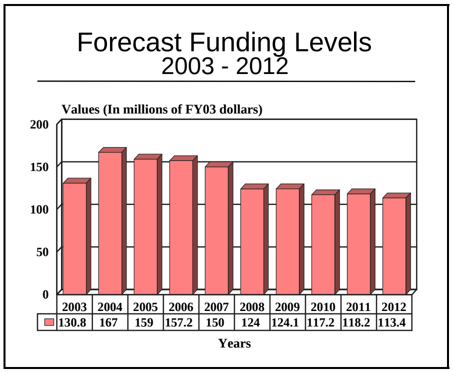
NAVSTAR GPS Terminals - Archived 12/2004

Outlook

- U.S. Naval Extended Range Guided Munition guided by Tru-Trak GPS receiver successfully engages target
- Rockwell Collins selected by the U.S. Army for the NAVSTAR Ground-Based GPS Receiver Application Module initiative
- Raytheon to develop the next-generation militarized GPS system with anti-jam and stealth capabilities for the F-35 Joint Strike Fighter



Orientation

Description. Three-dimensional, space-based navigation system. This report covers global positioning system (GPS) receivers for military, commercial, and civil aircraft applications.

Sponsor

United States Space Command
250 South Peterson Boulevard
Suite 116
Peterson AFB, Colorado (CO) 80914
USA
Web site: www.spacecom.af.mil/usspace

United States Air Force
Aeronautical Systems Center
Wright-Patterson AFB, Ohio (OH) 45433
USA
Web site: www.af.mil

United States Navy
Naval Air Systems Command (NAVAIR)
Air-09C/2.0C Bldg. 441
21983 Bundy Road, Unit #7
Patuxent River, Maryland (MD) 20670-1127
USA
Tel: +1 301 757 9044
Web site: www.navy.mil

United States Army
Communications & Electronics Command
Fort Monmouth, New Jersey (NJ) 07703
USA
Tel: +1 732 532 4511
Web site: www.army.mil

Contractors

ARINC Research Inc
2551 Riva Road
Annapolis, Maryland (MD) 21401
USA
Tel: +1 410 266 4000
Fax: +1 410 266 4040
Web site: http://www.arinc.com
(GPS integration/services for KC-10, E-4, C-9 aircraft)

The Boeing Company
(formerly McDonnell Douglas)
PO Box 3707
Seattle, Washington (WA) 98124
USA
Tel: +1 206 655 2121
Fax: +1 206 655 1177
Web site: http://www.boeing.com
E-mail: boeing@pss.boeing.com
(Integration of GPS/INS in F/A-18; GPS for T-1 and F-15 aircraft; GPS/INS for E-3 and Boeing 767 AWACS, and E-6 aircraft; GPS upgrades for B-1; and Pacer Crag upgrade kits)

Raytheon
(Chrysler Technologies Corp)
1725 Jefferson Davis Highway
Suite 500
Arlington, Virginia (VA) 22202
USA
Tel: +1 703 413 4416
Fax: +1 703 413 4443
Web site: http://www.raytheon.com
(GPS Mod kits for C-141 and C-130)

Harris Corp
Government Communications Systems Division
PO Box 91000
Melbourne, Florida (FL) 32902
USA
Tel: +1 800 442 7747
Fax: +1 407 729 4167
Web site: http://www.harris.com
E-mail: communications@harris.com
(Airborne GPS digital-analog converter program)

Honeywell Inc
Space & Aviation Control
Space Systems Group
13350 U.S. Hwy 19 North
Clearwater, Florida (FL) 34624
Tel: +1 813 539 3447
Web site: http://www.honeywell.com
E-mail: Query form available through Web site
(Embedded GPS/INS for helicopters and fixed-wing aircraft)

Lockheed Martin Aeronautical Systems
86 South Cobb Drive
Marietta, Georgia (GA) 30063
USA
Tel: +1 404 494 4411
Fax: +1 404 494 7518
Web site: http://www.lockheedmartin.com
(INSII/GPS for S-3B and ES-3A navigation upgrade; GPS retrofit kits for F-16C/D)

Northrop Grumman Corp
1840 Century Park East
Los Angeles, California (CA) 90067
USA
Tel: +1 310 553 6262
Fax: +1 310 201 3023
Web site: http://www.northgrum.com
(GPS-aided munitions for B-2 aircraft; embedded GPS/INS; MAGR; embedded GPS/INS for F/A-18 and EA-6B aircraft)

Rockwell Collins Inc
400 Collins Road NE
Cedar Rapids, Iowa (IA) 52498
USA
Tel: +1 319 295 1000
Fax: +1 319 295 5429
Web: http://www.rockwell.com
E-mail: collins@collins.rockwell.com
(MAGR; multimode receivers for commercial aircraft)

Sechan Electronics Inc
525 Furnace Hills
Lititz, Pennsylvania (PA) 17543-8954
USA
Web site: http://www.sechan.com
(GPS modification kits for C-5)

Smiths Industries Aerospace & Defense Systems Inc
4141 Eastern Avenue SE
Grand Rapids, Michigan (MI) 49518
USA
Tel: +1 616 241 7000
Fax: +1 616 241 7533
Web site: http://www.smithsind-aerospace.com
(GPS for navigation system aboard 7HC-130P/N aircraft)

Trimble Navigation Ltd
Military Systems
645 North Mary Avenue
Sunnyvale, California (CA) 94086
USA
Tel: +1 408 481 8000
Fax: +1 408 481 2000
Web site: http://www.trimble.com
(CUGR for U.S. Army UH-1 helicopters)

Status. GPS achieved full operational status in July 1995. Various receivers for military and commercial applications are in development and/or production.

Total Produced. Since NAVSTAR GPS devices have been developed into a variety of products, it has become impractical to track the production of all NAVSTAR GPS terminals.

Application. GPS is designed to provide worldwide navigation coverage at sea, on the ground, in the air, or in low-Earth orbit.

Price Range. Considering the variety of NAVSTAR GPS terminals available, it is not practical to provide a price range for these devices.

Technical Data

Satellite Segment Design Features. The NAVSTAR (Navigation System Time and Ranging) GPS (Global Positioning System) program uses 21 active satellites and three spares placed in 12-hour period, 55° inclination-angle orbits. They are longitudinally segregated into six equally spaced planes (60° separation), with satellites evenly spaced (120° separation) in each of these planes. The altitude of each of the orbits is 20,200 kilometers (10,900 nm). The system provides 24-hour positioning data worldwide.

All GPS satellites are controlled over an S-band link: 2,227.5 MHz for the uplink, 1,783.74 MHz for the downlink. They transmit navigation data in spread-spectrum format using two frequencies: the L1 frequency band (1,575.42 MHz) and the L2 frequency band (1,227.6 MHz).

User Equipment Design Features. A wide range of NAVSTAR equipment has evolved over the years, hence this section clarifies the equipment features in very general terms. The GPS user segment consists of signal receivers/processors, antennas, and control/display units. Receivers calculate pseudo-range and pseudo-range rate. Pseudo-range is the distance from each satellite to the receiver, plus an offset due to clock bias. Because this distance is not perfectly measured, it is called a pseudo-range instead of simply a range. Pseudo-range rate gives the velocity between receiver and satellite – again, with a clock offset.

The basic calculation method is to determine the time lag from each satellite's transmitter to the GPS receiver. Then the ephemeris of each satellite is calculated, giving the position of each satellite when it transmitted each bit of data. From four satellites, the receiver may obtain three-dimensional (position, velocity, and time) data.

Operational Characteristics. Based on tests conducted by the U.S. Air Force using an initial constellation of seven satellites, the GPS demonstrated accuracy in position to within 35 feet for aircraft and ground vehicles. Speeds have been measured to within 0.1 knot, and time transmitted with an accuracy to within millionths of a second. The accuracies indicated were achieved through the use of two satellite channels simultaneously. Accuracy is not dependent on the number of channels. Rather, it is a function of the time it takes to gain a fix and reacquire it.

Up until May 2000, the United States Department of Defense had opted for a selected availability (SA) security capability that allowed the U.S. to intentionally degrade the GPS signals by closing out the P code (Precision Positioning Service) to all except military users. This left the less accurate Standard Positioning Service capability for commercial users. The SPS was designed to provide positional accuracy no better than 100 meters. However, commercial C/A code receivers have demonstrated accuracies in the 20- to 40-meter range. In May 2000, use of the SA signal was discontinued by order of President Clinton. However, the signal can be utilized in times of national emergency.

The NAVSTAR system is available for use on any kind of aircraft, vehicle, vessel, or individual, for both navigation and recreation. The receiver processes the position and time signals produced by the satellites and displays processed data on readout equipment. The various types of receivers installed on military and civilian equipment scan the skies for a satellite signal. The more channels that are scanning, the greater the number of satellites being tracked, allowing a more precise location and velocity value to be obtained. Logistics is the main driver, particularly if there is no aiding source or if alignment from sources such as an Inertial Navigation System (INS) is available. The higher channel receivers are more robust and have anti-jamming benefits, especially important for more dynamic applications such as fighter aircraft.

Variants/Upgrades

With the increased usage of GPS devices, the number of military and commercial GPS receivers has proliferated. It is expected that GPS devices will continue to evolve at a rapid pace as new uses for GPS are discovered.

Program Review

Background. The origins of GPS can be traced back to the early 1960s, when the U.S. Navy sponsored two navigation programs called Transit and Timation. Transit became operational in 1964 and supplied navigation data to low-dynamic users such as the Navy Fleet. Timation was a developmental program formulated to advance 2D (latitude and longitude) navigation. The Air Force was also working in the same direction, except that its program, called 621B, was a 3D approach (i.e., it added altitude).

The 1973 Joint Chiefs of Staff master navigation plan called for a single, precise satellite-based positioning system to serve a variety of U.S. DoD requirements. As the result of an Office of Secretary of Defense directive in 1973, the Air Force was designated as the executive service to consolidate the various efforts under the NAVSTAR GPS umbrella, with the U.S. Air Force Systems Command Space Division acting as the executive agency.

In 1974, Rockwell received contracts to design, produce, launch, and operate three prototype GPS satellites, as well as two flight-acceptance navigation development satellites. The first GPS constellation was created in 1978, when four advanced-development GPS satellites were launched. In 1979, Rockwell received contracts to build two operational GPS satellites, as well as to modify the space shuttle to use GPS for navigation. Due to cost concerns raised in 1980, the scope of the program was somewhat reduced, from 21 satellites in the constellation to 18. By mid-1989, the total had been bumped back up to 21, with three backups.

The complete constellation of 21 GPS satellites plus three on-orbit spares became operational in 1995. As Block II satellites aged and failed, the Air Force replaced them with updated Block IIR satellites – a process that began in 1997. Lockheed Martin was the prime contractor for the 21-satellite Block IIR replacement program. The final deliveries of these satellites were made in 1999.

The next generation of NAVSTAR satellites is being procured. Three teams led by Hughes, Lockheed Martin, and Rockwell International competed in a winner-take-all contest for a 33-satellite package, submitting proposals in October 1995. In 1996, the Air Force selected Rockwell International (now Boeing Space Systems) to build the next generation of NAVSTAR GPS spacecraft. Rockwell received an initial contract worth US$382.4 million to build the first six GPS Block IIF satellites. The contract had one option for 15 satellites and a second option for 12 more.

In February 1996, the Air Force reversed course and announced that Boeing would build only 12 Block IIF spacecraft, and not 33 as originally planned. USAF cited the need for advanced technology in future satellites beyond the current Block IIF design. In November 2000, Boeing and Lockheed Martin were awarded study contracts worth US$16 million each to further develop the design concept for GPS Block III.

Early Military Receivers. Rockwell International Corporation's Collins Government Avionics Division was awarded the original contract for production of GPS user equipment receivers for the U.S. DoD in 1985. The contract, worth approximately US$61 million, called for Collins to produce a complete range of receivers for all of the U.S. military services. This contract covered approximately 4,300 receivers split between ARN-151(V) receivers (for F-16C/D Block 40, A-6E, F-111, B-52, and SH-60B platforms) and ARN-149(V) receivers (for the CH-47D, MH-47, UH-60, and MH-60 helicopters). This contract is believed to have been completed in 1991.

In October 1987, the Navy Avionics Center awarded Canadian Marconi and SCI second-source production contracts for US$7.5 million and US$7.1 million, respectively. Both three-year contracts called for each company to produce a total of 150 systems for evaluation, in order to compete against Collins for receiver procurement starting in FY90.

The GPS Joint Program Office announced in early 1988 that plans to open GPS receiver procurement to competition would emphasize non-developmental items or off-the-shelf receivers, taking advantage of the growing number of GPS receivers, in addition to Rockwell Collins hardware, to reduce acquisition costs.

In September 1990, SCI Technology won the US$17 million, Phase IV, low-rate production contract, with options for 1,200 ARN-149(V) and 4,100 ARN-151(V) sets over five years starting in 1992. A follow-on award was made to SCI in July 1992 for additional receivers.

Wartime GPS Use. The 1991 Persian Gulf War gave GPS applications a major boost. Because of the lack of terrain features, GPS receivers became a critical navigation aid. Available receivers were rushed over, even though some were still only developmental models. The urgency was such that the U.S. Air Force stopped encoding GPS signals so that U.S. forces could use commercial systems and still achieve military accuracy.

The opening battle for Kuwait saw the satellite system providing navigation for U.S. Air Force Special Operations Forces (SOF) MH-53J helicopters escorting U.S. Army AH-64 Apache attack helicopters into Iraq. The Apaches were instrumental in knocking out several Iraqi radar installations, which threatened the first wave of allied aircraft heading for Baghdad. Equipped with NAVSTAR GPS satellites, the MH-53Js led the helicopter attack force at low altitude in the early morning hours.

Overall, it is believed that U.S. forces deployed approximately 15,000 GPS receivers, ranging from handheld units such as Trimpak and Magellan to the Collins family of airborne receivers.

In the recent war with Iraq, Iraqi troops made efforts to jam U.S. GPS receivers. Using six GPS jamming devices, the Iraqis unsuccessfully tried to jam U.S. GPS satellite navigation and weapon-guiding systems. All the systems were quickly destroyed by U.S. forces. In one case the U.S. military claims that a GPS guided munition was utilized to destroy one of the jamming devices.

Embedded GPS/Inertial Navigation Systems. Technological advancements have dramatically reduced the size of the GPS receivers and inertial-grade ring laser gyros. These packaging enhancements consequently led to the development of hybrid systems known as Embedded GPS/Inertial Navigation Systems, or EGIs. An EGI eliminates the need for the special secure databus and other security requirements, allowing the GPS pseudo-range and range-rate data to be directly combined with inertial data.

The U.S. Air Force initially tested two EGI designs, the Honeywell H-764G and the Litton/Rockwell LN-100G (GINA – GPS Inertial Assembly) ring laser gyro-based INS, in order to demonstrate the concept. Litton/Rockwell provided the LN-100G embedded GINA system to the U.S. Navy for the T-45 Goshawk trainer and the Army's AH-64 Apache attack helicopter, while the Marines carried out test flights of the Honeywell H-764G on board the AH-1W SuperCobra attack helicopter.

In pursuit of this technology, the Defense Advanced Research Projects Agency (DARPA) has sponsored development of the GPS Guidance Package (GGP), a compact, lightweight GPS/Inertial Navigation System for aircraft, missile, and unmanned air vehicle (UAV) applications. In August 1992, DARPA selected the team of Texas Instruments (now Raytheon Systems Company) and Honeywell to develop the GGP. TI was to supply the multichannel GPS receiver, mated to a Honeywell inertial measurement unit. DARPA investigated the possible application of GGP to existing and future missile systems to correct for navigation errors during missile flight, with GPS signals permitting the missiles to explode within 3 meters of the intended target without pilot assistance.

In early 1997, the U.S. DoD announced the completion of a successful demonstration of GPS and INS used together in an advanced navigation set aboard an F/A-18 aircraft. DARPA and the Navy conducted the test. Many contracts for Embedded GPS/INS were already in place at the time the test occurred.

In recent years, several contracts and production approvals have been issued for various GPS systems such as the MAGR 2000 GPS receivers and Rockwell Collins' Miniature Precision Lightweight Global Positioning System Receiver Engine (MPE-S). These smaller and lighter GPS components are being integrated into other systems such as the Joint Precision Approach and Landing System (JPALS).

In October 2002 Raytheon and Rockwell Collins received contracts to participate in the development of the Defense Advanced GPS Receiver (DAGR). This next generation of GPS devices is a digital handheld terminal capable of fusing secure GPS navigation with computing functions. By permitting the user to overlay GPS navigational information onto digital maps, more accurate situational awareness can be achieved. Raytheon and Rockwell Collins were to develop and deliver DAGR prototypes by May 2003. A single DAGR producer was to be selected toward the end of 2003.

The U.S. Navy is currently pursuing the Navigation Sensor System Interface (NAVSSI) development program. NAVSSI, a surface ship program, will integrate real-time navigation and time sources, primarily GPS, with combat systems, combat support systems, air alignment systems, and support systems. Over 54 systems/interfaces on 131 surface ship platforms will be affected by the NAVSSI program. Also, under this program low-cost Versa Module Europa (VME) GPS Receiver Card (GVRC) technology combined with fiber optic antenna capability and a new security chip will be replacing the WRN-6 GPS receiver, also referred to as Receiver 3S. In addition to surface ships, the WRN-6 GPS receivers on U.S. submarines will also be replaced by GVRC card technology.

Funding

U.S. FUNDING[a]

	FY02 QTY	FY02 AMT	FY03 QTY	FY03 AMT	FY04 QTY	FY04 AMT	FY05 QTY	FY05 AMT
RDT&E (U.S. Air Force) PE#0305164F Project 3028 NAVSTAR GPS User Equipment	-	47.8	-	85.2	-	100.6	-	104.4

	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT	FY09 QTY	FY09 AMT
	-	92.9	-	89.4	-	76.1	-	73.8

	FY02 QTY	FY02 AMT	FY03 QTY	FY03 AMT	FY04 QTY	FY04 AMT	FY05 QTY	FY05 AMT
RDT&E (U.S. Navy) PE#0604777N Project X0921 NAVSTAR GPS Equipment	-	12.8	-	18.7	-	22.1	-	15.0

	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT	FY09 QTY	FY09 AMT
	-	22.0	-	22.4	-	22.8	-	23.3

	FY02 QTY	FY02 AMT	FY03 QTY	FY03 AMT	FY04 QTY	FY04 AMT	FY05 QTY	FY05 AMT
Procurement (U.S. Army) NAVSTAR GPS (K47800) Equipment	-	19.7	-	26.8	-	44.3	-	39.6

	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT	FY09 QTY	FY09 AMT
	-	42.3	-	37.9	-	25.0	-	27.0

Source: FY04/05 U.S. DoD Biennial Budget Estimates

All US$ are in millions.

[a]The programs presented here pertain specifically to GPS equipment funding under the respective services. More funds are allocated to the RDT&E and procurement of GPS systems under a variety of other programs such as JPALS and specific platforms.

Recent Contracts

Contractor	Award ($ millions)	Date/Description
Boeing	35.0	Jan 2001 – Modification to contract number F04701-96-C-0025 to provide for modernization of the operational control segment supporting the GPS to allow interaction with new capabilities on the GPS IIR and IIF Satellites. Contract completed by January 2002.

Contractor	Award ($ millions)	Date/Description
Raytheon Systems Co	8.6	Jan 2001 – Firm fixed-price contract for research and development support for the Defense Advanced Global Positioning System (GPS) Receivers (DAGR) program. These efforts will clarify performance specifications for multiple future GPS ground receiver programs. Work completed by March 2002. Space and Missile Systems Center, Los Angeles AFB, California, is the contracting authority. (Contract number F04701-01/C-0005)
Rockwell Collins	6.8	Jan 2001 – Firm fixed-price contract for research and development support for the Defense Advanced Global Positioning System (GPS) Receivers (DAGR) program. These efforts will clarify performance specifications for multiple future GPS ground receiver programs. Work completed by March 2002. Space and Missile Systems Center, Los Angeles AFB, California, is the contracting authority. (Contract number F04701-01/C-0004)
Allen Osborne Associates Inc	2.2	Jan 2001 – Firm fixed-price contract for research and development support for the Defense Advanced Global Positioning System (GPS) Receivers (DAGR) program. These efforts will clarify performance specifications for multiple future GPS ground receiver programs. Work completed by March 2002. Space and Missile Systems Center, Los Angeles AFB, California, is the contracting authority. (Contract number F04701-01/C-0006)
Alliant Integrated Defense Co	2.1	Jan 2001 – Firm fixed-price contract for research and development support for the Defense Advanced Global Positioning System (GPS) Receivers (DAGR) program. These efforts will clarify performance specifications for multiple future GPS ground receiver programs. Work completed by March 2002. Space and Missile Systems Center, Los Angeles AFB, California, is the contracting authority. (Contract number F04701-01/C-0007)
Trimble	2.7	May 2001 – Contract from Boeing for the U.S. Air Force KC-10A Aircraft Global Air Traffic Management (GATM) upgrade program. Trimble will incorporate its SAASM capability in its TASMAN ARINC-12 (TA-12) GPS receiver.
Raytheon Systems Co	5.0	Nov 2002 – Firm fixed-price contract to provide First Article Test equipment software, training package development, and data in support of the Defense Advanced Global Positioning System Receivers (DAGR). Work to be completed by May 2003. Headquarters Space and Missile Systems Center, Los Angeles Air Force Base, California, is the contracting authority. (F04701-02-C-0011, F04701-02-C-0012)
Rockwell Collins	5.0	Nov 2002 – Firm fixed-price contract to provide First Article Test equipment software, training package development, and data in support of the Defense Advanced Global Positioning System Receivers (DAGR). Work to be completed by May 2003. Headquarters Space and Missile Systems Center, Los Angeles Air Force Base, California, is the contracting authority. (F04701-02-C-0011, F04701-02-C-0012)
Rockwell Collins	N/A	Jul 2003 – Contract from the U.S. Army CECOM for the NAVSTAR GPS JPO Ground-Based GPS Receiver Application Module (GB-GRAM) initiative. Rockwell Collins will supply its 12-channel miniature PLGR Engine SAASM (MPE-S) GPS receiver for U.S. Army communication equipment and weapon platforms over the next 10 years. The estimated value of the contract is US$30 million if all options are exercised.

Contractor	Award ($ millions)	Date/Description
Raytheon	25.8	Sep 2003 – Contract to develop the next-generation militarized GPS system with anti-jam and stealth capabilities for the F-35 Joint Strike Fighter (JSF). Raytheon is to develop the Digital Anti-jam Receiver (DAR), which will feature 24 channels, Selective Availability Anti-Spoofing Module (SAASM), and adaptive beam-steering anti-jam electronics. DAR will be incorporated into a single line replaceable unit form/fit compatible with the existing GAS-1 antenna electronics.

Timetable

Month	Year	Major Development
Dec	1973	Milestone I – concept validation
Jun	1974	Initial space segment contract issued to Rockwell
Oct	1974	General Dynamics receives control user contract (Phase 2)
Feb-Dec	1978	NAVSTAR 1, 2, 3, 4 launched
Jul	1979	Phase 2 user set development contract awarded; Milestone II – full-scale development achieved
Jan	1980	First Minuteman 3 with NAVSTAR receiver launched
Feb	1980	NAVSTAR 5 and 6 launched
Dec	1981	NAVSTAR 7 launched, destroyed in booster failure accident
Jul	1983	NAVSTAR 8 launched with nuclear-detonation detection system payload
Nov	1983	Congress asks for civilian use of NAVSTAR
Jun	1984	NAVSTAR 9 launched via an Atlas-E
Sep	1984	NAVSTAR 10 launched
Apr	1985	Rockwell Collins awarded initial user equipment contract
	1985	First NAVSTAR launch via the Space Shuttle
Oct	1985	NAVSTAR 11 launched
Sep	1987	First Collins GPS user equipment delivered for integration by the U.S. Air Force
Dec	1987	First-production 3S user equipment five-channel receiver delivered to U.S. Navy
	1987	U.S. Air Force completes development of GPS standard interface
Feb	1989	First Block II GPS satellite launched
Jun	1989	Canadian Marconi and SCI receivers begin testing
Late	1991	FAA conducts preliminary flight tests of GPS as a Category 1 landing aid
Jun	1993	FAA announces approval of supplemental use of GPS for en route navigation and non-precision approaches to airports
Nov	1993	Phase II for CAT-I GPS landings; Embedded GPS/INS hybrid development increases
	FY93/4	Initial low-rate production of MAGR begins
Mar	1994	Launch of 24th NAVSTAR GPS satellite
Apr	1994	FAA formally declares GPS ready for implementation under IOC
Jun	1994	FAA approves development of GPS-based CAT-II and CAT-III approach/landing system
Jul	1995	Full operational capability of GPS satellite constellation achieved
Dec	1996	Modified AGM-86C Conventional Air-Launched Cruise Missile launched from a B-52 bomber and guided successfully to a target entirely by GPS
Jan	1997	Successful demonstration of Embedded GPS/INS aboard F/A-18
Jul	1997	First successful NAVSTAR Block IIR satellite launched
Aug	1997	First civil GPS landing system (Honeywell/Pelorus SLS-2000) receives FAA SCAT-I approval
Jul	1998	FAA allows GPS for non-precision approaches
May	2000	Use of Selective Availability signal discontinued by the U.S. DoD
	2001	Final Block IIR deliveries; initial deliveries and launches of Block IIFs

Month	Year	Major Development
Oct	2002	U.S. GPS Joint Program Office issues Defense Advanced GPS Receiver (DAGR) development contracts to Raytheon and Rockwell Collins
4Q	2003	Final selection of producer for DAGR

Worldwide Distribution

GPS terminals are available worldwide for all types of platforms.

Forecast Rationale

A congressional mandate (Public Law 103-160, November 30, 1993) will make it law for virtually all U.S. military platforms and weapons systems to be fitted with NAVSTAR GPS receivers. The law states that “after September 30, 2005 funds may not be obligated to modify or procure any Department of Defense aircraft, ship, armored vehicle or indirect-fire weapon system that is not equipped with a Global Positioning System receiver.” This law plus the effectiveness of NAVSTAR have inspired the U.S. military to invest heavily in new uses for GPS. Global positioning systems are being embedded in various platforms, munitions, and communication and navigation devices.

In the summer of 2002 a U.S. Naval Extended Range Guided Munition (ERGM) with an imbedded Tru-Trak GPS receiver successfully received signals from nine GPS satellites to track and engage a target. The experimental ERGM was guided by the GPS receiver for 39 miles at a speed of 1,875 miles per hour. The GPS receiver, which is capable of receiving and decoding signals from up to 12 GPS satellites, includes an Interstate Electronics Corp (IEC) XFactor anti-jamming module.

A year earlier, IEC delivered its first Selective Availability Anti-Spoofing Module (SAASM)-based GPS receivers to Raytheon Missile Systems. Able to withstand the 15,000g acceleration produced by the firing of a cannon, these receivers are to be utilized in the U.S. Army’s Excalibur program. Three hundred and thirty-one receivers ordered by Raytheon are to be used for initial testing of the 155 mm U.S. Army projectile. At least 200,000 units are expected to be produced for the Excalibur program through 2011.

IEC’s Tru-Trak GPS receiver is also being used in the U.S. Air Force’s Wind Corrected Munitions Dispenser program. This program turns gravity bombs into all-weather precision-guided weapons by using a relatively inexpensive tail-kit to direct them to their target.

The Tru-Trak GPS receiver was originally designed for the Combat Survivor Evader Locator (CSEL) radio. CSEL recently entered low-rate initial production. The U.S. Air Force is anticipating a full-rate-production decision on CSEL by January 2004. While the Air Force plans to acquire approximately 17,000 CSEL radios, over 52,000 radios are expected to be procured by all the U.S. Armed Forces.

Raytheon and Rockwell Collins were chosen by the U.S. GPS Joint Program Office (JPO) to provide first-article test units of the Defense Advanced GPS Receiver (DAGR). DAGR is the planned successor to the Precision Lightweight GPS Receiver (PLGR), approximately 107,000 of which are fielded today. The main difference between these two systems is that the DAGR weighs less than the PLGRS (1-1.5 lb for the DAGR, 2.5 lb for the PLGR). According to a U.S. Army after-action report, many soldiers brought commercially made GPS receivers to Iraq because of their lighter weight and faster access to navigation data. However, these commercial GPS receivers do not carry encryption devices and can be intercepted easily. Two hundred and fifty DAGR test units were to be supplied by both companies to JPO by May 2003. Selection of a single contractor was expected in the fall of 2003, and low-rate production is likely to begin in late 2004.

Raytheon won a contract in September 2003 to develop the next-generation militarized GPS system with anti-jam and stealth capabilities for the F-35 Joint Strike Fighter (JSF). Under a US$25.8 million contract Raytheon is to develop the Digital Anti-jam Receiver (DAR), which will feature 24 channels, Selective Availability Anti-Spoofing Module (SAASM), and adaptive beam-steering anti-jam electronics. DAR will be incorporated into a single line replaceable unit form/fit compatible with the existing GAS-1 antenna electronics.

It was reported in July 2003 that the U.S. Army was considering coupling GPS receivers with inertial navigation systems aboard its future vehicles. This dual system would provide the accuracy of a GPS receiver with the reliability of a gyroscope internal navigation system. External factors such as thick foliage, heavy weather, or urban areas can interfere with GPS signals.

Soldiers need a navigational system that remains operative when traveling through canyons, thick forest, and caves.

Also in July 2003, Rockwell Collins secured a significant contract from the U.S. Army when CECOM chose it for the NAVSTAR GPS JPO Ground-Based GPS Receiver Application Module (GB-GRAM) initiative. For GB-GRAM, Rockwell Collins will supply its 12-channel miniature PLGR Engine SAASM (MPE-S) GPS receiver for U.S. Army communication equipment and weapon platforms over the next 10 years. The estimated value of the contract is US$30 million if all options are exercised.

In June 2003, shortly before the Rockwell Collins contract was awarded, Raytheon was awarded a Program Research and Development Announcement (PRDA) contract from the U.S. Air Force for initial development work on the Air Force's next generation of military GPS receivers. The objective of this contract is to provide the groundwork for developing a more precise GPS receiver to satisfy the U.S. Air Force's needs in the coming decade. Work for this contract will be completed by February 2005.

The U.S. Air Force also announced in August 2003 that it was planning to use US$10 million from the Pentagon's US$16 billion discretionary Iraqi Freedom Fund to improve GPS accuracy. Although specifics of the plan were not revealed, it is estimated that the improvements would take approximately 12 months to execute. Currently, the U.S. Air Force is upgrading its 19 RC-135 Reconnaissance aircraft with the Northrop Grumman LN-20G GPS augmented inertial navigation system. The contract was awarded in March 2003, and deliveries of the LN-20G are scheduled to begin in 2006.

With the NAVSTAR GPS program expanding into a variety of areas ranging from weapons guidance to automated landing systems, the demand for GPS receivers has grown exponentially. As microprocessors evolve, the equipment involved in NAVSTAR GPS is becoming smaller, lighter, less expensive, and more accurate. This has permitted NAVSTAR to be fitted on a variety of land, seaborne, and airborne platforms. Reduction in both size and cost has made NAVSTAR GPS receivers a viable means for guiding weapons. Over the next decade approximately US$1.2 billion will be spent specifically on the development and procurement of military NAVSTAR GPS devices. As NAVSTAR GPS devices are included in several other programs, additional funds will be spent on GPS receivers.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR FUNDING ($ in millions)

				High Confidence Level			Good Confidence Level			Speculative		
Designation	**Application**	**Thru 02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**Total 03-12**
NAVSTAR GPS TERMINALS	PROCUREMENT (U.S. ARMY)	285.400	26.800	44.300	39.600	42.300	37.900	25.000	27.000	24.300	22.700	18.300	308.200
NAVSTAR GPS TERMINALS	RDT&E (U.S. AIR FORCE)	353.887	85.241	100.589	104.387	92.949	89.387	76.067	73.860	71.200	74.600	77.900	846.180
NAVSTAR GPS TERMINALS	RDT&E (U.S. NAVY)	809.284	18.712	22.127	14.979	21.962	22.417	22.839	23.267	21.700	20.900	17.200	206.103
Total Funding		1448.57	130.75	167.02	158.97	157.21	149.70	123.91	124.13	117.20	118.20	113.40	1360.48