SPACE TELECOMMUNICATIONS - THE FUTURE IS NOW

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Abstract

The present communication satellites used for international and domestic traffic employ low-powered transponders. This characteristics is compatible with the mission of interconnecting a few earth stations in a high density traffic mode. From the total system viewpoint when there are a small number of earth stations, it is economical to spend more on the earth station and minimize the cost of the satellite segment.

However, if the number of earth stations is large, it is far more economical to reduce the size and cost of the earth terminal and increase the power (and cost) of the spacecraft. The total systems cost is lowered by the reduced cost of the total ground segment.

Communications experiments with the Applications Technology Satellite-VI and the Communications Technology Satellite, both high-powered spacecraft, broadcasted to low-cost earth stations. These experiments demonstrated that low-cost, good performance earth stations are a reality.

INTRODUCTION

Space Telecommunications has advanced dramatically in the past decade. Television via satellite is viewed daily on news broadcasts. A good case in point is the recent coverage of the Winter Olympics. The concept of large earth stations being required to receive high quality television signals however, is erroneous. The state-of-the-art has advanced and the technology proven that the total system can be planned and implemented according to the demands and needs of the user.

U.S. DOMESTIC COMMUNICATION SATELLITE SYSTEMS

The United States Domestic Communications Satellite Systems incorporates the ultimate in space technology. Design life-times of seven to ten years are the norm. Twelve to twenty-four transponder channels are available. Antennas cover the lower forty-eight states with spot beams available to Alaska, Puerto Rico and Hawaii. However, all transponders are low-powered, i.e., normally 5 watts per channel. With the associated antenna gain, effective isotropic radiated power (EIRP) ranges from 22 dBw to 33 dBw. These powers fall within the allowable power flux density limitations and are compatible with the mission of interconnecting a few earth stations that operate in in a high density traffic mode.

The receive earth-stations operating in the 4 GHz band are large, sensitive and expensive terminals. Figure-of-merit ranges from 30 dB/^{O}K to 41 dB/^{O}K with antenna sizes from 10 meters to 30 meters. These terminals are capable of multi-channel telephony and high quality video performance. A receive-only capability earth station costs will start about $65,000 for a ten-meter antenna with a transistorized front-end.

The synchronous orbital slots that are available are rapidly diminishing. Protection from interference requires spacing and the orbital arc that enjoys good look angles for the earth stations is limited.

The spectrum at 6/4 GHz shared with terrestrial services provides 12 thirty-six MHz channels.

THE APPLICATIONS TECHNOLOGY SATELLITE VI

The Applications Technology Satellite (ATS-6) is a multi-purpose experimental satellite. The spacecraft, launched in May 1974, contained many scientific and technological experiments onboard as well as a complex communications payload. The main feature of the satellite, a nine-meter parabolic antenna, provided a remarkable departure from the conventional spacecraft. The effective isotropic radiated power (EIRP) at S-band frequencies was 52 dBw (180,000 watts). The Health/Education Telecommunications (HET) Experiment conducted by the Department of Health, Educztion and Welfare deployed 119 small earth terminals in isolated regions of Appalachia, the Rocky Mountain area and the states of Alaska and Washington.

It was the high power of ATS-6 for HET experiment that reduced the size (and cost) as well as the complexity of the earth terminal. Operating in the 2500 to 2690 MHz band, the terminal consisted of a 3 meter antenna, an outdoor preamplifier unit mounted on the antenna, and an indoor unit which demodulated and processed the signals to provide, as outputs, the video and associated aural signals at baseband. The figure-of-merit of the earth station is 7.2 dB/^{O}K. The earth terminal is procured for the HET experiment cost less than $4,000 each (FOB) in 1973. The current estimate in quantities of 100 or more is approximately $5,000 each. The earth station weighs about 320 kilograms (700 pounds) and can be installed in one day by two men.

The receiver is capable of receiving either of two TV channels provided by ATS-6. Also four aural channels are available with each video channel.

Data collected during the nine months of the HET experiment, with the earth stations operated by non-technical users, indicated a median peak-to-peak video signal-to-weighted RMS noise ratio of 51.1 dB.

In considering the cost of the entire system, it would be unfair to weight the total cost by the cost of ATS-6, since the spacecraft was developmental and included a multi-discipline payload (over 25 experiments). The multi-discipline payload not only added directly to the cost but also added weight which created the high launch costs. The cost of a spacecraft operating with the same EIRP, frequencies and number of channels is estimated to provide a more fair comparison. The simplified satellite consists of an earth-coverage horn, a 6 GHz receiver and a two-channel S-band transponder with a shaped-beam antenna. The spacecraft provides a 50 dBw EIRP and it is assumed to be launched on a 3914 vehicle. The estimated total system cost (1976 dollars) are:

Spacecraft	*$15.0 M*
Up-link Station	*.30M*
120 video receive terminals @ $5K ea	*.60M*
	$15.9M

There are limiting issues to be addressed if such a system were planned to be operational. Orbital occupancy in this case would be determined only by the choice of 6 GHz as the up-link frequency. The S-band down-link is restricted in power flux density, but the use of energy dispersed signals will allow this ERIP. Terminals will most likely be only located in rural isolated regions. The metropolitan areas, having Instructional Television Fixed Service (ITFS) and Multi-point Distribution Service (MDS) would present a serious coordination problem for small earth terminals.

THE COMMUNICATIONS TECHNOLOGY SATELLITE (CTS)

The Communications Technology Satellite (CTS) is another experimental satellite. A joint venture between the Department of Communication, Canada, and the National Aeronautics and Space Administration, CTS was launched in January 1976 and also provides a high ERIP. A 200-watt travelling wave tube amplifier (TWTA) over 50% efficient, operating in the 12 GHz band provides 59 dBw on beam center. The antenna coverage is larger than ATS-6 (2.6 degrees compated to 1.0 degrees). The earth-station, as presently configured, consists of a 1.8 meter antenna, an outdoor translator and an indoor unit for demodulation. Since CTS (like ATS-6) has no north-south station-keeping, motorized vernier adjustments of the antenna is provided for operation. The earth-stations as procured for CTS experiments, cost $10,800 each in quantities of two. The earth station weighs approximately 110 kilograms. These earth stations are capable of receiving one TV channel and four associated aural channels.

As of this writing, the spacecraft is undergoing in-orbit tests by NASA. Early video performance test indicate received carrier levels ±0.5 dB of pre-launched calculated values. These calculations predict a clear weather peak-to-peak video-to-weighted RMS noise of 54 dB.

As in the case of ATS-6, for total system costs, a spacecraft, sized to provide the same EIRP, frequency and channels such as the Japanese BSE, is used for total system cost comparison.

Uplink costs for CTS, capable of providing the wideband TV signals are still comparable to domestic up-links. The total system cost is summarized below:

Spacecraft	*$15.0 M*
Up-link	*.3 M*
120 video receive terminal @$10K ea	*1.2 M*
	$16.5 M

Since CTS operates in the 12/14 GHz frequency bands, coordination of orbital slots with future systems would be required. The Satellite Business System satellites planned for 1979-1980 use this same band. At the present time coordination with terrestrial facilities are minimal and there is no power flux density limitation above 10 GHz.

COMPARISON OF TOTAL SYSTEM COST

In comparing the three-systems' total cost of the ground segment and the space segment, assume each satellite would be launched on the same type of vehicle (e.g. Delta 3914). The initial cost consists of the satellite and an up-link transmitter and a receiver. In order to properly weight the cost of the satellite, the spacecraft cost is divided by the number of usable transponders yielding a unit, dollars/channel. Then the cost of additional earth stations is added to provide the curve shown in Figure 1.

Two curves are indicated for the C-Band system. Curve #1 reflects the more sensitive earth station (G/T 41 dB/^{o}K); curve #2 the less sensitive earth station (G/T 27 dB/^{o}K). The Ku band and S-Band systems use the previously mentioned prices with no learning curves applied.

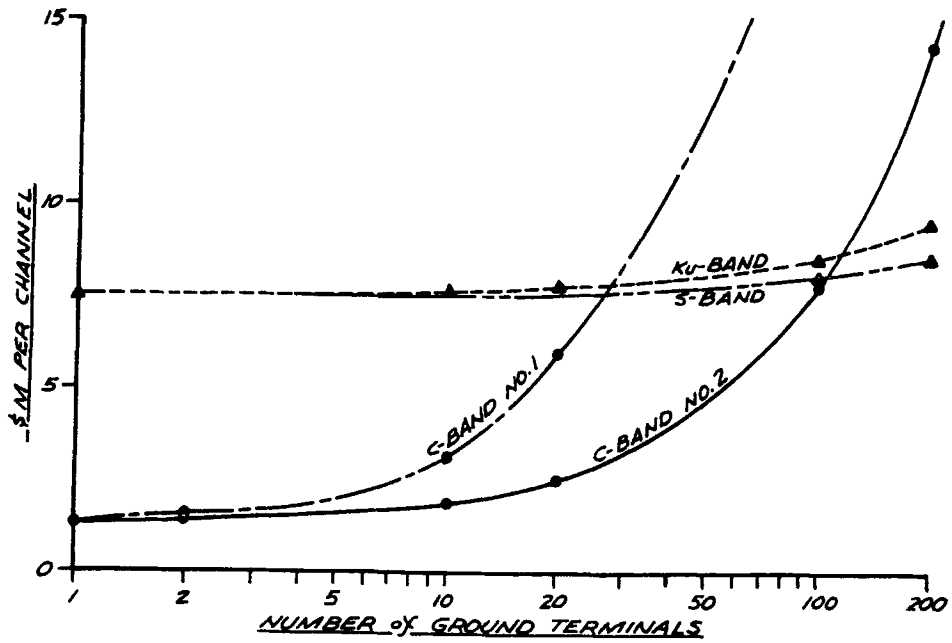

FIGURE 1

CONCLUSIONS

The technology exists to provide high quality communications to relatively low earth stations. The total system requirements (present and future, allowing for growth) must be determined and the system can be sized economically. The major decisions are not to be made by the technologists but by the user community. If the market is available the interprenuers of the commercial satellite systems can and will provide the capacity.