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ABSTRACT

This paper describes the network coordination for the Health, Education, Telecommunications (HET) system. Specifically, it discusses HET network performance as a function of a specially-developed coordination system which was designed to link terrestrial equipment to satellite operations centers. Because all procedures and equipment developed for the HET network control and interface were routed through, or originated at, the Network Coordination Center (NCC) in Denver, Colorado, the focal point of this report is the NCC. For perspective, general information is provided about the network including signal strength and hardware reliability findings. The paper is, however, primarily concerned with the management coordination function; equipment is discussed only to explain that function. Contained in detail are: (1) explanations about the technical mechanisms and administrative procedures used for coordination; and (2) analysis of the strength and weaknesses found in these joining elements. (Author/EMH)

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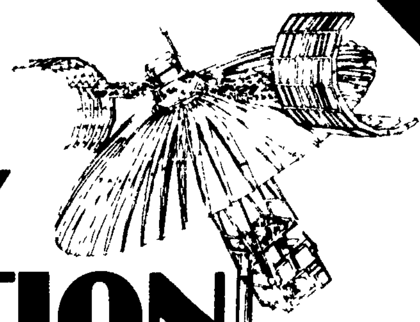

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NETWORK PERFORMANCE AND COORDINATION IN THE HEALTH, EDUCATION, TELECOMMUNICATIONS SYSTEM

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ABSTRACT

This paper describes network coordination for the Health, Education, Telecommunications (HET) system. Specifically, it discusses HET network performance as a function of a specially-developed coordination system, which was designed to link users of terrestrial equipment to a satellite operations center. Because all procedures and equipment developed for HET network control and interface were routed through, or originated at, the Network Coordination Center (NCC) in Denver, Colorado, the focal point for this report is the NCC. For perspective, general information is provided about the network, including signal strength and hardware reliability findings. The paper is, however, concerned primarily with the management coordination function; equipment is discussed only to explain that function. Contained in detail are: (1) explanations about the technical mechanisms and administrative procedures used for coordination; and (2) analysis of the strengths or weaknesses found in these joining elements.

INTRODUCTION

The Health, Education, Telecommunications (HET) network was composed not only of three Applications Technology Satellites (ATS's) provided by the National Aeronautics and Space Administration (NASA), but also of six distinctively-configured--and separately-funded--education and health experiments. The ATS-6, sixth in the series of Applications Technology Satellites, was used for all television transmissions; the ATS-3 and ATS-1 were used for two-way voice and data transmissions. All three satellites were controlled by NASA's Applications Technology Satellite Operations Control Center (ATSOCC), located at the Goddard Space Flight Center in Greenbelt, Maryland.

One hundred nineteen relatively remote sites, participating in one or more of the six experiments, used the services provided by these satellites. Although each of the six experiments had a unique program, audience, and equipment configuration, each had a common denominator: all the experiments used low-cost, satellite-compatible equipment to receive and/or transmit signals; and all 119 terminals were equipped with 2.5 receive-only systems, designed to receive and demodulate a single video signal and four associated audio channels. Additionally, 47 of the sites in the Rocky Mountains, Appalachia, and Alaska and the Pacific Northwest had specially-designed VHF systems for two-way voice and/or data traffic.

The remainder of the HET ground segment consisted of NASA earth stations in Rosman, North Carolina and Mojave, California, as well as the principal uplink earth station in Morrison, Colorado; the HET Network Coordination Center (NCC) in Denver, Colorado; and regional control centers in Lexington, Kentucky, Fairbanks, Alaska, and Seattle, Washington.

The NCC was responsible for coordinating all the experiments in the terrestrial network. Designed and built by the Broadcast and Engineering Component of the Satellite Technology Demonstration (STD), the NCC provided "network integrity" by developing specifications for remote terminal operations, as well as by assigning control and interface tasks for the Center.

The high level of equipment performance at the HET remote terminals is well documented. (See the "Reference" section.) The 2.5 GHz Receive-Only Terminals originally were designed for a 49 dB peak-to-peak signal to weighted rms noise ratio. Results from daily measurements at the remote installations indicated that the original standard was slightly exceeded, and average intelligibility was persistently maintained at a "5 by 5" and "3 by 3" audio comment notation. This notation indicated: (1) "no annoyance and imperceptible distortion and/or noise in the video picture"; and (2) "good or very good audio signals with maximum readability." The results for the VHF terminals were similar. The originally-required specification was set at a minimum test-tone signal-to-noise (SNR) of 20 dB. Investigations have shown the average test-tone SNR ratio at the HET sites was on the order of 22 dB, with a "3 by 3" audio average readability comment.

HET NETWORK COORDINATION

Network coordination began during the development phase of the HET experiments. During that time, a series of meetings was held for the six experimenters and NASA officials both to develop a mutual understanding of goals and needs of each experiment and to provide further details about the capabilities of the satellite system being developed. Patterns of information and needs evolved. These patterns were used to develop agreements among the experimenters and to specify a network plan. In conjunction with the plan, the STD's Engineering staff developed the Site Operator Manual, which contained equipment usage information and operational procedures. These procedures were the key to network coordination.

A digital control device, which is directly related to a network coordination system, was built into the VHF Communications Console as part of the VHF system. This capability was experimental in nature; it was not used for network coordination until the final phase of the experiment, and then only on a limited basis.

After the ATS-6 was launched on May 30, 1974 and system checkouts were conducted, the HET network became operational in July, 1974. The NCC subsequently became the "nucleus" for receiving, transmitting, relaying, monitoring, and controlling all HET network user activities.

Control and interface capabilities at the NCC were derived by both administrative prerogative and equipment attributes. For example, verbal or technological directions from the NCC to the sites superseded all others. The different operational control and interface tasks are discussed in the remainder of this paper.

ATSOCC Interface

The NCC was added to the NASA Communications Network (NASCOM) to interface with the Applications Technology Satellite Operations Control Center (ATSOCC). The ATSOCC communications linkage consisted of a mechanically-switched teletypewriter and a dedicated SCAMA (Switching, Conferencing, and Monitoring Arrangement) phone line. NASA's primary switching center (in Greenbelt, Maryland) was the central source for information about schedules and technical operations. The NCC, in turn, generated remote network status data to the affiliated NASCOM stations.

NASCOM was an efficient and pragmatic system for network coordination which combined both voice and teletype circuits. In future installations, more attention should be given to soundproofing the teletype installation to diminish interference with normal operations.

Multi-Signal Routing and Multi-Output and Switching

Two rack-mounted patch panels--one for audio and one for video--were built side-by-side into the NCC's console. Each panel was "normaled" into standard daily routes, requiring simple dial-up and turn-on techniques at the operator's console.* Seated in front of the audio board, the operator could select from nine video inputs and from an audio system that had 20 inputs, 8 mixer channels, and 6 outputs. When a non-normaled route was required, the operator could return to the patch panel and, using any number of video and/or audio cords, rechannel signals both into and out of the NCC.

The audio and video patch panels provided easy access to audio and video lines and contributed significantly to the efficiency of the network coordination function. In addition to providing signal routing flexibility, the panels were used for signal diagnosis information.

The audio board and video switcher, although used effectively by NCC operators, could neither simultaneously and automatically transmit audio/video signals nor insure smooth trans t'ons between switching segments. Therefore, a master audio/video switcher with multi-switching capability would have been an operational improvement.

Televised Network Announcements

A "character generator" was used for coordinating purposes, which included transmitting program previews, program titles, emergency network information, and special directions to site operators. This generator transmitted typed information which was first set up and checked on a preview monitor, then used "on-line."

The NCC's character generator performed well, but as with other NCC equipment items, a deluxe model would have increased benefits, such as greater character-storage capability and memory retention. A double keyboard would have allowed the character generator to be operated simultaneously so that it could have been shared, for example, with production.

Pre-Program Polling

Predetermined protocol procedures enabled the NCC to receive remote network status reports during a specified pre-program lineup time. Information was recorded on a network log and relayed to the ATSOCC for satellite pointing and configuration checkout. This

* At the onset of the experiment, the video and audio patch panels were not normaled and this made signal routing difficult. However, this problem was corrected early in operations.

system was used for five of the HET experiments; The Veterans Administration (VA) experiment in the Appalachian area did not require the VHF capability. The VA sites were polled by telephone. Depending on the number of the operating stations, pre-program polling took 5 to 15 minutes.

Link reliability in the VHF range (135 MHz to 149 MHz) was not always adequate in comparison with operation at 2.5 GHz. In addition to propagation-related fades, interference also was experienced from non-U.S. operators in various Western Hemisphere locations. With the 300-watt transmitter at the Denver Earth Station, the NCC was able to override most interference and reach the remote sites. The 90-watt transmitters at remote sites, however, were subject to interference, and incoming messages to the NCC occasionally were unintelligible. Consequently, the VHF interaction loop (which permitted all sites to interact by rebroadcasting STD questions over the ATS-6) was unreliable. As a management coordination tool for relay of pre- and post-program data, however, the VHF was effective.

In Alaska, site operators used expert voice protocol, but a more relaxed agreement existed with regard to pre-program polling, and inclusive remote site status was not always provided before programs. This informality was a threat to network integrity, as well as to operational stability. In the future, understandings and agreements between users and the NCC should be clarified in a written document, for either strict or "relaxed" network arrangements.

Monitoring

Facing the NCC operator's console were specially-designed mapboards which presented visually the three geographical regions in the HET experiments: (1) Rocky Mountain region; (2) the Appalachian region; (3) and Alaska and the Pacific Northwest. Although the "real time" status of sites displayed on the mapboard through the planned digital control system was not available, the mapboard was a useful visual aid, displaying all HET remote stations by location and type of equipment configuration.

The operators monitored video signals on two 19-inch color monitors and three 17-inch black and white sets. One color monitor received C-Band and S-Band signals via a 12.5 GHz microwave relay from the Morrison Earth Station which was the location of the Denver Uplink Terminal (DUT). Another color monitor was used to observe the signal being transmitted on-line from the NCC to the DUT. Of the three remaining monitors, one was used for character generator preview, one for preview of materials about to be transmitted from the NCC, and one as a spare.

The two color monitors enabled operators to monitor--effectively and efficiently--the space-segment link status, but the black and white monitors were too large in size and too few in number to operate effectively as a coordinating mechanism. The NCC supervisor would have preferred six small monitors within the tilted portion of the console. Three would have been used to monitor the three VTR's: one for on-line studio segments; one for character generator preview; and one for preview of all materials about to be transmitted from the NCC.

In addition to the monitors, a waveform oscilloscope, mounted in the console, was used to check the technical parameters of the various signals, including video level, sync, and color burst. The waveform monitor was a standard technical item that performed effectively.

The DUT also was equipped with the waveform oscilloscope, video monitors, and necessary test equipment for both baseband and rf measurements. This equipment provided an extra measure of quality control.

Program Interface with VA

The Veterans Administration (VA) experiment did not require VHF; therefore, a "dedicated" phone line, separate from the direct-dial phone line for polling and failure reporting, was used between the NCC and the VA program origination center at KMGH-TV in Denver, Colorado. The dedicated phone was a necessary and valuable communications link.

Failure Reporting

By means of the pre-program polling and monitoring methods already described, the NCC could provide remote network status in an on-off basis at the 24 sites having two-way VHF capabilities or, as in the VA experiment, having dedicated telephone links. All remote site operators were provided with specific operational standards to use. For example, "Was the terminal operative?" and "Was it operating in such a manner that the signals received were adequate for audience viewing and listening?". Documentation required by the engineering staff necessitated knowledge of the operational status of sites not polled. Further, because the STD had maintenance and repair responsibilities for three of the HET experiments, equipment failures at all sites had to be reported. In the Appalachian Educational Satellite Project (AESP), STD maintenance personnel located in that area received equipment failure reports from the AESP control center in Lexington, Kentucky. In the VA experiment and the STD, site operators were required to report--via direct-dial phone to the NCC--any deviation from the normally prescribed operational status of equipment, thus providing immediate troubleshooting with the operator and the prompt dispatch of STD engineers.

The NCC had the capability to troubleshoot problems at operating sites. It seemed logical. then, to place the responsibility for coordinating site failure reports with the NCC. But once the network system was established, there were several difficulties in reporting problems. First, the NCC operators were neither hired nor trained to troubleshoot field equipment; successful troubleshooting, therefore, depended on who was operating the equipment at the time a malfunction was reported. Second, site operators sometimes used reporting channels other than those specified. This misuse of the equipment resulted in a less efficient means of communications. For these reasons, the following recommendations should be considered in the future:

1. Increase remote site operators' understanding of repair services and use of the direct-dial phone;
2. Either reroute the special failure-report phone link directly to broadcast and engineering repair offices; or
3. Insure that one NCC operator with technic ; repair competency is on-line at all times.

Additional Internal Interface Capabilities

Three in-house phone extensions were used by NCC operators for additional supervisory contact with engineering and administrative staff at the STD; an "intercom" system was used for communications with the production personnel. The intercom system and in-house phone extensions were sufficient and useful for coordinating operations.

Network Redundancy

Alternative backup systems for equipment failures, including the satellite, were developed. The plan provided for contingencies such as: (1) restructuring the network communications plan, in both temporary and prolonged failure situations; (2) compensating for malfunctions at STD sites; and (3) rescheduling missed programs. The NCC was responsible for coordinating all HET contingency actions. In instances of VHF failure--either from the NCC or the Morrison Earth Station Uplink--land-line arrangements that interconnected satellite facilities at the Bureau of Standards in Boulder, Colorado, and General Electric in Schenectedy, New York, were used to maintain contact with the ATS-3 and the ATS-1. In instances of ATS-3 transmitter failure at Morrison, a 90-watt transmitter on the third floor of the NCC building was used. For Alaska, an additional backup was provided by a phone-line link to the Alaska transmitting station. During an ATS-6 system failure, land-line arrangements with the Rocky Mountain Public Broadcasting Network Delay Center enabled programs to be routed via PBS land-lines to participating public television stations.

Network failures were of short duration, and available backup equipment generally provided adequate network redundancy. Two comments, however, should be mentioned. First, if all HET experimenters had obtained videotape recorders, the NCC would have been able to provide additional backup services. Second, the verbal agreements with backup sources (such as General Electric in Schenectedy, New York) did represent an imposition; therefore, written service agreements specifying conditions for backup should be developed.

VHF Digital Control and Two-Way Data

The counterpart of the digital control device built into the VHF system at the remote sites was a Master Digital Coordination/Control unit at the NCC. The custom-designed system was composed of control, display, and interface devices. The basic network control and interface functions were as follows:

1. To establish a visual indication of transmission between Denver and remote sites.
2. To arrange for transmissions between remote sites for other HET network users.
3. To accept questions during the inetractive mode of operation in the Rocky Mountains.
4. To monitor and record all transmissions.

5. To assist other HET network users with their programs and execute remote control operations.
6. To provide an automatic shutdown capability for the network in the event of an emergency or misuse of the network.

The Denver VHF transmitting and receiving systems were located at the uplink station, not at the NCC, because pre-operational testing suggested that the NCC's office building had an extremely noisy rf environment. Since VHF activity occurred simultaneously on two satellites, numerous dedicated phone links were required between the NCC and Morrison, and digital and voice communications were transmitted over these phone lines. The microwave link could have been used to provide this service at less cost, but was not incorporated into the original plans because the STD had planned to use four audio channels to broadcast multi-language programs.

The control function required computer services, and a Hewlett-Packard 2100A was leased. It was used in a real-time mode for daily network operations. Data flow and processing were planned for three main tasks:

1. Data was to be sent and received to and from the remote network sites.
2. Data was sent to the earth station for control of the VHF equipment.
3. Data was sent to the visual display mapboard system at the NCC.

A CRT (Computer Remote Terminal) keyboard and display was utilized in the NCC to assist network operations.

The CRT, used in computer operations, exhibited incoming calls to inform the network operator that a call had been received, and commands sent to the remote sites also were displayed to maintain an active presentation of network status. Further, status of control functions at the earth station were retained, giving the operator all the information necessary to control the system. The mapboard system visible to all NCC personnel was used as an aid to the operators, as well as for general display. The control board was a map with all remote sites identified with lights: red, green, and amber. Based on information fed to the computer from the remote sites or the network operator, the light represented site operational status.

The digital equipment in a modified form and associated VHF hardware for field use were integrated and installed on time at the remote sites, even though the Denver-Based digital equipment proved to be far more complicated and difficult to make operational than was expected. The result was a delay in the use of the system. On April 28, 1975, successful tests were run between Denver and Saratoga, Wyoming, using the VHF link with computer control. The overall results were encouraging.

STD Uplink Complex (DUT)

The STD uplink complex (DUT) was capable of originating a single video channel with four associated program channels to each of the regions served. The DUT was located in a valley two miles south of the town of Morrison, Colorado. The natural shielding of the surrounding mountains enabled the earth station to share the 4/6 GHz frequency band which was used extensively by terrestrial systems in the Denver vicinity.

The station used an 11-meter (36-foot) prime-focus antenna, a 3 kilowatt transmitter, and a 90°K uncooled parametric amplifier, which provided an EIRP of 84 dBW and a G/T of 29 dB°K. A 12-mile 12.5 GHz microwave relay interconnected the uplink with the NCC's headquarters in Denver. Engineering personnel learned to operate the uplink equipment by means of an on-the-job training program. These personnel had extensive background in television broadcasting, but they had no previous experience with satellite earth stations.

The DUT operation was highly successful. The complex complied with all FCC requirements pertaining to coordination of fixed-satellite earth stations; and, although little time was available to procure, integrate, and "debug" the facility, quality of signals and reliability of equipment was exceptional.

Broadcast and Engineering's prediction that no catastrophic failure of critical components would occur during the operational phase of the Project proved to be accurate. (This risk would not have been assumed had there been adequate provision in the budget for spare parts.) The reliability of the complex was exceptional. The situation was operational 99.6 percent of the time. From October, 1974, through May, 1975, the DUT was on the air approximately 550 hours. Total outages, including power failure and operator error, amounted to 117 minutes. This accomplishment is remarkable, given the minimal redundancy built into the system and considering that the operators had no previous experience with satellite earth stations.

CONCLUSIONS

The performance of the HET network coordination system (implemented through NCC and DUT operations) was satisfactory and provided hard data concerning many factors involved in the implementation of a satellite ground system. Given the severe time and budget constraints, choices of equipment were adequate; however, NCC operations could have been improved.

In general, better layout of equipment in the NCC would have eased operations, as would have the purchase of more sophisticated models of certain equipment items. Specific improvements would have been:

1. To consolidate the many phone links (which were dispersely located, making it difficult for the NCC operators to respond quickly) in the NCC into one audio control with headphones.

2. To install additional phone lines rather than to use leased phone lines in the microwave relay which interconnected the NCC with the uplink.

REFERENCES

National Aeronautics and Space Administration, HET Network Operations Plan, October, 1972.

Satellite Technology Demonstration, Broadcast and Engineering Hardware Reliability Results, October 7, 1974 - March 31, 1975, Federation of Rocky Mountain States, Denver, Colorado.

Satellite Technology Demonstration, Broadcast and Engineering Training Manual for HET Site Operators, Federation of Rocky Mountain States, Denver, Colorado, June 7, 1974.

Satellite Technology Demonstration, The Voice/Data Communications System in the HET Experiment, Federation of Rocky Mountain States, Denver, Colorado.

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