

## CABLE AND EARTH STATIONS - A BUSINESS CONNECTION

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### ABSTRACT

In practically every cable franchise being awarded today, the recipient is required to install an "institutional B cable" to serve the communication needs of the business community. Although to date very little use is being made of this non-entertainment cable, industry predictions indicate an explosive growth for business communications over the next ten years. The purpose of this paper is to identify and explain the characteristics of this potentially large business market, and to give an overview of the techniques and equipment requirements for the business/cable and cable/earth station interconnect. It seeks to alert franchise operators that the time to prepare for serving this market is now, when they are applying for franchises and building and rebuilding their cable system.

### Introduction

Much has been said about the evolution of the United States from an industrial society to an information society. Just as the number of people working in industry outnumbered the people working in agriculture in the early 1900's, the people working in information occupations now outnumber those working in industrial occupations.

Information and the way it is used will be the key strategic variable in many businesses. For this to happen, effective information transfer can no longer be constrained by a communication system that was designed for voice transmission.

With the advent of the communication satellite, large amounts of information can be sent easily from one city to another. Cable operators need to know that the satellite carriers are well along on their plans and their investment in intercity distribution of information. The bottleneck lies in the local distribution. The cable that is now being laid for distribution of television can be used for a substantial part of this local distribution. The linking of satellite earth stations

with cable television distribution systems offers many new opportunities as the information society emerges.

### Business Communications Needs

A number of large businesses are essentially information-based. Included are banks, insurance companies, investment companies, and stock exchanges. Their principal business depends on gathering and assimilating large amounts of data. This is currently being done by processing large amounts of paper, but office automation will allow the information to be processed and stored electronically with only summary information being recorded on paper. Communication and transfer of this information will be accomplished by the interconnected cable and satellite systems described in this paper.

Although productivity improvements have occurred in agriculture, manufacturing and service industries, productivity improvement in the office has been slow. Very little has been done to bring spiraling office cost under control. However, office tools are now being put in place to change this situation. These include communicating word processors, facsimile devices, computer-to-computer links, voice messages stored in digital format, integrated voice and data PABX, and intrafacility communication networks. A sophisticated business communication system will allow charts, budgets, last-minute schedules changes, press releases, contracts, and photographs to be transmitted quickly and reliably. Many people will be able to work at home connected by cable to their office. Executives attending out-of-town meetings and salespeople on the road will be able to have immediate and accurate access to information back at the home office. In the future, a person will be able to substitute teleconferencing for some business travel. The possibilities seem unlimited.

With office automation moving ahead, satellite common carriers have recognized business communications as a viable

market. These satellite carriers are shaping intercity business communications with their new concept of shared earth stations. Digital satellite carriers offer business customers a capability to transmit vast amounts of data, voice, electronic mail and other business signals from the earth station up to the satellite and back down to another earth station. Cable is a logical choice for a medium to distribute this data from the earth station to the businesses in each city.

#### Business Communications Services

Satellite and cable systems offer increased communications capabilities for text, facsimile, data transmission, integrated voice and visual aids and video conferencing. In the past, text transmission has been handled principally by telex which is slow and has a rudimentary character set. Telex is being replaced with communicating word processors which allow typewritten material to go from one machine to another at high speed. Much of the transmission and storage is accomplished electronically, thus creating tremendous communications needs. With a satellite/cable communications system, a secretary can type a letter, attach the appropriate electronic "address" and send a copy directly to another terminal at a distant facility.

Graphs, pictures and photographs do not lend themselves to character transmission and are better sent by facsimile. In order to obtain high resolution and transmit at a rate of one page per second, the bit rate needs to be of the order of 256 Kbps. This high data rate is available on the satellite. It creates the need for a high capacity local distribution system such as cable can provide.

The next step beyond communicating by voice and still pictures is conferencing using full-motion video. Point-to-multi-point video conferencing now makes economic sense. Many national sales meetings have been set up with regional salespeople coming to local auditoriums where earth stations are installed or have been temporarily set up. The salespeople view the program material on large television screens and respond to the presenter by phone. Point-to-point teleconferencing is very costly when using full-motion video because of the large bandwidth required. Analog video requires one quarter to one full transponder of satellite. The use of this much capacity for a normal business meeting would be excessively expensive, hence there is a need to digitize the information and reduce the data.

NTSC color video can be digitized at the rate of about 90 Mbps with no visible degradation. Removing redundancy allows a video signal to be sent at 20 Mbps with insignificant loss in video quality. When the motion is limited and the camera is fixed, it is possible to reduce the bit rate to 6 Mbps with limited loss in quality. The challenge is to reduce the bit rate to 1.5 Mbps and maintain reasonable cost in the video source coding equipment. As more devices for video coding are invented and as the cost of travel increases, business teleconferencing will become a common event.

Consider next data transmission. Large computers can manipulate data at rates of one Mbps or faster. Efficient resource sharing, computer back-up, file protection, core diagnosis and other factors make it necessary for distant computers to communicate with each other. Transmission at Mbps rates is required for computer communications in the future.

The office of the future will be integrated electronically. A number of scenarios for linking the equipment and people become evident. One scenario sees the hub of the automated office being an integrated voice and data PABX. The PABX permits users to transmit, switch, and store voice, data and images. Another possibility has local networks connecting office machines, digital telephones, and intelligent terminals or work centers. These terminals process and display data, text, pictures, and graphs. Regardless of the method, there will be a need for rapid communication of information within the office and from office to office.

#### Satellite Business Communications

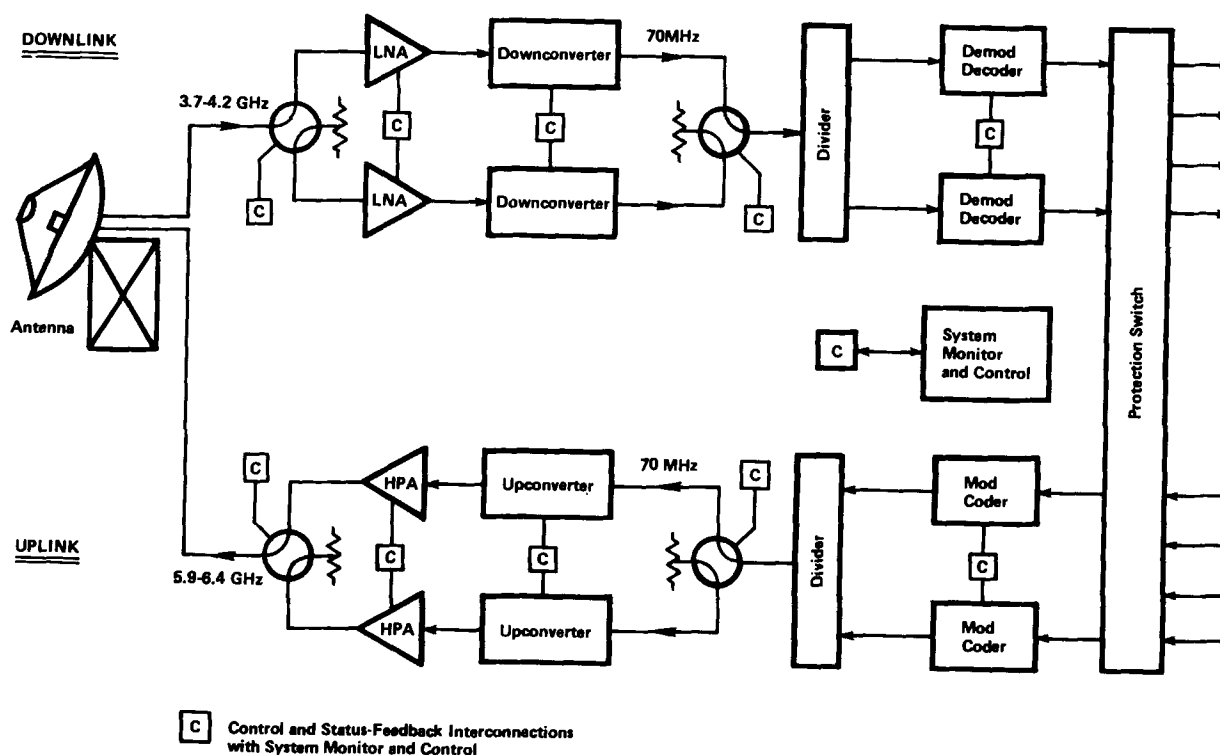
Satellite business carriers have made great strides in the intercity portion of satellite business communications. Carriers such as RCA, Western Union, and American Satellite Company have provided increasingly sophisticated business communications facilities for their customers. American Satellite through its satellite data exchange (SDX) service has specialized in providing voice and data communications to small earth stations located on end-users premises. American Satellite now has over 50 earth stations operating and another 34 under contract. RCA Communications is providing a data, voice, facsimile, slow scan TV and teleprint service called "56 Plus". Western Union also offers a similar data service to its customers.

A typical customer-premises earth station may have a 5, 7, or 10 meter antenna, redundant GaAs FET low noise amplifiers, redundant 5 watt to 125 watt high power amplifiers, 56 to 1544 Kbps digital modems, and a modem protection switch. Scientific-Atlanta furnishes this equipment and a microprocessor-based monitor and control unit in a complete earth terminal which is called DET-56. A block diagram of this system is shown in Figure 1. Each 56 Kbps channel can carry a 56 Kbps data circuit or can be multiplexed to carry many data circuits of different speeds. Voice channels can be provided using PCM or CVSD encoding. Data from computers, terminals, and facsimile can also be be transmitted over the DET-56. Figure 2 shows the DET-56 earth stations that have been installed to date in the United States.

Communication of business data by satellite offers a number of advantages.

The telephone system normally restricts data transmission to speeds of 9.6 Kbps and below. Data rates of one to forty Mbps can be transmitted by satellite. The telephone network can be expected to produce on the average, one error per 100,000 ( $10^5$ ) bits transmitted. Elaborate error checking and correcting schemes, which reduce efficiency, have been developed to overcome this problem. Error rates of fewer than one error per 10,000,000 ( $10^7$ ) bits are easily accomplished using satellite communications.

Satellite Business Systems (SBS), a partnership among wholly-owned subsidiaries of Comsat General Corporation, IBM and AETNA Life and Casualty Company, is implementing an extensive digital time division multiple access (TDMA) system for transmitting voice, data, and image. The \$7 billion intracompany business communications market is SBS's principal target. The company offers complete voice,



Simplified Block Diagram of Digital Earth Terminal

Figure 1

data, facsimile, and teleconferencing services.

**DET-56 Earth Stations for Business Communications**

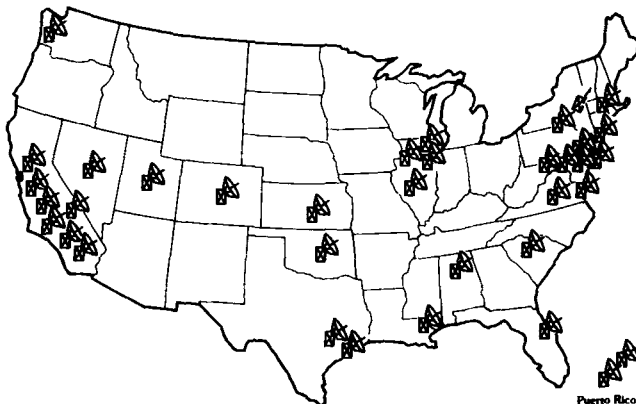


Figure 2

The earth stations, which are shown in Figure 3, operate in the 12/14 GHz frequency band so that they can be located in cities without frequency interference problems. The system offers private networks that are fully switchable and allow capacity expansion on demand. Facilities are provided to enable the companies to dynamically monitor and control the use of their networks. The terminals are small (5.5 meter and 7.7 Meter antennas) and can be located on customer premises or at cable headends. The satellite's capacity is so large that users will be able to send information between locations at rates hundreds of times those used today.

In addition to private networks with dedicated facilities, SBS will offer shared services between two or more users whose traffic volume does not justify customer premises facilities. SBS is also planning an exchange services network between 150 metropolitan areas served by 20 SBS switching centers. A twenty earth station network is to be completed by January 1982. Twenty-five earth stations are to be added by May 1982 and 50 more by January 1983. The shared and exchange services require local data transfer facilities that can be ideally provided by cable.

The need of insurance companies to share data has stimulated the formation of a resale common carrier of SBS service. ISACOMM, a communications subsidiary of Insurance Systems of America, is selling communications services to smaller users, principally in the insurance industry. ISACOMM initiated service through an

earth station in Wausau, Wisconsin and one in St. Louis, Missouri in early 1981. ISACOMM is now building earth stations in Baltimore, Atlanta, Houston and Sacramento and anticipates a total network of 40 earth stations by early 1984.

#### LOCAL DISTRIBUTION BY CABLE

##### Digital Headend

In several articles which have been published recently reference has been made to the "digital headend". This digital headend will process signals that are somewhat different from video signals and will use modulation methods that may be unfamiliar. Nevertheless, the analogy to the classical cable television headend is apparent.

On the customer's premises, racks of equipment consisting of digital multiplexers and standard bandwidth modems are installed. The output of the modems are frequency multiplexed on a two-way system with the output from other modems. At the earth station, there will be much larger "Digital headends" receiving the modem RF signals and processing them to a format compatible with the satellite equipment. For installations where the digital earth station is not co-located with the cable headend, data translators may be required to allow full access to any location in the system. In many respects this "digital headend" is less complex than some of the very sophisticated cable headend systems which are being installed today.

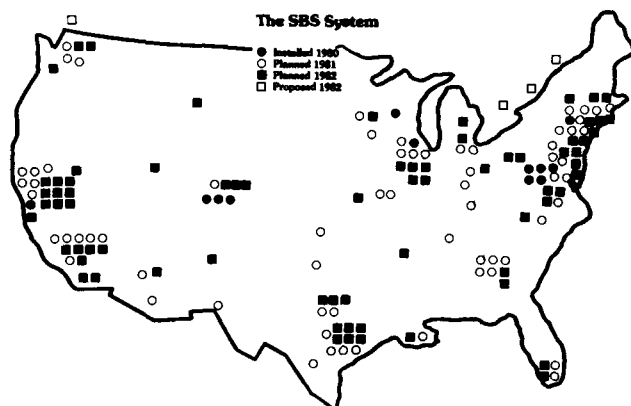


Figure 3

## Distribution

The type of distribution systems used to carry the data signals can be any one of several types. In practice, most systems installed primarily to handle data have been of the mid-split type. This equipment is readily available and offers approximately equal bandwidth in either direction. Typical band edges for mid-split amplifiers are 5MHz-108MHz upstream and 174MHz-300MHz downstream. Several manufacturers have recently introduced new amplifiers which take advantage of the 400 MHz technology to extend the data handling capacity beyond that of the mid-split system. This system is referred to as a hi-split system and provides a bandwidth of 10MHz-172MHz in the upstream direction and 234MHz-400MHz downstream. It should be pointed out however that for limited data applications, data signals can co-exist on the same cable with entertainment and other services as long as sufficient spectrum is available. As is well known, the majority of these systems are designed around a sub-split concept (5-30MHz, 54-300/400MHz) with its obvious lack of equality in bi-directional capacity.

Regardless of the type of system, the broadband cable with its inherent high signal to noise ratio and linearity offers an ideal environment for the transmission of data signals.

## Multiplexing/Access

The information that is to be sent by cable can be multiplexed using time division multiplexing (TDM) or frequency division multiplexing (FDM). Some combination of time and frequency division access will probably be used for most applications. Consider the data rates which are commonly used in satellite circuits (Table 1). If many low data rate ports are available at one location, the most cost effective method of transmitting the signals is to time division multiplex before modulation. On the other hand, the higher data rate services are usually sent single channel per carrier (SCPC) using frequency division multiplex on the coax or satellite.

Another item that needs to be mentioned is changing access according to the changing needs of different users (multiple access). Pure time division systems may be made multiple access by allowing different users to occupy different time slots on demand (TDMA). Likewise, frequency division multiplex systems can be extended to demand access (TDMA or DAMA). Another method that is commonly used is called carrier sense multiple access/collision detection (CSMA/CD).

Basically, a station wishing to transmit using CSMA/CD listens to the circuit. If the link is idle, it transmits. If two stations should transmit simultaneously (collide), each attempts to transmit again after a random delay.

TABLE 1

### Commonly Used Data Rates for Satellite and Terrestrial Services

Multiples of 1.2 Kbps	1.2, 2.4, 4.8, 9.6, 19.2 Kbps
Multiples of 56 Kbps	56, 112, 224, 448 Kbps
T1	1544 Kbps
2T1	3088 Kbps
T1C	3152 Kbps
T2	6312 Kbps

## Modulation

In addition to the multiplexing and accessing method, one also has to consider the modulation that is to be used. The basic possibilities are amplitude shift keying (ASK), phase shift keying (PSK), and frequency shift keying (FSK). An attractive method for transmitting on non-linear systems (satellites) is PSK. PSK transmission can take place using any number of phases, e.g., two phases (bi-phase, BPSK), four phases (quad-phase, QPSK), etc. BPSK and QPSK are widely used in satellite SCPC circuits. When transmitting at high data rates on cables, the frequency spectrum must be conserved. Since the cable is relatively linear and the signal-to-noise ratios are high, an attractive modulation method is a combination of amplitude and phase shift keying. The measure of transmission efficiency normally used is called bits/Hz. This is the number of bits per second that can be transmitted in one Hz bandwidth. The number of bits/Hz for BPSK is one, QPSK is two and for a combination of amplitude and phase shift keying, can be 3 or more. For data rates of T1 or larger, a combination of amplitude and phase shift keying should be considered for use on the cable in order to conserve spectrum.

On the other hand, consider the case of a large number of users at different locations, each user having a relatively low data rate, and each user transmitting occasionally. Here a modulation method can be employed that uses spectrum less efficiently but yields less costly hardware, e.g. FSK. In addition, the system could employ CSMA/CD, giving all users access to the same channel. In most cases, it is evident which type of modulation method should be employed. For further information on data modems for

cable networks see the reference below.

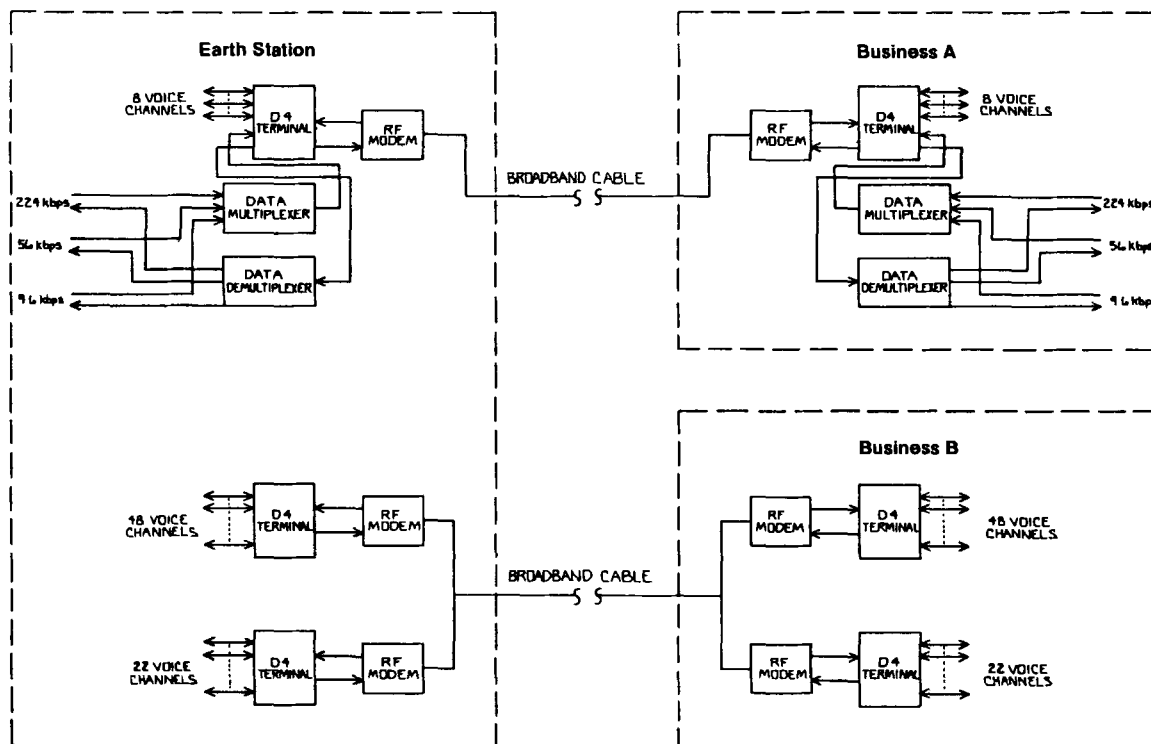
#### Application for Cable

We have discussed the potentially large market for cable serving as the local distribution facility connecting businesses with satellite common carriers. We have discussed some of the technical methods that are available for implementing this cable distribution system. Now let us consider an example of two current business needs that Scientific-Atlanta is helping address. Business A wants to establish a dedicated communication link to another city with 8 voice channels, one 9.6 Kbps circuit, one 56 Kbps circuit and one 224 Kbps circuit. Business B wishes to communicate with 70 voice channels through the same satellite communications earth station. Forty-eight voice channels can be digitized on a commercially available D4 channel bank and sent on a TIC (3.152 Mbps) circuit. Data multiplexers can be added to one D4 channel bank in order to provide the 8 voice channels and the various data circuits. The TIC output from the D4 channel bank is then fed into a spectrum efficient TIC modem and converted to the appropriate frequencies

for transmission on the cable. (Figure 4) It should be noted that Scientific-Atlanta modems can transmit TIC (3.152 Mbps) using slightly more than 1 MHz (1/6 of a video channel). The 70 voice channel requirement for Business B can be satisfied using two D4 channel banks and two TIC modems. Both customer requirements can be satisfied economically using the configuration shown in Figure 4.

#### CONCLUSION

Cable television systems can play an important part in the intracity distribution of voice, data, electronic mail, and other business communications. In only a few years, cable has gone from an auxiliary system for areas with poor television reception to the most versatile and economical system for mass distribution of many channels of video entertainment. The next step will be equally dramatic. It will involve cable operators finding new business customers for using the cable system to distribute business communications within the city. These customers will be satellite communications carriers, large corporations, financial institutions, municipal agencies, and hospitals and university complexes.



Cable Data Communications Link Equipment Configuration

Figure 4

H.W. Katz, "Status Report on EIA  
Broadband Modem Standards," NCTA, 1980.