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MILSTAR AND AEHF SATELLITES: MILITARY COMMUNICATION

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The current Military Strategic and Tactical Relay (MILSTAR) operates in the extremely high frequency (EHF) range to provide secret and jam-resistant communications. It was originally designed for communication with the US strategic nuclear forces. However, with the demise of an active cold war and the upswing of regional wars under the new world order, the Pentagon has restructured the MILSTAR program to support tactical military operations.

The Advanced EHF satellite (AEHF) is fairly new in development and is a follow-on to MILSTAR. No satellites have yet been placed in orbit.

Before proceeding with EHF satellites, I should mention other satellite communications systems. There are constellations of military communications satellites presently in orbits -- the Fleet Satellite Communications system (FLTSATCOM) and its follow-on (the UHF Follow On), and the Defense Satellite Communication System (DSCS). A further follow on to the UHF Follow On -- the Mobile User Objective System which will also communicate with hand-held terminals (like cell phones) -- is in the concept definition stage and scheduled to start operation in 2007. Two follow ons to DSCS (the Wideband Gapfiller and the Advanced Wideband) are scheduled for operation in 2004 and 2008 respectively. In addition, the Air Force Satellite Communications system (AFSATCOM) has communication transponders riding piggy back on other satellites. There is also the Arctic Satellite Communications system (ARCTICSATCOM) which has a highly-elliptical polar orbit. It swoops low to within a couple hundred miles of the earth around the south pole and then climbs to a very high apogee over the arctic. ARCTICSATCOM spends most of its time over the northern hemisphere and provides better communication at the northern latitudes than do FLTSATCOM and DSCS which are in earth-synchronous (geosynchronous)¹ orbit over the equator. Several ARCTICSATCOMs equally spaced would provide continuous communication coverage in the arctic. Later models of FLTSATCOM and DSCS may have some EHF capability but that seems to be mainly for development testing and to eventually tie in with MILSTAR. Nevertheless, these satellites could, and probably do, communicate with submarines having an antenna on the ocean's surface.

¹Geosynchronous, or Earth-Synchronous, satellites are in equatorial orbit (always over the equator) and at an altitude of approximately 22,300 miles where one orbit of the satellite is synchronized with one revolution of the earth, thus causing the satellite to hover over one spot on the equator -- they appear stationary in the sky.

An adjunct to DSCS is a high capacity communications satellite called the Wideband Gapfiller which is funded jointly by the Air Force and the Army. On 3 January 2001, Boeing Satellite Systems (El Segundo, California) was awarded a \$160.3 million Air Force contract for research and development toward the first three satellites. The final cost of the three satellites will be about \$700 million. If the Air Force decides to buy six spacecraft, the contract could grow to \$1.3 billion. The first Gapfiller is scheduled to go into orbit in 2004. Boeing Satellite Systems also builds the UHF Follow On satellite to replace FLTSATCOM. On 8 January 2001 it was announced that Boeing has been authorized to begin production of the 11th in a series of UHF Follow On satellites.

Follow-on to DSCS and Gapfiller is the Advanced Wideband satellite which should start becoming operational around 2008.

The National Reconnaissance Office (NRO) also has a constellation of communications satellites to relay information from its intelligence-gathering satellites. The details and quantity of these spacecraft are secret. They are also built by Boeing Satellite Systems.

1. *MILSTAR As A First-Strike Element.*

Design of the EHF MILSTAR satellite started early in the 1980s at Lockheed Missiles & Space Company (now Lockheed Martin Space Systems Company). Originally MILSTAR was designed to operate at a low data rate (75-2,400 bits/second) for sending launch instructions to strategic nuclear forces. Those are the best rates for sending teletype and compressed-voice communications.

Just prior to launching missiles there would be no danger to a Trident submarine in putting an antenna on the surface to pick up more rapid satellite transmissions -- both for communication and to determine the submarine's true position from NAVSTAR navigation satellites. In April 1983, then director of the Defense Advanced Research Projects Agency, Dr. Robert Cooper, revealed that submarines are being equipped with extreme high frequency (EHF) receivers. "That combination of ELF [extreme low frequency -- which penetrates deep into the ocean] bell-ringer and the EHF capability," he said "should provide appropriate communication to our submarines in the latter part of (censored)."² It is now known that the censored date is the latter part of the 1990s. In May 1986, Assistant Navy Secretary Melvyn R. Paisley confirmed that missile-launching submarines will be able to receive MILSTAR satellite EHF messages.³

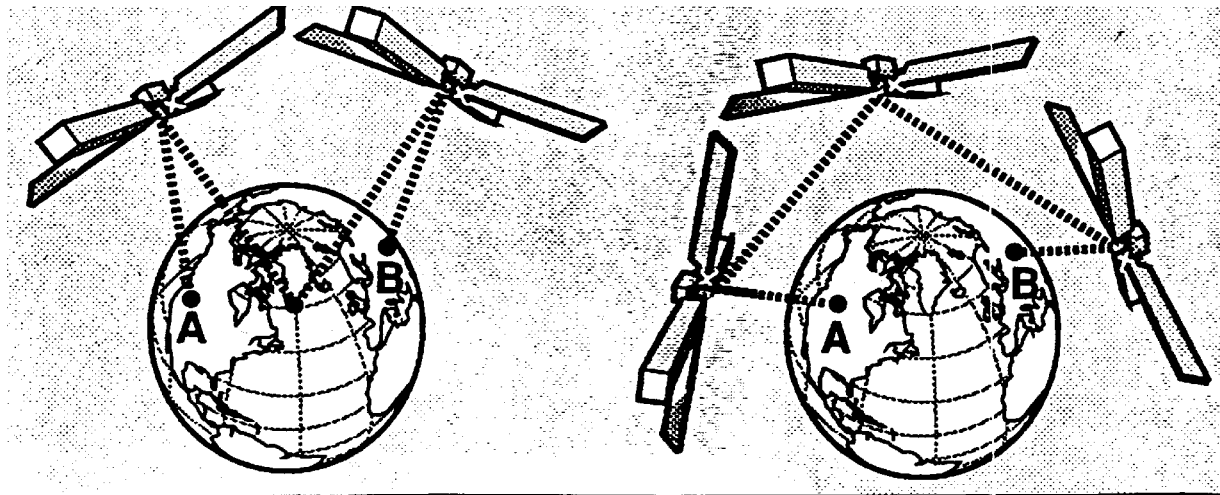
The reason why it is no great risk to use rapid EHF communication to send missile launch instructions to the submarine is because avoiding detection is a moot point at the time of launch. The submarine must approach the surface anyway to get a position fix from navigation satellites. Also, missiles cannot be launched from great depths or while the submarine is moving (unless it has surfaced). The hovering system required to stabilize the submarine at essentially zero speed prior to launching missiles would be far more detectable than an antenna on the surface.

2. *MILSTAR Now Supports Regional Wars.*

Low data rate transmissions are best for strategic uses but for tactical operations, such as in regional wars, they are not adequate. A medium data rate of between 4,800 and 1.5-million bits/second is required for regular voice communications and imagery. Therefore, with the end of the cold war,

²HASC-84, Part 5, p. 991.

³SAC-87, Part 2, p. 230.



Standard Satellite System

To send between "A" and "B" the standard system must relay through a ground station. MILSTAR does not. (Source: *Mercury News*).

MILSTAR

Congress directed in the fiscal year 1991 military budget that MILSTAR be restructured or an alternative advanced communications satellite program be commenced.

The Pentagon did restructure MILSTAR. To reduce cost it cut the planned eight-satellite constellation to six, reduced the amount of ground-based equipment, and eliminated several survivability features (such as nuclear electromagnetic-pulse shielding). To support tactical operations it scheduled the medium-data-rate capability for satellite number 4 and after.

In October 1992, again based on pressure from Congress, the Pentagon further reduced the planned constellation of satellites to four. The plan at that time was to launch the first two with the original low-data-rate design and then pick up the medium data rate on satellite number 3.

A year later, after the October 1993 bottom-up review of major weapons programs, the Pentagon held the constellation size at four but limited total production to six. The first two, known as MILSTAR Block-1, would be low data rate only. The next four, known as MILSTAR Block-2, would have both low and medium data rate. Presumably the last two Block-2s would replace the two Block-1s. Block-2 will have 100 times the tactical communications capacity of Block-1.

3. MILSTAR.

MILSTAR provides ultra-secure and jam-resistant EHF communication between any two places on earth, although it does have capabilities in other frequencies. It is the first system to provide such communication 24 hours a day. It is also the first space constellation capable of relaying messages between satellites to eliminate dependence on ground stations. Transmission from a ground command post, ship, or aircraft will be received by the nearest satellite, relayed to the satellite closest to the message's destination, and then transmitted back down to the recipient. With on-board data processing, each of these 5-ton spacecraft will be relatively autonomous.

Present plans call for four MILSTAR satellites in geosynchronous orbit and some capability for communication in the northern latitudes. The latter could be accomplished by putting MILSTAR payloads piggyback on existing satellites, such as ARCTICSATCOM.

The first MILSTAR satellite (a Block-1) was put into orbit on 7 February 1994 -- about seven years behind original schedules. The second satellite (also a Block-1) was launched on 6 November

1995. The third MILSTAR (the first Block-2 satellite) was launched in April 1999. It failed to reach a useful orbit and was eventually declared an \$800-million loss. The fourth satellite (the second Block-2 but the first to achieve orbit) was launched into orbit on 27 February 2001, more than a year behind schedule. It was placed in geosynchronous orbit over the United States. The fifth MILSTAR (the third Block-2) was put into orbit on 15 January 2002. It was placed in geo-synchronous orbit over the Mid East and Afghanistan. The sixth MILSTAR (the fourth Block-2) is scheduled for launch in November 2002. It will be placed in geosynchronous orbit over the Pacific.

Lockheed Martin Space Systems Company (LMSSC -- Sunnyvale, California) is the prime contractor. TRW Space and Electronics Group (Redondo Beach, California) provides the low-data-rate payload, Boeing Satellite Systems (El Segundo, California) supplies the medium-data-rate payload for the Block-2, and Lockheed Martin Astronautics Company (Denver, Colorado) makes the Titan-4 launch vehicle with the wide-body Centaur upper stage.

MILSTAR is a dangerous addition which will make America's war machine more aggressive. Further launches should be canceled to lessen world tensions. Existing communications satellite provide all the communication necessary for defensive purposes.



MILSTAR-2 artists conception
Source: Lockheed Martin

4. *Advanced EHF Satellite (AEHF).*

The Advanced EHF satellite is to be smaller than, equally robust as, capable of handling ten times more traffic than, and cost only a fraction of MILSTAR-2.⁴ The Pentagon wanted some semblance of competitive bidding so, in September 1999, Lockheed Martin (teamed with TRW) and Boeing Satellite Systems (El Segundo, California) were each awarded a \$22 million, 18 month study contract to define an AEHF system. The winner would become prime contractor.

Competition was not to happen. Conglomeration and technical specialization won out. The study was not even half over in April 2000 when the three companies involved convinced the Pentagon that AEHF could be obtained 18 months sooner (launch by December 2004 rather than June 2006) if they worked as a team. Using this as justification, the Pentagon canceled the competitive studies and awarded the \$2.6-billion prime contract to Lockheed Martin. TRW and Boeing would be subcontractors for major subsystems. Lockheed Martin expects to receive \$825 million over ten years and the balance would go the TRW and Boeing along with a string on minor subcontractors and vendors. So we had the same trio lined up to build AEHF that produced MILSTAR.

In November 2000 Canada signed on as a partner in the Advanced EHF satellite program so that it would have access to dedicated military space communication.

In early March 2001 it was announced that this "dream team" of contractors would not be able to deliver on schedule. The first satellite was at least 6 months behind schedule. The budget for AEHF was \$204 million in fiscal year 2000 and \$553 million in fiscal year 2001. Then on 16 March

⁴The Advanced EHF satellite is sometimes referred to as the Military Satellite Communications (MilSatCom) satellite.

2001 the Air Force announced a bailout -- the awarding of a \$86-million contract modification that extends the system definition phase and allows for additional preliminary design effort.

By June 2001 the satellite was a year behind schedule and the cost estimate had jumped to \$3 billion. Boeing's role was reduced -- essentially making it a subcontractor to TRW which took over some of Boeing's responsibilities. Boeing's share of the profits was cut from \$800 million to \$500 million.

Things still got worse. On 15 August 2001, just four months after the contract was awarded, the Defense Acquisition Review Board announced that the contract was already \$1 billion over its \$2.6 billion budget and that the 2004 launch date was unlikely -- so unlikely that the first launch was again scheduled for the original launch date of 2006 with the full constellation available by 2010.

Harris Corporation in July 2001 was awarded the 7-month, \$1.3 million study contract for Navy ship, shore, and submarine terminals for AEHF.

The Advanced EHF satellite original contract was for five satellites. The Pentagon envisions a constellation of four crosslinked satellites to provide communication coverage from 65° north latitude to 65° south latitude. The fifth will be a spare on the ground or a functional spare in orbit. In addition to being more secure, AEHF will provide ten times the total capacity of MILSTAR-2. Each AEHF will have 50 communications channels through multiple and simultaneous downlinks. In addition to the low and medium data rates of MILSTAR-2, AEHF will also have a higher data rate that will transmit 8.2 million bits/second. That is a better mode for transmitting battlefield maps and targeting information, and is 150 times faster than a 56K modem on personal computers.

In October 2001 the Pentagon announced it was looking at an alternative scheme called the Global Communications System. In this there would only be two AEHF satellites augmented by the Wideband Gapfiller satellites and the constellation of NRO satellites.

On 16 November 2001 the Pentagon announced that the Lockheed Martin-TRW team would be awarded the \$2.7-billion Systems Development and Demonstration contract to build just the two spacecraft required for the alternate scheme (originally it was about the same amount for five satellites) and replacing existing communications satellite ground stations to be compatible with the AEHF spacecraft. The first AEHF launch is scheduled for 2006. The work is to be completed by December 2011. If additional AEHF satellites are desired at a later date, a new contract will have to be awarded.

At the same time the contract was awarded in November 2001, Boeing announced that it is withdrawing from the AEHF project, saying: "We are disappointed that we are no longer going to participate on the Advanced EHF program... But considering the direction the program has taken, we felt we could not continue."⁵ It may be that cutting the contract down to only two satellites influenced Boeing's decision.

The AEHF contract will be managed by the Air Force. Lockheed Martin Space Systems Company (Sunnyvale, California) will be the overall systems integrator and prime contractor and will supply the spacecraft bus and mission control segment. Lockheed Martin Management & Data Systems is supplying the ground component. TRW Space & Electronic Group (Redondo Beach, California) will be the payload integrator responsible for the digital processing subsystem, the nulling antenna subsystem to prevent jamming, the downlinks, and the inter-satellite crosslinks.⁶ It is

⁵Cited in *Defense News*, 19 November 2001, pg. 4.

⁶A **crosslink** is the communication path between satellites. A **downlink** is the communication path from the satellite to a ground station. An **uplink** is the communication path from a ground station to a satellite.

believed that TRW will take over Boeing's previous responsibilities of providing the uplinks, the crosslink mirrors, the radio-frequency electronics, and the phased array antennas.

The Pentagon has requested \$920 million to continue development of the AEHF satellite during fiscal year 2003.

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GLOSSARY

AFSATCOM	Air Force SATellite COMmunications system.
AEHF	Advanced Extremely High Frequency satellite -- the MILSTAR follow-on.
ARTICSATCOM	ARCTIC SATellite COMmunications system. .
DSCS	Defense Satellite Communications System.
EHF	Extreme High Frequency.
ELF	Extreme Low Frequency.
FLTSATCOM	FleeT SATellite COMmunications system.
LMSSC	Lockheed Martin Space Systems Company.
MilSatCom	Military Satellite Communications.
MILSTAR	MILitary Strategic and TActical Relaysatellite.
NAVSTAR	NAVigation System Time And Ranging.
NRO	National Reconnaissance Office.