Force Support--Air Force Satellite Control Network

Force support, the ability to sustain forces, includes the space mission of on-orbit support for satellites.(2) During the entire life of any satellite or military space system, from prelaunch checkout to on-orbit operations, there is a requirement for constant control, support, and direction of the satellite and its assigned mission. The Air Force maintains this critical operations capability through the Air Force Satellite Control Network (AFSCN).

The AFSCN is a global system to provide command, control, and communications for space vehicles (SV). The AFSCN consists of dedicated and common-user equipment and facilities which, collectively, provide operational telemetry, tracking, and commanding (TT&C) support for virtually all Department of Defense (DOD) SVs plus selected National Aeronautics and Space Administration (NASA) and foreign allied nations' space programs.

DOD space programs support requirements of the national command authorities (NCA), the Joint Chiefs of Staff, and the unified and specified war-fighting commanders under peacetime and wartime conditions. In addition to providing TT&C support, the AFSCN processes and distributes satellite mission data to the appropriate users and provides research and development (R&D) support for space test activities.(3)

Satellite command and control is the essential mission of the AFSCN. To accomplish this complex task, various control centers are organized to integrate incoming and outgoing satellite control data for decision making. The complexity of the AFSCN mission increases with the number of active satellite missions.(4) Supporting resources of the AFSCN consist of leased and allocated communications, and host-base-provided facilities and utilities.(5

Dedicated and Common-User Elements

Elements of the AFSCN generally fall into two groups: (1) dedicated elements that support a single space program or military space system and (2) common-user elements that support a number of different space programs or military space systems. Most of these elements are at fixed locations throughout the world, but the AFSCN can deploy a number of transportable assets whenever and wherever military forces need them.(6)

Dedicated elements specific to one satellite system support dedicated programs. A dedicated program is a closed system with separate control centers and remote tracking hardware. Two examples of dedicated satellite programs supported by dedicated elements are the Defense Meteorological Satellite Program (DMSP) and the Global Positioning System (GPS) satellite program.

The dedicated control centers for DMSP are located at Fairchild Air Force Base (AFB), Washington, and the Multi-Purpose Satellite Operations Center (MPSOC) at Offutt AFB, Nebraska. The dedicated control center for the GPS program, known as the Master Control Station (MCS), is located at Falcon AFB, Colorado.(7)

Common-user elements of the AFSCN include a wide variety of assets strategically located around the world. These elements consist of command posts, mission control centers, resource control centers, and remote tracking stations, as well as various communication links, computer facilities, and training and testing facilities. These elements support multiple programs. The principle common-user mission control centers and command posts are located at Falcon AFB, Colorado, and Onizuka AFB, California.(8)

Types of Satellite Support

The AFSCN has the ability and flexibility to support continuously a wide variety of space vehicles in various orbits and altitudes. Operations support for satellite missions and limited ballistic/suborbital vehicle flights generally fit into five categories.(9)

Low-altitude satellites are characterized by near-polar orbits, with altitudes ranging from 100 to 200 nautical miles. Their operational lifetimes are short, and the satellites have a short pass duration (2.5 to 10 minutes per tracking station). They are the most dynamic of all vehicles supported, requiring frequent command message transmission.

Medium-altitude satellites generally have an orbital inclination of near 90 degrees, with altitudes ranging from 200 to 10,000 nautical miles. These satellites average one tracking station contact every other revolution, with a pass duration ranging from 10 to 20 minutes. Planned support is for one year or longer.

High-altitude satellites usually have low-inclination (equatorial) orbits, with altitudes exceeding 10,000 nautical miles (NM). Their operational lifetimes are measured in years. Because of varied servicing support requirements, a support period (pass) may vary from five minutes to several hours.

Included in the next category are ballistic missiles and suborbital test vehicles usually launched from the Western Space and Missile Center at Vandenberg AFB, California.

Tracking and telemetry data for ascent and midcourse flight phases are recorded by the appropriate remote tracking stations (RTS). Total support time varies from 10 to 30 minutes. This kind of support requires considerable planning and readiness testing from the AFSCN.

The AFSCN supports certain orbital vehicles during launch and ascent or during ascent only. Support may vary from 10 minutes to 16 hours (continuous), depending on a vehicle's orbital characteristics and the support requirements levied. Tracking and telemetry data retrieval is the primary support objective.

Satellite Operations Centers

The task of the satellite operations centers (SOC) is to provide prelaunch, launch, early orbit, anomaly resolution, and operational TT&C support to all assigned space vehicle missions. Twelve functions are associated with satellite control:

1. satellite orbit determination,

2. ephemeris data generation,

3. command load assembly,

4. pass planning,

5. pass plan brief to tracking station,

6. satellite acquisition and tracking,

7. satellite commanding,

8. telemetry data retrieval,

9. data analysis,

10. satellite health and status determination,

11. corrective action determination, and

12. satellite data transfer to users.(10)

SOCs consist of hardware, software, and personnel that interact to accomplish these space support operations: resource control, mission control support, and communications control functions. Certain SOCs at Onizuka AFB, California, provide backup capability to Falcon AFB SOCs, while others are dedicated to unique programs not part of the AFSCN. Each SOC provides service for one or more specific satellite programs. Although the capabilities of SOCs vary, each is configured to support multiple satellite contacts simultaneously and/or to carry out premission rehearsals or exercises based on assigned satellite programs.

SOCs are physically isolated from each other but are electrically connected to allocated range resources. The SOCs at Onizuka AFB are connected to the resource control complex (RCC) at Onizuka AFB, and the SOCs at Falcon are connected to the RCC at Falcon AFB. During a satellite contact, mission personnel exercise direct control of the assigned resources through on-line workstations in the SOC that access processing equipment, interactive controls, computer programs, and interfaces to internal and external elements. An SOC usually has two mainframe computers, one acting as a contact support processor and the other as a planning and evaluation processor. These processors, with associated software, carry out planning, contact support, evaluation, training and rehearsal, simulation, data base management, and system development.

Space Vehicle Support--Pass/Contact Description

SOC satellite operations divide into three distinct phases: planning, pass support (i.e., operational satellite contact), and evaluation. The usage of the term pass as in pass support evolved from early space operations history when satellites would "pass by" as they moved in orbit from horizon to horizon relative to the operators. The length of these phases, especially pass support, varies widely depending on the type of satellite supported, its orbital geometry, and individual mission support requirements (fig. 1). The following is an overview of these phases.(11)

The planning phase mainly involves activities conducted by the SOC and the RCC. The SOC develops an overall contact support plan (CSP) and identifies what is required to support a particular satellite contact. The CSP includes resource requirements, telemetry parameters, and command and ephemeris data. The SOC may simultaneously prepare multiple satellite support plans. The result of this planning effort is requests by the SOCs and other users to the RCC for AFSCN resources.

The RCC then produces a schedule for all AFSCN satellite support based on resources and priorities. There are both long-range and near-term schedules that dictate what resources can support specific satellite passes. Resource scheduling is an ongoing activity. There are opportunities throughout the planning phase to deconflict complex satellite pass support requirements.

The pass support phase includes both prepass and satellite contact time. The SOC, RCC, RTS, and communications elements act in concert to configure all resources, conduct readiness testing, and place the systems into final configuration for the actual satellite support (pass).

The SOC mission control team (MCT) initiates the prepass by requesting that the network communications voice operator establish communications nets. When the operator establishes the nets, the MCT members log on to their respective computer terminals to configure hardware and software. The MCT crew commander provides a briefing over an operations (OPS) communications net and the MCT ground controller (GC) briefs over another communications net, termed the configuration net.

The GC briefs the RCC resource controller (RC), the lead communications operator (LCO), the Defense Communications System/Satellite Control Facility Interface System (DSIS) operator, the wideband operator, and the RTS antenna operator on data rates, communications and data channel activity, and overall resource configuration for the particular support. Upon briefing completion, the LCO, DSIS, and wideband operators perform channel checks. The RC then performs commanding, telemetry, and antenna slaving tests. The GC then performs similar readiness testing.

During the testing period, all of the above elements are involved in the prepass checks and assist in troubleshooting and reconfiguring, if necessary. The RTS antenna is then positioned in preparation for satellite acquisition. Satellite contact begins when the RTS acquires and tracks the satellite. RTS makes contact by either sending out a turn-on command to activate satellite signals or by simply receiving transmitted satellite signals. The RTS in turn relays satellite telemetry data to the SOC while the RCC and communications elements monitor the operations in progress. The MCT evaluates the telemetry data in real time and verifies user data reception. The MCT may send commands to the satellite via the RTS according to the pass plan. The support ends when the objectives are met and the MCT commander directs the RTS to terminate tracking of the satellite.

The evaluation phase is also the postpass phase. While the communications nets are still operating, the MCT crew commander discusses any support-related problems with the RTS, verifies the next pass time, and calls the network configuration voice operator to terminate the OPS net. The GC discusses any pass-related problems with people on the configuration net and releases the net participants through the RC. When the LCO notifies the RC that resources are normalized, and the MCT crew commander has directed the communications operators (wideband, DSIS, LCO, etc.) to terminate both nets, time-critical postpass activities are concluded, and the RTS and communications links are then available for another support. The MCT may continue such evaluation activities as analyzing payload data, satellite performance, data quality, and orbital parameters.

Remote Tracking Stations

Remote tracking stations provide the satellite-to-ground interface for satellite command and control; they provide the actual TT&C contact with any space vehicle supported by the AFSCN. The contact is accomplished under the direction of a SOC.

The RTS relays satellite telemetry to the control complex, either generates commands for or relays commands to the satellite, and provides tracking data to the control complex. The specific RTS tasks vary depending on the communications interface and the mission. AFSCN RTSs are located worldwide and provide prelaunch, launch and early orbit, and on-orbit TT&C support for assigned US and allied satellites, ballistic missile launches, and the Space Transportation System (STS)--the space shuttle.(12)

RTSs are strategically located at nine sites with 16 antennas to maximize area coverage for timely and effective use of RTS resources as well as for flexible, multiple support capability (fig. 2). The RTSs are available to control complexes on a time-shared basis for supporting satellite operations and are a scheduled resource. Scheduling is accomplished by the RCC at either Falcon AFB or Onizuka AFB. The RCC allocates time to each RTS for operations, maintenance, and training.

The RTSs within the AFSCN have been modernized as automated remote tracking stations (ARTS). ARTS sites may be a new site, such as the Colorado Tracking Station at Falcon AFB, or a modernized existing RTS site, such as the Vandenberg Tracking Station. All RTSs or ARTSs, while not identical in physical layout, function in approximately the same manner. Some RTSs are configured with additional equipment to support unique missions. We can visualize an RTS's antenna coverage as a cone, widening as the distance from Earth becomes greater. With higher satellite altitudes, a wider selection of RTSs can support a given satellite contact.

RTSs are functionally equivalent to each other and are scheduled for operations based on satellite support needs and the visibility of the satellite to the RTS. Satellite operations events such as TT&C directives, vehicle status and health, and SV commanding data--all pass between the mission control centers and the RTSs over communications links. The RTS uplink transmits satellite command data upload and ranging data. Satellite telemetry and ranging are received in as many as four simultaneous downlinks and transmitted via the communications system to control complexes.

The telemetry function involves tracking in the reception of information on the health, status, and mission payload telemetry of a satellite. An RTS receives satellite telemetry data and transmits this data to a control center. The tracking function involves satellite location and velocity determination. Antenna azimuth and elevation pointing data direct the antenna for satellite acquisition. After acquisition, the RTS transfers range and range-rate data, antenna pointing data, and status information to the control centers, usually via the DSIS. The SOC uses control center tracking data to predict future satellite contacts and to generate antenna pointing data, for real-time acquisition by remote tracking antennas.

The command function includes transmitting coded signals to a satellite to do such things as fire thrusters, start or stop mission tasks, switch power sources, or update sequence programs. The SOC transfers encrypted or clear blocks of command data to the RTS for transmission to the SV. Verification and authentication for each command is normally within the satellite telemetry transmission to the RTS ground antenna and back to the SOC. The SOC then verifies that the satellite properly received the transmitted commands.

Remote Tracking Station Communications. Each RTS has communications capabilities that provide primary and alternate connectivity for data and voice circuits to and from control complexes. One capability is to encrypt and decrypt information and to communicate intrastation via intercom or telephone. Primary communication is accomplished using the DSIS, which links the RTS, via the Defense Satellite Communications System (DSCS) or commercial communication satellites, with either Falcon or Onizuka AFB. Alternate communications links carry digital voice and data, usually on leased commercial telephone circuits, between all AFSCN RTSs and external users. The capabilities of these links vary considerably depending on the support requirements of the different control complexes.

An additional communications system used by the AFSCN is called Mission-22 (M-22). It uses DOD host vehicles that are in highly elliptical orbits. Just as the AFSCN is a complex assembly of elements supporting US space assets, the communications links required to carry out the AFSCN mission are a complex suite of networks within and between all elements of the AFSCN and external users. These communications links provide communications security, redundancy, data recording, and interface capability with communications satellites, land lines, fiber optics, and microwave circuits for transmission of data, voice, teletype, and facsimile information.

The wideband communications network provides the primary communications links used in the AFSCN between the control centers and the RTSs. This network uses the DSIS, which links the RTS via DSCS II and DSCS III satellites or commercial communication satellites with either Falcon or Onizuka AFBs. DSIS provides high data rate communications between the RTSs and the control centers. Narrowband communications are an alternative to the wideband system for data and digital voice capability. Additionally, the network uses M-22 communications satellites that provide the capability of minimum essential wideband support in the event of any wideband link outages to any RTS. Some RTSs have a data link terminal (DLT) to specifically utilize M-22. An RTS with two antennas, but no DLT, can still use M-22 for real-time transmission if one antenna tracks, while the other relays data via M-22. The M-22 data rate is limited, but its capability fulfills most present and future vehicle reception requirements.

Remote Tracking Station--Mission Unique Interfaces. RTSs also interface with

dedicated elements within the AFSCN in support of specific requirements of the DMSP and GPS programs. Specific mission unique interfaces at the Thule (Greenland), Hawaii, and New Hampshire RTSs provide DMSP support. The RTSs provide an interface for command and telemetry data between the RTSs and the dedicated DMSP elements. The dedicated elements of the DMSP are the Multi-Purpose Satellite Operations Center and the Fairchild Satellite Operations Center. The RTSs provide an interface for primary mission data recovery for transmission to the Air Force Global Weather Central, as well as to the Navy Fleet Numerical Oceanography Center.

A mission unique enhancement at the Colorado Tracking Station (CTS) provides GPS program support. This mission unique interface provides the CTS with a GPS ground antenna command and telemetry processing capability--which allows the GPS SOC at Falcon AFB to directly control the CTS.

Command Centers

There are two command centers in the AFSCN: the Wing Command Post (WCP) located at Falcon AFB and the Group Operations Center (OC) at Onizuka AFB. The WCP exercises operational control over the AFSCN. The OC provides backup functions for the WCP and primary operational control over selected programs specific to Onizuka AFB.(13)

The Wing Command Post's primary job is to support the 50th Space Wing commander, providing a command post for the 50th Space Wing and Falcon AFB.

The wing commander requires this command post to fulfill responsibilities as the manager and operator of the unique worldwide AFSCN. The WCP also links assigned AFSCN assets into a fully responsive, integrated system supporting multiservice and multiagency programs and serves as the focal point through which the Air Force Space Command (AFSPACECOM) commander exercises real-time combatant command over AFSCN forces. Some of the functions carried out by the WCP include

1. monitoring and reporting space system health, status, and readiness information of AFSCN elements including dedicated centers and AFSCN mobile resources,

2. implementing operations plans and contingency plans,

3. disseminating AFSCN element hostile attack warnings,

4. disseminating intelligence information affecting satellite control operations,

5. maintaining interoperability with the OC, and

6. conducting training exercises, both internally and in conjunction with other elements involved with US space assets.

The 750th Satellite Tracking Group OC, located at Onizuka AFB, serves as a subcenter of the WCP at Falcon AFB. The OC plays an active role in providing downward direction to the RTSs and in channeling information from the RTSs to the WCP. The OC provides a backup capability for command and control of the AFSCN if the WCP cannot sustain its mission. The OC also interfaces with control centers at Onizuka AFB that are dedicated to programs not supported by the AFSCN.

Network Control System

The network control system (NCS) is composed of RCCs located at Falcon AFB and Onizuka AFB. The RCCs provide dual-node resource scheduling capability necessary to support the other elements of the AFSCN. Functional equivalency between the two RCCs allows each complex to perform all AFSCN common-user resource scheduling and resource control functions.(14)

The NCS mission compromises four different categories: plans and analysis (P&A), resource scheduling (RS), resource control (RC), and interrange operations (IRO).

The plans and analysis branch collects long-term resource utilization requests for flight preparation and nonflight activities. It then develops long-range forecasts and schedules and distributes them to affected elements. P&A also analyzes resource utilization, system performance, and other associated data.

The resource scheduling branch collects flight resource utilization requests and combines them in a common data base with requests collected by plans and analysis. RS schedules the common-user resources, identifies conflicts, and coordinates conflict resolution in the non-real-time planning period. RS also requests, when necessary, support of internetted resources from appropriate agencies. RS then publishes and distributes the established schedule, performs real-time changes and conflict resolution, and makes data base updates.

The resource control branch configures network common-user resources, conducts prepass and readiness testing, and transfers resource control to the user. RC also monitors resource status and reallocates resources to users in real time as determined by RS. Other RC activities include resuming control of resources released by users, being the focal point for resource outage and restoration status reports, coordinating maintenance activities, and initiating fault localization and isolation testing as required. RC also exercises control over the start, stop, and failure switchover of all scheduled communications link connectivities between the communications control complex (CCC) and AFSCN users.

Interrange operations organizations are located at both Falcon AFB and Onizuka AFB. IRO is the single operational interface through which external space agencies (e.g., NASA) without affiliated SOCs request and obtain support from AFSCN resources. IRO reports operationally to the WCP, but is functionally part of the NCS. IRO obtains early orbit determination and computation of miss-between-orbit data from the Space Defense Operations Center (SPADOC) and provides predictive avoidance data support to SPADOC. The IRO also performs satellite management support and radio frequency interference analyses and predictions.

The NCS consists of hardware, software, personnel, operational procedures, and facilities that interact to provide for scheduling, allocating, configuring, and testing of AFSCN common-user resources. The NCS analyzes resource usage; monitors resource status; conducts fault detection, localization, and isolation for all network resources; and provides the interface for users and resources external to the AFSCN.

Communications System--Major Components

The communications control complex is one of the essential control complexes located in the common-user control centers. The CCC performs initiation of circuit connectivity, circuit monitoring, circuit restoration, and fault isolation for AFSCN communications between the common-user control centers and the common-user RTSs. The CCC is also the interface between the AFSCN and external users (for example, NASA). The CCC acts as the interface between the mission and mission support communications services required by the AFSCN.(15)

Falcon AFB currently does not have primary independent connectivity to the RTSs. An interim configuration called "Backhaul" connects Falcon to the RTSs by going through Onizuka AFB via a domestic satellite link.

The remote communications/telemetry areas (RC/TA) are the remote termination of the mission communications links at the RTSs. The RC/TA performs monitor, circuit restoration, and troubleshooting functions similar to a CCC at a control center.

Primary and alternate communications links internet the AFSCN control centers and the RTSs. These links provide interstation and intrastation communications to common-user elements. Interstation communications consist of primary and alternate communications links connecting control nodes with other AFSCN and external facilities. Intrastation communications distribute data and voice communications within various complexes, control centers, and RTSs.

A number of AFSCN communications functional areas should be highlighted. The recording, storage, and playback area is located at the RTSs and common-user control centers. This area serves as a backup for real-time receive activities and as non-real-time playback for satellite support activities. Types of data involved are primary and backup telemetry, voice, time, and command/control/status signals. The CCC records information by exception; therefore, users must schedule any recording.

The AFSCN communications system provides the necessary interface equipment to permit access between satellite and various terrestrial communications agencies. This area, which includes communications satellite links, interconnect facilities, leased common carrier communications links, and commercial telephone, provides the primary and alternate connectivity between the globally dispersed AFSCN elements.

Additional Systems

The Command and Control System (CCS) is the new operating system that was formerly known as Data Systems Modernization. When configured for CCS support, the RTS relays the entire telemetry stream back to a CCS-compatible SOC at either Falcon AFB or Onizuka AFB for telemetry processing. The RTS also relays satellite commands from a CCS SOC to the space vehicle. The Air Force plans to transfer all of its space vehicle operations to the CCS.(16)

The AFSCN uses two major testing facilities: the Software Development Test Laboratories (SDTL) and the Operational Software Maintenance Complex (OSMC). The OSMC, located at Falcon AFB, provides a software maintenance, testing, and operational support capability for Falcon assets. Capabilities include software maintenance, verification test bed for delivered products, end-to-end system testing, data-base validation, simulation/rehearsal scenario execution, and engineering support. The SDTL located at Onizuka AFB provide similar support functions for the Consolidated Space Test Center (CSTC). This support includes CSTC testing and training support, and software development for newly acquired space vehicle programs to be supported by the AFSCN.(17)