Satellite Systems - Communications Systems

The world's first communications satellite—Project SCORE—was launched by the Air Force Ballistic Missile Division, SMC's predecessor, on 18 December 1958. The SCORE payload consisted of commercial communications equipment modified by the Army Signal Corps and installed in an Atlas B missile as a proof-of-concept mission for orbiting communications repeaters. The project was executed under ARPA's direction. AFBMD launched the entire missile, minus the spent half stage, into a low orbit, where it remained for about a month, relaying voice and telegraph messages between ground stations in the United States. Among its first experimental transmissions was President Eisenhower's Christmas message to the world, the first time that a human voice had been transmitted from space. The world's second military communications satellite was Courier 1B, developed by the Army Signal Corps under ARPA's direction. AFBMD successfully launched it on 4 October 1960, using a Thor Able Star launch vehicle. Courier further tested the feasibility of orbiting communications repeaters but did so with a spherical, self-contained satellite that included solar cells and rechargeable batteries. Unfortunately, the spacecraft suffered a command system failure after 17 days in orbit.

The first military satellite communications system to be used for operational purposes was known as the Initial Defense Communications Satellite Program (IDCSP). The development program began in 1962, following the cancellation of an earlier, unsuccessful development program called Project Advent. The IDCSP system consisted of small, 100-pound satellites launched in clusters. Twenty-six such satellites were placed into orbit in four launches carried out between June 1966 and June 1968. Two fixed and thirty-four mobile ground terminals also became operational in 1968. IDCSP transmitted both voice and photography to support military operations in Southeast Asia. It provided an experimental but usable worldwide military communications system for the Defense Department for ten years until a more sophisticated system could be developed.

That more sophisticated system was known as the Defense Satellite Communications System, Phase II (DSCS II). The DSCS II satellites were much larger and more sophisticated than the IDCSP satellites, offering increased communications capacity, greater transmission strength, and longer lifetimes. In addition to horn antennas for wide area coverage, they had dish antennas that were steerable by ground command and provided intensified coverage of small areas of the earth's surface. SAMSO awarded a development contract for the DSCS II system to TRW on 3 March 1969, and the first pair of satellites was launched on 2 November 1971. It was the first operational military communications satellite system to occupy a geosynchronous orbit (22,237 miles). Two launch failures delayed completion of the satellite network, but by January 1979, the full constellation of four satellites was in place and in operation. A total of 16 DSCS II In 1973, planning began for the Defense Satellite Communications System, Phase III (DSCS III). DSCS III satellites carried multiple beam antennas to provide flexible coverage and resist jamming, and they offered six active communication channels rather than the four offered by DSCS II. The first DSCS III satellite was successfully launched on 30 October 1982, and a full constellation of five DSCS III satellites was completed on 2 July 1993. Two DSCS IIIs were launched into orbit from a Space Shuttle on 3 October 1985. The constellation was replenished with five launches from 28 November 1993 to 20 October 2000. By early 2003, only two unlaunched DSCS III satellites remained in the inventory. In view of the fact that the DSCS III system would have to support tactical military operations until a follow-on system could be acquired, SMC began an initiative to improve the tactical utility and extend the lifetime of DSCS III satellites. Known as the Service Life Enhancement Program (SLEP), the initiative added improvements to the last four DSCS III satellites before they were launched. Lockheed Martin was placed under contract to carry out the SLEP modifications on 28 March 1996.satellites was built and launched during the life of the program, with the last launch occurring on 4 September 1989.

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DSCS satellites were developed to serve users who transmitted message traffic at medium to high data rates using relatively large ground terminals. However, satellites were also needed to serve users who transmitted at low to medium data rates, using small, mobile or transportable terminals. During the 1960s, experimental satellites were placed into orbit to test technology that might perform this tactical communications mission. Lincoln Experimental Satellites 5 and 6, launched on 1 July 1967 and 26 September 1968, were solid-state, ultra high frequency communication satellites built by Lincoln Laboratory. The 1,600 pound Tactical Communications Satellite, launched on 9 February 1969, operated in both ultra high frequency and super high frequency and tested the feasibility of communications with small, mobile, tactical communications equipment that could be used by ground, naval, and air forces. In July 1970, an initial operational capability for tactical communications was established, using the Tactical Communications Satellite and Lincoln Experimental Satellite 6.

These experimental satellites paved the way for the Fleet Satellite Communications System (FLTSATCOM), the first operational system serving tactical users. The Navy managed the overall program, but SAMSO managed acquisition of the satellites. Development of FLTSATCOM was authorized on 27 September 1971, and five satellites were launched from 9 February 1978 to 6 August 1981. Four achieved orbit and went into operation, but one was damaged during launch and never became operational. Three replenishment satellites were launched from 5 December 1986 to 25 September 1989. Two reached orbit, but one was lost when its booster was hit by lightning.

In addition to the long-haul users served by DSCS and the tactical users served by FLTSATCOM, there was a third group of users—the nuclear capable forces—who could be satisfied at the time with low data rates but required high availability, worldwide coverage, and the maximum degree of survivability.

The Air Force Satellite Communications System (AFSATCOM) was developed to serve their needs and allow the Air Force to command and control its strategic forces. The space segment of the system relied on transponders (receiver/transmitters) placed on board FLTSATCOM satellites and other DOD spacecraft. The space segment of AFSATCOM became operational on 15 April 1978, and the terminal segment attained initial operational capability on 22 May 1979.

The communications satellites discussed above were all acquired for the U.S. military, but other communications satellites were acquired for the United Kingdom and the North Atlantic Treaty Organization during the 1960s and 1970s. The British Skynet program began in 1966. The first of two Skynet I satellites was placed into orbit on 21 November 1969 and provided the United Kingdom with its first military communications satellite system. The second Skynet satellite was launched from Cape Canaveral on 19 August 1970, but a malfunction in the launch vehicle caused permanent loss of contact with the satellite. In 1970, SAMSO and the United Kingdom began development of a more advanced Skynet II satellite system. The first Skynet II satellite was launched on 18 January 1974, but a malfunction in the launch vehicle again caused the loss of the satellite. The second Skynet II satellite, launched on 22 November 1974, attained orbit successfully and was turned over to the United Kingdom in January 1975.

Development of the NATO satellites began in April 1968, with the initial series of satellites being known as NATO II. One NATO II satellite was placed in orbit on 20 March 1970 and another on 3 February 1971. Both the Skynet and NATO satellites were designed to be compatible and usable with each other and with the Defense Satellite Communications System. Work on a more advanced system, NATO III, began in 1973, and three NATO III satellites were successfully launched between 1976 and 1978. The constellation was replenished in November 1984, when a fourth satellite was successfully launched.

The next space communications system to be acquired by SMC was Milstar. Milstar I satellites carry a low data rate payload that provides worldwide, survivable, highly jam-resistant communications for the National Command Authority and the tactical and strategic forces. Advanced processing techniques on board the spacecraft as well as satellite-to-satellite cross linking allow Milstar satellites to be relatively independent of ground relay stations and ground distribution networks. Space Division awarded concept validation contracts for the satellite and mission control segment of Milstar I in March 1982 and a development contract to Lockheed on 25 February 1983. The first Milstar I was successfully launched on 7 February 1994, and the second, on 6 November 1995. In October 1993, SMC awarded a contract for development of the Milstar II satellite, which carried both low and medium data rate payloads. The addition of the medium data rate payload greatly increased the ability of tactical forces to communicate within and across theater boundaries. Only four Milstar II satellites were produced because DOD had decided in 1993 that they were to be replenished by a new, lighter, cheaper series of Advanced EHF satellites. Unfortunately, the first Milstar II satellite went into an unusable orbit on 30 April 1999. The next two Milstar II satellites were successfully launched on 27 February 2001 and 16 January 2002 to complete an on-orbit constellation of four satellites. The sixth and last Milstar satellite was successfully launched on 8 April 2003.

In view of the limited future of the Milstar system, SMC soon began the acquisition of a follow-on EHF military communications system, known as the Advanced EHF system or AEHF. The system was compatible with Milstar elements and incorporated them throughout their useful lifetimes. The completed AEHF constellation would consist of four satellites in geosynchronous orbit. Like Milstar, but greatly enhanced, the AEHF system featured on-board signal processing and satellite crosslinks to eliminate reliance on ground stations for routing data. Data uplinks to the satellites and crosslinks between satellites operated at EHF, and downlinks operated at SHF. Whereas Milstar offered low and medium data rate payloads, AEHF satellites had high data rate payloads as well, providing up to 8.2 Mbps. The AEHF system provided ten times as much data throughput as Milstar for a much larger area of coverage. It enabled a variety of types of communications, including broadcasting, real-time video, data and voice networking, and voice-conferencing. All services used AEHF terminals, which were located on a wide variety of platforms on land, sea, and air.

After competitive system definition efforts ending in 1999, SMC awarded a contract to the team of Lockheed Martin and TRW for the System Development and Demonstration phase of the AEHF system, including production of the first two satellites and the Mission Control Segment. A third satellite was added to the contract in 2006 and a fourth in 2010. In 2009, OSD cancelled a planned follow-on program known as the Transformational Satellite Communications System (TSAT) that would have followed the fourth AEHF satellite, and it directed the Air Force to acquire the fifth and sixth AEHF satellites instead. By 2014, the first three AEHF satellites had been successfully launched on Atlas V vehicles.

In 2000, SMC also led a multi-service program to acquire a new series of communications satellites—known eventually as the Wideband Global SATCOM (WGS) system—to augment DSCS III and finally replace it. However, the capabilities of the WGS system were vastly enhanced in comparison to DSCS. WGS provided not only two-way tactical military communications, but also a two-way Ka-band augmentation of the older one-way, wideband satellite broadcast system called the Global Broadcast Service (GBS). Each WGS satellite could provide up to 3.6 Gbps of data transmission, well over ten times the X-band communications capacity of a DSCS satellite, and 4.875 GHz of instantaneously switchable bandwidth. Block II satellites (starting with WGS-4) provided ultra-high bandwidth and data rates using a radio frequency bypass capability to support airborne intelligence, surveillance and reconnaissance platforms such as unmanned aerial vehicles.

SMC awarded a contract for design and advance procurement of the first three WGS satellites, which constituted Block I, as well as ground-based command and control elements to Boeing Satellite Systems in 2001. It awarded a contract for the next three satellites, constituting Block II, to Boeing in 2006 and a Block II follow-on contract for WGS satellites 7 through 10 in 2010. By 2014, the first six WGS satellites had been successfully launched, the first two on Atlas V vehicles and the next four on Delta IVs.