ABSTRACT

The Air Force Satellite Control Network (AFSCN) provides real-time telemetry, tracking and command (TT&C) services for the Department of Defense (DoD) space systems. It consists of a worldwide network of Remote Tracking Stations (RTSs), the Air Force Satellite Test Center (STC), at Sunnyvale, California, and the soon to be completed Consolidated Space Operations Center (CSOC), located near Colorado Springs, Colorado.

The object of this paper is to present an overview of the wideband communications systems which provide connectivity between these elements, and the planned evolution of the communications architecture required to support future growth.

INTRODUCTION

The Air Force Satellite Control Facility (AFSCF) has provided command and control for DoD space systems for over 25 years. The AFSCF consists of 12 Remote Tracking Stations (RTSs), located at seven geographically dispersed locations, and the STC, located in Sunnyvale, California (see Figure 1). Command originating in Mission Control Centers (MCCs) at the STC are relayed to the RTSs for transmission to space vehicles. Telemetry and tracking data received by the RTSs from the space vehicle are relayed back to the MCCs for processing (see Figure 2).

In the early days of the AFSCF, the communications between the STC and the RTSs were limited to low speed, 1200 BPS, data lines. In the late 1970s, the AFSCF installed a wideband communications system known as the Defense Communications System/Satellite Control Facility Interface System (DSIS), to provide a means of relaying high
speed satellite telemetry data (up to 1.024 MBPS), multiplexed with voice and other data streams at aggregate rates of up to 1.536 MBPS, from each RTS (see Figure 3). This system, with minor improvements, continues to serve as the backbone of the AFSCF communications network.

The creation of the AFSCN with the addition of CSOC, the Data Systems Modernization (DSM) program, the installation of the new Automated Remote Tracking Stations (ARTS), and higher satellite telemetry data rates (greater than 1.024 MBPS) led to requirements for upgrades of the communications network.

BACKGROUND

Over the years since the installation of the first DSIS system, the capacity of the current communications system has been pushed to its limits, resulting in the use of “bandaids” to provide the necessary operational support. In particular, the limited number of channels and the bit rate limitations of the current system have resulted in the need for additional sub- and super- multiplexers on individual links. An example is provided in Figure 4.

The modernization of the AFSCN has been planned to increase the capacity of the network in order to support a greater number of vehicles, and the higher data rates planned for these satellites. Both DSM and ARTS have been designed to support up to five telemetry streams for each vehicle with individual data rates up to 5 MBPS. These systems are also designed to permit rapid reconfiguration so that the setup time between supports can be reduced, thus increasing the overall system efficiency.

The CSOC has been designed, in part, to provide a second control node in the network with full, independent, connectivity to all current and future RTSs, further enhancing the AFSCN’s capacity and survivability.

In order to effectively use the enhanced capabilities of these systems, an upgrade of the communications segment of the network was undertaken as part of the CSOC Communications Segment. Figure 5 depicts the planned wideband communications system after CSOC becomes operational.

REQUIREMENTS

The specifications for the AFSCN wideband communications system were developed to overcome currently identified system limitations, to meet known system needs in the near-term, and to provide growth capacity to ensure continued support through the 1990s. The key areas of the specification to be discussed in this paper are Dual Node Commanding and the Multiplex/Demultiplex Functional Requirement.
Dual Node Commanding

A key requirement for the AFSCN Wideband Communications Upgrade is to insure that both the STC and CSOC have full, independent access to all of the RTSs and that either control node is capable of operating with any of the RTSs. The AFSCN Operations Concept also calls for a capability for either control node to operate in a hot-backup capacity for the other control node during certain critical operations.

These requirements dictate that the final communications architecture provide full period connectivity for both control nodes to all RTSs simultaneously.

In order to conserve communication satellite bandwidth, a single high rate return link from each RTS will broadcast simultaneously to both STC and CSOC. This link will contain the necessary control, status, and secure voice signals, for both control nodes, in addition to the mission vehicle telemetry data.

Figure 6 shows the configuration of the current DSIS communication system between a typical RTS and the STC. Figure 7 shows a likely configuration for the new AFSCN wideband system. Note that the new system will require new Inter-Connect Facilities (ICFs) and modems at the STC and the RTSs, as well as at CSOC, to enable both STC and CSOC to properly receive the broadcast links from the RTSs.

One of the more significant management and planning challenges to be faced is the installation and checkout of this new system without impact to on-going operations, which use the existing DSIS system, at the STC.

Multiplex/Demultiplex

The central component of the wideband communications system is the multiplexer/demultiplexer (MUX/DMUX). Some of the specified capabilities for the MUX/DMUX are enumerated below.

a. A minimum of twelve channels - this requirement represents a significant increase over the existing DSIS capacity of seven channels (RTS to STC) and five channels (STC to RTS), and should minimize the need for additional sub-multiplexing.

b. Channel data rate capacity from 250 BPS to 5.0 MBPS - this is consistent with the capabilities of the DSM and ARTS programs and will handle the foreseen increases in space vehicle telemetry data rates.
c. Aggregate data rate capability of 35 KBPS to 10 MBPS for a single side and up to 20 MBPS for dual sided RTSs - this capability is designed to insure that the MUX/DMUX can serve its function well into the 1990s. The near-term (1987 - 1990) established requirements call for approximately 3.0 MBPS for a single RTS and 6.0 MBPS for a dual sided RTS.

d. The telemetry channels must be capable of accommodating the following input perturbations:

<table>
<thead>
<tr>
<th>Perturbation</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Term Drift</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Flutter</td>
<td>+/- 1% (one sigma 0.5 Hz - 200 Hz)</td>
</tr>
<tr>
<td></td>
<td>+/- 0.25% (one sigma 200 Hz - 1 Khz)</td>
</tr>
<tr>
<td></td>
<td>+/- 0.5% (one sigma 1 KHz - 10 KHz)</td>
</tr>
<tr>
<td>Transient</td>
<td>+/- 3% for 1 msec</td>
</tr>
</tbody>
</table>

These specifications are required to permit the wideband system to support telemetry from space vehicle tape recorder playback.

e. Telemetry Channel to Time Channel correlation:

   +/- 0.5 msec

Time correlation of the telemetry data stream is required to permit calibration of the space vehicle’s on-board clock.

**TRANSITION**

**Backhaul**

Program redirection and delays in the development of the wideband communications system have led to the need to install an interim communications capability. This capability is needed to support the installation and checkout of the DSM system at CSOC and the CSOC Initial Operational Capability (IOC). The interim system uses the existing STC to RTS DSIS links and a new communications relay between the STC and CSOC to provide connectivity between CSOC and the RTSs. The “backhaul” system is expected to be installed and operational by September 1986. The system, shown in Figure 8, will provide for the testing, training, and early operations of the CSOC, and permit adequate time for the development of the final wideband communications system.
THE FUTURE

The trends in satellite telemetry, RTS command, control, status and voice communications requirements all indicate that higher data rates will be required in the 1990s. The bandwidth limitations of the DSCS satellites and ground equipment dictate that more efficient methods of using these resources be developed. The Defense Communications Agency (DCA) is currently developing a common user Time Division Multiple Access (TDMA) system which is intended for deployment in the 1990 time frame to meet this need. Previous studies have shown that, because of the time varying telemetry support requirements of the AFSCN, significant bandwidth savings on the communications satellites can be obtained through the use of demand assigned TDMA. The AFSCF and CSOC development organizations are coordinating the AFSCN wideband communications upgrade program with DCA to ensure a compatibility between these two efforts.
FIGURE 1. THE AIR FORCE SATELLITE CONTROL FACILITY WIDEBAND COMMUNICATIONS
FIGURE 2. AFSCF TELEMETRY AND COMMANDING
Figure 3. **DSIS System**  
RTS Single Side Station
Figure 4. IOS Current Configuration
Figure 5. AIR-FORCE SATELLITE CONTROL NETWORK
WIDEBAND COMMUNICATIONS
FIGURE 8. INTERIM CSOC WIDEBAND COMMUNICATIONS ("BACKHAUL")