

Compiled by Tamar A. Mehuron, Associate Editor



On the following pages appears a variety of information and statistical material about space—particularly military activity in space. This almanac was compiled by the staff of *Air Force Magazine*, with assistance and information from 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.

2001 Space Almanac

The spacecraft depicted in this artist's concept represents a space-based laser.



Introduction

What's Up There

As of May 31, 2001

Country/Organization	Satellites	Space Probes	Debris	Total
CIS (Russia/former USSR)	1,329	35	2,556	3,920
USA	766	46	2,916	3,728
People's Republic of China	33	0	334	367
European Space Agency	29	2	261	292
Japan	67	5	48	120
Iridium	85	0	0	85
Intl. Telecom Sat. Org.	56	0	0	56
Globalstar	52	0	0	52
France	31	0	16	47
Orbcomm	35	0	0	35
India	21	0	1	22
United Kingdom	21	0	1	22
Germany	18	2	1	21
European Telecom Sat. Org.	19	0	0	19
Canada	17	0	0	17
Italy	12	0	3	15
Luxembourg	11	0	0	11
Brazil	10	0	0	10
Sweden	10	0	0	10
Australia	7	0	2	9
Indonesia	9	0	0	9
Intl. Maritime	9	0	0	9
NATO	8	0	0	8
Arab Sat. Comm. Org.	7	0	0	7
Sea Launch (Launch Demo)	1	0	6	7
South Korea	7	0	0	7
Mexico	6	0	0	6
Spain	6	0	0	6
Argentina	5	0	0	5
Czech Republic	4	0	0	4
Intl. Space Station	1	3	0	4
Thailand	4	0	0	4
Turkey	4	0	0	4
Asia Sat. Telecom Co.	3	0	0	3
Israel	3	0	0	3
Malaysia	3	0	0	3
Norway	3	0	0	3
Egypt	2	0	0	2
France/Germany	2	0	0	2
Philippines	2	0	0	2
Saudi Arabia	2	0	0	2
Chile	1	0	0	1
China/Brazil	1	0	0	1
Denmark	1	0	0	1
Portugal	1	0	0	1
Republic of China (Taiwan)	1	0	0	1
Saudi Arabia/France	1	0	0	1
Singapore/Taiwan	1	0	0	1
South Africa	1	0	0	1
UAE	1	0	0	1
Total	2,729	93	6,145	8,967



Robert Goddard stands in 1926 with one of his first successful liquid-fueled rockets. Goddard is considered one of the pioneers of modern space flight.



A Titan IVB lifts a Milstar satellite into orbit on Feb. 27, 2001.

Lockheed Martin Space Systems photo by Russ Underwood

Worldwide Launches by Site, 1957–2000

Launch Site	Nation	Launches
Plesetsk	Russia	1,462
White Sands Missile Range, N.M.	US	1,130
Tyuratam/Baikonur	Kazakhstan	1,084
Vandenberg AFB, Calif.	US	576
Cape Canaveral AFS, Fla.	US	570
Poker Flat Research Range, Alaska	US	281
Kourou	French Guiana	135
JFK Space Center, Fla.	US	120
Kapustin Yar	Russia	84
Tanegashima	Japan	30
Xichang	China	29
Wallops Flight Facility, Va.	US	27
Shuang Cheng-tzu/Jiuquan	China	24
Uchinoura	Japan	23
Taiyuan	China	12
Indian Ocean Platform	Kenya	9
Sriharikota	India	9
Edwards AFB, Calif.	US	5
Hammaguir	Algeria	4
Pacific Ocean Platform	Sea Launch	4
Svobodny	Russia	3
Yavne	Israel	3
Gando AFB, Canary Islands	Spain	3
Woomera	Australia	2
Barents Sea	Russia	1
Kwajalein	US	1
Total		5,631

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.patrick.af.mil
50th Space Wing	www.schriever.af.mil

Industry

Boeing Space Systems	www.boeing.com/defense-space/space
Lockheed Martin Astronautics	www.ast.lmco.com
Orbital Sciences	www.orbital.com
Loral Space & Communications	www.loral.com
Spectrum Astro	www.spectrumastro.com
TRW	www.trw.com

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	www.jpl.nasa.gov
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

June 13, 2000

NASA announces work with MSE Technology Applications, Inc., Butte, Mont., to develop plasma rocket technology that could one day reduce time to reach Mars from eight months to just over three—opening exploration of solar system by humans within next decade.

June 30

Findings published in *Science* reveal NASA's Global Surveyor has observed indications of current sources of liquid water at or near the surface of Mars.

July 8

Fifth test flight of National Missile Defense (NMD) prototype ends in failure after exoatmospheric kill vehicle did not receive a separation signal from its booster rocket.

July 16

Nearly two-hour lunar eclipse—longest in 140 years—occurs.

July 24

Cape Canaveral AFS, Fla., celebrates 50 years of launches from the Cape.

July 25

Russian service module, Zvezda, to serve as living quarters for first crew aboard International Space Station (ISS), successfully docks with ISS.

Aug. 7

NASA announces that its Hubble space telescope has seen at least a half-dozen minicomets with tails, the remains of comet Linear, which most astronomers thought had completely disintegrated.

Aug. 12

The peak of annual Perseid meteor shower arrives just as shock wave from Sun strikes Earth's magnetosphere, triggering powerful geomagnetic storm and brilliant Northern Lights display.

Aug. 17

Robert R. Gilruth, 86, director of NASA's Manned Spacecraft Center during Mercury, Gemini, and Apollo programs, dies.

Aug. 23

Boeing successfully launches its new Delta III rocket, following two earlier failures.

Aug. 25

Researchers report in *Science* that magnetic readings taken by NASA's Galileo provide strong evidence that Europa, one of Jupiter's moons, harbors an ocean of water underneath its icy coat.

Sept. 1

President Clinton announces his intent to leave any decision on NMD deployment to next President.

Sept. 26

NASA announces that images from its Transition Region and Coronal Explorer (TRACE) spacecraft solve decades-old enigma by pinpointing that most heat in Sun's coronal loops occur at their bases. Corona is home to eruptions that can disrupt high-tech systems on Earth.

Sept. 27

USAF changes standard uniform for space and missile operators from blue

one-piece uniform to green flight suit worn by aircrews.

Oct. 1

Maui Space Surveillance Complex in Hawaii transfers from Air Force Space Command (AFSPC) to Air Force Materiel Command (AFMC).

Oct. 9

Retired Gen. James V. Hartinger, first AFSPC commander, dies at 75.

Oct. 23

The 527th Space Aggressor Squadron activates at Schriever AFB, Colo. Mission is to demonstrate how space can be used by an enemy to thwart USAF operations.

Oct. 25

USAF announces it has taken over Mid-course Space Experiment (MSX) satellite, which provides deep space surveillance of satellites, and its ground support infrastructure from Ballistic Missile Defense Organization.

Oct. 31

US astronaut William Shepherd and Russian cosmonauts Yuri Gidzenko and Sergei Krikalev blast off from Baikonur, Kazakhstan, as Expedition 1—first ISS residents.

Oct. 31

China successfully launches its first navigation positioning satellite.

Nov. 3

First of three new Ground-based Electro Optical Deep Space Surveillance system telescopes is installed at Maui Space Surveillance Complex.

Nov. 3

NASA announces that its Chandra X-ray Observatory has spotted never-before-seen clues in afterglow of a gamma-ray burst that may support a "hypernova" model.

Nov. 21

For first time a single Delta II rocket, lifting off from Vandenberg, launches two different primary payloads.

Nov. 30–Dec. 11

Endeavour's crew delivers 17-ton package of solar arrays and equipment to ISS and installs first set of solar panels—measuring 240 feet tip to tip.

Dec. 11

Three North Carolina high school students using NASA's Chandra X-ray Observatory win first place in Siemens–Westinghouse Science and Technology Competition for discovery of first evidence of neutron star in nearby supernova.

Jan. 10–16, 2001

China launches and successfully lands Shenzhou II spacecraft carrying small animals—further preparation for manned flight within next five years.

Jan. 11

Congressionally mandated Space Commission issues report recommending significant organizational realignments and increased responsibilities for USAF.

Jan. 22

AFSPC activates its first counterspace technology unit—76th Space Control Squadron.

Jan. 22–26

AFSPC's Space Warfare Center conducts Schriever 2001—first wargame to explore requirements for space control, counters to enemy space capabilities, and ability of an enemy to deny US and allied use of space.

Feb. 12

NASA's NEAR spacecraft continues transmitting data as it becomes first man-made object to land on an asteroid—Eros—which it had orbited for a year.

Feb. 27

From Cape Canaveral, Titan IVB Centaur launches second Milstar II, the first to successfully reach orbit.

March 1

NASA halts funding of Lockheed Martin's X-33, a subscale single-stage-to-orbit demonstrator, and Orbital Sciences's X-34, a reusable rocketplane demonstrator, in favor of funding for full scale development of a second-generation Reusable Launch Vehicle (RLV) by mid-decade.

March 23

Russia de-orbits Mir space station after more than 15 years' service.

April 7

NASA's return to Mars begins with Delta II launch of Mars Odyssey spacecraft.

April 18

India joins short list of nations able to launch large satellites into deep orbit via their own booster with launch of its Geosynchronous Satellite Launch Vehicle (GSLV).

April 28

Soyuz rocket blasts off from Baikonur carrying world's first space tourist, US businessman Dennis Tito, on week-long excursion to ISS.

May 8

Defense Secretary Donald Rumsfeld announces major national security space management and organizational initiative that designates USAF as DOD Executive Agent for Space.

May 9

USAF announces it will realign AFMC's Space and Missile Systems Center in Los Angeles under AFSPC by Oct. 1.

May 23

X-40A, 85-percent scale model unpiloted RLV completes seventh and final test flight, clearing way for unpiloted flight test of full-scale X-37—a NASA, USAF, Boeing program—as early as 2002.

May 25

Galileo completes closest flyby of Jupiter's moon, Callisto, passing within 86 miles of surface and gathering valuable scientific data.

June 1

Abe Silverstein, early architect of Apollo moon landing, dies at 92.

June 2

NASA destroys X-43A moments after Pegasus booster that was to carry the unpiloted aircraft to 95,000 feet went out of control during first flight test of the experimental hypersonic, scramjet craft. X-43A is a step toward a low-cost, reusable spaceplane.



Military & Civilian Space Budgets

US Space Funding, Current Dollars

(Millions, as of Sept. 30, 2000)

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	174	6,526
1969	3,822	2,013	170	6,005
1970	3,547	1,678	141	5,366
1971	3,101	1,512	162	4,775
1972	3,071	1,407	133	4,611
1973	3,093	1,623	147	4,863
1974	2,759	1,766	158	4,683
1975	2,915	1,892	158	4,965
1976	4,074	2,443	199	6,716
1977	3,440	2,412	194	6,046
1978	3,623	2,738	226	6,587
1979	4,030	3,036	248	7,314
1980	4,680	3,848	231	8,759
1981	4,992	4,828	234	10,054
1982	5,528	6,679	313	12,520
1983	6,328	9,019	327	15,674
1984	6,858	10,195	395	17,448
1985	6,925	12,768	584	20,277
1986	7,165	14,126	477	21,768
1987	9,809	16,287	466	26,562
1988	8,322	17,679	741	26,742
1989	10,097	17,906	565	28,568
1990	11,460	15,616	511	27,587
1991	13,046	14,181	777	28,004
1992	13,199	15,023	805	29,027
1993	13,064	14,106	739	27,909
1994	13,022	13,166	640	26,828
1995	12,543	10,644	766	23,953
1996	12,569	11,514	834	24,917
1997	12,457	11,727	795	24,979
1998	12,321	12,359	829	25,509
1999	12,459	13,203	979	26,641
2000	12,521	13,197	991	26,709
Total	\$278,391	\$293,752	\$16,607	\$588,750

US Space Funding, Constant Dollars

(Millions, as of Sept. 30, 2000)

FY	NASA	DOD	Other	Total
1959	\$1,257	\$2,359	\$164	\$3,780
1960	2,182	2,650	204	5,036
1961	4,333	3,809	323	8,464
1962	8,296	5,993	923	15,212
1963	16,536	7,068	1,181	24,785
1964	22,608	7,207	974	30,788
1965	22,862	7,004	1,086	30,951
1966	22,158	7,389	949	30,497
1967	20,264	6,981	906	28,151
1968	18,379	7,974	723	27,075
1969	15,291	8,054	681	24,026
1970	13,586	6,427	540	20,554
1971	11,274	5,497	589	17,360
1972	10,614	4,863	460	15,936
1973	10,197	5,351	485	16,032
1974	8,697	5,567	498	14,762
1975	8,580	5,569	465	14,613
1976	10,905	6,539	533	17,977
1977	8,309	5,826	469	14,603
1978	8,391	6,341	523	15,256
1979	8,740	6,584	538	15,863
1980	9,416	7,742	465	17,623
1981	9,248	8,944	434	18,626
1982	9,342	11,288	529	21,159
1983	10,010	14,267	517	24,795
1984	10,382	15,690	598	26,415
1985	10,106	18,632	852	29,590
1986	10,127	19,966	674	30,767
1987	13,541	22,484	643	36,669
1988	11,192	23,776	997	35,965
1989	13,155	23,330	736	37,221
1990	14,375	19,589	641	34,605
1991	15,766	17,138	939	33,843
1992	15,373	17,497	938	33,808
1993	14,881	16,068	842	31,791
1994	14,466	14,626	711	29,803
1995	13,622	11,559	832	26,013
1996	13,367	12,245	887	26,499
1997	12,998	12,236	830	26,063
1998	12,641	12,680	851	26,172
1999	12,621	13,375	992	26,987
2000	12,521	13,197	991	26,709
Total	\$512,610	\$451,125	\$29,109	\$992,844

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; and the Environmental Protection Agency (only through 1998). (Note: NSF recalculated its space expenditures since 1968, making them significantly higher in some years than previously reported.) Fiscal 2000 figures are preliminary.

NASA Spending on Major Space Missions

FY 2002 Proposal, Current Dollars

Project Office	Millions
Aerospace technology	\$2,228.8
Biological & physical research	360.9
Earth science	1,515.0
Human spaceflight	7,296.0
Safety, mission assurance, engineering	47.8
Space operations	482.2
Space science	2,786.4
Total	\$14,717.1



People & Organizations

Space Leaders

(As of July 1, 2001)

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–

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, National Reconnaissance Office

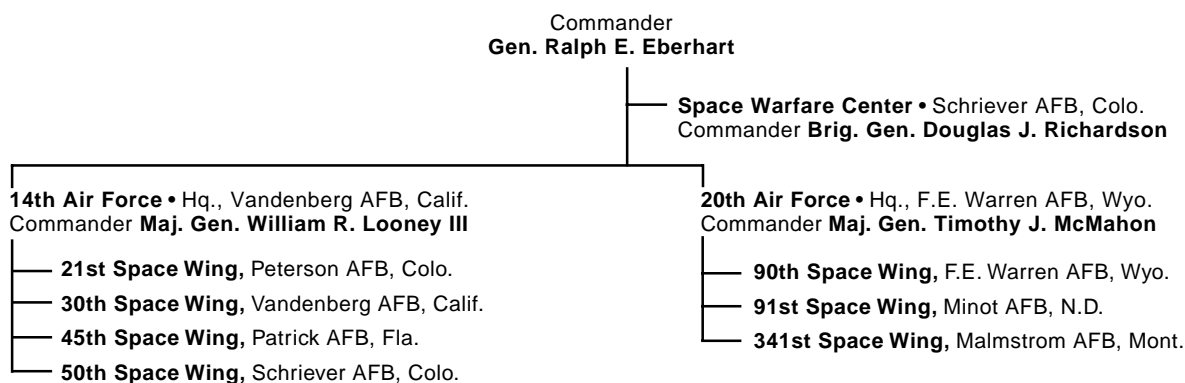
Joseph V. Charyk	Sept. 6, 1961–March 1, 1963
Brockway McMillan	March 1, 1963–Oct. 1, 1965
Alexander H. Flax	Oct. 1, 1965–March 11, 1969
John L. McLucas	March 17, 1969–Dec. 20, 1973
James W. Plummer	Dec. 21, 1973–June 28, 1976
Thomas C. Reed	Aug. 9, 1976–April 7, 1977
Hans Mark	Aug. 3, 1977–Oct. 8, 1979
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–

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, 2001)



Note: The Space and Missile Systems Center in Los Angeles will realign from Air Force Materiel Command to AFSPC in October.



Gen. Ralph E. Eberhart, speaking in June in California to the Tennessee Ernie Ford Chapter of the Air Force Association, heads NORAD, US Space Command, and Air Force Space Command.

Major Military Space Commands

Unified Command	Personnel	Budget, FY2002	Activities
US Space Command Peterson AFB, Colo.	877	\$66.8 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 and attack missions.
Service Command Air Force Space Command Peterson AFB, Colo.	33,600	\$1.9 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.	444	\$117.3 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.	650	\$50.0 million	Manages joint tactical use of DSCS through the 1st Satellite Control Battalion; operates the Army and Army National Guard 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. Brian A. Arnold**

- Defense Meteorological Satellite SPO¹
- 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
Brig. Gen. Craig R. Cooning

- MILSATCOM³
- Space Based Infrared System³
- Evolved Expendable Launch Vehicle³
- ICBM/National Missile Defense
- Navstar Global Positioning System JPO^{2/3}

USAF Mission Area Director for Space & Nuclear Deterrence
Maj. Gen. (sel.) Joseph B. Sovey

¹System Program Office

²Joint Program Office

³Program 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)

Headquarters: Washington, D.C.
 Established: 1947
 Director: George J. Tenet

Mission, Purpose, Operations

The CIA's Directorate for Science and Technology includes the Office of Development and Engineering, which develops 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 18,000

National Oceanic and Atmospheric Administration (NOAA)

Headquarters: Washington, D.C.
 Established: Oct. 3, 1970
 Administrator and Undersecretary for Oceans and Atmosphere: Scott Gudes (acting)

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 814
 Other NOAA employees 11,681
 Total 12,495

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. Two offices and four directorates report up to the level of the director. Offices are management services and operations and corporate operations. 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 assurance 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.



Space Operations

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: 570.

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: 120.

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: 576.

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 DOD missions and NASA's suborbital

sounding rockets.

Launches: 27.

Launch vehicles: Pegasus.

History: Established in 1945, it is one of world's oldest launch sites.

Acres: 6,166.

Sea Launch

Location: Equator, 154° W, Pacific Ocean.

Mission/operations: Provide heavy lift GTO launch services for commercial customers worldwide. Sea Launch is owned by an international partnership: Boeing, RSC Energia, Anglo-Norwegian Kvaerner Group, and SDO Yuzhnoye/PO Yuzhmash.

Launches: Five.

Launch vehicles: Zenit and Block DM-SL.

History: Established in April 1995; demonstration launch March 1999.

Spaceport Florida Authority

Location: 28.5° N, 80° W.

Mission/operations: Various launch complexes and support facilities developed, operated, and/or financed by the state of Florida at the Cape Canaveral Spaceport (comprising Cape Canaveral AFS and Kennedy Space Center). SFA operates launch complexes 20 and 46 for orbital and suborbital launch vehicles. SFA also developed and/or owns infrastructure at launch complexes 37 and 41 and manages a multiuser launch control facility, space station experiment laboratory, and other facilities.

Launches: 12.

Launch vehicles: Athena I, II; Minotaur; Minuteman III; Taurus; Terrier.

History: Established in 1989.

Spaceport Systems International, L.P.

Location: 34.70° N, 120.46° 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: Two.

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 is complete. Funding secured by Alaska Aerospace Development Corp., Alaska's spaceport authority. KLC will be the only nonfederally run commercial launch range in US. Complex designed for all indoor processing of payload and launch vehicles.

Launches: Three.

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: 11 (since 1995).

Launch vehicles: Athena I, II; Black Brant; Minotaur; Orion; Pegasus; Taurus; Terrier.

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: 281.

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: 1,130.

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: Launches from 1957–2000, 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 Operations

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. Develop computer network attack capabilities to be used in operations that disrupt, deny, degrade, or destroy information resident in computers and computer networks, or the computers and networks themselves.

Environmental/Remote Sensing

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

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.

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.

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.

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.

USAF photo by SrA. Suzanne Jenkins



A Boeing Delta II rocket taking off from Vandenberg AFB, Calif., on Nov. 21, 2000, successfully boosts two primary payloads into orbit.

US Military vs. Civilian Launches (As of Dec. 31, 2000)

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
2000	11	17	28
Total	511	708	1,219

US Satellites in Orbit and Deep Space (As of Dec. 31, 2000)

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	15	10	0	25
1965	18	18	0	36
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	12	4	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	22	3	4	29
1991	10	4	2	16
1992	11	4	4	19
1993	13	5	3	21
1994	11	4	5	20
1995	10	4	10	24
1996	15	5	6	26
1997	9	5	65	79
1998	7	7	71	85
1999	8	11	57	76
2000	8	19	18	45
Total	435	254	291	980

USN photo by Michael J. Bloomfield



Space shuttle Endeavour returned with this photo of the evolving International Space Station. It shows the addition of the 240-foot-long, 38-foot-wide solar array.

Upcoming Shuttle Flights

Month/Year	Mission	Name
8/2001	STS-105	<i>Discovery</i>
11/2001	STS-108	<i>Endeavour</i>
1/2002	STS-109	<i>Columbia</i>
2/2002	STS-110	<i>Atlantis</i>
4/2002	STS-107	<i>Columbia</i>
4/2002	STS-111	<i>Discovery</i>
7/2002	STS-112	<i>Atlantis</i>

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
2000	5	31
Total	131	656

US Payloads by Mission, 1957–2000

Category	Number
Applications	663
<i>Communications</i>	514
<i>Weather</i>	106
<i>Geodesy</i>	20
<i>Earth resources</i>	21
<i>Materials processing</i>	2
Automated lunar, planetary	64
<i>Moon</i>	26
<i>Mercury</i>	1
<i>Venus</i>	8
<i>Mars</i>	13
<i>Outer planets</i>	5
<i>Interplanetary space</i>	11
Earth orbital science	240
General engineering tests	69
Launch vehicle tests	13
Minor military operations	44
Navigation	88
Other military	18
Other civilian	5
Piloted activities	171
<i>Earth orbital</i>	120
<i>Earth orbital (related)</i>	14
<i>Lunar</i>	20
<i>Lunar (related)</i>	17
Platforms	0
Reconnaissance	435
<i>Photographic</i>	250
<i>Electronic intelligence</i>	96
<i>Ocean electronic intelligence</i>	39
<i>Early warning</i>	50
Theater communication	0
Weapons-related activities	2
<i>Fractional orbital bombardment</i>	0
<i>Anti-satellite targets</i>	2
<i>Anti-satellite interceptors</i>	0
Total	1,812

Endeavour lifts off in April from Kennedy Space Center on mission STS-100.





A Lockheed Martin Athena II low- to medium-weight booster stands on a pad at Vandenberg AFB, Calif.

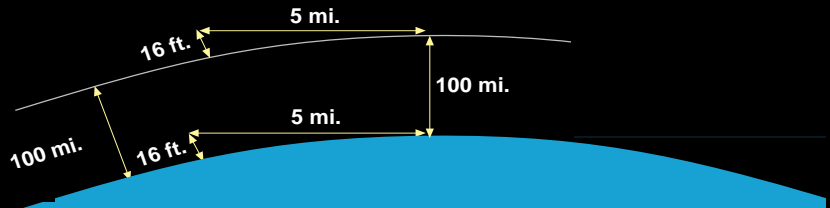


A USAF Milstar satellite sits at the top of a Titan IV booster at Cape Canaveral AFS, Fla.

Continued on p. 44.

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.

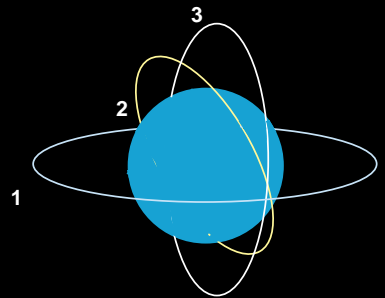
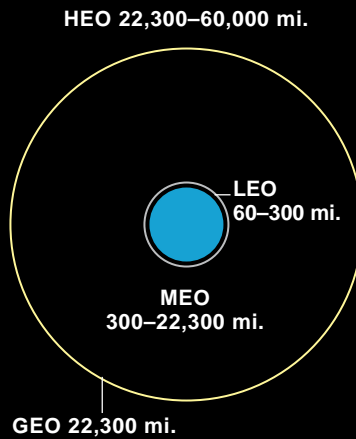


Orbital Altitude

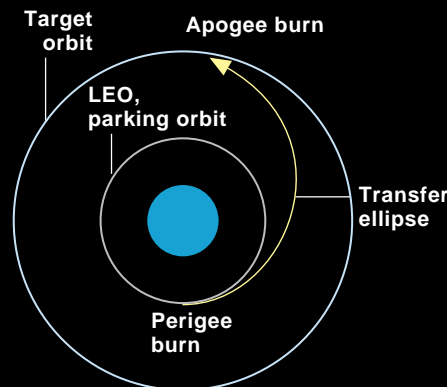
- LEO Low Earth Orbit
- MEO Medium Earth Orbit
- GEO Geosynchronous Earth Orbit
- HEO High Earth Orbit

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.

Space Shuttle Flights, 1981–2001

(As of June 6, 2001)

Flight	Mission	Launch	Return	Flight	Mission	Launch	Return
1	STS-1	4/12/81	4/14/81	53	STS-54	1/13/93	1/19/93
2	STS-2	11/12/81	11/14/81	54	STS-56	4/8/93	4/17/93
3	STS-3	3/22/82	3/30/82	55	STS-55	4/26/93	5/6/93
4	STS-4	6/27/82	7/4/82	56	STS-57	6/21/93	7/1/93
5	STS-5	11/11/82	11/16/82	57	STS-51	9/12/93	9/22/93
6	STS-6	4/4/83	4/9/83	58	STS-58	10/18/93	11/1/93
7	STS-7	6/18/83	6/24/83	59	STS-61	12/2/93	12/13/93
8	STS-8	8/30/83	9/5/83	60	STS-60	2/3/94	2/11/94
9	STS-9	11/28/83	12/8/83	61	STS-62	3/4/94	3/18/94
10	STS-10	2/3/84	2/11/84	62	STS-59	4/9/94	4/20/94
11	STS-11	4/6/84	4/13/84	63	STS-65	7/8/94	7/23/94
12	STS-12	8/30/84	9/5/84	64	STS-64	9/9/94	9/20/94
13	STS-13	10/5/84	10/13/84	65	STS-68	9/30/94	10/11/94
14	STS-14	11/8/84	11/16/84	66	STS-66	11/3/94	11/14/94
15	STS-15	1/24/85	1/27/85	67	STS-63	2/3/95	2/11/95
16	STS-16	4/12/85	4/19/85	68	STS-67	3/2/95	3/18/95
17	STS-17	4/29/85	5/6/85	69	STS-71	6/27/95	7/7/95
18	STS-18	6/17/85	6/24/85	70	STS-70	7/13/95	7/22/95
19	STS-19	7/29/85	8/6/85	71	STS-69	9/7/95	9/18/95
20	STS-20	8/27/85	9/3/85	72	STS-73	10/20/95	11/5/95
21	STS-21	10/3/85	10/7/85	73	STS-74	11/12/95	11/20/95
22	STS-22	10/30/85	11/6/85	74	STS-72	1/11/96	1/20/96
23	STS-23	11/26/85	12/3/85	75	STS-75	2/22/96	3/9/96
24	STS-24	1/12/86	1/18/86	76	STS-76	3/22/96	3/31/96
25	STS-25	1/28/86	No Landing	77	STS-77	5/19/96	5/29/96
26	STS-26	9/29/88	10/3/88	78	STS-78	6/20/96	7/7/96
27	STS-27	12/2/88	12/6/88	79	STS-79	9/16/96	9/26/96
28	STS-29	3/13/89	3/18/89	80	STS-80	11/19/96	12/7/96
29	STS-30	5/4/89	5/8/89	81	STS-81	1/12/97	1/22/97
30	STS-28	8/8/89	8/13/89	82	STS-82	2/11/97	2/21/97
31	STS-34	10/18/89	10/23/89	83	STS-83	4/4/97	4/8/97
32	STS-33	11/22/89	11/27/89	84	STS-84	5/15/97	5/24/97
33	STS-32	1/9/90	1/20/90	85	STS-94	7/1/97	7/17/97
34	STS-36	2/28/90	3/4/90	86	STS-85	8/7/97	8/19/97
35	STS-31	4/24/90	4/29/90	87	STS-86	9/25/97	10/6/97
36	STS-41	10/6/90	10/10/90	88	STS-87	11/19/97	12/5/97
37	STS-38	11/15/90	11/20/90	89	STS-89	1/22/98	1/31/98
38	STS-35	12/2/90	12/10/90	90	STS-90	4/17/98	5/3/98
39	STS-37	4/5/91	4/11/91	91	STS-91	6/2/98	6/12/98
40	STS-40	6/5/91	6/14/91	92	STS-95	10/29/98	11/7/98
41	STS-43	8/2/91	8/11/91	93	STS-88	12/4/98	12/15/98
42	STS-48	9/12/91	9/18/91	94	STS-96	5/27/99	6/6/99
43	STS-44	11/24/91	12/1/91	95	STS-93	7/22/99	7/27/99
44	STS-39	4/28/91	5/6/91	96	STS-103	12/19/99	12/27/99
45	STS-42	1/22/92	1/30/92	97	STS-99	2/11/00	2/22/00
46	STS-45	3/24/92	4/2/92	98	STS-101	5/19/00	5/29/00
47	STS-49	5/7/92	5/16/92	99	STS-106	9/8/00	9/19/00
48	STS-50	6/25/92	7/9/92	100	STS-92	10/11/00	10/24/00
49	STS-46	7/31/92	8/8/92	101	STS-97	11/30/00	12/11/00
50	STS-47	9/12/92	9/20/92	102	STS-98	2/7/01	2/20/01
51	STS-52	10/22/92	11/1/92	103	STS-102	3/8/01	3/20/01
52	STS-53	12/2/92	12/9/92	104	STS-100	4/19/01	5/1/01



Air Force Capt. Robert M. White (center) became the first person to gain astronaut status in a winged aircraft when he flew the X-15 rocket-powered research aircraft to an altitude of nearly 60 miles on July 17, 1962.



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 C² 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: 2005, planned.
Constellation: four.
Orbit altitude: 22,300 miles.
Contractors: Lockheed Martin, Boeing 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 Integrated Program Office.
First launch: May 23, 1962.
Constellation: two (primary).
Orbit altitude: 500 miles (nominal).
Contractor: Lockheed Martin.
Power plant: solar array, 500–600 watts.
Dimensions: width 4 ft, length 20 ft 2 in (with array deployed).
Weight: 2,545 lb (including 592-lb sensor).

Defense Satellite Communications System III

Common name: DSCS III
In brief: nuclear-hardened and jam-proof spacecraft used to transmit high-priority C² 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: US Navy.
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 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 (and four spares).
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: four.
On orbit: three.
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: 1997.
Constellation: two.
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: 4 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: nine.
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 2004.
Function: wideband communications and point-to-point service (Ka-band, X-band frequency).
Operator: AFSPC.
First launch: FY04, planned.
Constellation: three.
Orbit altitude: GEO.
Contractor: Boeing.
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: 20.
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).

Continued on p. 50.

Continued from p. 47.

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 2002 Proposal (Current Dollars)

■ Discovery

Funding: \$217.1 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: July 2001; CONTOUR: July 2002.

■ Earth Observing System

Funding: \$371.9 million. **Mission:** Document global climatic change and observe environmental processes via satellites. **Launch schedule:** First launch Dec. 18, 1999. Other launches scheduled for 2001–03.

■ Explorer

Funding: \$155 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:** IMAGE launched March 25, 2000. Additional launches through 2005.

■ Hubble Space Telescope

Funding: \$161.8 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 missions:** 2002.

■ Relativity (Gravity Probe B)

Funding: \$40.2 million. **Mission:** Test Einstein's theory of general relativity. **Launch schedule:** October 2002.

■ Space shuttle

Funding: \$3.3 billion **Mission:** Provide safe, reliable, and effective access to space for wide variety of missions, such as

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 (ISS). **Launch schedule:** seven flights for FY01, seven for FY02.

■ International Space Station

Funding: \$2.1 billion. **Mission:** Establish a long-term residence and laboratory for science research and set-up permanent crew capability. FY01 was first year of crewed on-orbit operations.

■ Russian Program Assurance

Funding: FY02 funding is under review. **Mission:** Fund contingency activities and backup capabilities in the event Russia delays or fails in its commitments to ISS.

■ Other space operations

Funding: \$39.2 million. **Missions:** Support of planetary missions includes NEAR, Stardust, Genesis, and CONTOUR.



Foreign Space Activities

Russian Operational Spacecraft (As of Dec. 31, 2000)

Mission	Type	Number
Communications	Bonum-1	1
	Ekran-M	1
	Ekspres	4
	Gals	2
	Gonets-D	4
	Gorizont	5
	Kosmos (Geizer)	2
	Kosmos (Strela-3)	6
	LMI	1
	Molniya-1	4
	Molniya-3	4
	Raduga/Raduga-1	5
	Yamal	1
	Early warning	Kosmos (Oko)
Electronic intelligence	Kosmos (EORSAT)	1
	Kosmos (Tselina-2)	2
Geodesy	Kosmos (Etalon)	2
	Kosmos (GEO-IK)	1
Meteorology	Meteor-3	1
Navigation	Dedicated SAR	1
	Kosmos (civil)	4
	Kosmos GLONASS	12
	Kosmos (military)	6
Photoreconnaissance	Kosmos (Yantar-4KS1)	1
	Kosmos (Orlets-2)	1
Remote sensing	Okean	1
	Okean-O	1
	Resurs-01	2
Space station activity	Kristall (Mir)	1
	Kvant-1 (Mir)	1
	Kvant-2 (Mir)	1
	Mir core	1
	Priroda (Mir)	1
	Progress M (Mir)	1
	Progress-M1 (ISS)	1
	Soyuz-TM (ISS)	1
	Spektr (Mir)	1
	Zarya (ISS)	1
Zvezda (ISS)	1	

Russian Payloads by Mission, 1957–2000 (As of Dec. 31, 2000)

Platforms	518
Earth orbital science	211
Automated lunar, planetary	86
<i>Moon</i>	34
<i>Mercury</i>	0
<i>Venus</i>	33
<i>Mars</i>	19
<i>Outer planets</i>	0
<i>Interplanetary space</i>	0
Applications	534
<i>Communications</i>	315
<i>Weather</i>	74
<i>Geodesy</i>	34
<i>Earth resources</i>	100
<i>Materials processing</i>	11
Piloted activities	259
<i>Earth orbital</i>	90
<i>Earth orbital (related)</i>	161
<i>Lunar</i>	0
<i>Lunar (related)</i>	8
Launch vehicle tests	27
General engineering tests	4
Reconnaissance	1,101
<i>Photographic</i>	805
<i>Electronic intelligence</i>	133
<i>Ocean electronic intelligence</i>	84
<i>Early warning</i>	79
Minor military operations	161
Navigation	223
Theater communication	535
Weapons-related activities	56
<i>Fractional orbital bombardment</i>	18
<i>Anti-satellite targets</i>	18
<i>Anti-satellite interceptors</i>	20
Other military	1
Other civilian	2
Total	3,718



Lockheed Martin photo by Russ Underwood

A Lockheed Khrunichev Energia International (LKEI) Proton booster waits for launch at the Baikonur Cosmodrome in Kazakhstan.



This 1996 photo shows Russia's Mir space station in orbit. The Russians de-orbited the Mir on March 23, 2001, after more than 15 years' service.

Russian Military vs. Civilian Launches

(As of Dec. 31, 2000)

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	26
2000	7	28	35
Total	1,636	1,000	2,634

Russian Launches

(As of Dec. 31, 2000)

	Launches	Spacecraft
Commercial/Foreign	15	24
Communications	5	5
Dedicated SAR	1	1
Dummy satellite (ELV test)	3	4
Electronic intelligence (ocean recon)	1	1
Navigation	1	3
Photoreconnaissance	3	3
Piloted flight	2	2
Remote sensing	2	2
Space station module	1	1
Unmanned space station resupply	5	5
Total	39	51

Russian Launch Site Activity

(As of Dec. 31, 2000)

Spacecraft	Number of launches
Baikonur Cosmodrome, Tyuratam, Kazakhstan	
Dniepr	1
Proton-K	14
Soyuz-U	9
Soyuz-U/Fregat	4
Zenit-2	2
Total	30
Svobodny Cosmodrome, Svobodny, Russia	
Start-1	1
Total	1
Odyssey Platform, Pacific Ocean (Sea Launch)	
Zenit-3SL	2
Total	2
Plesetsk Cosmodrome, Plesetsk, Russia	
Kosmos-3M	3
Rokot	1
Total	4

Russian Manned Spaceflights

(As of Dec. 31, 2000)

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
2000	2	5
Total	90	205

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

Spacefarers*

(As of Dec. 31, 2000)

Nation	Persons	Nation	Persons
Afghanistan	1	Mongolia	1
Austria	1	Netherlands	1
Belgium	1	Poland	1
Bulgaria	2	Romania	1
Canada	8	Russia	92
Cuba	1	Saudi Arabia	1
Czechoslovakia	1	Slovakia	1
France	8	Spain	1
Germany	9	Switzerland	1
Hungary	1	Syria	1
India	1	Ukraine	1
Italy	3	United Kingdom	1
Japan	5	United States	250
Mexico	1	Vietnam	1
		Total	397

*Individuals who have flown in space.

Payloads in Orbit

(As of Dec. 31, 2000)

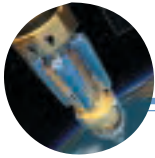
Launcher/operator	Objects	Launcher/operator	Objects
Russia	1,371	Mexico	6
United States	980	Spain	6
Japan	71	Argentina	5
ITSO*	56	Czechoslovakia	4
France	50	Thailand	4
China	35	International Space Station	3
ESA	30	Israel	3
United Kingdom	29	Malaysia	3
Germany	20	Norway	3
India	20	Turkey	3
Canada	17	Egypt	2
Italy	11	France/Germany	2
Luxembourg	11	Philippines	2
Brazil	10	Chile	1
Indonesia	9	Denmark	1
Saudi Arabia	9	Portugal	1
Sweden	9	Singapore	1
NATO	8	South Africa	1
Australia	7	Taiwan	1
South Korea	7	United Arab Emirates	1
		Total	2,813

*International Telecommunications Satellite Organization

Other, Launches

(As of Dec. 31, 2000)

Year	China	ESA	France	India	Israel	Japan
1965			1			
1966			1			
1967			2			
1968						
1969						
1970	1		2			1
1971	1		1			2
1972						1
1973						
1974						1
1975	3		3			2
1976	2					1
1977						2
1978	1					3
1979		1				2
1980				1		2
1981	1	2		1		3
1982	1					1
1983	1	2		1		3
1984	3	4				3
1985	1	3				2
1986	2	2				2
1987	2	2				3
1988	4	7			1	2
1989		7				2
1990	5	5			1	3
1991	1	8				2
1992	4	7		1		1
1993	1	7				1
1994	5	6		2		2
1995	2	11			1	1
1996	3	10		1		1
1997	6	12		1		2
1998	6	11				2
1999	4	10		1		
2000	5	12				
Total	65	129	10	9	3	53



Space Firsts

March 22, 1946

First US rocket to leave Earth's atmosphere, JPL-Ordnance WAC reaches 50-mile height after launch from White Sands Proving Ground, N.M.

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/Agema 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/Agema D standard launch vehicle successfully fired from Vandenberg.

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 II 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 in US spacecraft 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's Neil A. Armstrong is first human to walk 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 and 23 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 (NEAR) 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.

July 23–27, 1999

Air Force Col. Eileen M. 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.

Feb. 14, 2000

NEAR spacecraft becomes first man-made object to orbit, and later to land on, asteroid—433 Eros.

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.

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. *Deep Black.* New York: Berkley Publishers Group, 1988.

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

Canan, James W. *War in Space.* New York: Harper & Row, 1982.

Collins, John M. *Military Space Forces.* Washington, D.C.: Pergamon–Brassey's, 1989.

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

Department of Defense Space Technology Guide, FY 2000–01. Office of the Secretary of Defense, 2001 (on Web at www.c3i.osd.mil/org/c3is/spacesys/index.html).

Goure, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium.* Washington, D.C.: CSIS Press, 1997.

Hall, R. Cargill, and Jacob Neufeld, eds. *The US Air Force in Space: 1945 to the 21st Century: Proceedings, Air Force Historical Foundation Symposium.* Washington, D.C.: USAF History and Museums Program, 1998.

Hayes, Peter. *Space Power Interests.* Boulder, Colo.: Westview Press, 1996.

Hobbs, David. *Space Warfare.* Old Tappan, N.J.: Prentice–Hall, 1986.

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.

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

Hopkins University Press, 1997.

Muolo, Michael L., Richard A. Hand, Bonnie Houchen, and Lou Larson. *Space Handbook* (two volumes). Maxwell AFB, Ala.: Air University Press, 1993.

The National Space Transportation Policy: Issues for Congress. US Congress. Office of Technology Assessment. Washington, D.C.: Government Printing Office, 1995.

Neal, Valerie, Cathleen S. Lewis, and Frank H. Winter. *Spaceflight: A Smithsonian Guide.* New York: Macmillan, 1995.

Newberry, Maj. Robert D., USAF. *Space Doctrine for the Twenty-First Century.* Maxwell AFB, Ala.: Air University Press, 1998.

Oberg, James E. *Space Power Theory.* Washington, D.C.: Government Printing Office, 1999 (on Web at www.spacecom.af.mil/usspace/SPT/overview.htm).

Peebles, Curtis. *The Corona Project: America's First Spy Satellites.* Annapolis, Md.: Naval Institute Press, 1997.

Report of the Commission to Assess United States National Security Space Management and Organization. US Department of Defense, 2001 (on Web at www.space.gov).

Richelson, Jeffrey T. *America's Secret Eyes in Space.* New York: Harper & Row, 1990.

Richelson, Jeffrey T. *America's Space Sentinels: DSP Satellites and National Security.* Lawrence, Kan.: University of Kansas Press, 1999.

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.

Smith, Marcia S. *Space Activities of the United States, CIS, and Other Launching Countries/Organizations: 1957–1993.* Washington, D.C.: Congressional Research Service, 1994.

Smith, Marcia S. *US Space Programs.* Washington, D.C.: Congressional Research Service, 1993.

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

Wolfe, Tom. *The Right Stuff.* New York: Bantam Books, 1980.

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 extended 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