SATELLITE COMMAND AND CONTROL ARCHITECTURE

Col. J. E. Sanders
Commander
HQ Air Force Satellite Control Facility (AFSCF)
Sunnyvale Air Force Station, California 94086

ABSTRACT

This presentation will consist of a review of the DoD common-user Satellite Command & Control network to include: how the AFSCF evolved; a description of today's satellite control network, its capabilities and limitations; a discussion of the approved upgrade program; and a view of what will be required for Satellite Command & Control for the 1990s.

INTRODUCTION

The Air Force Satellite Control Facility (AFSCF) is a USAF world-wide network composed of a control center, called the Satellite Test Center (STC); a number of Remote Tracking Stations (RTS); and all of the systems, equipment, and computer programs required to track and control satellites during ascent, on-orbit, and recovery of re-entry systems from space. The AFSCF is fundamentally a service organization that provides round-the-clock tracking, command, and control functions for the various DoD satellite users. Tracking stations are strategically located to (1) support satellite launches from the Eastern Space and Missile Center into high altitude and equatorial orbits; (2) support satellite launches from the Western Space and Missile Center into polar and near-polar orbits at low and medium altitudes; and (3) continuously support all satellites in their various orbits.

The earliest antecedent of the present AFSCF was established in July, 1956, as "Subsystem H," a part of Weapon System 117L (WS117L) Program under the Western Development Division of the Air Research and Development Command. WS117L was an operational military space program that had grown out of an advance concept project. Its development and implementation had little sense of urgency or haste. The original program called for launching spacecraft from Cape Canaveral. Subsystem H was the supporting Telemetry, Tracking, and Command (TT&C) facility with ground stations located at the Cape, Grand Bahama, Ascension, and Hawaii. With the launch of Sputnik I on 4 October 1957, the world entered the space age and the US space program was accelerated "at the maximum rate consistent with good management." The WS117L Program moved into high gear and in short order the Discoverer Satellite Program was establsihed to develop a research and development space program designed to demonstrate Air Force capabilities to launch, stabilize, control, and recover an instrumented capsule (payload) from orbit. The Discoverer Program was given formal approval in January of 1958 with a planned launch in January 1959. The WS117L Program became operational in 1959 and was separated into three areas of operation: launch systems, space systems and ground support system. The Ground Support System became the 6594 Test Wing (Satellite), the forerunner of the Air Force Satellite Control Facility. The wing was organized into four major units: a headquarters, an operations center, five tracking stations, and a recovery group.

The headquarters and the operations control center were temporarily located in Palo Alto; however, in June, 1960, the headquarters and operations control moved into their permanent quarters in the Satellite Control Center located on Sunnyvale AFS.

The five tracking stations were located at Cheniak and Annette Island, Alaska; Kaena Point, Hawaii; Vandenberg, California; and New Boston, New Hampshire. As operational requirements changed in the sixties and seventies, station locations were changed and equipment updated. The stations are now located at Vandenberg, AFB, California; New Boston AFS, New Hanpshire; Thule AFB, Greenland; Mahe Island, Seychelles Republic; Anderson AFB, Guam; and Kaena Point, Hawaii. An additional station was added in 1979 when an agreement was reached with the British government to use their tracking station in Borden Hants, England. The tracking station commands, tracks, and collects data from satellites; processes the data; and forwards the data to the Satellite Test Center.

The Recovery Group was formed at Hickam AFB, Hawaii, in August 1958 and was equipped with C-119 and shipboard helicopters to provide an aerial and surface recovery capability. Through the years the aircraft and equipment have been replaced or modified to meet changing requirements. With the advent of aerial refueling, the surface ships were replaced with tanker aircraft and long-range helicopters, thus providing a more effective operation. Today the Group has twelve JC130 aircraft, three C130 aircraft modified for aerial refueling, and seven HH53 helicopters. These resources provide the 6594th Test Group with the capability to simultaneously support two recovery missions using the JC130 for aerial recovery and the HH53 for surface recovery.

CURRENT AFSCF ORGANIZATION

The AFSCF is a subordinate unit within Air Force Systems Command. The chain of command extends from Command through the Deputy Commander for Space Operations of Space Division, who is responsible for all military manned and untanned space operations.

The AFSCF employs approximately 3800 military, civil service, and contractor personnel. The headquarters is manned primarily with military and civil service personnel; the Satellite Test Center manning is shared jointly by military, civil service, and contractor personnel; and the tracking stations are manned primarily with contractor personnel performing operations and maintenance tasks with a small military/civil service unit providing management tasks. The 6594th Test Group is primarily a blue-suit operation with a few civil service and a couple of contractor personnel assigned for assistance.

The AFSCF is organized into twelve major directorates, offices, and units. Five directorates are dedicated to operations activities, four to support functions, and three are dedicated to development activities.

The Air Force Satellite Control Facility resources are valued at 575 million dollars with an annual operating budget of 250 million dollars.

GENERAL COMMENTS

Of the two types of Satellite Control networks, Dedicated networks and Common User networks, Dedicated networks are useful for programs that require a mission ground station in view of the satellites for processing of high data rate mission data. An example is the DSP network. Common user networks (i.e., AFSCF) exploit the economies of scale by sharing resources such as computers, people, antennas, RF systems, communication, and buildings among several programs. Looking towards the future, it seems clear that both types of networks will be required. Whether any specific program requires a dedicated network will depend upon the program’s mission requirements and affordability issues.

It is unwise for either type of network to exist with single-node failure points. A measure of redundancy for the major processing and command and control centers will be needed. On the other hand, proliferation of dedicated single program networks in an effort to achieve survivability is probably not affordable. A more reasonable approach is to insure some measure of interoperability capability between networks. This would be highly desirable to provide an overall resiliency beyond the redundant nodes within the networks. With widespread backup capability the satellite control function for any particular satellite program could not be rendered inoperable by the destruction of a single network. Major disruptions would have to occur to all the networks, both Dedicated and Common User. The key to achieving interoperability is standardization, commonality, and modularity, all of which are time proven methods in other military arenas. The Data Systems Modernization (DSM) Project currently being undertaken by the AFSCF offers an outstanding leg-up in achieving this goal.

It appears that a Distributed network with Mission Control Complexes at the Satellite Test Center (STC), Space Operation Center (SOC), and possibly other locations using shared remote facilities (and relay satellites as they come into the inventory) is the proper way for a network to evolve.

Dedicated stations would probably still be required to support particular programs; however, either the STC or the SOC should have the capability to back up any dedicated Mission Ground Station (MGS). In those few cases, when a satellite's operation is essential to a command mission, then that command could colocate a liaison detachment or field at either the STC or the SOC for operational control. The key to making this work efficiently, of course, is to have all satellite command and control resources under one organization. This organization would allocate time or equipment to satellites on an as-needed priority basis.

Beyond redundant nodes and interoperability, several elements that will play a part in future satellite control are mobile terminals both ground and airborne, hardening of communication channels for jamming resistance, Satellite Control Relay Satellites, a graceful degradation posture including low data rate, and tape interface operations (record at one location--physical transportation to another). As an ultimate goal, autonomous mission satellites capable of operating without ground support for six months or more will reduce the magnitude and complexity of satellite control networks of the far future.

SATELLITE COMMAND AND CONTROL ARCHITECTURE IMPROVEMENTS

In the recent past the AFSCF has undertaken a review of the road map of the future for the satellite control activities of the DoD. There are a number of areas that we believe need to be pursued in order to insure an orderly and effective satellite control posture on into the next century. What follows is a brief discussion of the highlights of these areas.

ADVANCED TELEMETRY, TRACKING, AND COMMANDING (ATT&C)

The present TT&C system in use by the DoD is known as SGLS for Space Ground Link System and is a product of the early 1960s and operates in the S-band region of the spectrum. As this portion of the spectrum has become congested, the ability for growth with the SGLS has vanished. At the same tine the need to support higher data rates between satellites and ground stations has increased. Therefore, there is a pressing need to develop an Advanced TT&C system for Common User operation at higher frequencies in the less congested K-band region. A Multipurpose feed for Ku-band can be installed on the present generation of AFSCF 46-foot antennas or new off-the-shelf ten meter antennas could be added at the AFSCF Remote Tracking Stations (RTSs) and ground stations. This would not only support new programs but could give “backup” TT&C capability for some of the present Dedicated networks such as TDRSS. Additional attributes of this system should include: spectral bandwidth that will support high data rate (gigabit) down links; spread spectrum techniques for lower susceptibility to jamming, better signal to noise ratios, more sophisticated signal processing, and more secure command and telemetry channels; and interoperability between programs by using standardized, common frequencies, data rates, modulation, and signal processing techniques.

All of these improvements can be accomplished by utilizing state-of-the-art equipment which has been developed since the advent of the SGLS. The use of available commercial equipment can help mitigate the cost of deploying this new system.

MODERNIZED REMOTE TRACKING STATION (MRTS)

The AFSCF Remote Tracking Stations have grown over the years in an evolutionary fashion. Events are now prompting a reevaluation of the station configuration to determine if it is wiser to design a new RTS from the ground up or continue to modify the existing equipment. One such event is the Data Systems Modernization Program which provides an interface at each RTS for automatic control and status of station equipment and should greatly reduce station O&M costs. The station equipment, however, is generally not remotable without modification. Consequently, without a modernization program the potential O&M savings may not be fully realizable. Another event that affects the RTS configuration is the recent concern that sugests that dispersal of satellite command and control is necessary to achieve an acceptable degree of survivability for ground networks. This concept involves giving RTSs some limited satellite control capability beyond that currently available, even under DSM improvements. A limited telemetry processing capability may be necessary. As a minimum, a modernized RTS should not preclude this capability.

SATELLITE CONTROL RELAY SATELLITE

The AFSCF has been looking forward for over ten years to an RTS is orbit. There are a number of reasons why such a Satellite Control Relay Satellite is attractive and these have been strengthened by the passage of time. The four most compelling reasons are increased visability of the mission satellites, secure data transfer from mission satellites directly to CONUS, lessened dependence upon overseas stations, and accommodation of very high (gigabit) data rates. At the present time the visability of low altitude satellites is limited to as low as 7% of the tine through the ground network. This can be increased to 24 hours per day with a Satellite Control Relay Satellite network. Increased visability is essential for protection of mission satellites against physical attacks and can enhance their mission capabilities. Both secure data transfer and high data rates can be accommodated by the use of frequencies in the V-band or communications lasers for mission-to-relay crosslinks and K-band downlinks from the relay directly to CONUS.

At this time, the inclusion of a satellite control relay capability on the MIL Star Satellite constellation is a most attractive consideration. Deployment of a four-satellite system in geosynchronous orbit in the late 1980s with a capability for a general mission satellite to CONUS relay for gigabit mission data and TT&C would markedly enhance the survivability and effectiveness of the nation’s satellite control posture.

CENTRAL CONUS RTS

Locating an additional Remote Tracking Station in a mid-CONUS site would provide a significant increase in the AFSCF’s survivability posture. An RTS situated, say, in Colorado or New Mexico would provide a backup for either the New Hampshire Station or the Vandenberg Station in the event of a catastrophe at either site. Addiotionally, a site in view of the Telemetry and Data Relay Satellites could provide a redundant location for ground entry of data relayed through the TDRSS. Mid-CONUS locations have a low potential for natural disasters, such as earthquakes, and are sufficiently far inland to be protected from offshore electronic warfare operations. Finally, a central CONUS site could provide sufficient area for good protection against physical attack. Since Kirtland AFB, New Mexico, meets all of these conditions, it is a good candidate location for such an RTS.

GRACEFUL DEGRADATION

Emphasis on survivability has made it clear that a posture within and between satellite control networks that allows for a graceful degradation from normal operations to stress mode operations is a necessity. A fall-back node of operation from normal high data rates to a jam resistant low data rate mode, possibly using narrow band circuits, is essential. This is particularly critical for systems where the ground entry of data is remote from the central processing capability. As an adjunct to low data rate operations, the capability to record high data rates at several possible ground entry locations, such as the AFSCF’s RTSs with physical transportation of the records to the user, would provide for degraded but useful continued operations in times of conflict.

CONCLUSION

The existing DoD Satellite Control Architecture has evolved to a series of networks of major national importance. This architecture has provided for systems that perform outstandingly in the current environment. Looking forward commonality, standardization, and modularity of satellite control capabilities are areas that should be vigorously pursued to establish an interwoven structure of capabilities with a resilience such that complete disruption cannot be accomplished without destroying the entire fabric of the whole system. The interconnection and development of a mutual backup posture between the Defense Meteorological Satellite Program (DMSP), Global Positioning System (GPS), Defense Satellite Communication System (DSCS), and AFSCF networks is a good example of the opportunities in this direction.