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ABSTRACT

A satellite system to interconnect the Public Broadcasting Service (PBS) and 165 public television stations (PTV) is planned to replace the present terrestrial system. Stations are located on and outside of the United States mainland. Advantages offered by satellite are: (1) equal cost of program originations from points close to and remote from the national origination center, (2) nearly identical technical quality and reliability at all stations, (3) program distribution to non-mainland PTV stations and simultaneous delivery of two or more programs economically feasible, (4) program exchanges between PTV stations in separate geographical areas possible without pre-empting service to others, and (5) ability for PTV stations in close proximity to receive different programs at the same time. Proposed major components of the system are: (1) the space segment to be provided by Western Union's WESTAR satellites, (2) Receive-Only (R/O) Ground Terminals owned, operated, and maintained by PTV stations, (3) Main Origination (M/O) Ground Terminal owned and operated by PBS, and (4) Receive/Transmit (R/T) Ground Terminals dispersed throughout the country. Major specifications and objectives of R/O Ground Terminal are appended. (KP)

THE PUBLIC BROADCASTING SATELLITE INTERCONNECTION SYSTEM

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THE PUBLIC BROADCASTING SATELLITE INTERCONNECTION SYSTEM

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This paper describes the satellite interconnection system that is planned to serve the Public Broadcasting Service (PBS) and approximately 165 public television (PTV) stations located on the U.S. mainland, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands. The space segment of the system will be provided by Western Union's WESTAR satellites and the ground segment will be owned, operated, and maintained by PBS and the individual PTV stations.

Introduction

Since 1971 PBS has been operating a national terrestrial interconnection system which is leased primarily from the American Telephone and Telegraph Company (AT&T). Approximately 20,000 miles of microwave and cable facilities are thus used to interconnect some 143 PTV licensees who operate 254 TV broadcast transmitters that serve between 75% and 80% of the American public. The terrestrial system is a single channel system in that it delivers a single video signal plus a single audio signal to each licensee's studio location. While the national programming for the system in the main originates from the PBS technical operations center in Washington, D.C., the system has been configured such that program originations from other locations are possible, in the East, or from certain other locations in the South and Mid-West, where the terrestrial facilities have been routed on a "round-robin" basis such that a number of stations on the loop can originate to all other stations in the system. The system, in addition, can, as required, be broken down into large geographically contiguous sub-networks for time-zone delay and regional program originations. Nevertheless, despite this flexibility the terrestrial system has a number of major limitations as follows:

1. Program originations from locations beyond the round-robin injection points can be expensive to set up, particularly if such points are some distance from the round-robin. This is particularly so for originations from the West Coast or from the Rocky Mountain region.

2. The technical quality and reliability of the national program distribution service decreases with increase in terrestrial route mileage of each PTV station from Washington, D.C.

3. The provision of a program distribution service to the non-mainland PTV stations, e.g., in Alaska, Hawaii, etc. is not economically feasible.

4. Program exchanges between PTV stations in non-contiguous states is not feasible without pre-empting other users of the terrestrial system.

5. All PTV stations, at least on any given segment of the terrestrial system, are delivered the same program feed, due to the single channel nature of the system.

6. The delivery of two or more program feeds to each PTV station is not economically feasible.

In contrast with the above limitations of the terrestrial system, the satellite system, as described in more detail later, offers distinct advantages as follows:

1. Program originations from points remote from the national origination center are no more costly than originations from points close to the national origination center.

2. The technical quality and reliability of the satellite system service can be made almost identical at all points served irrespective of their distance from the point of program origination.

3. The provision of a program distribution service to non-mainland PTV stations is economically feasible.

4. Program exchanges between PTV stations in widely separate geographic areas of the country are possible without pre-empting service to other PTV stations.

5. PTV stations that are in close proximity to each other can receive different programs at the same time.

6. The simultaneous delivery of two or more programs to each PTV is economically feasible.

Major Components of the Satellite System

The public broadcasting satellite interconnection system will have four major components as follows:

1. The Space Segment will be the Western Union WESTAR satellites. WESTAR I, located at 99°W longitude will be the primary satellite with WESTAR II, located at 123.5°W longitude, serving as the secondary or back-up satellite. A minimum of three WESTAR I transponders will be leased on a full-time basis, with additional transponders available either for lease on a full-time basis or on an occasional basis. Agreement has been reached with Western Union on the technical performance of the satellite transponder service. Some of the more significant specifications are:

a. Satellite position
   - latitude $\pm 0.1^\circ$
   - longitude $\pm 0.1^\circ$
   - attitude $\pm 0.1^\circ$

b. Satellite service will not be degraded during sun eclipse periods.

c. Satellite e.i.r.p values are guaranteed at all PTV sites throughout the service contract period.

d. Minimum satellite transponder sensitivity and G/T values have been agreed upon.

e. Transponders leased by public broadcasting will be backed up by an additional transponder in the primary and back-up satellites.

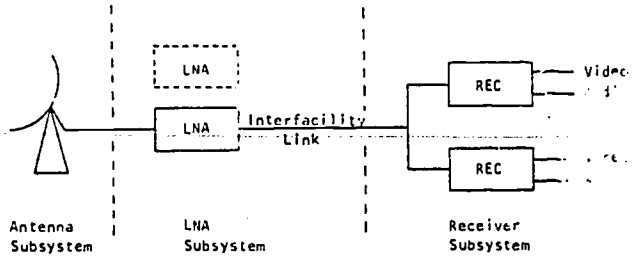
f. Provided public broadcasting does not exceed the signal level and bandwidth restrictions that have been agreed upon with regard to the satellite up-link, there shall be no other restrictions regarding modulation technique used nor type of traffic transmitted.

2. The Receive-Only (R/O Ground Terminals, of which there will be approximately 150, will be owned, operated, and maintained by the PTV stations. Wherever possible these terminals will be installed adjacent to the studio location of each PTV station. As shown in Figure 1, the R/O ground terminal will consist of three major subsystems:

a. The antenna subsystem, which will be a 10-meter diameter antenna having a hand crank pointing mechanism capable of looking at any part of the domestic orbital arc.

b. A redundant low-noise amplifier (LNA) subsystem utilizing, in the main, transistorized LNA's.

c. A receiver subsystem consisting of two FM video receivers. Each receiver will be frequency agile across the full satellite down-link frequency band (3.7 - 4.2 GHz) and will, in addition to providing a video signal output, provide an audio channel (15 kHz) output.



RECEIVE-ONLY GROUND TERMINAL

BLOCK SCHEMATIC

Figure 1

Table 1 lists the major specifications and objectives that have been set for the R/O ground terminal.

3. The Main Origination (M/O) Ground Terminal will be located in the Washington, D.C. area and will be owned and operated by PBS. The M/O ground terminal will consist of

a. Two 11-meter antennas

b. Five 3kw high-powered amplifiers and associated satellite up-link equipment.

c. Two redundant LNA subsystems, one associated with each antenna.

d. Five FM video receivers.

e. A prime power system with a standby diesel generator.

The M/O terminal will be linked to the PBS technical operations center in Washington, D.C. via a multi-channel terrestrial microwave system.

4. The Receive/Transmit (R/T) Ground Terminals, of which there will be approximately five, will be dispersed throughout the country and will be basically R/O ground terminals with a single channel transmitter (3kw) added. The transmitter will be frequency-agile to permit rapid tuning of the up-link to any one of the leased transponder frequencies.

System Implementation

Prior to the implementation phase, all preparatory site survey and selection work must be completed at all of the PTV station sites. This work includes frequency coordination studies, on-site measurements, civil engineering surveys and site zoning and construction approvals. The system implementation phase is scheduled to start in mid 1977 and should be completed late 1978.

Table 1

MAJOR SPECIFICATIONS AND OBJECTIVES
OF R/O GROUND TERMINAL

Antenna Subsystem		
Antenna diameter	:	10m ± 0.35m
Main reflector surface tolerance (r.m.s.)	:	0.75mm (static) 1.25mm (dynamic)
Main beam gain*	:	≥50 dB
Sidelobes:	:	32 - 25 log (θ) dBi from 1° to 48° -10 dBi from 48° to 180°
Pointing	:	70°W to 135°W longitude of satellite orbital arc
Continuous pointing	:	40° orbital arc coverage
Pointing accuracy	:	± 0.5°
Cross polarization discrimination	:	28 dB
LNA Subsystem		
Bandwidth	:	3.7 GHz to 4.2 GHz
Gain	:	60 dB ± 1 dB
Gain slope	:	± 0.2 dB/10 MHz
Gain linearity	:	± 0.5 dB over bandwidth
AM to PM	:	0.5°/dB
Group Delay	:	In any 40 MHz segment, Linear: 0.1ns/MHz Parabolic: 0.03ns/MHz^2 Ripple: 0.5ns p-p
Receiver Subsystem (excluding IF filter)		
Frequency agility	:	1 MHz incremental tuning across 3.7 GHz to 4.2 GHz
I.F	:	70 MHz
Noise Figure	:	14 dB
Gain/Frequency	:	0.2 dB p-p ± 6.5 MHz 0.4 dB p-p ± 12 MHz 0.8 dB p-p ± 18 MHz
Group delay (±16.6 MHz)	:	Linear: ± 0.03ns/MHz Parabolic: 0.02 ns/MHz^2 Ripple: 1.0ns p-p
Baseband output	:	± 0.25 dB, 10 Hz to 8 MHz
Video output	:	± 0.25 dB, 10 Hz to 4.1 MHz
Video polarity	:	Selectable
Audio output (6.8 MHz subcarrier)	:	50 Hz to 15 kHz, ± 0.5 dB to -1 dB

TOTAL SYSTEM

G/T = 26 dB/°K (typical)	Audio S/N = 65 dB
Video S/N = 53 dB	Audio distortion = 1%.
Video diff. gain = 3%	
Video diff. phase = 2°	

*Where improved sidelobe performance will facilitate the frequency coordination at specific sites, the main beam gain can be reduced to 49 dB provided the sidelobe characteristics can be reduced to -20 dBi from 120° to 180°.