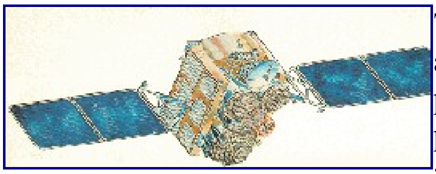
DSCS-3

The DSCS III is the third generation of general purpose military communication satellites. The first DSCS III was launched in 1982. In contrast to its predecessors, DSCS III offers significantly greater capacity and longer life, and improved resistance to hostile activities such as jamming. The DSCS III satellite, which has a design life of ten years, is designed to support all three military services, and its signals can be received by ground antennas that range in diameter from 33 inches to 60 feet. Signals are broadcast on 6 channels between 7250 and 8400 MHz (television broadcasts between 54 MHz and 800 MHz). The satellite also carries a Single Channel Transponder (SCT) that is used to transmit Emergency Action Messages from the President to nuclear forces.



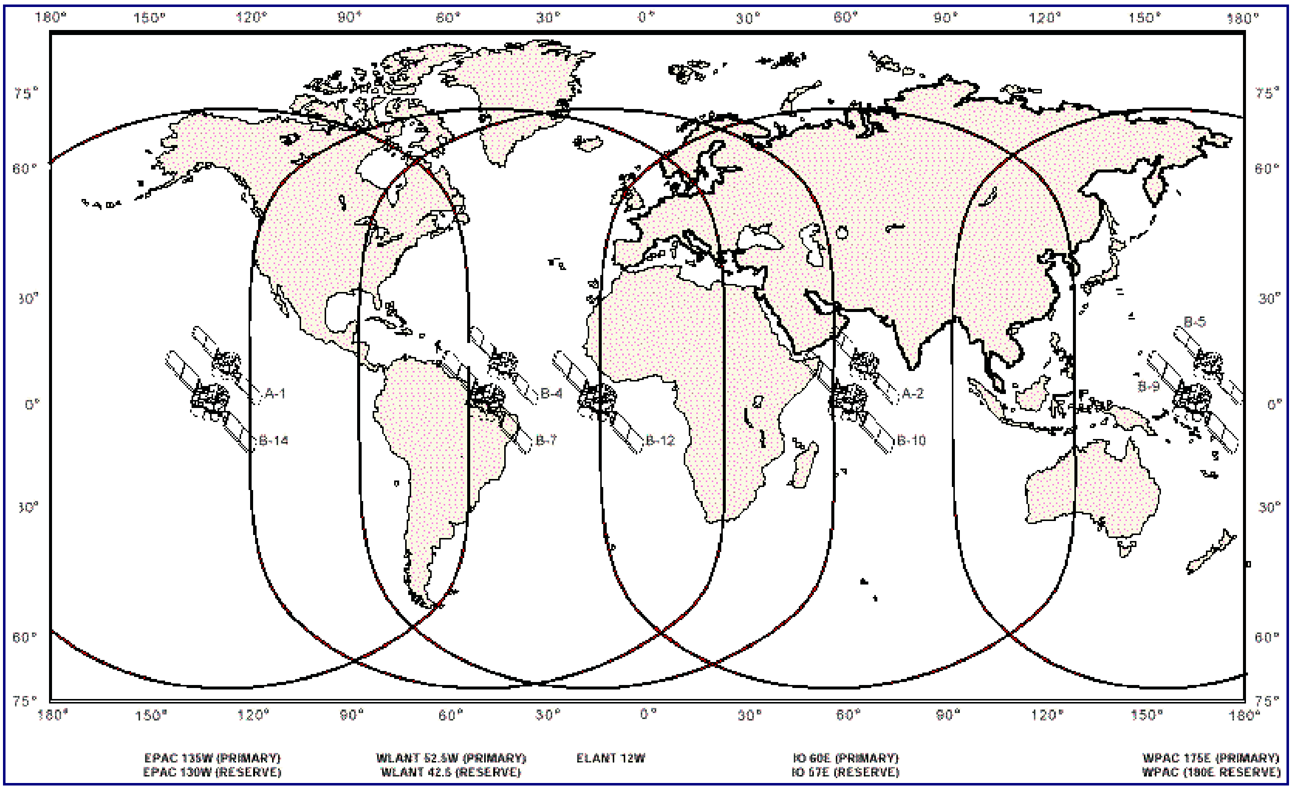
The DSCS III system is built with single- and multiple-beam antennas that provide more flexible coverage than its predecessors. Phase III satellites bring more capacity while providing greater assured communications through improved ability to resist jamming. Antenna design for DSCS III allows users to switch between fixed, Earth coverage, and multiple-beam antennas. The latter provides an Earth coverage beam as well as electrically steerable area and narrow-coverage beams. In addition, a steerable transmit dish antenna provides a spot beam with increased radiated power for users with small receivers. In this way, operators can tailor the communications beams to suit the needs of different size user terminals almost anywhere in the world.(1)

The Air Force began launching the more advanced Phase IIIs in 1982. Previous launch vehicles included Titan 34D/IUS and the Space Shuttle. The 3 October 1985 launch of the Space Shuttle "Atlantis" carried two Defense Satellite Communications System (DSCS-III) satellites, which were propelled to geosynchronous orbit, 22,500 miles above the Earth by an Inertial Upper Stage (IUS). Although NASA and the Defense Department continued their policy of not announcing the payloads of military flights of the Shuttle, the payload of the Atlantis was readily identifiable from public sources. An August 1981 Air Force Space Division fact sheet on the DSCS program stated that the "first launch of a DSCS III on the Shuttle is scheduled for mid-1985." A 1983 press report noted that a "crucial launch appears to be scheduled in 1985, when a pair of DSCS III's are to be launched from the Shuttle using and IUS booster."(2) And another trade press report the following year noted that two DSCS III's would "be launched together next year on a single Space Shuttle mission, apparently on the Atlantis mission from the Cape in September."(3) Phase III satellites, with the Integrated Apogee Boost Subsystem (IABS), are currently configured to launch only on the Atlas II launch vehicle. The first Atlas II launch of a DSCS III IABS occurred on 10 February 1992. Additional launches of these satellites are planned at yearly intervals.

DSCS-3 spacecraft weigh 2,580 pounds, and have a design life of ten years, twice as long as the Phase IIs. The spacecraft's rectangular body is 6 feet x 6 feet x 7 feet; with a 38-foot span with solar arrays deployed. Phase III solar arrays generate 1,100 watts, decreasing to 837 watts after five years. Each DSCS III satellite costs about $100,000,000.

The DSCS program is managed by the Air Force Space Division in Los Angeles, CA. The prime contractor is Martin Marietta (formerly GE General Electric) Astro Space Division, of Valley Force, PA. Martin Marietta Astro Space (MMAS) provides DSCS III orbital operations support, including anomaly resolution based on detailed design knowledge, ground system unique software support, and telemetry analysis at Onizuka AS, CA and Falcon AFB, CO. The contractor maintains ground system mission unique software, on orbit spacecraft software, spacecraft simulator hardware and software and technical analyst workstation hardware and software. In addition, Astro Space conducts anomaly analysis and vehicle checkout based on telemetry data, DSCS III design and test histories.(4)

DSCS III satellites (Phase III), which are now used exclusively, were first placed in operation in 1983; nine are currently active (five primary and four reserve), and five are in inventory. The most recent launch was in October 1997 (B-13). Future DSCS III launches are tentatively scheduled for 1999 (B-8), 2000 (B-11), 2002 (B-6), and 2003 (A-3). DSCS III satellites, designed to provide SHF SATCOM capability through the year 2000 and beyond, are being placed in geosynchronous orbital positions 22,300 miles above the equator to provide coverage between 75 o north latitude and 75 o south latitude. The DSCS constellation provides communications services in each of the following five satellite areas: East Pacific (EPAC), West Atlantic (WLANT), East Atlantic (ELANT), Indian Ocean (IO), and West Pacific (WPAC).



DSCS III Footprint

There are two series of DSCS III satellites: A-series and B-series. The A-series are the first-generation DSCS III satellites. The B-series are newer and have received upgrades to various support subsystems and the communications subsystem (Note: Model A-3 awaiting launch will be upgraded and have the same capabilities as a B-series model). The essential difference between the A-series and B-series DCSC III satellites is in the single channel transponder (SCT) package. The A-series DSCS/ SCT has only the UHF downlink capability while the B-series DSCS/ SCT has both UHF and SHF downlink capability. Thus, when the Navy is operating over DSCS III B-series channel one, the regular communications channel will have to share the channel one traveling wave tube (TWT) power amplifier with the SCT community; however there is no power sharing required with the SCT community over the DSCS III A-series satellites. The DSCS III satellites are designed for an operational life span of 10 years.

Current DSCS Satellite Constellation

SATELLITE OCEAN AREA	DSCS III SATELLITE MODEL	LONGITUDE (Degrees)
East Pacific Primary	B-14	135W
East Pacific Reserve	A-1	130W
West Atlantic Primary	B-7	52.5W
West Atlantic Reserve	B-4	42.5W
East Atlantic Primary	B-12	12W
Indian Ocean Primary	B-10	60E
Indian Ocean Reserve	A-2	57E
West Pacific Primary	B-9	175E
West Pacific Reserve	B-5	180E

DSCS III Satellite Capability. The DSCS III satellites provide substantial capability to support high-capacity links between all terminals and to permit AJ communications and control of the satellites during crisis and contingency situations. DSCS III satellites operate in the X-band region, providing uplink services in the 7900-8400 MHz band and downlink services in the 7250-7750 MHz band. The frequency spectrum is divided into six bands by the use of six limited-bandwidth transponders which are switchable between antennas by DSCS ground control. Communications performance is optimized by allowing these independent transponders to be connected to various types of antennas. This permits selection of Earth coverage (EC), area coverage (AC), spot coverage, grouping of channels with similar modulation, and antenna gain-to-noise temperature (G/T) ratios to meet user needs. Any type of modulation or multiple access may be used since the transponders do not process or modulate the signals. The DSCS III satellites are three-axis stabilized (geostationary) vehicles that have a dry weight of 1,950 pounds and a maximum weight of 2,550 pounds with propellant. The dimensions of the satellite body are approximately 80 inches (6.5 feet) on each side and 460 inches (38 feet) in length, with solar arrays (SA) deployed. Communications antennas include a receive 61-beam multibeam antenna (MBA) and two transmit 19-beam MBAs, two receive and two transmit Earth coverage horns (ECH), and a transmit-only gimballed dish antenna (GDA). In addition, there is one transmit and one receive SCT UHF antenna.

SATELLITE CHARACTERISTICS	DSCS III	DSCS III SLEP
Effective Isotropic Radiated Power (EIRP)	EC Beacon, 27 dBW NC Beacon, 40 dBW	EC Beacon, (TBD) NC Beacon, (TBD)
Power Output	40-watt RF, Channels 1 and 2 10-watt RF, Channels 3 through 6	50-watt RF, Channels 1 through 6
EC Beacon 1 Frequency	7600 MHz	7600.000000 MHz
EC Beacon 2 Frequency	7604 MHz	7604.705882 MHz
Beacon EIRP	13 dBW	TBD
Satellite Weight	1,950 pounds (2,550 pounds with propellant)	TBD

Size	Main structure: Length: 9.2 feet with panels Width: 6.3 feet Depth: 6.4 feet (no antenna tips) Solar array: With Yoke: 15.9 feet Fully Extended: 38.1 feet	Main structure: Length: 9.2 feet with panels Width: 6.3 feet Depth: 6.4 feet (no antenna tips) Solar array: With Yoke: 15.9 feet Fully Extended: 38.1 feet
Lifetime	10 Years	10 Years

DSCS III Supporting Subsystems

SUBSYSTEM	KEY FEATURES
Attitude Control	Autonomous initial sun acquisition and operation Earth and sun sensors for attitude sensing Four skewed reaction wheels Time-shared central digital processor for all control modes 0.08^{o} roll, 0.08^{o} pitch, 0.8^{o} yaw control accuracy
Propulsion	Hydrazine propulsion system with redundant thrusters and tanks 600 pound capacity beginning of life (BOL) 1.0 pound thruster
Telemetry, Tracking and Command (TT& C)	Command and telemetry interface with Satellite Control Facility, DSCS terminals, and the shuttle Rapid MBA reconfiguration Incorporation of SHF communications security (COMSEC) equipment
Electrical Power and Distribution	Regulated Bus -28V dc ± 1% 126 square feet of solar array 96 Ah NiCd battery capacity 1188 watt output from solar array at BOL Fully redundant Rapid response to load changes Load fault isolation/ transient protection
Thermal Control	Passive during normal operation North/ South radiator panels use optical solar reflectors Survive failure modes include attitude loss and total battery failure
Structures and Mechanism	Provides accessibility and modularity North/ South array through drive shaft Independent propulsion module Vibration damped equipment panels Lightweight, stiff, and dimensionally stable Growth and option flexibility
Single Channel Transponder (SCT)	Separate dedicated UHF transmit and receive antennas Integral UHF/ SHF transponder assembly Supports UHF/ SHF uplink, single UHF downlink channel

	SHF downlink available on B-series satellites (requires utilization of percentage of channel 1 traveling wave tube amplifier [TWTA])

Attitude Control Subsystem (ACS). The ACS is a three-axis, zero momentum stabilization system using on-board electronic processing to provide attitude control. The ACS orients and stabilizes the satellite after launch vehicle separation, maintains pointing during on-orbit and payload operations, and controls the satellite attitude during orbit adjustment operations.

Propulsion Subsystem (PS). The PS consists of four propellant tanks, two thruster banks (eight thrusters each bank), and six propellant fill and drain valves. Individual thruster banks are capable of performing all mission functions.

Telemetry, Tracking and Command (TT& C) Subsystem. The TT& C subsystem provides the capability to command the satellite and transmit TT& C data over redundant control links. The TT& C is a secure (encrypted) telemetry link used primarily for command and control of communications payload operations and on-orbit testing. (Chapter 3 of this NTP provides additional information on DSCS control.)

Electrical Power and Distribution Subsystem (EPDS). The EPDS provides for the conversion of solar energy to electrical power and the regulation and distribution of power to the other satellite subsystems. EPDS also provides storage of electrical energy for subsequent use by other subsystems throughout satellite mission life.

Thermal Control Subsystem (TCS). The TCS utilizes passive and active temperature control techniques. Passive control techniques include a multilayer insulation blanket (with selective sized cutouts to regulate heat retention) completely enclosing the satellite, thermal coatings, insulation spacers, RF transparent thermal shrouds, thermostats, and flight temperature sensors. During normal operation, only passive TCS techniques are required; however, automatically powered survival heaters actively maintain the minimum survival temperature required.

Structures and Mechanisms Subsystem. The major fixed structural assemblies of the DSCS III satellites include a central bay structure, north and south panels, antenna supports, solar array substrates, and a launch vehicle adapter. The main body structure provides hard point mounts for the propulsion system and the communication antennas. The center bay is constructed of aluminum honeycomb panels for mounting components.

SCT Subsystem. The SCT subsystem consists of a UHF receive antenna, a UHF transmit antenna, and an integral UHF/ SHF transponder assembly. The SCT subsystem's primary function is to provide secure and reliable dissemination of emergency action messages (EAM) and Single Integrated Operations Plan (SIOP) communications between command post ground stations, aircraft, and theater force elements.

DSCS III Communications Subsystem

The DSCS III Communications Subsystem includes six independent RF channels, jammer location electronics (JLE), one receive 61-beam MBA, two receive ECHs (E1R and E2R), two transmit 19-beam EC/ narrow coverage (NC) MBAs (M1X and M2X), one transmit GDA, and two transmit ECHs (E1X and E2X). Channels 1 and 2 are designated as high power channels and each operates with a 40-watt TWTA. Channels 3 to 6, the low power channels, operate with a combination of 10-watt TWTAs/ high efficiency solid-state amplifiers (HESSA), and linear solid-state amplifiers (LSSA). The last four DSCS III satellites scheduled for launch (B-8, B-11, B-6, and A-3) will receive performance upgrades through the DSCS SLEP. Responding to the Services' need for more capacity, the original DSCS III SLEP has been revised. The revised SLEP provides improved satellite capability for the next four DSCS satellites to be launched with the first scheduled in July 1999 and the fourth in fiscal year (FY) 2003 (a fifth satellite is currently unfunded). Major revised SLEP upgrades to the DSCS III satellite include increased transponder bandwidth and 50-watt

TWTA in all six channels. The 50-watt TWTA and bandwidth addition is predicted to provide a 700 percent increase in tactical communications capacity.

Furthermore, upgrades to the low noise amplifiers (LNA) is estimated to provide an approximately 30 percent increase in data rates for smaller terminals. The increased power capability in all channels on SLEP DSCS III satellites will allow shifting of nontactical users on channels 2 through 4 to channels 5 and 6 by using bandwidth-efficient modulation techniques. This compression technique provides greater bandwidth utilization but, in the past, was not feasible due to the increased power-per-bit requirement. SLEP will increase the mean mission duration (MMD) from 7.5 to 10 years per satellite. The downlink EIRP for SLEP-modified DSCS III satellites is to be determined.

ITEM	KEY FEATURES
DSCS Receive Antennas	One 61-beam waveguide lens, MBA Full 61-beam control of amplitude and phase Broadband, selective nulling Accurate, rapid control of selective coverage pattern Two EC horn antennas
DSCS SHF Transponders	Six, one for each channel High gain for enhanced small terminal operation Channel 1 bandwidth: 60 MHz (freq. plan I), 50 MHz (freq. plan II) Channel 2 bandwidth: 60 MHz (freq. plan I), 75 MHz (freq. plan II) Channel 3 bandwidth: 85 MHz (freq. plan I), 85 MHz (freq. plan II) Channel 4 bandwidth: 60 MHz (freq. plan I), 85 MHz (freq. plan II) Channel 5 bandwidth: 60 MHz (freq. plan I), 60 MHz (freq. plan II) Channel 6 bandwidth: 50 MHz (freq. plan I), 50 MHz (freq. plan II) Low noise figure (4.0 dB) Passive thermal design for maximum reliability Fully hardened components Low-loss, lightweight filters Low-phase distortion
DSCS Transmit Antennas	Two 19-beam waveguide lens MBAs Full 19-beam amplitude control Accurate, rapid selective coverage Two EC horn antennas High-gain mechanically steerable parabolic dish antenna connectable to channels 1, 2, or 4; 1 and 4; or 2 and 4

DSCS III Communications Subsystem Key Features

CHANNEL	EC HORN	GDA	MBA (EC)	MBA (NC)
1	-	46	31	42
2	-	45.5	31	42
3	27	-	25	36
4	27	41	25	36
5	27	-	-	-
6	26	-	-	-

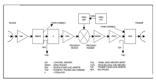
DSCS III Downlink EIRP (dBW)

CHANNEL	EC HORN	GDA	MBA (EC)	MBA (NC)

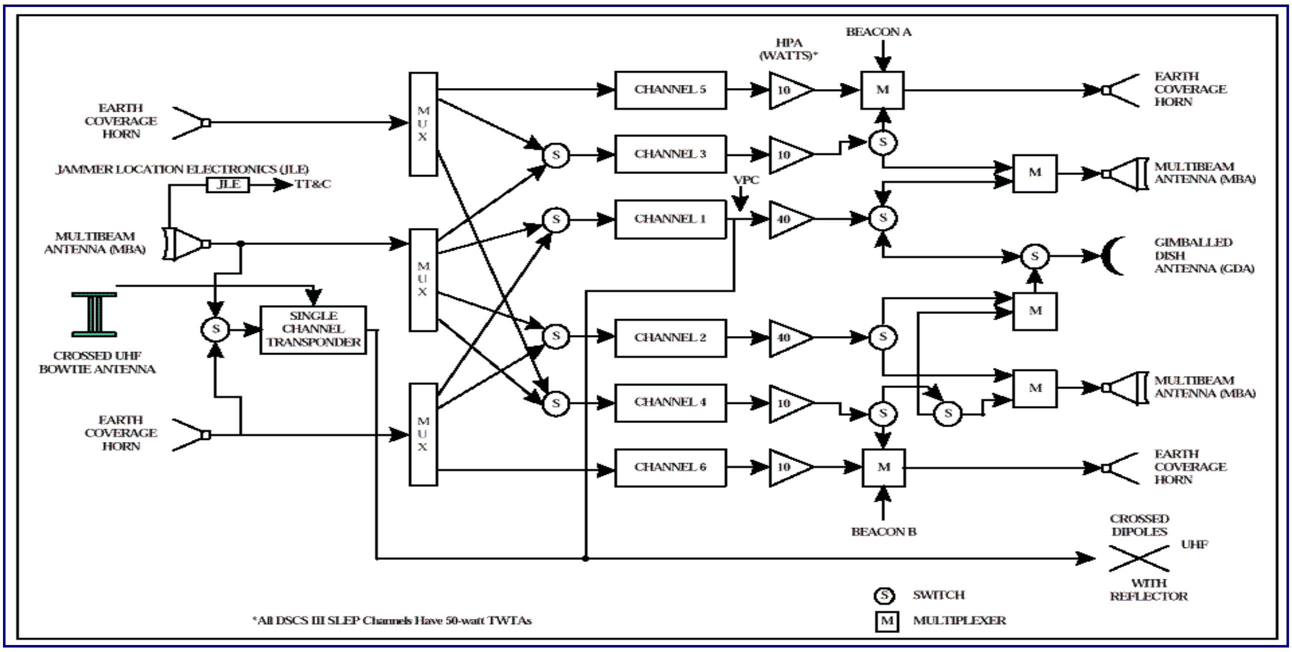
1	-	TBD	TBD	TBD
2	-	TBD	TBD	TBD
3	TBD	-	TBD	TBD
4	TBD	TBD	TBD	TBD
5	TBD	TBD	-	-
6	TBD	-	-	-

Downlink EIRP (dBW) of DSCS IIIs with SLEP Upgrade
(Models A-3, B-6, B-8, and B-11)

DSCS III Communications Channel Block Diagram



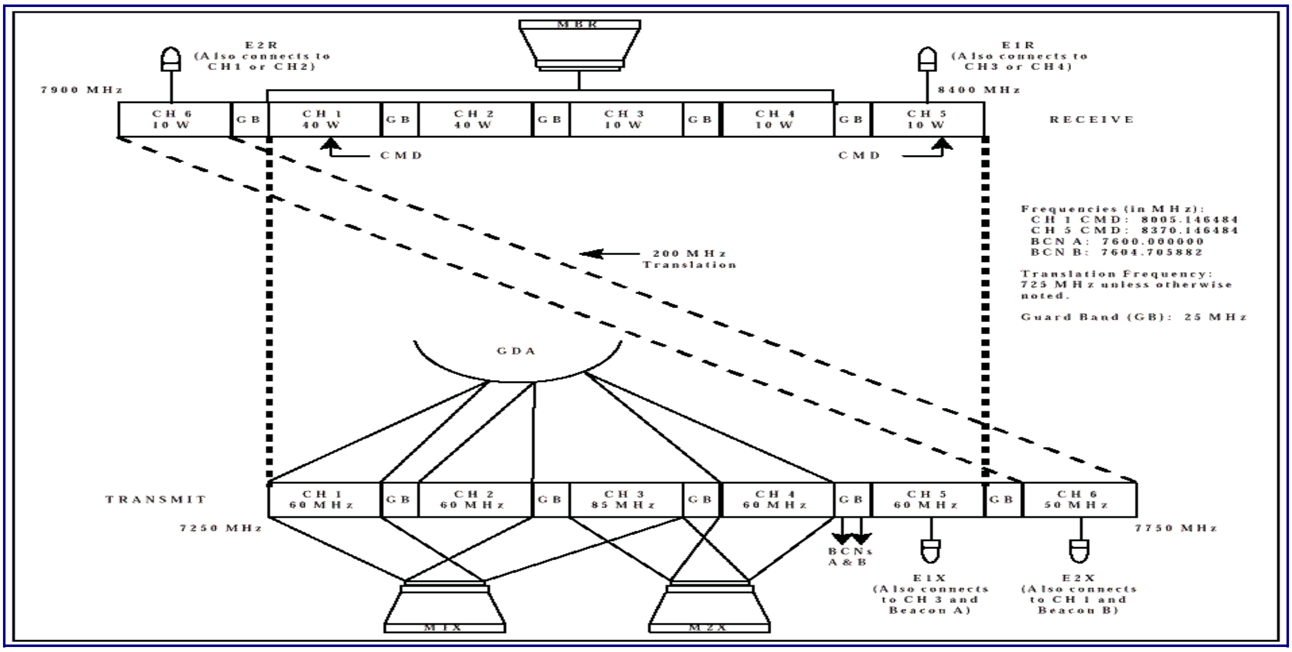
DSCS III Satellite Block Diagram



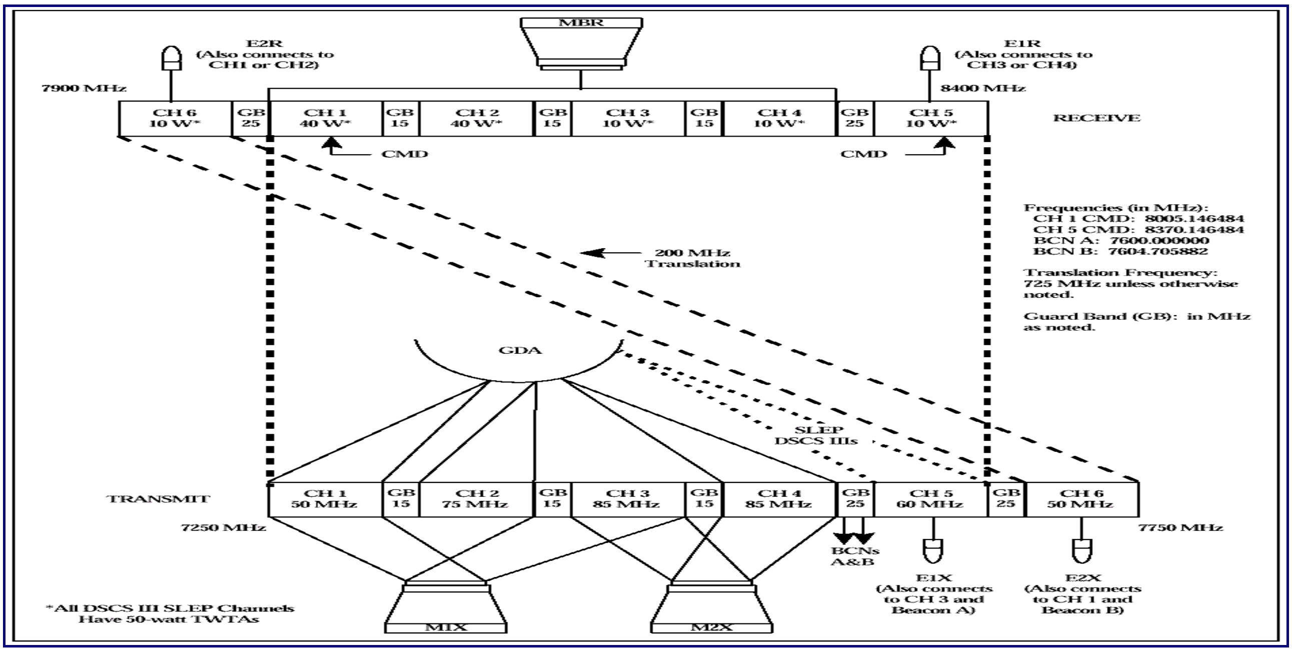
The six independent RF channels operate in the SHF band to relay telephone, data, wideband imagery, and secure digital signals. Figure 2-3 shows a typical DSCS III communications subsystem functional block diagram for an individual channel composed of the receive antenna, transponder, frequency standard, frequency generator, and transmit antenna. Figure 2-4 shows the functional relationship of each of the major components that make up the communications subsystem. The communications subsystem operates in the X-band region. The uplink and downlink frequency plan used in the DSCS III satellite Models A-1, A-2, B-4, B-5, and B-7 is illustrated in figure 2-5. Four of the six RF channels have 60-MHz bandwidth. Channel 3 has an 85-MHz bandwidth, and channel 6 has a 50-MHz bandwidth. The total usable bandwidth is 375 MHz. These six RF channels are arranged with uniform 25-MHz guard bands between them. Each uplink channel frequency is translated down by 725 MHz on the downlink with the exception of channel 6, which is translated by 200 MHz. The newer DSCS III satellites including B-9, B-10, B-12, and B-14 (and Models A-3, B-6, B-8, B-11 and B-13 awaiting launch) provide an improved satellite channelization with a total usable bandwidth of 405 MHz, as depicted in figure 2-6. Under this new frequency plan, the bandwidth of channels 2 and 4 is increased through a reduction in the size of the guard bands and a decrease in the bandwidth of channel 1. Channel 1 has a 50-MHz bandwidth; channel 2 has a 75-MHz bandwidth; and channel 4 has an 85-MHz bandwidth. There is a 15-MHz guard band between channels 1, 2, 3, and 4; and a 25-MHz guard band between channels 4, 5, and

6.

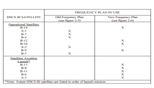
Frequency Plan of DSCS III Satellite Models A-1, A-2, B-4, B-5, and B-7



Frequency Plan of DSCS III Satellite Models B-9, B-10, B-12, and B-14 (including Models A-3, B-6, B-8, B-11and B-13 awaiting launch)



DSCS III Frequency Plans



The communications subsystem partially supports the TT& C subsystem, as well as the SCT subsystem. Communications operations can be conducted simultaneously with TT& C and SCT operations without mutual interference. TT& C commands are received by the satellite through the communications subsystem's receive MBA or receive EC antenna. Two telemetry uplinks are received at separate frequencies, one in the communications subsystem channel 1 and the other in channel 5. Each input signal is fed through the communications transponder front-end which provides preamplification and filtering. The output signal is then downconverted in two steps to the intermediate frequency (IF) input required by the TT& C COMSEC equipment (redundant KI-24s for decrypting and encrypting). The plain text output of the KI-24 is fed to the command and telemetry unit (CTU) for decoding and distribution to the intended subsystem for execution. The telemetry link is used primarily for normal command and control of the satellite support subsystems and also during vehicle anomalies. It supports Space Ground Link Subsystem compatible pseudorandom noise turnaround ranging, coherent Doppler tracking, noncoherent telemetry, secure encrypted or plain text telemetry transmission and command reception. The telemetry link uses crossed-dipole antennas mounted on opposite sides of the satellite to provide near spherical coverage. Redundant receivers provide carrier lock, and demodulate ranging and command signals. Command data cipher text is fed to the CTU which routes it to a preselected KIR-23 decoder for distribution to the intended subsystem for execution.

DSCS III satellites currently in use are equipped with two high power 40-watt TWTAs, channels 1 and 2, and four low power 10-watt TWTAs/ HESSAs for channels 3-6. A steady growth in user requirements has necessitated additional design improvements, including the modification and replacement of the 10-watt HESSAs with 16-watt LSSAs for use in channels 5-6. The last four DSCS III satellites scheduled for launch (B-8, B-11, B-6, and A-3) will receive SLEP modifications which include the replacement of all high power amplifiers (HPA) with 50-watt TWTAs, providing significantly greater linear output power than is available from either the 10-watt HESSAs or 16-watt LSSAs.

DSCS III SATELLITE	HPA			
	40-watt TWTA	10-watt HESSA	16-watt LSSA	50-watt TWTA
Operational Satellites				
B-14	CH 1 & 2	CH 3, 4, 5, & 6	---	---
A-1	CH 1 & 2	---	---	---
B-7	CH 1 & 2	CH 3 & 4	CH 5 & 6	---
B-4	CH 1 & 2	CH 6	---	---
B-12	CH 1 & 2	CH 3, 4, 5, & 6	---	---
B-10	CH 1 & 2	CH 3 & 4	CH 5 & 6	---
A-2	CH 1 & 2	CH 6	---	---
B-9	CH 1 & 2	CH 3, 4, 5, & 6	---	---
B-5	CH 1 & 2	---	---	---
Satellites Awaiting Launch*				
B-13	CH 1 & 2	CH 3 & 4	CH 5 & 6	---
B-8 (SLEP)	---	---	---	CH 1 - 6
B-11 (SLEP)	---	---	---	CH 1 - 6
B-6 (SLEP)	---	---	---	CH 1 - 6
A-3 (SLEP)	---	---	---	CH 1 - 6

*Notes: Future DSCS III satellites are listed in order of launch mission.
HESSA - High Efficiency Solid-State Amplifier
LSSA - Linear Solid-State Amplifier
SLEP - Service Life Enhancement Program

DSCS III HPA Configurations

Two low power channels (channels 5 and 6) are dedicated to EC reception and transmission using EC horns. These horns are designated E1R and E2R for reception and E1X and E2X for transmission. Channels 1 and 2 (high power) and 3 and 4 (low power) can be commanded from the ground to connect to the EC horn receive antennas or to the 61-beam receive MBA. For transmission, channels 1 and 2 are connected to the two 19-beam MBAs (E1X and E2X) or to the GDA. Channels 3 and 4 have the option of connecting to EC horns or sharing a 19-beam transmit

MBA with a high power channel. In addition, channel 4 may also be switched to the GDA.

The communications subsystem may simultaneously employ full Earth coverage, area coverage, and narrow coverage modes for transmission and reception. Using the MBAs, the capability exists to provide narrow coverage, area coverage, or selectively shaped area coverage by combining multiple, simultaneous narrow coverage patterns. A high gain, narrow transmit coverage capability is provided by the GDA.

The receive MBA capability includes the ability to eliminate or reduce the effect of jammers by putting them in a null between sidelobes of an NC beam or by forming nulls in a broad area (up to full Earth coverage) antenna pattern. The receive and transmit MBAs have the ability to simultaneously cover multiple areas, thereby maximizing link gain between terminals in the illuminated areas and reducing the effect of off beam jamming signals. This capability is not normally used during naval operations, but may be employed as directed for contingencies.

Each transponder channel is capable of relaying, with minimal performance degradation, time-division multiplexer (TDM)/ FDMA, CDMA, and time-division multiple access (TDMA) signals. When relaying FDMA signals, the transponder HPA must operate in an essentially linear mode. CDMA and TDMA signals permit operation in a near-saturated mode. The gain of the transponder is controlled prior to the TWTA/ HESSA to ensure the desired degree of TWT saturation for varying input levels. Input variations depend on the number of uplink signals and the EIRP of the Earth terminals.

References

1. Kostas Liopiros and Edward Lam, "Extremely High Frequency Satellites Offer Flexibility," Signal, vol. 44, no. 11, July 1990, page 79.

2. Jack Cushman, Defense Week, 19 September 1983.

3. Defense Daily, 28 December 1984, page 284.

4. Adapted from: Space and Missile Systems Center, "Defense Satellite Communication System (DSCS III) Orbital Operations Support Sol F04701-95-R-0013," Commerce Business Daily, Issue No. PSA-1257, 6 January 1995.

Other Resources

- CHAPTER 2 SYSTEM DESCRIPTION NTP 2 NAVAL TELECOMMUNICATIONS PROCEDURES NAVY SUPER HIGH FREQUENCY SATELLITE COMMUNICATIONS
- DSCS Program Office USAF Space and Missile Systems Center
- FY98 Budget 0303110F Def Satellite Comm Sys (Space)
- Atlas IIA/DSCS successfully launches after one-hour delay

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http://www.fas.org/spp/military/program/com/dscs_3.htm
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