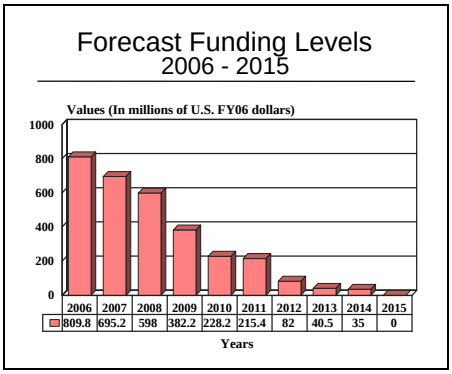
Advanced EHF Satellites - Archived 2/2007

Outlook

- Delays of National Security Agency-furnished cryptology systems impacts costs and schedule
- First AEHF satellite scheduled to launch in 2008, the second in 2009, and the third in 2010
- Forecast International expects the Air Force to purchase a fourth AEHF satellite



Orientation

Description. The Advanced Extremely High Frequency (AEHF) satellite is follow-on to replace the MILSTAR satellite system.

Sponsor

U.S. Air Force (USAF)
MILSATCOM Joint Program Office
Space & Missile Systems Center
Los Angeles AFB, California (CA)
USA

Status. The AEHF satellite completed an overall system Critical Design Review in May 2004 and the antenna uplink side was successfully tested in September 2004. The Flight One payload completed the initial phase of payload/space-vehicle mechanical integration at Northrop Grumman in August 2005. Flight One payload is currently scheduled to be returned to Lockheed Martin in April 2007 and the first scheduled AEHF satellite launch is in April 2008.

Total Produced. No AEHF satellites have been produced to date. The USAF has committed to purchase three satellites and a fourth satellite order is predicted. Production began in 2003 and the first satellite is slated for launch in 2008.

Application. The AEHF satellite will provide secure, survivable, jam-resistant worldwide communications for high-priority military ground, sea and air assets.

Price Range. According to the MILSATCOM Joint Program Office, each satellite will cost approximately $580 million. Taking projected total program dollars to be spent puts each satellite in the $2 billion price range if three satellites are procured.

Contractors

BAE Systems Space Systems & Electronics, http://www.iews.na.baesystems.com/business/sse.htm, 144 DW Highway, North, Merrimack, NH 03054 United States, Tel: + 1 (603) 885-6812, Fax: + 1 (603) 885-5258, Email: john.m.kobzik@baesystems.com, Consortium Member

EMS Technologies, Inc, http://www.ems-t.com, 660 Engineering Drive, Norcross, GA 30091 United States, Tel: + 1 (770) 263-9200, Ext: 4326, Fax: + 1 (770) 447-4397, Email: pr@ems-t.com, Consortium Member

LinQuest Corporation, http://www.linquest.com/, 6701 Center Drive West, #425, Los Angeles, CA 90045 United States, Tel: + 1 (310) 410-2400, Subcontractor (Systems Engineering Support)

Lockheed Martin Space Systems - Sunnyvale, http://www.lockheedmartin.com/ssc, 1111 Lockheed Martin Way, Sunnyvale, CA 94088-3504 United States, Tel: + 1 (408) 742-7151, Fax: + 1 (408) 742-8484, Lead Contractors

Northrop Grumman Space Technology, Division HQ, http://www.st.northropgrumman.com, One Space Park, Redondo Beach, CA 90278-1001 United States, Tel: + 1 (310) 812-4818, Fax: + 1 (310) 813-7548, Consortium Member

Titan Corporation, http://www.titan.com/home.html, 3033 Science Park Rd, San Diego, CA 92121 United States, Tel: + 1 (858) 552-9500, Fax: + 1 (858) 552-9645, Consortium Member

Alliant Techsystems - ATK Space Systems, Programmed Composites, http://www.atk.com, 250 Klug Circle, Corona, CA 92880 United States, Tel: + 1 (951) 520-7300, Program Participant (Service)

Technical Data

Specifications

Frequency	EHF (44 GHz) uplink SHF (20 GHz) downlink
Data rates	75 bps – 8.192 Mbps
System security	Terminal-to-terminal COMSEC TRANSEC-governed frequency hopping
Interoperability	MILSTAR LDR, MDR & AEHF modulation modes
Antenna coverage	1 Earth coverage beam, 4 agile beams, 24 time-shared spot beams, 2 nulling spot beams, and 6 dwelling spot beams
Crosslinks	2 per satellite (each bi-directional), compatible with MILSTAR and AEHF requirements – 60 Mbps

Lockheed Martin Space System's AEHF Satellite

Source: Lockheed Martin Space Systems

Design Features. The new AEHF satellite constellation was intended to consist of four satellites that cover 65°N and 65°S. A fifth satellite was planned as a spare; however, increased costs have reduced the number of AEHF satellites to three. The AEHF satellite provides the basis for the next-generation military communications satellite system. It enables secure, survivable, jam-resistant worldwide communications for strategic and tactical warfighters in all Department of Defense (DoD) services. Due to the satellites' smaller payloads, they will be launched from medium-sized launch vehicles rather than from the Titan rockets currently used for MILSTAR satellites.

The AEHF satellites will provide 10 times greater total capacity than MILSTAR II communications satellites, and offer channel data rates that are six times higher (8.2 Mbps). The higher data rates permit transmission of tactical military communications such as real-time video, battlefield maps, and targeting data. Additionally, the antenna for the AEHF satellite will be the

first phased array antenna operating at 44 GHz to be utilized in space.

The AEHF program provides follow-on capability to the MILSTAR I and II satellites. The requirement is for the AEHF satellite to have one single-channel protected data rate of 6 to 8 Mbps using the existing MILSTAR II Medium Data Rate (MDR) waveform. Each AEHF satellite employs more than 50 communications channels via multiple, simultaneous downlinks. For global communications, the AEHF system uses inter-satellite crosslinks, eliminating the need to route messages via terrestrial systems.

Variants/Upgrades

Pathfinder. After the failure of the launch of the third MILSTAR satellite, the U.S. DoD decided to accelerate the AEHF satellite program. Because of the timetable advancement, an interim AEHF satellite was planned. This satellite, named Pathfinder, was to have the minimum capability of the MILSTAR II and the ability to be upgraded to the AEHF configuration.

In September 2000, the team of Lockheed Martin, Boeing Satellite Systems (formerly Hughes Electronics Corp), and TRW announced that they had identified how to apply the same configuration to all the AEHF satellites, thus eliminating the need for a less capable Pathfinder interim satellite.

Program Review

Background. In 1993, the U.S. Secretary of Defense's "Bottom-Up Review" outlined a decision for the U.S. military to field a lower cost, advanced Military Satellite Communications (MILSATCOM) system. The program was intended to maximize use of commercial bus developments and reduce orbital support and launch integration costs. In 1995, funding was allocated in PE#0603430F, MILSATCOM, to provide the basis for the next generation of military communications satellite systems. The objective of this program was to replenish existing EHF, UHF (MILSTAR II) and SHF (Defense Satellite Communications System III) systems. Incorporating standardized spacecraft components and modular EHF and SHF payloads, each satellite was to be launched separately on a medium-launch vehicle.

In 1996, TRW (now owned by Northrop Grumman) and Lockheed Martin formed a team for development of the AEHF satellite. Both TRW and Boeing Satellite Systems (formerly Hughes Electronics Corp) were awarded contracts in the spring of 1997 to produce prototype processors for the AEHF satellite program.

In 1999, Lockheed Martin and Hughes Space and Communications Company (now owned by Boeing) were separately awarded competing $22 million contracts. Each company was given 18 months for system definition, design, and development. Since the AEHF satellites will replace the MILSTAR satellite constellation, these contracts are the beginning of the end for the MILSTAR program.

AEHF National Team. An unsuccessful launch of the third MILSTAR satellite in April 1999 left a gap in coverage. In order to fill this gap, the DoD had to either procure another MILSTAR satellite or accelerate the AEHF satellite program. In order to cut 18 months from the AEHF schedule, the DoD decided to eliminate competitive bidding. In April 2000, the DoD approved a plan that allowed the three top rivals (Lockheed Martin, Boeing, and TRW) to work collaboratively on the AEHF program.

Initially, the AEHF National Team was scheduled to deliver the first satellite, called the Pathfinder, in December 2004. The Pathfinder was intended to be an interim AEHF satellite. The need for Pathfinder was eliminated when the AEHF National Team discovered a way to configure all the satellites the same for more capability and flexibility.

New Requirements. As the program progresses, the USAF has been imposing new requirements for more bandwidth. Compounding this problem is the growing need for increased wideband communications, as demand for activities like video teleconferencing rises. Additionally, intelligence, surveillance and reconnaissance feeds from the U-2 and the Global Hawk UAV will need a significantly larger bandwidth. The USAF and the AEHF National Team continue to negotiate the requirements.

In March 2001, the AEHF National Team announced that the manufacturing cost of the AEHF satellite system would most likely exceed the agreed-upon firm fixed price of $2.6 billion. The team said that in order to produce a "mature vision" of the AEHF satellite system, it would need an additional $300 million. Instead of accepting the AEHF National Team's "mature vision," the USAF directed the team to revise its design so that production falls within the $2.6 billion agreement.

Delays. That same month, Lockheed Martin and TRW were awarded an $86 million firm fixed-price contract modification to extend the systems definition phase of the AEHF program. Later, citing cost and schedule

problems, the USAF announced it would delay the launch date of the first AEHF satellite from December 2004 to December 2005. Later, a budget shortfall in the program of approximately $1 billion was identified and the USAF was able to trim costs by stretching out the launch schedule again by an average of three years. This pushes Full Operational Capability from 2010 to 2012. Initial Operational Capability (IOC), involving the first two satellites, will not be affected.

Undersecretary Aldridge approved the AEHF satellite program for system development and demonstration (SDD) in an Acquisition Decision Memorandum issued on October 10, 2001. In that same memo, Undersecretary Aldridge directed the USAF to study alternatives to purchasing additional AEHF satellites. Following Undersecretary Aldridge's approval, a $2.7 billion firm fixed-price and cost-plus-award-fee contract was rewarded to the AEHF National Team for the SDD phase of the AEHF satellite program. Under this effort, two satellites will be produced, and MILSATCOM ground command and control segment components will be upgraded to support AEHF.

Boeing Backs Out. Just prior to the issuance of this contract, Boeing decided to withdraw from the program because the AEHF program was no longer profitable for the company. This left Lockheed Martin and Northrop Grumman as the main contractors for the AEHF satellite program.

2004/2005 Progress. Progress on the development and construction of the AEHF satellite continued in 2004. In February, Northrop Grumman announced that it had successfully demonstrated electrical performance capabilities of the downlink phased array antenna. Shortly thereafter, in April, Northrop Grumman completed the payload critical design review (CDR) of the AEHF payload. That same month, EMS Technologies delivered the first set of beam-forming networks (BFN) for the AEHF satellite. BFNs provide the AEHF antennas anti-jam protection by nulling out potential jammers while permitting authorized users to access the satellite.

In May 2004, Lockheed Martin completed a system CDR which validated the detailed design of the overall AEHF system. Northrop Grumman successfully tested the uplink side of the AEHF antenna in September, and two months later received the flight structure and key payload support equipment from Lockheed Martin. Northrop Grumman will integrate flight hardware onto the flight structure to construct the first AEHF satellite.

In November 2005, Lockheed Martin and ATK Space Systems successfully completed static load testing of the satellite structure. This test validated the satellite's strength and ability to sustain its launch weight of over 13,000 lbs.

In October 2004 the USAF wanted to forgo the purchase of a fourth AEHF satellite in hopes of keeping funding available for its next-generation Transformational Satellite Communications System (TSAT) laser satellite communications program. Congress, on the other hand, cut the TSAT request in the 2005 defense spending bill, and warned the USAF it was trying to proceed too rapidly with the TSAT program.

Nunn-McCurdy Kicks In. On December 2, 2004, USAF Secretary James Roche notified Congress about the AEHF cost overrun of 20 percent in accordance with the Nunn-McCurdy law that requires this notification for programs that overrun by at least 15 percent. If the cost growth hits 25 percent, the law requires the Pentagon to justify the program continuation. The Pentagon could easily justify the program based on its importance to national security, and the lack of a viable alternative for less cost. A major problem that has led to recent cost escalation is the National Security Agency's (NSA) delayed delivery of the KI-54 crypto payload. This payload secures the data passed over the system and the NSA has opted for a more advanced system than the system originally planned. Others problems include replacement of critical electronic parts and added payload component testing. However, Air Force officials say these two problems did not result in schedule delays.

Funding

U.S. FUNDING

	FY05 QTY	FY05 AMT	FY06 QTY	FY06 AMT	FY07 QTY	FY07 AMT	FY08 QTY	FY08 AMT
RDT&E (U.S. Air Force)								
PE#0603430F								
AEHF								
MILSATCOM								
Project 4050								
Adv.	-	606.7	-	665.3	-	632.0	-	430.0

MILSATCOM

	FY09 QTY	FY09 AMT	FY10 QTY	FY10 AMT	FY11 QTY	FY11 AMT	FY12 QTY	FY12 AMT
PE#0603430F AEHF MILSATCOM Project 4050 Adv. MILSATCOM	-	233.8	-	93.8	-	82.2	-	Continuing

All $ are in millions.

Source: Department of the U.S. Air Force FY2005 RDT&E Budget Estimates, February 2005

Recent Contracts

Contractor	Award ($ millions)	Date/Description
Lockheed Martin and TRW	2,698.0	Nov 2001 – The AEHF National Team was awarded a $2.698 billion not-to-exceed, firm-fixed-price and cost-plus-award-fee contract for the SDD phase of the AEHF satellite program. This effort involves the production of two satellites, and the replacement and upgrade of existing MILSATCOM ground command and control segment components to support AEHF. At the time of contract, $12,250,000 of the funds had been obligated. This work will be completed by December 2011. The contractors will perform this effort in Sunnyvale, CA (45%) and Redondo Beach, CA (55%). The Space & Missile Systems Center, Los Angeles, CA, is the contracting agency. (F04701-02-C-0002)
Lockheed Martin and TRW	498.0	May 2002 – A $498 million firm-fixed-price contract modification. This is an amendment to the contract issued November 16, 2001. The contract is for the AEHF SDD phase. The purpose of this amendment is to increase the not-to-exceed value from $2.698 billion to $3.196 billion. This increase is a result of the fiscal year 2002 appropriation act decrease of $70 million, and the loss of $30 million in international partner funding. Also, the increase covers the efforts necessitated by the recent revision of the National Security Agency's KI-54 Interface control document, which will require an estimated $46 million. The Space & Missile Systems Center, Los Angeles, CA, is the contracting agency. (F04701-02-C-0002, P00007)
BAE Systems	55.0	Jul 2002 – An award from TRW (now Northrop Grumman) to BAE Systems for the development and production of radiation-hardened electronics for the AEHF satellite. BAE Systems provides RAD750 single-board computers and custom logic and memory components. The contract was scheduled to be completed in 2004 and is now complete.
BAE Systems	9.5	Sep 2002 – A contract from Lockheed Martin for command and control subsystem computers based on BAE Systems RAD6000. Engineering models were delivered in 2003, and final flight units in 2005. The contract included options for additional flight units.

Contractor	Award ($ millions)	Date/Description
Titan Corp	29.0	Feb 2003 – A cost-plus-award-fee contract by Lockheed Martin's Management and Data Systems, having a value of $29 million through March 2008. Under this award, Titan will develop a significant portion of the AEHF Mission Planning Element software, and provide systems engineering in support of that development.
Lockheed Martin	8.994	May 2003 – A contract modification as an amendment to the AEHF SDD contract that was definitized April 15, 2001. The purpose of this amendment is to increase the contract value from $2,630,166,866 to $2,639,160,373. This increase is the result of an engineering change proposal to implement a new AEHF system alternate key management plan (AKMP). The effort is within the scope of the existing contract, and necessitated by design changes to meet National Security Agency (NSA) security requirements that have been validated by Air Force Space Command. This work will be completed in June 2008. The Space & Missile Systems Center, Los Angeles Air Force Base, CA, is the contracting agency. (F04701-02-C-0002, P00029)
Lockheed Martin	9.988	May 2003 – A cost-plus-award-fee, cost-plus-fixed-fee, firm-fixed-price contract modification to redesign the host accessory logic Application Specific Integrated Circuit (ASIC) for the AEHF program in response to a specification upgrade for the KI-54 cryptographic device. This work was completed in January 2004. The Space & Missiles Systems Center, Los Angeles, CA, is the contracting agency. (F04701-02-C-0002, P00034)
Lockheed Martin	5.2	Jun 2003 – A contract to modify the AEHF payload to accommodate resources to process Rapid Reconfiguration Order Wire (RROW) AEHF Access Control Channel Uplink (XC2) streams. The change ensures backward compatibility with MILSTAR operations. It will impact multiple documents, the Mission Planning Element of the Mission Control Segment, the Configurable Onboard Router in the Digital Processing Subsystem, and the payload software. This work will be completed in September 2008. The Space & Missile Systems Center, Los Angeles Air Force Base, Los Angeles, CA, is the contracting agency. (F04701-02-C-0002, P00031)
Lockheed Martin	78.5	Aug 2003 – A cost-plus-award-fee, cost-plus-fixed-fee, firm fixed-price contract modification to incorporate the impacts of the KI-54 Interface Control Document (ICD) Revision F-Phase 2. No additional funds will be obligated with this issuance. This work will be completed by September 2008. The Space & Missile Systems Center, Los Angeles, CA, is the contracting agency. (F04701-02-C-0002, P00046)
Lockheed Martin	15.0	Dec 2003 – A cost-plus-award-fee contract modification. This modification incorporates Option 5 of the investigation of an analysis study that defines Mission Planning Element (MPE) versus Terminal Functionality into the AEHF baseline. This technical change will provide two different connection modes to allow MPE to communicate with Army and Air Force terminals and adapt to different terminal and network changes. This work will be complete by September 2008. The Headquarters Space and Missile Systems Center, Los Angeles, CA., is the contracting agency. (F04701-02-C-0002, P00042)

Contractor	Award ($ millions)	Date/Description
Lockheed Martin and Northrop Grumman	149.0	May 2004 – A contract modification which incorporates within-scope changes resulting from revision to the KI-54 Cryptographic Interface Control Document (ICD). The KI-54 ICD, modified by the NSA's contractor, the AEHF prime and subcontractor team (Lockheed Martin and Northrop Grumman) was required to redesign the Host Accessory Logic Application Specific Integrated Circuit (HAL ASIC) in the AEHF communication payload. This effort was captured in Phase 1. In Phase 2, the AEHF contractor team will receive a four-month program extension to identify and mitigate the AEHF system-level risks associated with the HAL ASIC redesign. This change to the AEHF Technical Baseline will allow the contractor team to proceed with the development of the AEHF program with reduced technical risk. Providing this technical change ensures that system compatibility issues with the KI-54 will be addressed in a thorough fashion to ensure mission success. This work will be complete September 2008. The Space and Missile Systems Center, Los Angeles, CA., is the contracting agency. (F04701-02-C-0002, P00061)
Lockheed Martin and Northrop Grumman	32.6	Aug 4, 2004 – A cost-plus-award-fee contract modification. This contract change procures spare critical components to be used, if necessary, in the factory by the contractor during assembly and test and of AEHF satellites. This work will be complete by January 2009. The Headquarters Space and Missile Systems Center, Los Angeles, CA., is the contracting agency. (F04701-02-C-0002, P00083)
LinQuest Corp	6.5	Nov 2004 – A cost-plus-award-fee contract modification. This modification extends for one fiscal year the specialized systems engineering support. This includes analysis of requirements, waveform development, Interface Control Documents, advanced concepts development, training, system design support, and systems integration. Total funds have been obligated. Work was completed September 2005. The Headquarters Space and Missile Systems Center, Los Angeles, CA., is the contracting agency. (F04701-98-C-0046, P00091)
Lockheed Martin	78.2	Mar 2005 – A cost-plus-award-fee, cost-plus-fixed-fee, firm-fixed-price contract modification to provide for the advance procurement of long-lead parts for the AEHF Satellite Vehicles #3 (SV3) in FY05. This advance procurement ensures that parts requiring significant leadtime to manufacture will be in place to assemble SV3 on schedule. At this time, $39,113,000 of the funds has been obligated. This work will be complete by September 2008. The Headquarters Space and Missile Systems Center, Los Angeles, CA., is the contracting agency. (F04701-02-C-0002, P000102)

Timetable

Month	Year	Major Development
Apr	1999	Third MILSTAR satellite fails to reach operational orbit, leaving coverage gap
Oct	1999	Lockheed Martin and Hughes each awarded a competitive design study contract
Apr	2000	Pentagon approves Lockheed Martin, Boeing Satellite Systems (formerly Hughes Electronics Corp) and TRW collaboration to speed up the program by 18 months
Sep	2000	AEHF National Team announces that they are able to apply the same configuration to all the AEHF satellites, thus eliminating the need for a less capable Pathfinder interim satellite

Month	Year	Major Development
Oct	2000	TRW's prototype digital processor successfully passes functional tests, verifying that the processor meets government requirements. The processor is capable of processing new AEHF uplink and downlink protocols, and is also backward-compatible with the MILSTAR satellite terminals
Oct	2001	Undersecretary Aldridge gives the go-ahead for the SDD phase
Oct	2001	Boeing withdraws from AEHF National Team
Nov	2001	AEHF National Team awarded a contract for SDD phase
May	2004	AEHF program passes Critical Design Review
Mar	2005	USAF commits to buy a third AEHF satellite
Apr	2008	Scheduled launch of first AEHF satellite
Apr	2009	Scheduled launch of second AEHF satellite
Apr	2010	Scheduled launch of third AEHF satellite
	2012	Anticipated Full Operational Capability

Worldwide Distribution

The AEHF satellite is a **U.S.** system that has not been deployed. The first launch is scheduled for 2008. A total of three AEHF satellites have been produced. Forecast International believes a fourth satellite will be purchased.

Forecast Rationale

Forecast International predicts that Congress will win the satellite dollars battle. Congress cut the USAF's TSAT request in the 2005 defense spending bill, and warned that the USAF was trying to proceed too rapidly with the TSAT program. The TSAT program uses laser beams rather than radio frequency signals to communicate and this is still a research and development technology. The USAF would rather forgo a fourth AEHF satellite in hopes of keeping funding available for its TSAT laser satellite communications program, but this outcome seems unlikely. To appease the USAF, the AEHF Team could add additional capabilities to its AEHF mature technology and plan to place the AEHF satellites over "hot spot" areas. These additional capabilities would mean more funding for AEHF contractors. The defense budget may shrink with a new administration and expenses are rising for large cost centers such as the F/A-22 Raptor, the Joint Strike Fighter and Operation Iraqi Freedom. Forecast International believes that the MILSATCOM office will purchase a fourth AEHF satellite due to TSAT budget cuts and to avoid the cost and delivery risks associated with a new development program.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR FUNDING ($ in millions)

				High Confidence Level			Good Confidence Level			Speculative			
Designation	System	Thru 05	06	07	08	09	10	11	12	13	14	15	Total 06-15
ADVANCED EHF SATELLITES	(U.S. AIR FORCE)	3182.811	809.780	695.190	598.040	382.200	228.200	215.400	82.000	40.500	35.000	0.000	3086.310