Future U.S. Military Satellite Communication Systems

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The current military satellite communications network represents decad technology. To meet the heightened demands of national security in the years, newer and more powerful systems are being developed.

Advances in information technology are fundamentally changing the way military conflicts ability to transmit detailed information quickly and reliably to and from all parts of the globe streamline military command and control and ensure information superiority, enabling faster highly mobile forces capable of adapting quickly to changing conditions in the field. Satellite communications play a pivotal role in providing the interoperable, robust, "network-centric" c needed for future operations.

Military satellite communications (or milsatcom) systems are typically categorized as wideband, protected, or narrowband. Wideband systems emphasize high capacity. Protected systems stress antijam features, covertness, and nuclear survivability. Narrowband systems emphasize support to users who need voice or low-data-rate communications and who also may be mobile or otherwise disadvantaged (because of limited terminal capability, antenna size, environment, etc.).

In 1997, the Senior Warfighters' Forum established a road map chart the course of military satellite communications through 2010. In 20 there will be course corrections as the Department of Defense purs aggressive acceleration in the delivery of improved communication capability.

Milsatcom is a system of systems that provides balanced wideband, narrowband, and protected communications to a broad range of users across diverse mission areas. The anticipated implementation of advanced architectures, supported by heightened connectivity in space as well as on the ground, will security space communications to take advantage of commercially developed Internet-like communications, but with greater assurance and security.

For wideband communication needs, the Wideband Gapfiller Satellite program and the Advanced Wideband System will augment and eventually replace the Defense Satellite Communication (DSCS). These satellites will transmit several gigabits of data per second—up to ten times the satellites being replaced. Protected communications will be addressed by a global extreme frequency (EHF) system, composed of the Advanced Extremely High Frequency System and Polar System. These systems are expected to provide about ten times the capacity of current satellites (the Milstar satellites). Narrowband needs are supported by the UFO (Ultra-high-frequency On) constellation, which will be replaced by a component of the Advanced Narrowband System (Milsatcom Timeline).

Capacity gains in these systems will also be matched by improved features, such as multipl...
beams that are particularly important for small terminal and mobile users. Satellite, terminal, planning segments will utilize emerging technology to ensure the best capability for the cost among ground, air, and space segments and between government and commercial assets deployment of the most efficient, effective, and affordable communications systems.

Wideband Communications

Assured capacity is the primary goal of the military communications sector. Wideband data rates are those greater than 64 kilobits per second, although a distinction between wideband and narrowband is blurring; data rates to disadvantaged users move higher wideband requirements are currently supported by the Global Broadcast Service, as well as commercial services. These military systems, together with the planned Gapfiller satellites, will form the Interim Wideband System, which will eventually give way to the Advanced System.

Wideband Gapfiller Satellites

The Wideband Gapfiller Satellite program will provide the next generation of wideband communications for the Department of Defense. (Boeing Satellite Systems)

The name “Gapfiller” is somewhat misleading because it implies a low-capacity satellite, but the very capable wideband communication payload will include state-of-the-art technology and provide a leap in capability. Preliminary estimates indicate that one Wideband Gapfiller spacecraft will provide up to 2.4 gigabits per second. This capability alone exceeds the capacity of existing DSCS and Global Broadcast Service constellations.

Throughput capacity is divided among nine X-band beams and ten Ka-band beams. Eight of the X-band beams are formed by separate transmitting and receiving phased-array antennas, which are used to shape and scale coverage areas. The ninth X-band beam, known as the “global beam,” provides Earth coverage. The ten Ka-band beams are formed by gimbaled dish antennas and include three beams with reversible polarization (Polarization—the direction of the electric field of an antenna—plays an important part in optical reception or reducing the effects of jamming).

The military satellite communications framework is a system of systems that provides connectivity across a range of users across diverse mission areas. In the future the framework will support network-on-a-plane through an architecture that promotes the interconnection of satellites and constellations in space and on the ground.

The key to the very flexible payload is the digital channelizer (or digital signal processor). Th
The first, and very successful, use of the Global Broadcast Service was in support of operations in 1996, where commercial satellites were used to broadcast military data to modified commercial broadcast set-top receivers and decoders.

Global Broadcast Service

Operation Desert Storm clearly demonstrated the need for the rapid delivery of large volumes of information to users on the front lines. During Desert Storm, air-tasking orders and intelligence reports were sometimes delivered by hand due to the lack of available communications bandwidth. This concern drove the creation of the Global Broadcast Service in the mid-1990s. With the advent of this service, most critical information could be transmitted in seconds. For example, a 1-megabyte air tasking order that might take up to an hour to transmit over Milstar or UFO (at 2.4 kilobits per second) could now be delivered in less than a second. The ability to push megabits of data to a small terminal was made possible through commercial advancements in high-power satellite transponders and direct broadcast service. The first, and very successful, use of the Global Broadcast Service was in support of operations in 1996, where commercial satellites were used to broadcast military data to modified commercial broadcast set-top receivers and decoders.

Today, the Global Broadcast Service is provided through a series of four Ka-band transponders.
steerable beams hosted on the Navy’s UFO 8, 9, and 10 spacecraft. Ground terminals with diameters of 0.6 to 1 meter receive data at rates up to 24 megabits per second per transponder of the two 500-nautical-mile diameter spot beams. Rates up to 1.5 megabits per second can through the 2000-nautical-mile diameter spot beam. Data are uplinked to the transponders at Primary Injection Points and transportable Theater Injection Points. The receiving suites and management suites supplied by Raytheon Company support military Ka-band and commercial operations.

In the future, the Wideband Gapfiller Satellite will provide the Global Broadcast Service through transponders. This is the second hosted Global Broadcast Service implementation, and its still under consideration with regard to the Advanced Wideband System.

**Advanced Wideband System**

The successor to the Defense Satellite Communications System and the Wideband Gapfiller program is the Advanced Wideband System. The system’s final configuration has not yet so ongoing milsatcom transformational efforts, but the concept is one of applied technology and that will remove capacity as a constraint on warfare communications. Analyses by the Defense Systems Agency and Joint Staff indicate that a global wideband satellite communications capacity excess of 15 megabits per second will be needed by the middle of the next decade.

The Advanced Wideband System will take advantage of the commercial and government technology advances of the first half of this decade to meet expected needs. Laser crosslinks, space-based data processing and routing systems, and highly agile multibeam/phased-array antennas will most likely be included. A constellation of advanced wideband-capable satellites is planned with a first launch at the end of this decade.

Capacity in the right place is the overall requirement, but getting adequate capacity to ever-smaller terminals worldwide is becoming increasingly difficult because of the limits on the amount of international bandwidth in the X and Ka bands for DOD use (see related article, “Critical Issues in Spectr Management for Defense Space Systems”). Several options for mitigating the current limit consideration, including the use of higher frequencies (notably in the 40–75-gigahertz range). Also, the number of wideband-capable satellites over a region would increase with directional antennas to use an allocated frequency band on more than one satellite in a approach would increase effective bandwidth by simultaneously reusing allocated frequencies and use of small independent beams or cells, achievable through multibeam/phased-array antennae. Frequency reuse is an important characteristic of terrestrial and space-based cellular systems, and the frequency components with more efficiency and power will also be used to get more data to terminals, similar to the way commercial direct broadcast service transponder technology was used in the Global Broadcast Service a decade earlier.

Synchronization of the various Advanced Wideband System segments is beginning. To support efforts, new terminals, such as the GMT, will be introduced, and the CCS-C will be employed to provide significant additional capability to address the increased complexity in providing high capacity communications to highly mobile forces.

**Protected Communications**

Protected systems have the ability to avoid, prevent, negate, or mitigate the degradation, dis unauthorized access, or exploitation of communications services by adversaries or the environ
protected systems include the Advanced Extremely High Frequency System and Advanced EHF.

**Advanced EHF**

The loss of Milstar Flight 3 in 1999 and the last deployment of a Milstar satellite (Flight 6) in 2003 have increased the need for a successor system with full operational capability by 201. Consequently, in November 2001, the Advanced Extremely High Frequency (AEHF) System awarded to the Lockheed Martin Space Systems and TRW Space and Electronics team for Development and Demonstration phase of the new program. Under this contract, three satellite associated ground command and control segment will be produced. Under DOD transformation initiatives, other protected milsatcom options are being considered to complete the needed strategic and tactical capability; however, if full operational capability cannot be achieved in transformational options, then the original program to acquire four AEHF satellites plus one restored. All new protected satellites will be interoperable with the Milstar satellites.

The AEHF System will have up to 12 times the total throughput of Milstar, in some scenarios. Single-user data rates will increase from a maximum of 1.544 megabits per second (medium data rate) to 8 megabits per second (high data rate). Along with capacity, the new system will provide an almost tenfold increase in the number of spot beams for improved user access. These small beams will focus power to improve reliability and data rates to small and large terminals and to minimize interception and interference opportunities for regional adversaries. Overall, the AEHF System network will support twice as many tactical networks as Milstar. Improvements in network capability will also help ensure compatibility with international partners.

As in Milstar, the AEHF System crosslinks will enhance routing and reduce vulnerability to terrestrial disruption. The new crosslinks will operate at several times the current Milstar data rate.

By 2010, about 2500 terminals are expected in the protected communications inventory for the Air Force, Navy, Army, and Marines. Portable, mobile, and fixed terminals with low, medium, and high data rates will support ground units, aircraft, surface ships, and submarines. Standard antennas will range in size from a few centimeters to about 3 meters. Applicable milsatcom terminals include the Family of Advanced Beyond line-of-sight Terminals (FAB-T), the Single-Channel Antijam Man-Portable Terminal (SCAMP), Secure Mobile Antijam Tactical Terminal (SMART-T), and Submarine High Data Rate (Sub HDR) system. The FAB two previous programs, the Airborne Wideband Terminal and Command Post Terminal Rep establishes a family of terminals with a common open architecture for airborne and ground platforms.

For mission control, the system will have a dedicated segment consisting of communications mobile command and control centers, Satellite Ground Link Standard/Unified S-Band (SGLS) control, and EHF in-band satellite control. The CCS-C will interface with the AEHF satellite to provide SGLS/USB command capabilities.

**Advanced Polar**

The demand for protected satellite communications to support submarines and other platforms and operating in the high latitudes has steadily over the last twenty years.
Requirements Over approved the Polar Requirements Document. It paved the way for addressing the polar Communications (PolarCom) demand. Subsequent decision was made to launch a series of modified Eaglestar-class host satellites. The modified package was launched in 1999 and the remaining two scheduled for launch in 2001. All hosted capability which provided critical service to the Joint Force Structure, it only met a fraction of the requirements spelled out in that Operational Requirements Document. Consequently, a replacement system was considered for the 2002 timeframe. The Air Force and the Joint Program Office completed a polar Communications (PolarCom) study that covered 35 wide area options for a future polar capability. As a result of this study, two satellites in highly inclined, Molniya orbits have been recommended. In addition, transformational initiatives within the Defense have put forward a proposed National Strategic SATCOM System that would combine polar coverage for highly survivable communications, all in one system.

Narrowband Communications

In the past, the term “narrowband” implied data rates of less than 64 kilobits per second, but that boundary could apply in the future as higher data rates to small terminals become possible. Other small terminal users depend on high-power, low-data-rate satellite systems to receive broadcast (as in the Navy’s Fleet Broadcast) and for two-way communications. Narrowband generally transmitted in the ultrahigh-frequency (UHF) range—are supported by the UFO constellation which will be replaced by a component of the Advanced Narrowband System.

Advanced Narrowband System

The Advanced Narrowband System is DOD’s next-generation narrowband tactical satellite communications system, and its goal is to provide global narrowband communications services to tactical users (typically quite mobile). The Advanced Narrowband System consists of six segments: DOD’s commercial space; telemetry, tracking, and command; network control; user entry; and gateways. The Mobile User Objective System is the successor to the Navy’s current Boeing-built UFO the key transport element in the Advanced Narrowband System. The Mobile User Objective System provides beyond-line-of-sight communication to support mission objectives across all branches of the military.

The Communications Satellite Program Office of the Space and Naval Warfare Systems Command completed concept studies resulting in several approaches to addressing narrowband needs. It has supported the Navy in evaluating these approaches and has collaborated, from an Advanced Narrowband System perspective, on possible commercial satellite communications augmentations.

The current UFO constellation has eight satellites, plus one on-orbit spare, each of which provides a mix of 38 UHF communication channels at 5 and 25 kilohertz and one 25-kilohertz fleet broadcast channel. About 7500 UHF terminals are in use today. The capacity of this system will fall far short of anticipated needs by the end of this decade, considering that the estimated 2010 Combined Theater of War requirement is about 42 megabits per second with over 2,300 simultaneous accesses—hence, the urgent need for the Advanced Narrowband and Mobile User Objective Systems.

The Advanced Extremely High Frequency system will have as much as 12 times the total throughput of MILSTAR, in some scenarios. Single-user data rates will increase to 8 megabits per second. The system will also provide a large increase in the number of spot beams for improved user access. (Lockheed Martin Missiles and Space Systems)
Launches could begin before the end of the decade, paving the way for full operational capability by 2013. The number of narrowband satellite communications terminals of all types is expected to approach 82,000 in 2010. About 50 percent of those will be handheld Combat Survivor Evader Locator units, and the remainder will be predominately legacy and advanced Joint Tactical Radio System terminals.

The Mobile User Objective System will employ commercial technology to enable communications with users of large terminals and small or handheld terminals. Commercial systems such as Thuraya in the Middle East and AceS in Southeast Asia have shown that more than 10,000 low-data-rate handheld terminals can be serviced over a region with one satellite. Large multibeam antennas, some more than 12 meters in diameter, enable the use of several hundred spot beams to improve signal-to-noise levels and achieve up to 30 times frequency reuse. Systems with these capabilities currently operate at L-band (1.5 gigahertz downlink) frequencies.

In addition to the Mobile User Objective System, the Navy is keeping other alternatives open. Advanced Narrowband System requirements. One alternative would be to field or lease commercial systems, if the commercial market proves sufficiently mature. Another option would be to field evolved UFO satellites to allow the commercial sector to mature and improve government operations. The Navy has dubbed this alternative “UFO-E,” indicating that the Navy would consider continuing constellation with gradual improvements.

**Accelerating Capability**

In early fiscal year 2002, DOD initiated a Transformational Communications Study to accelerate delivery of advanced capabilities with state-of-the-art technology to the field. The study is led by the National Security Space Architect (NSSA) and is springboarding off the NSSA’s Mission Information Management Communications Architecture (see sidebar, The Space Architect). The study is increased intersystem connectivity via optical crosslinks, greater reliance on ground fiber, and the use of commercial assets as appropriate. Potentially, all U.S. government satellite programs in planning or development could be affected.

The Space Architect’s vision of the future closely integrates government satellite communications of systems. Additionally, it treats communications as an enterprise and balances air, space, and ground communications capabilities.

A large part of achieving advanced capabilities involves applying the best technology to existing programs. To ensure milsatcom's technological edge in world satellite communications, the Joint Program Office has established a Milsatcom Innovation Center to accelerate the introduction...
technologies into new systems. Aerospace, MITRE, MIT Lincoln Laboratory, and NASA's Je Laboratory are contributing onsite to the Center's activities. MILSATCOM will most definitely have a future.

Further Reading