	3	0	0	3
France/Germany	2	0	0	2
Malaysia	2	0	0	2
Philippines	2	0	0	2
Turkey	2	0	0	2
Chile	1	0	0	1
China/Brazil	1	0	0	1
Denmark	1	0	0	1
Egypt	1	0	0	1
Intl. Space Station	1	1	0	2
Portugal	1	0	0	1
Republic of China (Taiwan)	1	0	0	1
Sea Launch (Launch Demo)	1	0	0	1
Singapore/Taiwan	1	0	0	1
South Africa	1	0	0	1
Total	2,671	90	4,506	7,267

In 1919, Robert H. Goddard, known as the father of modern rocketry, published "A Method of Attaining Extreme Altitude" while studying for his doctorate. The paper laid the theoretical foundation for future US rocket development. It also mentioned that a rocket could be flown to the moon as a demonstration. He was dismissed by the public as a "crackpot."

Russian Konstantin Tsiolkovsky worked on rocket design and theory in the early 20th century. In his writings he proposed space exploration by rocket, liquid propellants, multistage rockets, and space stations.

German scientist Hermann Oberth contributed to the theory and design of rockets. In 1923, he published a work that proved flight beyond the atmosphere was possible. In 1929, he wrote *The Road to Space Travel,* which proposed liquid-propelled rockets, multistage rockets, space navigation, and re-entry systems.

On Oct. 13, 1936, Lt. John Sessums of the Army Air Corps visited Robert H. Goddard to officially assess the military value of Goddard's work. He reported that he found little military value but believed that rockets would be useful to drive turbines.

Worldwide Launches by Site, 1957–99

Launch Site	Nation	Launches
Plesetsk	Russia	1,458
White Sands Missile Range, N.M.	US	1,121
Tyuratam/Baikonur	Kazakhstan	1,054
Vandenberg AFB, Calif.	US	568
Cape Canaveral AFS, Fla.	US	556
Poker Flat Research Range, Alaska	US	278
JFK Space Center, Fla.	US	115
Kapustin Yar	Russia	84
Kourou	French Guiana	123
Tanegashima	Japan	30
Shuang Cheng-tzu/Jiuquan	China	24
Wallops Flight Facility, Va.	US	27
Uchinoura	Japan	23
Xichang	China	25
Indian Ocean Platform	Kenya	9
Sriharikota	India	9
Edwards AFB, Calif.	US	5
Hammaguir	Algeria	4
Taiyuan	China	11
Yavne	Israel	3
Woomera	Australia	2
Svobodny	Russia	2
Gando AFB, Canary Islands	Spain	1
Barents Sea	Russia	1
Pacific Ocean Platform	Sea Launch	2
Total		**5,535**

Space on the Web

(Some of the space-related sites on the World Wide Web)

Defense	***Web address***
US Space Command	www.spacecom.af.mil/usspace
Air Force Space Command	www.spacecom.af.mil/hqafspc
21st Space Wing	www.spacecom.af.mil/21sw
30th Space Wing	www.vafb.af.mil
45th Space Wing	www.pafb.af.mil
50th Space Wing	www.schriever.af.mil
Industry	
Boeing Space Systems	www.boeing.com/defense-space/space
Hughes Space & Communications	www.hughespace.com
Lockheed Martin Astronautics	www.ast.lmco.com
Orbital Sciences	www.orbital.com
Rotary Rocket	www.rotaryrocket.com
Space Systems Loral	www.ssloral.com
TRW	www.trw.com/seg/products.html
NASA	
Integrated Launch Manifest *(Launch forecast for shuttle and NASA payloads on ELVs)*	www-pao.ksc.nasa.gov/kscpao/schedule/mixfleet.htm
Jet Propulsion Laboratory Mission and Spacecraft Library	leonardo.jpl.nasa.gov/msl
Mars Global Surveyor	mars.jpl.nasa.gov/mgs
NASA Human Space Flight	spaceflight.nasa.gov
Space Center Houston	spacecenter.org
Other	
European Space Agency	www.esa.int
Florida Today (Current and planned space activity)	www.flatoday.com/space
Space and Technology	www.spaceandtech.com

Space and Missile Badges

Space/Missile Badge

Astronaut Pilot*

Missile Badge

Missile Badge with Operations Designator

*The astronaut designator indicates a USAF rated officer qualified to perform duties in space (50 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.

The Year in Space

July 8, 1999
Former Apollo astronaut Pete Conrad, who became third person to walk on moon, dies in motorcycle accident near Ojai, Calif.
July 20
After lying undisturbed on the ocean bottom for 38 years, astronaut Gus Grissom's Mercury capsule, Liberty Bell 7, is recovered.
July 23–27
Air Force Col. Eileen Collins becomes first woman to command shuttle mission when *Columbia* (STS-93) places Chandra X-Ray Observatory, world's most powerful X-ray telescope, in orbit.
July 31
Controlled crash of NASA's Lunar Prospector into crater near moon's south pole fails to confirm presence of water ice.
Aug. 27
Funding shortages compel Russia to leave 13-year-old Mir space station unmanned.
Sept. 3
NASA announces SeaWinds radar instrument aboard QuikScat satellite performs technological first by tracking massive iceberg B10A, a potential threat to international shipping.
Sept. 23
NASA's Mars Climate Orbiter, first interplanetary weather satellite, fails to enter Martian orbit because confusion between metric and English units causes navigation error.
Sept. 24
Space Imaging Corp.'s Ikonos, capable of 1-meter resolution, enters orbit and becomes world's first commercial, high-resolution Earth–imaging satellite.
Oct. 2
First critical test of National Missile Defense (NMD) system succeeds when Exoatmospheric Kill Vehicle strikes Minuteman II target 140 miles above Pacific Ocean.
Oct. 9
First launch succeeds from Boeing–led international Sea Launch platform, floating on Pacific Ocean approximately 1,400 miles southeast of Hawaii. (Payload: DirecTV communications satellite.)
Oct. 26
In first maneuver of its kind for International Space Station (ISS), flight controllers boost orbit to avoid dangerous space junk.
Nov. 20–21
China launches, monitors, controls, and lands its first unmanned spaceship, the experimental Shenzhou.
Nov. 23
Atlas IIA Centaur from Cape Canaveral AFS, Fla., sends US Navy's 10th UHF Follow-On communications satellite—third and final Block 3—into orbit.
Dec. 3
NASA's Mars Polar Lander disappears in failed attempt at soft landing near Red Planet's south pole.
Dec. 10
Powerful Ariane 5 rocket completes first commercial mission, lofting into orbit ESA's X-Ray Multi-Mirror satellite.
Dec. 11
Brazil's second attempt to launch an indigenous booster fails when rocket's second stage fails to ignite just minutes into flight from Alcantara Launch Center near Sao Luis.
Dec. 12
Air Force Titan II launches first Block 5D3 Defense Meteorological Satellite Program (DMSP) satellite into polar orbit from Vandenberg AFB, Calif.
Dec. 18
Atlas IIAS booster from Vandenberg launches NASA's Terra, world's first satellite to monitor Earth's "vital signs" or "state of health" on daily, global scale.
Dec. 19–27
Shuttle *Discovery* (STS-103), commanded by Air Force Col. Curtis L. Brown Jr., replaces failed gyroscopes and completes other repairs on Hubble Space Telescope.
Dec. 30, 1999–Jan. 15, 2000
US and Russian military personnel jointly man warning center at Peterson AFB, Colo., to ensure that possible computer malfunctions resulting from Y2K rollover do not spark nuclear missile exchange.
Jan. 18
Last-second sensor malfunction in missile interceptor results in failure of first fully integrated flight test of prototype NMD system.
Jan. 20
Air Force launches 11th Defense Satellite Communications System (DSCS) III satellite—first in final group of four modified under Service Life Enhancement Program (SLEP) to provide high-speed, jam-resistant communications service.
Jan. 26
Inaugural flight in US Air Force Orbital Suborbital Program uses Minotaur booster—two-stage Minuteman II with two Orbital Sciences Corp. Pegasus upper stages.
Feb. 9
Russia performs successful maiden flight of new Reusable Launch Vehicle (RLV) Fregat, which has engines that can be switched on and off several times in orbit.
Feb. 11–22
Shuttle *Endeavour* (STS-99) collects radar images to provide world's most accurate, most detailed, three-dimensional topographical maps of Earth.
Feb. 14
Near Earth Asteroid Rendezvous (NEAR) spacecraft becomes first man-made object to orbit asteroid—433 Eros.
Feb. 22
Stardust spacecraft begins first collection of interstellar dust particles for return to Earth in 2006.
Feb. 27
Russia completes experiment simulating long-duration mission aboard ISS; three crew members emerge after 240 days of isolation in two sealed compartments.
March 12
Russian–Ukranian rocket carrying British communications satellite falls into Pacific after liftoff in third attempt to use floating Sea Launch platform.
March 17
Iridium LLC abandons quest for new backers; bankruptcy judge authorizes mobile phone company to cut off service to 55,000 customers and burn up its 66 satellites in Earth's atmosphere.
March 25
NASA's Image satellite, first spacecraft dedicated to imaging Earth's magnetosphere, launches atop Delta II from Vandenberg and deploys four 820-foot wire antennas, making it longest artificial object in space.
April 4
Russian cosmonauts blast off in privately funded venture to resuscitate Mir space station as a tourist destination.
April 6
Powerful, fast-moving solar storm disturbs Earth's magnetic field, posing significant threat to satellites, communications, navigation systems, and power grids as sun reaches peak in 11-year storm cycle.
May 1
More precise Global Positioning System (GPS) navigation signals previously available to military users only is opened to civilians, thereby allowing 10 times greater accuracy.
May 8
After three consecutive Titan IV rocket failures at Cape Canaveral, Titan IVB successfully launches DSP missile warning satellite into geosynchronous orbit.
May 12
Mir crewmen Sergei Zalyotin and Alexander Kaleri apply cosmic version of "superglue" to test its ability to seal cracks in skin of aging space station.
May 19–29
Shuttle *Atlantis* (STS-101), piloted by Air Force Col. Scott J. Horowitz, completes mission to service ISS, including replacement of faulty batteries, and to boost station into higher orbit.
May 28
Air Force launches from Vandenberg a rocket built from parts of scrapped Minuteman II ICBMs to determine if such a hybrid might be used as cheaper target for NMD program.
June 4
NASA sends 17-ton Compton Gamma Ray Observatory into deliberate, controlled crash toward Pacific Ocean, ending highly successful, nine-year mission.
June 22
Scientists announce that images from NASA's Mars Global Surveyor suggest possibility of current sources of liquid water at or near surface of Red Planet. ■

Military & Civilian Space Budgets

US Space Funding, Current Dollars

(Millions, as of Sept. 30, 1999)

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	106	4,913
1976	4,074	2,443	143	6,660
1977	3,440	2,412	131	5,983
1978	3,623	2,738	157	6,518
1979	4,030	3,036	177	7,243
1980	4,680	3,848	233	8,761
1981	4,992	4,828	233	10,053
1982	5,528	6,679	311	12,518
1983	6,328	9,019	325	15,672
1984	6,858	10,195	392	17,445
1985	6,925	12,768	580	20,273
1986	7,165	14,126	473	21,764
1987	9,809	16,287	462	26,558
1988	8,322	17,679	737	26,738
1989	10,097	17,906	560	28,563
1990	11,460	15,616	512	27,588
1991	13,046	14,181	697	27,924
1992	13,199	15,023	769	28,991
1993	13,064	14,106	698	27,868
1994	13,022	13,166	601	26,789
1995	12,543	10,644	629	23,816
1996	12,569	11,514	750	24,833
1997	12,457	11,727	728	24,912
1998	12,321	12,359	744	25,424
1999	12,459	13,385	830	26,674
Total	**$265,870**	**$280,737**	**$14,358**	**$560,965**

US Space Funding, Constant Dollars

(Millions, as of Sept. 30, 1999)

FY	NASA	DoD	Other	Total
1959	1,241	2,329	162	3,731
1960	2,154	2,616	201	4,971
1961	4,277	3,760	319	8,355
1962	8,190	5,916	912	15,017
1963	16,323	6,978	1,166	24,467
1964	22,317	7,114	961	30,393
1965	22,568	6,914	1,072	30,553
1966	21,874	7,294	937	30,105
1967	20,004	6,892	895	27,790
1968	18,143	7,871	726	26,740
1969	15,095	7,950	558	23,602
1970	13,412	6,345	435	20,192
1971	11,129	5,426	456	17,011
1972	10,477	4,800	331	15,609
1973	10,066	5,282	355	15,702
1974	8,585	5,495	361	14,442
1975	8,470	5,497	308	14,275
1976	10,765	6,455	378	17,598
1977	8,202	5,751	312	14,265
1978	8,283	6,260	359	14,902
1979	8,628	6,500	379	15,507
1980	9,295	7,643	463	17,400
1981	9,130	8,830	426	18,385
1982	9,222	11,142	519	20,884
1983	9,882	14,084	508	24,473
1984	10,249	15,236	586	26,071
1985	9,976	18,393	836	29,204
1986	9,997	19,710	660	30,367
1987	13,368	22,196	630	36,193
1988	11,049	23,472	978	35,499
1989	12,987	23,031	720	36,738
1990	14,191	19,337	634	34,162
1991	15,563	6,917	831	33,312
1992	15,176	17,273	884	33,333
1993	14,690	15,862	785	31,336
1994	14,281	14,439	659	29,379
1995	13,446	11,411	674	25,531
1996	13,195	12,088	787	26,071
1997	12,831	12,079	750	25,659
1998	12,478	12,517	754	25,749
1999	12,459	13,385	830	26,674
Total	**$493,667**	**$432,488**	**$25,493**	**$951,648**

Figures may not sum due to rounding. 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. (Note: NSF recalculated its space expeditures since 1980, making them significantly higher than reported in previous years.) Fiscal 1999 figures are preliminary.

NASA Spending on Major Space Missions

FY 2001 Proposal, Current Dollars

Project Office	Millions
Human spaceflight	$5,499.9
Space science	2,398.8
Earth science	1,405.8
Aerospace technology	1,193.0
Space operations	529.4
Life and microgravity sciences	302.4
Safety and mission assurance	47.5
Total	**$11,376.8**

In October 1946, a V-2 rocket launched from White Sands Proving Ground, N.M., carried a camera that took motion pictures of the Earth at approximately 65 miles altitude.

On March 7, 1947, a US Navy V-2 rocket from White Sands took the first photograph at 100 miles altitude.

People • Organizations

Space Leaders

(As of July 1, 2000)

Commanders in Chief, US Space Command

Gen. Robert T. Herres	Sept. 23, 1985–Feb. 5, 1987
Gen. John L. Piotrowski	Feb. 6, 1987–March 30, 1990
Gen. Donald J. Kutyna	April 1, 1990–June 30, 1992
Gen. Charles A. Horner	June 30, 1992–Sept. 12, 1994
Gen. Joseph W. Ashy	Sept. 13, 1994–Aug. 26, 1996
Gen. Howell M. Estes III	Aug. 27, 1996–Aug. 13, 1998
Gen. Richard B. Myers	Aug. 14, 1998–Feb. 22, 2000
Gen. Ralph E. Eberhart	Feb. 22, 2000–

Directors, National Reconnaissance Office

Joseph V. Charyk	Sept. 6, 1961–March 1, 1963
Brockway McMillan	March 1, 1963–Oct. 1, 1965
Alexander H. Flax	Oct. 1, 1965–March 11, 1969
John L. McLucas	March 17, 1969–Dec. 20, 1973
James W. Plummer	Dec. 21, 1973–June 28, 1976
Thomas C. Reed	Aug. 9, 1976–April 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–March 5, 1993
Jeffrey K. Harris	May 19, 1994–Feb. 26, 1996
Keith R. Hall (acting)	Feb. 27, 1996–March 27, 1997
Keith R. Hall	March 28, 1997–

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–March 29, 1990
Lt. Gen. Thomas S. Moorman Jr.	March 29, 1990–March 23, 1992
Gen. Donald J. Kutyna	March 23, 1992–June 30, 1992
Gen. Charles A. Horner	June 30, 1992–Sept. 13, 1994
Gen. Joseph W. Ashy	Sept. 13, 1994–Aug. 26, 1996
Gen. Howell M. Estes III	Aug. 26, 1996–Aug. 14, 1998
Gen. Richard B. Myers	Aug. 14, 1998–Feb. 22, 2000
Gen. Ralph E. Eberhart	Feb. 22, 2000–

Directors, NASA

T. Keith Glennan	Aug. 19, 1958–Jan. 20, 1961
James E. Webb	Feb. 14, 1961–Oct. 7, 1968
Thomas O. Paine	March 21, 1969–Sept. 15, 1970
James C. Fletcher	April 27, 1971–May 1, 1977
Robert A. Frosch	June 21, 1977–Jan. 20, 1981
James M. Beggs	July 10, 1981–Dec. 4, 1985
James C. Fletcher	May 12, 1986–April 8, 1989
Richard H. Truly	May 14, 1989–March 31, 1992
Daniel S. Goldin	April 1, 1992–

Air Force Space Command Headquarters, Peterson AFB, Colo.

(As of July 1, 2000)

Commander
Gen. Ralph E. Eberhart

- **Space Warfare Center** • Schriever AFB, Colo.
  Commander **Brig. Gen. Douglas J. Richardson**
- **14th Air Force** • Hq., Vandenberg AFB, Calif.
  Commander **Maj. Gen. William R. Looney III**
  - **21st Space Wing,** Peterson AFB, Colo.
  - **30th Space Wing,** Vandenberg AFB, Calif.
  - **45th Space Wing,** Patrick AFB, Fla.
  - **50th Space Wing,** Schriever AFB, Colo.
- **20th Air Force** • Hq., F.E. Warren AFB, Wyo.
  Commander **Maj. Gen. Timothy J. McMahon**
  - **90th Space Wing,** F.E. Warren AFB, Wyo.
  - **91st Space Wing,** Minot AFB, N.D.
  - **341st Space Wing,** Malmstrom AFB, Mont.

Major Military Space Commands

	Personnel	Budget, FY2001	Activities
Unified Command			
US Space Command Peterson AFB, Colo.	989	$48.5 million	Responsible for placing DoD satellites into orbit and operating them; supports unified commands with space-based communications, weather, intelligence information, navigation, and ballistic missile attack warning; enforces space superiority through protection, prevention, negation, and surveillance; ensures freedom of access to and operations in space and denies same to adversaries; applies force from or through space; plans for and executes strategic ballistic missile defense operations; supports NORAD by providing missile warning and space surveillance information; advocates the space and missile warning requirements of the other unified commands; responsible for DoD's computer network defense mission.
Service Command			
Air Force Space Command Peterson AFB, Colo.	33,600	$1.8 billion	Operates military space systems, ground-based missile-warning radars and sensors, missile-warning satellites, national launch centers, and ranges; tracks space debris; operates and maintains the USAF ICBM force (a component of US Strategic Command). Budget includes funding for 11,000 contractor personnel and operations and maintenance for seven bases and 40 worldwide sites.
Naval Space Command Dahlgren, Va.	463	$94.2 million	Operates assigned space systems for surveillance and warning; provides spacecraft telemetry and on-orbit engineering; develops space plans, programs, concepts, and doctrine; advocates naval warfighting requirements in the joint arena. Budget includes funding for more than 400 contractor personnel and operations and maintenance of headquarters, component commands, and field sites.
Army Space Command Colorado Springs, Colo.	606	$50.0 million	Manages joint tactical use of DSCS through the 1st Satellite Control Battalion; operates the Army space support teams; operates the Joint Tactical Ground Stations through the 1st Space Battalion; operates the Army National Missile Defense Element; manages the Army Astronaut Program.

Air Force Space Acquisition Organizations

Air Force Materiel Command • Wright–Patterson AFB, Ohio
Commander **Gen. Lester L. Lyles**

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

- **Defense Meteorological Satellite SPO**[1]
- **Launch Programs SPO**
- **Advanced Systems SPO**
- **Satellite and Launch Control SPO**
- **Space Based Laser Project Management Office**
- **Space & Missile Test & Evaluation Directorate, Kirtland AFB, N.M.**

USAF Program Executive Officer for Space
Brent R. Collins

- **MILSATCOM**[3]
- **Space Based Infrared System**[3]
- **Evolved Expendable Launch Vehicle**[3]
- **ICBM/National Missile Defense**
- **Navstar Global Positioning System JPO**[2/3]

USAF Mission Area Director for Space & Nuclear Deterrence
Brig. Gen. Brian A. Arnold

[1]System Program Office [2]Joint Program Office [3]Program offices located at Los Angeles AFB, Calif.

National Imagery and Mapping Agency (NIMA)
Headquarters: Bethesda, Md.
Established: Oct. 1, 1996
Director: Army Lt. Gen. James C. King

Mission, Purpose, Operations
Provide timely, relevant, and accurate imagery intelligence and geospatial information to support national security objectives. This DoD–chartered combat support agency is also a member of the Intelligence Community and has been assigned, by statute, important national-level support responsibilities.

Structure
Major facilities in Virginia, Maryland, Washington, D.C., and Missouri, with the NIMA College located at Ft. Belvoir, Va. Also, customer support teams and technical representatives stationed around the world at major customer locations.

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, for which assembly began in 1998. Launch satellites for space science, Earth observations, and a broad range of technology Research and Development. Conduct aeronautical R&D.

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

Personnel
Civilians 15,300

National Oceanic and Atmospheric Administration (NOAA)
Headquarters: Washington, D.C.
Established: Oct. 3, 1970
Administrator and Undersecretary for Oceans and Atmosphere: 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 in creating forecasts.

Structure
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 833
Other NOAA employees 11,767
Total 12,600

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

Mission, Purpose, Operations
Design, build, and operate reconnaissance satellites to support global information superiority for the US. It has operated hundreds of satellites since it was formed in 1960 and officially recognized in 1961. Responsible for innovative technology; systems engineering; development, acquisition, and operation of space reconnaissance systems; and related intelligence activities. Supports monitoring of arms control agreements, military operations and exercises, natural disasters, environmental issues, and worldwide events of interest to the US.

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. Three offices and four directorates report up to the level of the director. Offices are management services and operations, corporate operations, and operational support. Directorates are signals intelligence systems acquisition and operations, communications systems acquisition and operations, imagery systems acquisition and operations, and advanced systems and technology.

Personnel
Staffed by CIA (39 percent), USAF (39 percent), Navy/Marines (6 percent), Army (1 percent), and DoD civilians (15 percent). Exact personnel numbers are classified.

National Security Agency (NSA)
Headquarters: Ft. Meade, Md.
Established: 1952
Director: USAF Lt. Gen. Michael V. Hayden

Mission, Purpose, Operations
Protect US communications and produce foreign intelligence information. Tasked with two primary missions: an information systems security mission and a foreign intelligence information mission. To accomplish these missions, the director's responsibilities include: prescribing security principles, doctrines, and procedures for the government; organizing, operating, and managing certain activities and facilities to produce foreign intelligence information; and conducting defensive information operations.

Structure
Established by a Presidential directive in 1952 as a separately organized 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 signals intelligence and communications security activities of the government. A 1984 Presidential directive charged the agency with an additional mission: computer security. An operations security training mission was added in 1988. The Central Security Service was established in 1972 by a Presidential memorandum to provide a more unified cryptological organization within DoD. The NSA director also serves as chief of the CSS.

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; NORAD; and the FAA's Office of Commercial Space Transportation.

US Space Launch Sites

Orbital Sites

Cape Canaveral AFS, Fla.
Location: 28.5° N, 80° W. USAF's East Coast launch site.
Mission/operations: Launches satellites into geosynchronous orbit via ELVs. Hub of Eastern Range operations for civil and commercial space launches and military ballistic missile tests.
Launches: 3,242 (since 1950).
Launch vehicles: Athena I, II; Atlas II, III, V; Delta II, III, IV; Titan IV.
History: Designated simply as Operating Sub-Division #1 in 1950, it became Cape Canaveral Missile Test Annex and, for a time, Cape Kennedy AFS, then it became Cape Canaveral again in 1974.
Acres: 15,700.

John F. Kennedy Space Center, Fla.
Location: 28° N, 80° W.
Mission/operations: NASA's primary launch base for space shuttle.
Launches: 115.
Launch vehicles: Pegasus, space shuttle, Taurus.
History: NASA began acquiring land across the Banana River from Cape Canaveral in 1962. By 1967, its first launch complex—Complex 39—was operational. KSC facilities were modified in the mid to late 1970s to accommodate the space shuttle program.
Acres: 140,000 (land and water).

Vandenberg AFB, Calif.
Location: 35° N, 121° W. USAF's West Coast launch site.
Mission/operations: Satellite (weather, remote sensing, navigation, communications, and reconnaissance) launches into polar orbits via ELVs; sole site for test launches of USAF ICBM fleet; basic support for R&D tests for DoD, USAF, and NASA space, ballistic missile, and aeronautical systems; facilities and essential services for more than 60 aerospace contractors on base.
Launches: 568.
Launch vehicles: Athena I; Atlas II, III, V; Delta II, III, IV; Pegasus; Taurus; Titan II, IV.
History: Originally Army's Camp Cooke, turned over to Air Force January 1957. Renamed Vandenberg AFB Oct. 4, 1958.
Acres: 98,400.

Wallops Flight Facility, Va.
Location: 38° N, 76° W.
Mission/operations: East Coast launch site for Orbital Sciences' Pegasus and Taurus missions and NASA's suborbital sounding rockets.
Launches: 27.
Launch vehicles: Pegasus, Taurus.
History: Established in 1945, it is one of world's oldest launch sites.
Acres: 6,166.

Spaceport Florida Authority
Location: 28.5° N, 80° W.
Mission/operations: State-operated launch facilities—launch complexes 20, 37, 41, and 46—at Cape Canaveral; handles suborbital and orbital launch vehicles for equatorial and high-inclination (i.e., space station) missions; owns and manages separate multiuser launch control facility, research payload support facility, and a hangar facility for RLV systems.
Launches: 10.
Launch vehicles: Athena I, II; Minuteman III; Taurus; Terrier.
History: Established in 1989.

Spaceport Systems Intl. Commercial Spaceport
Location: 34.57° N, 120.63° W.
Mission/operations: Polar and near-polar LEO launches from Vandenberg; payload processing and launches for commercial, NASA, and USAF customers; small to medium launch vehicles up to 1 million pound thrust; payload processing facility for small and heavy satellites.
Launches: One (Jan. 26, 2000).
Launch vehicles: MM II–Delta III class.
History: SSI, a limited partnership formed by ITT and California Commercial Spaceport, Inc., achieved full operational status of the spaceport in May 1999.

Alaska Spaceport
Location: 57.5° N, 153° W.
Mission/operations: Commercial launch facility for polar and near-polar launches of communications, remote sensing, and scientific satellites up to 8,000 pounds.
Status: Construction of Kodiak Launch Complex was scheduled for completion June 2000. Funding secured by Alaska Aerospace Development Corp., Alaska's spaceport authority. KLC will be the only non-federally run commercial launch range in US. Complex designed for all indoor processing of payload and launch vehicles.
Launches: Two.
Launch vehicles: Suborbital.
Acres: 3,100.

Virginia Space Flight Center
Location: 38° N, 76° W. (South end of Wallops Flight Facility)
Mission/operations: State-owned, commercially operated launch facility for access to inclined and sun-synchronous orbits; recovery support for ballistic and guided re-entry vehicles; vehicle and payload storage and processing facilities; two commercially licensed launchpads and suborbital launch rails for commercial, military, scientific, and experimental launch customers.
Operator: DynSpace Corp.
Launches: Nine (since 1995).
Launch vehicles: Athena I, II; Minotaur; Pegasus; Taurus.

Suborbital Sites

Poker Flat Research Range, Alaska
Location: 65° N, 147° W.
Mission/operations: Launches primarily to investigate aurora borealis and other middle- to upper-atmosphere phenomena; military, NASA, and civilian launches.
Operator: Owned by University of Alaska and operated by its Geophysical Institute, under contract to NASA's Goddard Space Flight Center and Wallops Flight Facility.
Launches: 278.
Launch vehicles: Various.
History: Established 1968. Only US launch facility in polar region.
Acres: 5,280 in the range, 12 million in impact area.

White Sands Missile Range, N.M.
Location: 32° N, 106° W.
Mission/operations: Conducts suborbital sounding rocket launches.
Launches: 1,121.
Launch vehicles: Various.
History: Established July 9, 1945, as White Sands Proving Ground, where test flights with captured German World War II V-2 rockets were conducted.
Acres: 2.2 million.

Note: Number of launches from 1957–99, except where noted.

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.

Computer Network Defense
Coordinate and direct the defense of DoD computer systems and computer networks. Monitor incidents and potential threats and coordinate across DoD to stop or contain damage and restore network operations.

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

Space Environment/Meteorological Support
Operate ground-based systems and direct NOAA on the operations of space-based DMSP weather satellite systems to provide solar/geophysical support to the warfighter. Provide data on worldwide and local weather systems affecting combat operations.

Missile Defense
Employ space assets to support identification, acquisition, tracking, and destruction of ballistic and cruise missiles launched against forward deployed US forces, allied forces, or US territory.

Navigation
Operate GPS network. 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
Oversee satellite and booster preparation and integration. Conduct launch countdown activities. Operate Eastern and Western Ranges to support ballistic and spaceflight missions.

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

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

Force Application
US Space Command is identifying potential future roles, missions, and systems which, if authorized by civilian leadership for development and deployment, could attack terrestrial and space targets from space in support of national defense.

In 1945, American Arthur C. Clarke wrote an article for the British magazine *Wireless World,* outlining how global communications could be provided using three satellites positioned evenly around the equator at an altitude of 26,000 miles. His altitude was off by about 4,000 miles, but his theory, otherwise, was correct.

In November 1945, the Navy Committee for Evaluating the Feasibility of Space Rocketry, established by the Navy Bureau of Aeronautics a month earlier, recommended high priority for satellite development and estimated cost between $5 million and $8 million.

In a report to the Secretary of War in November 1945, Gen. Henry H. "Hap" Arnold, Commanding General, Army Air Forces, predicted that strategic bombers would eventually be replaced by long-range ballistic missiles that would need to be launched from true space stations, capable of operating outside the Earth's atmosphere.

In the period 1945–48, the US Army carried out Operation Paperclip, the transfer of 492 German and Austrian rocket scientists, their equipment, and documents to the US.

AAF established a think tank, known as Project RAND, in March 1946 as a department of Douglas Aircraft Corp. to study national security scientific issues, including Earth satellites. In May 1946, RAND produced a study, "Preliminary Design of an Experimental World-Circling Space Ship."

US Military vs. Civilian Launches
(As of Dec. 31, 1999)

Year	Military	Civilian	Total
1957	0	0	0
1958	0	7	7
1959	6	5	11
1960	10	6	16
1961	19	10	29
1962	31	21	52
1963	26	12	38
1964	32	25	57
1965	28	35	63
1966	32	41	73
1967	24	34	58
1968	20	25	45
1969	16	24	40
1970	15	14	29
1971	10	22	32
1972	11	20	31
1973	8	15	23
1974	6	18	24
1975	7	21	28
1976	7	19	26
1977	9	15	24
1978	8	24	32
1979	4	12	16
1980	5	8	13
1981	5	13	18
1982	6	12	18
1983	7	15	22
1984	12	10	22
1985	6	11	17
1986	3	3	6
1987	6	2	8
1988	6	6	12
1989	13	5	18
1990	13	14	27
1991	9	9	18
1992	12	16	28
1993	13	10	23
1994	12	14	26
1995	9	18	27
1996	11	22	33
1997	9	28	37
1998	7	27	34
1999	7	23	30
Total	**500**	**691**	**1,191**

US Satellites in Orbit and Deep Space
(As of Dec. 31, 1999)

Launch Year	Military	NASA & Civilian	Commercial	Total
1958	0	1	0	1
1959	0	4	0	4
1960	3	4	0	7
1961	5	3	0	8
1962	2	9	1	12
1963	8	9	1	18
1964	14	10	0	24
1965	17	18	0	35
1966	15	20	0	35
1967	27	16	0	43
1968	13	13	0	26
1969	15	12	0	27
1970	10	4	0	14
1971	12	3	0	15
1972	8	7	1	16
1973	8	5	0	13
1974	4	4	2	10
1975	5	6	2	13
1976	10	6	6	22
1977	11	4	0	15
1978	14	7	2	23
1979	8	1	2	11
1980	10	1	1	12
1981	5	3	3	11
1982	5	0	6	11
1983	14	4	4	22
1984	15	3	5	23
1985	9	1	4	14
1986	6	1	2	9
1987	10	1	0	11
1988	10	2	4	16
1989	14	3	0	17
1990	23	3	4	30
1991	10	5	2	17
1992	11	4	4	19
1993	13	5	3	21
1994	11	4	5	20
1995	10	5	10	25
1996	15	5	5	25
1997	9	5	66	80
1998	7	8	74	89
1999	8	12	57	77
Total	**424**	**241**	**276**	**941**

On March 7, 1946, Navy and AAF representatives met to work out a joint satellite development program, but nothing came of it. In fact, two years later, the Research and Development Board, Guided Missiles Committee, stated that neither the Navy nor USAF had as yet established either a military or scientific utility commensurate with the presently expected cost of a satellite vehicle. They added that the question of utility deserved further study and examination.

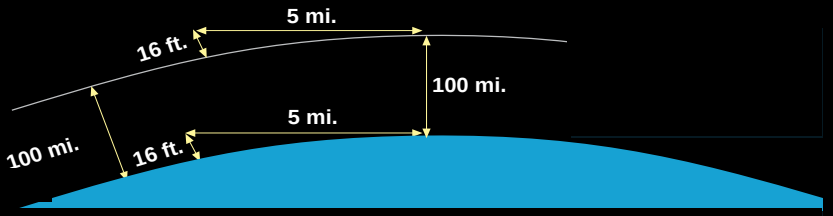
Life magazine in July 1945 published drawings of a manned space station, as envisioned by German rocket scientists.

Upcoming Shuttle Flights

Month/Year	Mission	Name
8/2000	**STS-106**	*Atlantis*
9/2000	**STS-92**	*Discovery*
11/2000	**STS-97**	*Endeavour*
1/2001	**STS-98**	*Atlantis*
2/2001	**STS-102**	*Discovery*
4/2001	**STS-100**	*Endeavour*
5/2001	**STS-104**	*Atlantis*
6/2001	**STS-105**	*Endeavour*

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 16 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 1g. Therefore, spacecraft velocity of five miles per second (18,000 mph) produces perpetual orbit at sea level, unless the spacecraft's flight is upset by perturbations, such as solar wind or mechanical anomalies.

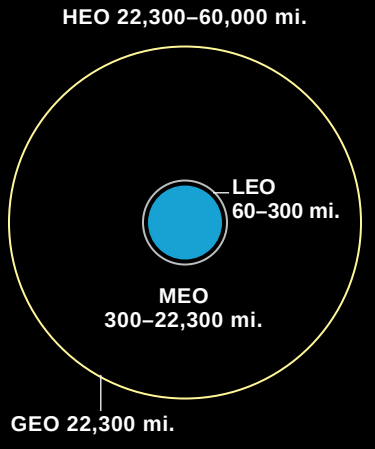


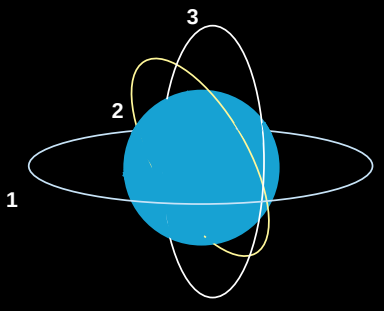
Orbital Altitude

LEO Low Earth Orbit
MEO Medium Earth Orbit
GEO Geosynchronous Earth Orbit
HEO High Earth Orbit

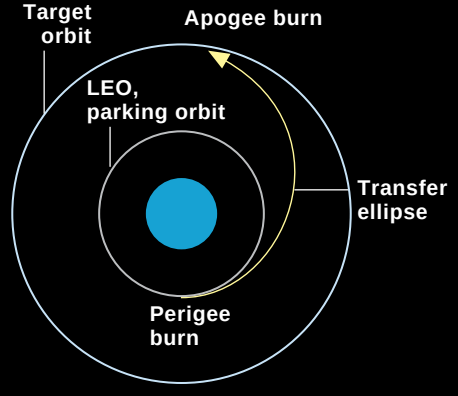
Orbital Inclinations

1 Equatorial
2 Sun synchronous
3 Polar





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.

US Payloads by Mission, 1957–99

Category	Number
Platforms	**0**
Earth orbital science	**237**
Automated lunar, planetary	**64**
Moon	26
Mercury	1
Venus	8
Mars	13
Outer planets	5
Interplanetary space	11
Applications	**634**
Communications	492
Weather	104
Geodesy	20
Earth resources	16
Materials processing	2
Piloted activities	**166**
Earth orbital	115
Earth orbital (related)	14
Lunar	20
Lunar (related)	17
Launch vehicle tests	**12**
General engineering tests	**61**
Reconnaissance	**433**
Photographic	249
Electronic intelligence	96
Ocean electronic intelligence	39
Early warning	49
Minor military operations	**44**
Navigation	**85**
Theater communication	**0**
Weapons-related activities	**2**
Fractional orbital bombardment	0
Anti-satellite targets	2
Anti-satellite interceptors	0
Other military	**18**
Other civilian	**5**
Total	**1,761**

US Manned Spaceflights

Year	Flights	Persons
1961	2	2
1962	3	3
1963	1	1
1964	0	0
1965	5	10
1966	5	10
1967	0	0
1968	2	6
1969	4	12
1970	1	3
1971	2	6
1972	2	6
1973	3	9
1974	0	0
1975	1	3
1976	0	0
1977	0	0
1978	0	0
1979	0	0
1980	0	0
1981	2	4
1982	3	8
1983	4	20
1984	5	28
1985	9	58
1986	1	7
1987	0	0
1988	2	10
1989	5	25
1990	6	32
1991	6	35
1992	8	53
1993	7	42
1994	7	42
1995	7	42
1996	7	43
1997	8	53
1998	5	33
1999	3	19
Total	**126**	**625**

Space Shuttle Flights, 1981–2000

(As of June 6, 2000)

Flight	Mission	Launch	Return
1	STS-1	4/12/81	4/14/81
2	STS-2	11/12/81	11/14/81
3	STS-3	3/22/82	3/30/82
4	STS-4	6/27/82	7/4/82
5	STS-5	11/11/82	11/16/82
6	STS-6	4/4/83	4/9/83
7	STS-7	6/18/83	6/24/83
8	STS-8	8/30/83	9/5/83
9	STS-9	11/28/83	12/8/83
10	STS-10	2/3/84	2/11/84
11	STS-11	4/6/84	4/13/84
12	STS-12	8/30/84	9/5/84
13	STS-13	10/5/84	10/13/84
14	STS-14	11/8/84	11/16/84
15	STS-15	1/24/85	1/27/85
16	STS-16	4/12/85	4/19/85
17	STS-17	4/29/85	5/6/85
18	STS-18	6/17/85	6/24/85
19	STS-19	7/29/85	8/6/85
20	STS-20	8/27/85	9/3/85
21	STS-21	10/3/85	10/7/85
22	STS-22	10/30/85	11/6/85
23	STS-23	11/26/85	12/3/85
24	STS-24	1/12/86	1/18/86
25	STS-25	1/28/86	No Landing
26	STS-26	9/29/88	10/3/88
27	STS-27	12/2/88	12/6/88
28	STS-29	3/13/89	3/18/89
29	STS-30	5/4/89	5/8/89
30	STS-28	8/8/89	8/13/89
31	STS-34	10/18/89	10/23/89
32	STS-33	11/22/89	11/27/89
33	STS-32	1/9/90	1/20/90
34	STS-36	2/28/90	3/4/90
35	STS-31	4/24/90	4/29/90
36	STS-41	10/6/90	10/10/90
37	STS-38	11/15/90	11/20/90
38	STS-35	12/2/90	12/10/90
39	STS-37	4/5/91	4/11/91
40	STS-40	6/5/91	6/14/91
41	STS-43	8/2/91	8/11/91
42	STS-48	9/12/91	9/18/91
43	STS-44	11/24/91	12/1/91
44	STS-39	4/28/91	5/6/91
45	STS-42	1/22/92	1/30/92
46	STS-45	3/24/92	4/2/92
47	STS-49	5/7/92	5/16/92
48	STS-50	6/25/92	7/9/92
49	STS-46	7/31/92	8/8/92
50	STS-47	9/12/92	9/20/92
51	STS-52	10/22/92	11/1/92
52	STS-53	12/2/92	12/9/92
53	STS-54	1/13/93	1/19/93
54	STS-56	4/8/93	4/17/93
55	STS-55	4/26/93	5/6/93
56	STS-57	6/21/93	7/1/93
57	STS-51	9/12/93	9/22/93
58	STS-58	10/18/93	11/1/93
59	STS-61	12/2/93	12/13/93
60	STS-60	2/3/94	2/11/94
61	STS-62	3/4/94	3/18/94
62	STS-59	4/9/94	4/20/94
63	STS-65	7/8/94	7/23/94
64	STS-64	9/9/94	9/20/94
65	STS-68	9/30/94	10/11/94
66	STS-66	11/3/94	11/14/94
67	STS-63	2/3/95	2/11/95
68	STS-67	3/2/95	3/18/95
69	STS-71	6/27/95	7/7/95
70	STS-70	7/13/95	7/22/95
71	STS-69	9/7/95	9/18/95
72	STS-73	10/20/95	11/5/95
73	STS-74	11/12/95	11/20/95
74	STS-72	1/11/96	1/20/96
75	STS-75	2/22/96	3/9/96
76	STS-76	3/22/96	3/31/96
77	STS-77	5/19/96	5/29/96
78	STS-78	6/20/96	7/7/96
79	STS-79	9/16/96	9/26/96
80	STS-80	11/19/96	12/7/96
81	STS-81	1/12/97	1/22/97
82	STS-82	2/11/97	2/21/97
83	STS-83	4/4/97	4/8/97
84	STS-84	5/15/97	5/24/97
85	STS-94	7/1/97	7/17/97
86	STS-85	8/7/97	8/19/97
87	STS-86	9/25/97	10/6/97
88	STS-87	11/19/97	12/5/97
89	STS-89	1/22/98	1/31/98
90	STS-90	4/17/98	5/3/98
91	STS-91	6/2/98	6/12/98
92	STS-95	10/29/98	11/7/98
93	STS-88	12/4/98	12/15/98
94	STS-96	5/27/99	6/6/99
95	STS-93	7/22/99	7/27/99
96	STS-103	12/19/99	12/27/99
97	STS-99	2/11/00	2/22/00
98	STS-101	5/19/00	5/29/00

On Dec. 19, 1958, an orbiting satellite broadcast the first communication from space. It was a Christmas message from President Eisenhower. The Project Score satellite continued to receive and rebroadcast on command new voice and teletype messages for 12 days.

Only 6 inches in diameter and weighing just 2.4 pounds, Vanguard I, built by the Naval Research Lab, was launched March 17, 1958, from Cape Canaveral and is still on orbit. It was the second satellite successfully placed in orbit by the US and was the first solar-powered satellite. Its solar cells operated for about seven years, while conventional batteries on board lasted only 20 days.

In February 1949, the Department of Space Medicine was established at the School of Aviation Medicine at Randolph AFB, Tex.

Major Military Satellite Systems

Advanced Extremely High Frequency Satellite Communications System

Common name: AEHF
In brief: successor to Milstar, AEHF will provide assured strategic, worldwide C^2 communications with at least five times the capacity of Milstar II but in a smaller, cheaper package.
Function: EHF communications.
Operator: MILSATCOM JPO (acquisition); AFSPC.
First launch: 2004, planned.
Constellation: four.
Orbit altitude: 22,300 miles.
Contractors: Lockheed Martin, Hughes Space and Communications, TRW.
Power plant: N/A.
Dimensions: N/A.
Weight: approx. 5,357 lb (on orbit).

Defense Meteorological Satellite Program

Common name: DMSP
In brief: satellites that collect air, land, sea, and space environmental data to support worldwide strategic and tactical military operations.
Function: environmental monitoring satellite.
Operator: NPOESS Program Office.
First launch: circa 1960s.
Constellation: two.
Orbit altitude: 500 miles.
Contractor: Lockheed Martin.
Power plant: solar array, 500–600 watts.
Dimensions: width 4 ft, length 20 ft 2 in (with array deployed).
Weight: 1,750 lb (on orbit).

Defense Satellite Communications System III

Common name: DSCS III
In brief: nuclear-hardened and jam-proof spacecraft used to transmit high-priority C^2 messages to battlefield commanders.
Function: SHF communications.
Operator: AFSPC.
First launch: October 1982.
Constellation: five.
On orbit: 10.
Orbit altitude: 22,000+ miles.
Contractor: Lockheed Martin.
Power plant: solar array, avg. 1,269 watts (pre–System Life Enhancement Program); avg. 1,500 watts (SLEP; first SLEP satellite launched Jan. 20, 2000.
Dimensions: rectangular body is 6 ft x 6 ft x 7 ft; 38-ft span (deployed).
Weight: 2,580 lb (pre–SLEP); 2,716 lb (SLEP).

Defense Support Program

Common name: DSP
In brief: early warning spacecraft whose infrared sensors detect heat generated by a missile or booster plume.
Function: strategic and tactical missile launch detection.
Operator: AFSPC.
First launch: November 1970.
Constellation: classified.
On orbit: classified.
Orbit altitude: 22,000+ miles.
Contractor: TRW, Aerojet.
Power plant: solar array, 1,485 watts.
Dimensions: width 22 ft (on orbit), length 32.8 ft (on orbit).
Weight: approx. 5,000 lb.

Global Broadcast System

Common name: GBS
In brief: wideband communications program, initially using leased commercial satellites, then military systems, to provide digital multimedia data directly to theater warfighters.
Function: high-bandwidth data imagery and video.
Operator: AFSPC.
First launch: March 1998 (Phase 2 payload on UHF Follow-On).
Constellation: three.
On orbit: three.
Orbit altitude: 23,230 miles.
Contractor: Raytheon (Phase 2).
Power plant: (interim host satellite: UHF Follow-On) 3,800 watts.
Dimensions: width 22 ft, length 86 ft.
Weight: 3,400 lb.

Global Positioning System

Common name: GPS
In brief: constellation of 24 satellites used by military and civilians to determine a precise location anywhere on Earth.
Function: worldwide navigation.
Operator: AFSPC.
First launch: Feb. 22, 1978.
Constellation: 24.
Orbit altitude: 12,636 miles (Block IIA); 12,532 miles (Block IIR).
Contractors: Boeing, Lockheed Martin.
Power plant: solar array, 700 watts (Block IIA); 1,136 watts (Block IIR)
Dimensions: body 8 ft x 8 ft x 12 ft, including solar arrays 11 ft x 19 ft (II/IIA); body 8 ft x 6 ft x 10 ft, span including arrays 37 ft (IIR).
Weight: 2,174 lb (Block IIA, on orbit); 2,370 lb (Block IIR, on orbit).

Milstar Satellite Communications System

Common name: Milstar
In brief: joint communications satellite that provides secure, jam-resistant communications for essential wartime needs.
Function: EHF communications.
Operator: AFSPC.
First launch: Feb. 7, 1994.
Constellation: three.
On orbit: two.
Orbit altitude: 22,300 miles.
Contractor: Lockheed Martin.
Power plant: solar array, almost 5,000 watts.
Dimensions: length 51 ft; solar array 116 ft (deployed).
Weight: approx. 10,000 lb.

Polar Military Satellite Communications

Common name: Polar MILSATCOM
In brief: USAF deployed a modified Navy EHF payload on a host polar-orbiting satellite to provide an interim solution for a cheaper alternative to Milstar to ensure warfighters have protected polar communications capability.
Function: polar communications.
Operator: AFSPC
First launch: late 1997.
Constellation: three.
On orbit: one.
Orbit altitude: 25,300 miles (apogee).
Contractor: classified.
Power plant: 410 watts consumed by payload (power from host solar array).
Dimensions: numerous items integrated throughout host.
Weight: 470 lb (payload).

Space Based Infrared System

Common name: SBIRS
In brief: advanced surveillance system for missile warning, missile defense, battlespace characterization, and technical intelligence. System includes High (satellites in GEO and HEO) and Low (satellites in LEO) components
Function: infrared space surveillance.
Operator: AFSPC.
First launch: planned, High FY04; Low FY06.
Constellation: High: 5 GEO sats, 2 HEO sensors. Low: (preliminary) 27 LEO sats, including three spares.
On orbit: none.
Orbit altitude: High at GEO & HEO; Low, LEO.
Contractor: Lockheed Martin (High); TRW and Spectrum Astro for preliminary system designs (Low).
Power plant: N/A.
Dimensions: N/A.
Weight: N/A.

UHF Follow-On Satellite

Common name: UFO
In brief: new generation of satellites providing secure, anti-jam communications; replaced FLTSATCOM satellites.
Function: UHF and EHF communications.
Operator: Navy, AFSPC.
First launch: March 25, 1993.
Constellation: four primary, four redundant.
On orbit: eight.
Orbit altitude: 22,300 miles.
Contractor: Hughes Space & Communications.
Power plant: solar array, 2,500–3,800 watts.
Dimensions: length 60 ft (F-2–F-7); 86 ft (F-8–F10) (deployed).
Weight: 2,600–3,400 lb.

Wideband Gap-Filler System

Common name: WGS
In brief: high data rate satellite broadcast system meant to bridge the communications gap between current systems—DSCS and GBS—and an advanced wideband system, tentatively scheduled for launch in Fiscal 2008.
Function: wideband communications and point-to-point service (Ka-band frequency).
Operator: AFSPC.
First launch: FY04, planned.
Constellation: three.
Orbit altitude: N/A.
Contractor: TBD.
Power plant: TBD.
Dimensions: TBD.
Weight: TBD.

Dark and Spooky

A number of intelligence satellites are operated by US agencies in cooperation with the military. The missions and, especially, the capabilities are closely guarded secrets. Using a page from the Soviet book on naming satellites, the US government started in the 1980s calling all government satellites "USA" with a sequential number. This allowed them to keep secret the names of satellites which monitor the Earth with radar, optical sensors, and electronic intercept capability. Most of the names of satellites, like White Cloud (ocean reconnaissance), Aquacade (electronic ferret), and Trumpet (Sigint) are essentially open secrets but cannot be confirmed by the Intelligence Community. However, the move to declassify space systems has led to the release of selected information on some systems. Pictures of the Lacrosse radar imaging satellite have been released without details on the system. Details of the Keyhole optical imaging systems in the Corona program have been released.

Major US Civilian Satellites in Military Use

Advanced Communications Technology Satellite

Common name: ACTS
In brief: technology demonstration satellite for new types of K- and Ka-band communications technologies.
Function: communications.
Operator: NASA.
First launch: Sept. 12, 1993.
Constellation: one.
Orbit altitude: 22,300 miles.
Contractor: Lockheed Martin.
Power plant: solar array, 1,400 watts.
Dimensions: width 29.9 ft, length 47.1 ft (deployed).
Weight: 3,250 lb.

Geostationary Operational Environmental Satellite

Common name: GOES
In brief: hovers over the equator to collect weather data for short-term forecasting.
Function: storm monitoring and tracking, meteorological research.
Operator: NOAA.
First launch: Oct. 16, 1975 (GOES-1).
Constellation: three.
Orbit altitude: 22,300 miles.
Contractor: Space Systems/Loral.
Power plant: solar array, 1,050 watts.
Dimensions: 6.6-ft cube, length 88.6 ft (deployed).
Weight: 4,600 lb.

Globalstar

Common name: Globalstar
In brief: mobile communications with provision for security controls.
Function: communications.
Operator: Globalstar L.P.
First launch: February 1998.
Constellation: 48.
Orbit altitude: 878 miles.
Contractor: Space Systems/Loral.
Power plant: solar array, 1,100 watts.
Dimensions: width 4.9 ft, length 35.3 ft (deployed).
Weight: 990 lb.

Inmarsat

Common name: Inmarsat
In brief: sometimes used for peacetime mobile communications services.
Function: communications.
Operator: International Maritime Satellite Organization.
First launch: February 1982 (first lease), Oct. 30, 1990 (first launch).
Constellation: nine.
Orbit altitude: 22,300 miles.
Contractor: Lockheed Martin (Inmarsat 3).
Power plant: solar array, 2,800 watts.
Dimensions: width 6.9 ft, length 5.9 ft, 57.8 ft (deployed).
Weight: 4,545 lb (Inmarsat 3).

Intelsat

Common name: Intelsat
In brief: routine communications and distribution of Armed Forces Radio and TV Services network.
Function: communications.
Operator: International Telecommunications Satellite Organization.
First launch: April 6, 1965 (Early Bird).
Constellation: 17.
Orbit altitude: 22,300 miles.
Contractor: Lockheed Martin (Intelsat 8).
Power plant: solar array, 4,800 watts.
Dimensions: width 8.3 x 7.2 ft, length 11.3 ft, 35.4 ft (deployed) (Intelsat 8).
Weight: 7,480 lb (Intelsat 8).

Landsat

Common name: Landsat
In brief: imagery use includes mapping and planning for tactical operations.
Function: remote sensing.
Operator: NASA/NOAA.
First launch: July 23, 1972.
Constellation: one.
Orbit altitude: 438 miles (polar).
Contractor: Lockheed Martin.
Power plant: solar array, 1,550 watts.
Dimensions: diameter 9 ft, length 14 ft.
Weight: 4,800 lb.

Loral Orion

Common name: Telstar (formerly Orion)
In brief: commercial satellite-based, rooftop-to-rooftop communications for US Army and other DoD agencies.
Function: communications.
Operator: Loral Orion.
First launch: November 1994.
Constellation: three.
Orbit altitude: 22,300 miles.
Contractor: Space Systems/Loral (Orion 2).
Power plant: solar array, 7,000 watts.
Dimensions: width 5.6 ft, length 6.9 ft, 72.2 ft (deployed).
Weight: 8,360 lb (Orion 2).

NOAA-14 (NOAA-J) and NOAA-15 (NOAA-K)

Common name: NOAA (with number on orbit) (also known as Television Infrared Observation Satellite or TIROS).
In brief: weather updates for all areas of the world every six hours.
Function: long-term weather forecasting.
Operator: NOAA (on-orbit); NASA (launch).
First launch: October 1978 (TIROS-N).
Constellation: two.
Orbit altitude: 530 miles.
Contractor: Lockheed Martin.
Power plant: solar array, 1,000+ watts.
Dimensions: diameter 6.2 ft, length 13.8 ft (NOAA-15).
Weight: approx. 4,900 lb (NOAA-15).

Orbcomm

Common name: Orbcomm
In brief: potential military use under study in Joint Interoperability Warfighter Program.
Function: mobile communications.
Operator: Orbcomm Global LP.
First launch: April 1995.
Constellation: 35.
Orbit altitude: 500–1,200 miles.
Contractor: Orbital Sciences.
Power plant: solar array, 160 watts.
Dimensions: width 7.3 ft, length 14.2 ft.
Weight: 90 lb.

Satellite Pour l'Observation de la Terre

Common name: SPOT
In brief: terrain images used for mission-planning systems, terrain analysis, and mapping.
Function: remote sensing.
Operator: SPOT Image S.A. (France).
First launch: Feb. 22, 1986.
Constellation: three.
Orbit altitude: 509 miles.
Contractor: Matra Marconi Space France.
Power plant: solar array, 2,100 watts (SPOT 4).
Dimensions: 6.6 x 6.6 x 18.4 ft (SPOT 4).
Weight: 5,940 lb (SPOT 4).

Tracking and Data Relay Satellite System

Common name: TDRS
In brief: global network that allows other spacecraft in LEO to communicate with a control center without an elaborate network of ground stations.
Function: communications relay.
Operator: NASA.
First launch: April 1983.
Constellation: six.
Orbit altitude: 22,300 miles.
Contractor: TRW.
Power plant: solar array, 1,800 watts.
Dimensions: width 45.9 ft, length 57.4 ft (deployed).
Weight: 5,000 lb.

Major US Launchers in Military Use

Athena I

Function: low- to medium-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: Aug. 22, 1997.
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: two.
Propulsion: stage 1 (Thiokol Castor 120 Solid Rocket Motor), 435,000 lb thrust; stage 2 (Pratt & Whitney Orbus 21D SRM), 43,723 lb thrust.
Dimensions: length 65 ft, max body diameter 7.75 ft.
Weight: 146,264 lb.
Payload max: 1,750 lb to LEO.

Athena II

Function: low- to medium-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: Jan. 6, 1998.
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: three.
Propulsion: stages 1–2 (Castor 120 SRMs), 435,000 lb thrust; stage 3 (Orbus 21D SRM), 43,723 lb thrust.
Dimensions: length 100 ft, max body diameter 7.75 ft.
Weight: 265,000 lb.
Payload max: 4,350 lb to LEO.

Atlas II

Function: medium-weight spacelift.
Variants: IIA and IIAS.
Operator: commercial (AFSPC oversight).
First launch: Dec. 7, 1991; Feb. 10, 1992 (USAF).
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: two.
Propulsion: (IIA and IIAS) stages 1–2 (Boeing MA-5A), 490,000 lb thrust; (IIAS) four strap-on Castor IVA SRMs
Dimensions: length 82 ft, max body diameter 10 ft.
Weight: with large payload fairing (IIA) 408,800 lb; (IIAS) 515,333 lb.
Payload max: (IIA) 14,500 lb to LEO; (IIAS) 19,050 lb to LEO.

Atlas III

Function: medium- to heavyweight spacelift.
Variants: IIIA and IIIB.
Operator: commercial (AFSPC oversight).
First launch: May 24, 2000 (IIIA).
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: two.
Propulsion: (IIIA and IIIB) stages 1–2 (Russian RD-180), 860,200 lb.
Dimensions: length 170 ft, diameter 10 ft.
Weight: with large payload fairing (IIIA) 486,500 lb; (IIIB) 496,908 lb.
Payload max: (IIIA and IIIB) 9,920 lbs to GTO.

Atlas V

Function: medium to heavy launch.
Operator: commercial (AFSPC oversight).
First Launch: planned for late 2001.
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: two.
Propulsion: RD AMROSS LLC RD-180, up to five strap-on SRMs.
Dimensions: length 106.2 ft, diameter 12.5 ft.
Weight: (400) with large payload fairing 734,850 lb; (551) with Contraves Short (5.4 meter) payload fairing 1,191,250 lb.
Payload max: 18,080 lb to GTO; 13,100+ lb to GSO.

Delta II

Function: medium-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: Feb. 14, 1989.
Launch site: CCAFS, VAFB.
Contractor: Boeing.
Stages: up to three.
Propulsion: stage 1 (Boeing RS-27A), 237,000 lb thrust; stage 2 (Aerojet AJ10-118K), 9,750 lb thrust; stage 3 (Thiokol STAR 48B SRM), 14,920 lb thrust; nine strap-on SRMs (Alliant Techsystems), 100,270 lb thrust.
Dimensions: length 125.2 ft, diameter 8 ft.
Weight: 511,190 lb.
Payload max: 11,330 lb to LEO.

Delta III

Function: medium-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: Aug. 26, 1998.
Launch site: CCAFS.
Contractor: Boeing.
Stages: up to three.
Propulsion: stage 1 (RS-27A), 237,000 lb thrust; stage 2 (Pratt & Whitney RL10B-2), 20,500 lb thrust; stage 3 Thiokol Star 48B (modified).
Dimensions: length 148 ft, diameter 13 ft.
Weight: 663,200 lb.
Payload max: 18,200 lb to LEO.

Delta IV

Function: medium to heavy launch.
Operator: commercial (AFSPC oversight).
First Launch: planned for 2001.
Launch site: CCAFS, VAFB.
Contractor: Boeing.
Stages: two.
Propulsion: RS-68.
Dimensions: stage 1 length 120 ft, diameter 16.8 ft.
Weight: 480,750 lb (stage 1).
Payload max: 27,400 lb (Delta IV heavy).

Evolved Expendable Launch Vehicle
Function: medium/heavy spacelift.
Note: Atlas V and Delta IV (see individual entries for specifications) are participating in USAF's EELV modernization spacelift program to cut launch costs by 25 to 50 percent. These systems will eventually replace Delta II, Atlas II, Titan II, and Titan IV launch vehicles.

Pegasus
Function: low-weight spacelift.
Variants: Standard and XL.
Operator: commercial (AFSPC oversight).
First launch: (Standard) April 5, 1990; (XL) June 27, 1994.
Launch site: dropped from L-1011 aircraft.
Contractor: Orbital Sciences/Alliant.
Stages: three.
Propulsion: (XL) stage 1, 109,400 lb. thrust; stage 2, 27,600 lb thrust; stage 3, 7,800 lb thrust (all Alliant Techsystems).
Dimensions: length 49 ft, wingspan 22 ft, diameter 4.17 ft.
Weight: 42,000 lb.
Payload max: (Standard) 850 lb to LEO; (XL) 1,050 lb to LEO.

Space Shuttle
Function: heavyweight manned spacelift.
Operator: United Space Alliance (NASA contract).
First launch: April 12, 1981.
Launch site: Kennedy Space Center, Fla.
Contractor: Boeing.
Stages: delta-winged orbiter.
Propulsion: three main engines, 394,000 lb thrust; two SRMs, 3.3 million lb thrust.
Dimensions: system length 184.2 ft; span 76.6 ft.
Weight: 4.5 million lb (gross).
Payload max: 55,000 lb to LEO.

Taurus
Function: low-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: March 13, 1994.
Launch site: CCAFS, VAFB, Wallops Is.
Contractor: Orbital Sciences.
Stages: three.
Propulsion: Castor 120 SRM, 495,400 lb thrust; stage 1, 109,140 lb thrust; stage 2, 26,900 lb thrust; stage 3, 7,200 lb thrust (stages 1–3, Alliant Techsystems).
Dimensions: length 89 ft, max body diameter 7.6 ft.
Weight: 50,000 lb.
Payload max: 3,000 lb to LEO.

Titan II
Function: low- to medium-weight spacelift.
Operator: commercial (AFSPC oversight).
First launch: April 8, 1964 (NASA).
Launch site: VAFB.
Contractor: Lockheed Martin.
Stages: two.
Propulsion: stage 1, 430,000 lb thrust; stage 2, 100,000 lb thrust (both Aerojet).
Dimensions: length 110 ft (stages 1+2), diameter 10 ft.
Weight: 408,000 lb.
Payload max: 4,200 lb to polar LEO.

Titan IVB
Function: heavyweight spacelift.
Operator: commercial (AFSPC oversight).
First launch: (IVB) Feb. 23, 1997.
Launch site: CCAFS, VAFB.
Contractor: Lockheed Martin.
Stages: two; may add Centaur or Inertial Upper Stages.
Propulsion: two SRM upgrades (Alliant Techsystems), 1.7 million lb thrust each; stage 1 (LR87-AJ-11), 551,200 lb thrust; stage 2 (LR91-AJ-11), 106,150 lb thrust (stages 1–2, Aerojet); Centaur, 33,000 lb thrust; IUS (Boeing), 41,700 lb thrust.
Dimensions: length (stage 1–2) 119.2 ft, diameter 10 ft.
Weight: 1.9 million lb.
Payload max: 47,800 lb to LEO.

Selected NASA Projects Fiscal 2001 Proposal (Current Dollars)

■ **Discovery**
Funding: $196.8 million. **Mission:** Low-cost planetary exploration program. Genesis spacecraft will collect samples of charged particles in the solar wind and return them to Earth for study. Comet Nucleus Tour (CONTOUR) will intercept and collect data on three comets. **Launch schedule:** Genesis: January 2001; CONTOUR: June 2002.

■ **Earth Observing System**
Funding: $447.1 million. **Mission:** Document global climatic change and observe environmental processes via satellites. **Launch schedule:** First launch Dec. 18, 1999. Complementary mission to measure ozone distribution and depletion scheduled for launch August.

■ **Explorer**
Funding: $138.8 million. **Mission:** Study the effects of solar wind on Earth's magnetosphere, measure the position and brightness of 40 million stars, and study organic compounds in interstellar clouds. **Launch schedule:** 1999–2004.

■ **Hubble Space Telescope**
Funding: $168.1 million. **Mission:** Perform observations at visible, near-ultraviolet, and near-infrared wavelengths. **Launch schedule:** First launched in April 25, 1990. Previous servicing missions: December 1993, February 1997, December 1999. **Upcoming servicing missons:** 2001, 2003.

■ **Relativity (Gravity Probe B)**
Funding: $13.8 million. **Mission:** Test Einstein's theory of general relativity. **Launch schedule:** September 2001.

■ **Space shuttle**
Funding: $3.2 billion **Mission:** Provide safe, reliable, and effective access to space for wide variety of missions, from rendezvous missions with Russian space station Mir, repair and service of the Hubble Space Telescope, advance of life sciences and technology through Spacelab and Spacehab missions, and initial assembly of the International Space Station. **Launch schedule:** six flights for FY00, nine for FY01.

■ **International Space Station**
Funding: $2.1 billion. **Mission:** Establish a long-term residence and laboratory for science research and permanently deploy a crew to the facility. **Launch schedule:** TBD.

■ **Russian Program Assurance**
Funding: $300 million. **Mission:** Fund contingency activities and backup capabilities in the event Russia delays or fails in its commitments to the International Space Station.

■ **Other space operations**
Funding: $80 million. **Missions:** Operation of Hubble Space Telescope, Chandra X-Ray Observatory, and International Solar Terrestrial Physics programs, among others. Support of planetary missions includes Cassini, NEAR, Stardust, and Genesis.

Foreign Space Activities

Russian Operational Spacecraft

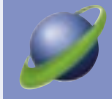
(As of Dec. 31, 1999)

Mission	Type	Number
Communications	Bonum-1	1
	Kosmos (Strela-3)	10
	Gonets-D	4
	Raduga/Raduga-1	5
	Gorizont	9
	Molniya-1	4
	Molniya-3	4
	Kosmos (Geizer)	2
	LMI	1
	Ekran-M	1
	Ekspress	2
	Gals	2
Navigation	Kosmos GLONASS	20
	Kosmos (military)	6
	Kosmos (civil)	4
Meteorology	Meteor-3	1
Early warning	Kosmos (Oko)	6
	Kosmos (Tselina-2)	2
Electronic intelligence	Kosmos (EORSAT)	1
Photoreconnaissance	Kosmos (Arkon-1)	0
Remote sensing	Okean	1
	Okean-O	1
	Resurs-01	2
Geodesy	Kosmos (Etalon)	2
	Kosmos (GEO-IK)	1
Space station activity	Mir	1
	Kvant-1	1
	Kvant-2	1
	Kristall	1
	Spektr	1
	Priroda	1
	Progress M	1
	Zarya (ISS)	1

Russian Payloads by Mission, 1957–99

(As of Dec. 31, 1999)

Platforms	**507**
Earth orbital science	**211**
Automated lunar, planetary	**86**
Moon	34
Mercury	0
Venus	33
Mars	19
Outer planets	0
Interplanetary space	0
Applications	**529**
Communications	310
Weather	74
Geodesy	34
Earth resources	100
Materials processing	11
Piloted activities	**252**
Earth orbital	88
Earth orbital (related)	156
Lunar	0
Lunar (related)	8
Launch vehicle tests	**22**
General engineering tests	**4**
Reconnaissance	**1,097**
Photographic	802
Electronic intelligence	132
Ocean electronic intelligence	84
Early warning	79
Minor military operations	**161**
Navigation	**219**
Theater communication	**535**
Weapons-related activities	**56**
Fractional orbital bombardment	18
Anti-satellite targets	18
Anti-satellite interceptors	20
Other military	**1**
Other civilian	**2**
Total	**3,682**



On June 5, 1927, the Society for Space Travel (Verein für Raumschiffahrt, known as VfR) formed in Breslau, Germany.

On April 4, 1930, the American Interplanetary Society, later the American Rocket Society, was founded in New York City for the promotion of interest in and experimentation toward interplanetary expeditions and travel.

Russian Military vs. Civilian Launches

(As of Dec. 31, 1999)

Year	Military	Civilian	Total
1957	0	2	2
1958	0	1	1
1959	0	3	3
1960	0	3	3
1961	0	6	6
1962	5	15	20
1963	7	10	17
1964	15	15	30
1965	25	23	48
1966	27	17	44
1967	46	20	66
1968	49	25	74
1969	51	19	70
1970	55	26	81
1971	60	23	83
1972	53	21	74
1973	58	28	86
1974	52	29	81
1975	60	29	89
1976	74	25	99
1977	69	29	98
1978	60	28	88
1979	60	27	87
1980	64	25	89
1981	59	39	98
1982	68	33	101
1983	58	40	98
1984	63	34	97
1985	64	34	98
1986	63	28	91
1987	62	33	95
1988	53	37	90
1989	42	32	74
1990	45	30	75
1991	30	29	59
1992	32	22	54
1993	26	21	47
1994	26	22	48
1995	15	17	32
1996	8	17	25
1997	10	18	28
1998	9	15	24
1999	6	22	28
Total	**1,629**	**972**	**2,601**

Russian Launches

(As of Dec. 31, 1999)

	Launches	Spacecraft
Commercial/Foreign	13	32
Communications	4	5
Dummy satellite (ELV test)	1	1
Early warning	1	1
Electronic intelligence (ocean recon)	1	1
Navigation	1	1
Photoreconnaissance	1	1
Piloted flight	1	1
Remote sensing	2	2
Science and technology	1	1
Unmanned space station resupply	2	2
Total	**28**	**48**

Russian Launch Site Activity

(As of Dec. 31, 1999)

Spacecraft	Number of launches
Baikonur Cosmodrome, Tyuratam, Kazakhstan	
Dniepr	1
Proton-K	7
Soyuz-U	3
Soyuz-U/Ikar	6
Tsyklon-M	1
Zenit-2	1
Total	**19**
Kapustin Yar Cosmodrome, Kapustin Yar, Russia	
Kosmos-3M	1
Total	**1**
Odyssey Platform, Pacific Ocean (Sea Launch)	
Zenit-3SL	2
Total	**2**
Plesetsk Cosmodrome, Plesetsk, Russia	
Kosmos-3M	1
Molniya-M	2
Soyuz-U	3
Total	**6**

In February 1959, the world's first polar orbiting satellite, Discoverer 1, lifted into space aboard a Thor/Agena booster. Discoverer was actually the cover name for Corona, America's first photoreconnaissance satellite program. It was declassified in 1995.

On March 23, 1961, weeks before Yuri Gagarin made his historic spaceflight, another Russian orbited the Earth. It was Ivan Ivanovich—the equivalent of John Doe in Russian. Ivan was a mannequin that had such lifelike features that Russian technicians wrote "model" on the forehead so anyone finding the "body" after it landed wouldn't be confused.

Russian Manned Spaceflights

(As of Dec. 31, 1999)

Year	Flights	Persons*
1961	2	2
1962	2	2
1963	2	2
1964	1	3
1965	1	2
1966	0	0
1967	1	1
1968	1	1
1969	5	11
1970	1	2
1971	2	6
1972	0	0
1973	2	4
1974	3	6
1975	4	8
1976	3	6
1977	3	6
1978	5	10
1979	2	4
1980	6	13
1981	3	6
1982	3	8
1983	2	5
1984	3	9
1985	2	5
1986	1	2
1987	3	8
1988	3	9
1989	1	2
1990	3	7
1991	2	6
1992	2	6
1993	2	5
1994	3	8
1995	2	6
1996	2	5
1997	2	5
1998	2	6
1999	1	3
Total	**88**	**200**

*Total number of personnel who flew in space in a given year. (Individuals may have made multiple flights.)

Spacefarers*

(As of Dec. 31, 1999)

Nation	Persons	Nation	Persons
Afghanistan	1	Mongolia	1
Austria	1	Netherlands	1
Belgium	1	Poland	1
Bulgaria	2	Romania	1
Canada	8	Russia	90
Cuba	1	Saudi Arabia	1
Czechoslovakia	1	Slovakia	1
France	8	Spain	1
Germany	8	Switzerland	1
Hungary	1	Syria	1
India	1	Ukraine	1
Italy	3	United Kingdom	1
Japan	5	United States	246
Mexico	1	Vietnam	1
		Total	**390**

*Individuals who have flown in space.

Payloads in Orbit

(As of Dec. 31, 1999)

Launcher/operator	Objects	Launcher/operator	Objects
Argentina	4	Luxembourg	9
Australia	7	Malaysia	2
Brazil	9	Mexico	6
Canada	16	NATO	8
Chile	1	Norway	3
China	30	Philippines	2
Czechoslovakia	4	Portugal	1
Denmark	1	Russia	1,368
Egypt	1	Saudi Arabia	7
ESA	27	Singapore	1
France	46	South Africa	1
France/Germany	3	South Korea	7
Germany	17	Spain	5
India	19	Sweden	8
Indonesia	9	Taiwan	1
Israel	3	Thailand	4
Italy	8	Turkey	2
ITSO*	56	United Kingdom	26
Japan	68	United States	941
		Total	**2,731**

*International Telecommunications Satellite Organization

Other, Launches

(As of Dec. 31, 1999)

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
1996		3	1	10	1	
1997		6	2	12	1	
1998		6	2	11		
1999		4		10	1	
Total	**10**	**60**	**53**	**117**	**9**	**3**

Space Lore

Space Firsts

March 22, 1946
First US rocket to leave Earth's atmosphere, JPL-Ordnance WAC reached 50-mile height after launch from White Sands Proving Ground.
Feb. 24, 1949
Bumper–WAC Corporal two stage rocket, first with fully tanked second stage, reaches record altitude of 244 miles and velocity of 5,150 mph.
July 24, 1950
Bumper No. 8 becomes first missile launched from Cape Canaveral, Fla.
Sept. 20, 1956
US Jupiter C rocket achieves record first flight, reaching altitude of 682 miles and landing 3,400 miles from Cape Canaveral.
Aug. 21, 1957
First successful launch of Soviet R7 rocket, which six weeks later will loft Sputnik into orbit.
Oct. 4
USSR launches Sputnik 1, first man-made satellite, into Earth orbit.
Nov. 3
First animal in orbit, a dog named Laika, is carried aloft by Soviet Sputnik 2.
Dec. 6
First US attempt to launch satellite fails when Vanguard rocket loses thrust and explodes.
Dec. 17
First successful USAF Atlas ICBM test flight.
Jan. 31, 1958
Explorer 1, first US satellite, launched.
May 15
USSR launches first automatic scientific lab aboard Sputnik 3.
Dec. 18
Project Score spacecraft conducts first US active communication from space.
Feb. 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.
Aug. 7
Explorer 6 spacecraft transmits first television pictures from space.
Sept. 12
Soviet Union launches Luna 2, which two days later becomes first man-made object to strike 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 single rocket.
Aug. 11
Capsule ejected from Discoverer 13 parachutes into Pacific Ocean and becomes first orbital payload ever recovered.
Aug. 12
First passive communications carried via Echo 1 satellite.
Aug. 19
Capsule containing first satellite photographs of Soviet Union ejected from Discoverer 14 becomes first orbital payload recovered in midair by C-119 Flying Boxcar.
Jan. 31, 1961
Preparing for manned spaceflight, US first tests life support by launching a Mercury capsule with chimpanzee Ham on a suborbital trajectory.
Feb. 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 15 minutes, 28 seconds.
Oct. 27
First flight of Saturn rocket marks beginning of more than 11 years of Apollo launches.
Feb. 20, 1962
Project Mercury astronaut Lt. Col. John H. Glenn Jr., aboard Friendship 7 capsule, completes first US manned orbital flight.
July 17
Air Force Capt. Robert M. White earns astronaut wings when he reaches altitude of nearly 60 miles in rocket-powered X-15, first aircraft to be flown to lower edge of space, considered to be 50 miles.
Dec. 14
Mariner 2 passes Venus at distance of 21,600 miles, becoming 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 EarlyBird communications satellite) orbits and "parks" over Atlantic to become world's first geosynchronous satellite.
Oct. 17
Vela Hotel satellite performs first space-based detection of nuclear explosion.
July 28, 1964
First close-up lunar pictures provided by Ranger 7 spacecraft.
Aug. 14
First Atlas/Agena D standard launch vehicle successfully fired from Vandenberg AFB.
March 18, 1965
First space walk 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 space walk.
July 14
Mariner provides first close-up pictures of Mars.
Aug. 21
Gemini 5 launched as first manned spacecraft using fuel cells for electrical power rather than batteries.
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 moon. It analyzes soil content and transmits surface images to Earth.
Jan. 25, 1967
Soviet Kosmos 139 anti-satellite weapon carries out first fractional orbit bombardment.
Jan. 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.
Sept. 8
Surveyor 5 conducts first chemical analysis of lunar soil.
Oct. 20, 1968
Soviet Kosmos 248 and Kosmos 249 spacecraft carry out first co-orbital anti-satellite test.
Dec. 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 moon.
Nov. 14–24
US Apollo 12 mission deploys first major scientific experiments on moon and completes first acquisition of samples from earlier spacecraft—Surveyor 3.
Feb. 11, 1970
Japan launches first satellite, Osumi, from Kagoshima Space Center using Lambda 4S solid-fuel rocket.
Jan. 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.
Oct. 28
First British satellite, Prospero, launched into orbit on Black Arrow rocket.
Nov. 2
Titan IIIC launches first Defense Satellite Communications System (DSCS) Phase II satellites into GEO.
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 moon as astronomical laboratory.
July 23
US launches first Earth Resources Technology Satellite (ERTS A), later renamed Landsat 1.
Dec. 3, 1973
Pioneer 10 becomes first space probe to come within reach of Jupiter.
July 15, 1975
US Apollo and Soviet Soyuz 19 perform first international docking of spacecraft in space.
July 20, 1976
NASA's Viking 1 performs first soft landing on Mars and begins capturing images of Red Planet's surface.
Aug. 12, 1977
Space shuttle *Enterprise* performs first free flight after release from Boeing 747 at 22,800 feet.
Feb. 22, 1978
Atlas booster carries first Global Positioning System (GPS) Block I satellite into orbit.
Dec. 13
Successful launch of two DSCS II satellites puts 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.
Dec. 20, 1982
First Defense Meteorological Satellite Program (DMSP) Block 5D-2 satellite launched.
June 13, 1983
Pioneer 10 becomes first spacecraft to leave solar system.
June 18
Space shuttle *Challenger* crew member Sally K. Ride becomes first American woman in space.
Sept. 11, 1985
International Cometary Explorer becomes first man-made object to encounter a comet (Giacobini–Zinner).
Sept. 13
First US anti-satellite intercept test destroys Solwind scientific satellite by air-launched weapon.
Oct. 3, 1985
First launch of *Atlantis* (STS-51J) results in first launch of pair of DSCS III satellites from space shuttle using Inertial Upper Stage.
Jan. 24, 1986
Voyager 2, launched Aug. 20, 1977, makes first solo planet flyby of Uranus and sweeps by Neptune on Aug. 24, 1989, becoming first spacecraft to visit these planets.
Jan. 28
Space shuttle *Challenger* explodes after liftoff, killing seven astronauts.
Feb. 22
France launches first *Satellite Pour l'Observation de la Terre* (SPOT) for remote sensing.
Aug. 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 LEO.
Nov. 15, 1988
USSR makes first launch of 30-ton shuttle *Buran* using Energia rocket.
Feb. 14, 1989
Launch of first Block II GPS satellite begins operational constellation.
Aug. 10, 1990
Unmanned spacecraft Magellan—on first dedicated US mission to study surface of Venus in detail using radar imagery—enters orbit around Venus.
Jan. 17, 1991
What USAF calls "the first space war," Operation Desert Storm, opens with air attacks.
Oct. 29
Galileo swings within 10,000 miles of Gaspra, snapping first close-up images of an asteroid.
May 13, 1992
First trio of space-walking astronauts, working from shuttle *Endeavour,* rescues Intelsat 6 from useless low orbit.
Jan. 13, 1993
USAF Maj. Susan Helms, flying aboard *Endeavour,* becomes first US military woman in space.
July 19
Launch of DSCS Phase III satellite into GEO provides first full five-satellite DSCS III constellation.
Dec. 2–13
USAF Col. Richard O. Covey pilots shuttle *Endeavour* on first mission to repair Hubble Space Telescope, setting a record for most extravehicular activities—five in one mission.
Jan. 25, 1994
Launch of 500-pound unpiloted Clementine spacecraft marks first post–Apollo US lunar mission.
Feb. 7 First Titan IV Centaur booster launches first Milstar Block I satellite into orbit.
March 13
First launch of Taurus booster places two military satellites in orbit.
Nov. 5
Ulysses, first probe to explore sun's environment at high latitudes, completes pass over sun's southern pole and reveals that solar wind's velocity at high latitudes (i.e., about 2 million mph) is nearly twice its velocity at lower latitudes.
Feb. 6, 1995
Shuttle *Discovery* (STS-63) and space station Mir perform first US–Russian space rendezvous in 20 years, with USAF 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.
March 8, 1996
First successful launch of Pegasus XL rocket from beneath modified L-1011 aircraft sends Air Force Radiation Experiment–II satellite into polar orbit.
June 27
Galileo captures first close-up images of Jupiter's moon Ganymede.
April 21, 1997
Celestis, Inc., of Houston performs first space "burial" when Pegasus rocket launched from L-1011 off coast of northwest Africa carries cremated remains of "Star Trek" creator Gene Roddenberry, LSD guru Timothy Leary, and 22 other space enthusiasts into orbit 300 miles above Earth.
April 29
US astronaut Jerry Linenger and Russian cosmonaut Vasily Tsibliev complete five-hour space walk outside Mir, the first such joint excursion in space history.
June 27
In first flyby of "dark, primitive main-belt" type asteroid, NASA's Near-Earth Asteroid Rendezvous spacecraft passes 253 Mathilde.
July 5
One day after Mars Pathfinder lands on surface of Red Planet, Sojourner rover becomes first mobile, semiautonomous, robotic vehicle to traverse another planet's surface.
May 29, 1998
First transfer of operational military space system to civilian agency occurs when Air Force hands to NOAA control of DMSP spacecraft.
June 17
Hughes completes first commercial mission to moon, having used dual lunar flybys to maneuver errant HGS-1 satellite into usable, geosynchronous orbit.
Dec. 4–15
Space shuttle *Endeavour* completes the first ISS assembly mission.

Space Terms

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

Aerospace plane. A reusable spacecraft able to operate effectively in both the atmosphere and space. Also known as a "transatmospheric vehicle" or, more currently, "spaceplane."

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 60 miles to about 50,000 miles from Earth's surface.

Constellation. A formation of satellites 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 GEO 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 (IUS). 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 30 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 60 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 LEO, which ends at about 300 miles altitude, and GEO, which is at an average altitude of 22,300 miles.

Mesosphere. A region of the atmosphere about 30 to 50 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 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 a spacecraft that provide data for mapping, construction, agriculture, oil and gas exploration, news media services, and the like.

Reusable Launch Vehicle (RLV). A launch vehicle that can be reused after flight.

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 12 hours.

Single-Stage-To-Orbit (SSTO) system. A 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 10 to 30 miles above Earth's surface.

Sun synchronous orbit. An orbit inclined about 98° to the equator and at LEO altitude. At this inclination and altitude, a satellite's orbital plane always maintains the same relative orientation to the sun.

Thermosphere. The thin atmosphere about 50 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 10 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.

US Space Command's Space Control Center at Cheyenne Mountain AFS, Colo., tracks nearly 9,000 man-made objects, softball-sized and larger, orbiting Earth. About 7 percent of these objects are operational satellites, 15 percent are rocket bodies, and the remainder are fragmentation and inactive satellites.

Reading About Space

Baker, David. *Scientific American Inventions from Outer Space: Everyday Uses for NASA Technology.* New York: Random House, 2000.

Boyne, Walter. *Beyond the Wild Blue: A History of the United States Air Force, 1947–1997.* New York: St. Martin's Press, 1997.

Burrows, William E. *This New Ocean: The Story of the First Space Age.* New York: Random House, 1998.

Chaikin, Andrew. *A Man on the Moon: The Voyages of the Apollo Astronauts.* New York: Viking Penguin, 1994.

Collins, Michael. *Carrying the Fire: An Astronaut's Journey.* Norwalk, Conn.: Adventure Library, 1998.

Dauber, Philip, and Richard Muller. *The Three Big Bangs: Comet Crashes, Exploding Stars, and the Creation of the Universe.* Reading, Mass.: Addison–Wesley Publishing Co., 1996.

Day, Dwayne A., John M. Logsdon, and Brian Latell, ed. *Eye in the Sky: The Story of the Corona Spy Satellites.* Washington, D.C.: Smithsonian Institution Press, 1998.

Gavaghan, Helen. *Something New Under the Sun: Satellites and the Beginning of the Space Age.* New York: Copernicus/Springer–Verlag, 1998.

Grinspoon, David H. *Venus Revealed: A New Look Below the Clouds of Our Mysterious Twin Planet.* Reading, Mass.: Addison–Wesley Publishing Co., 1997.

Lovell, Jim, and Jeffrey Kluger. *Lost Moon: The Perilous Voyage of Apollo 13.* Boston: Houghton Mifflin, 1994.

Mantz, Michael R. *The New Sword: A Theory of Space Combat Power.* Maxwell AFB, Ala.: Air University Press, 1995.

Mather, John C., and John Boslough. *The Very First Light: The True Inside Story of the Scientific Journey Back to the Dawn of the Universe.* New York: Basic Books, 1996.

McDougall, Walter A. *The Heavens and the Earth: A Political History of the Space Age.* Baltimore: The Johns Hopkins University Press, 1997.

Morgan, Tom, ed. *Jane's Space Directory, 1999–2000.* Alexandria, Va.: Jane's Information Group, Inc., 1999.

Oberg, James E. *Space Power Theory.* Government Printing Office, 1999. (Now only available on the Web: www.spacecom.af.mil/usspace/SPT/overview.htm)

Pace, Scott, et al. *The Global Positioning System: Assessing National Policies.* Santa Monica, Calif.: RAND Critical Technologies Institute, 1995.

Sagan, Carl. *Pale Blue Dot: A Vision of the Human Future in Space.* New York: Random House, 1994.

Shultz, Richard H. Jr., and Robert L. Pfaltzgraff Jr., eds. *Space: A New Strategic Frontier, The Future of Airpower in the Aftermath of the Gulf War.* Maxwell AFB, Ala.: Air University Press, 1992.

Sellers, Jerry Jon. *Understanding Space: An Introduction to Astronautics.* New York: McGraw Hill, 1994.

Slayton, Donald K., with Michael Cassutt. *Deke!: US Manned Space From Mercury to the Shuttle.* New York: St. Martin's Press, 1995.

Spires, David N. et al. *Beyond Horizons: A Half Century of Air Force Space Leadership.* Maxwell AFB, Ala.: Air University Press, 1998.

Stern, Alan, and Jacqueline Mitton. *Pluto and Charon: Ice Worlds of the Ragged Edge of the Solar System.* New York: John Wiley & Sons, Inc., 1999.

Trefil, James. *Other Worlds: Images of the Cosmos from Earth and Space.* Washington, D.C.: National Geographic Society, 1999. ■

The Golden Age of NASA

Name	**Project Mercury**
Duration	**Nov. 3, 1958–May 16, 1963**
Cost	$392.1 million (cost figures are in then-year 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 15-minute suborbital trip **Feb. 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 22 orbits in 34 hours

Name	**Project Gemini**
Duration	**Jan. 15, 1962–Nov. 15, 1966**
Cost	$1.3 billion
Distinction	First program to explore docking, long-duration flight, rendezvous, space walks, and guided re-entry
Highlight	Dockings and rendezvous techniques practiced in preparation for Project Apollo
Number of flights	10
Key events	**June 3–7, 1965** Flight in which Maj. Edward H. White II makes first space walk **Aug. 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 **Sept. 15, 1966** Conrad and Richard F. Gordon Jr. make first successful automatic, computer-steered re-entry

Name	**Project Apollo**
Duration	**July 25, 1960–Dec. 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	11
Key events	**May 28, 1964** First Apollo command module is launched into orbit aboard a Saturn 1 rocket **Jan. 27, 1967** Lt. Col. Virgil I. "Gus" Grissom, Lt. Cmdr. Roger B. Chaffee, and White die in a command module fire in ground test **Oct. 11–22, 1968** First manned Apollo flight proves "moonworthiness" of spacecraft **Dec. 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 **Dec. 7–19, 1972** Final Apollo lunar flight produces sixth manned moon landing

Every two years, NASA receives some 4,000 applications for its 20 or so openings for new astronauts.

The oldest person accepted for astronaut training was Barbara R. Morgan, a civilian selected into the 1998 US astronaut candidate class. She was 46.